MAR 20020011: BAD HEART SANDSTONE

Received date: Nov 22, 2002

Public release date: Nov 24, 2003

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NOV 22 2002
20020011

A REPORT AND BACKGROUND INFORMATION PERTINENT TO THE EXPLORATION AND ANALYSIS OF THE BAD HEART SANDSTONE ON PERMITS 9396110003 AND 9396110004

November 14, 2002

Ronald T. Owens

TABLE OF CONTENTS

November 19, 2002

Ronald T. Owens
202 - 5201 - 52 Avenue
Ponoka, AB T4J 1H6
Phone: 403-783-6487
Fax: 403-783-6586

Alberta Energy
Mineral Operations Division
Mineral Tenure Branch
9th Floor, 9945 - 108 St.
Edmonton, AB T5K 2G6

Attention: Hazel Hensen, Agreement Administrator

I hereby submit an Assessment Work Report to cover the required expenditures for the following lands:

All of section 21-6-09-079
All of section 22-6-09-079
All of section 26-6-09-079
All of section 27-6-09-079
All of section 34-6-09-079
All of section 35-6-09-079 A total of 3840 acres or 1554.048 hectares

All of section 2-6-09-080
All of section 3-6-09-080
All of section 7-6-09-080
All of section 8-6-09-080
All of section 9-6-09-080
All of section 10-6-09-080
The South-west quarter of section 11-6-09-080
The South one-half of section 16-6-09-080
The South one-half of section 17-6-09-080
The South one-half of section 18-6-09-080 A total of 4960 acres or 2007.312 hectares

The balance of the acreage of these two permits (9396110003 and 9396110004) I wish to drop at this time as they are no longer of interest for this project.

I have concentrated efforts on developing a leaching protocol for iron rich ore and comparing the results with a fusion protocol; however, getting a consistent correlation still requires more time and effort.

Respectfully yours,

[redacted]

Ronald T. Owens

Authorization to Reproduce or Copy

I hereby give authorization to reproduce or copy this report, after the customary one year delay.

[redacted]

Ronald T. Owens

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January 14, 2003

Alberta Energy
Mineral Development Division
7th Floor North Petroleum Plaza
9945 - 108 Street
Edmonton, AB T5K 2G6

Attention: Susan Carlisle, Director, Mineral Agreements
Coal and Mineral Development

Dear Ms. Carlisle:

In response to your letter of December 23, 2002, I will elaborate on the following queries:

1. Although I believe it necessary to continually up-grade my lab capabilities, I will accept the $13,500.00 amount that was previously acknowledged by you.

2. Although I have found it necessary to travel extensively in acquiring equipment and transporting re-agents as ("hazardous goods regulations" create courier and importation difficulties). Also, the necessity of prompt delivery of leach samples required a great deal of mileage. However, as I realize they are subjective, I will forgo all travel costs.

3. The efforts reported here relate to three components of the program of evaluating the Bad Heart Sandstone as a precious metal prospect.

   I have worked and spent on this program for over ten years; however, the results obtained were often inconclusive.

   For this reason, it appeared necessary to try and identify the causes of the varying results , by a systematic research program of in-house wet chemistry, suggested by an accredited chemist.

   Over two hundred separate leach trials were conducted; one hundred and twenty-five are reported here. The balance were either partial or total failures and so are not reported.

   Each leach trial required a minimum of six hours, three at a time, dictated by space in the fume cabinet for three stirring hot plates. This, along with the associated preparation of samples (drying, screening and weighing) and the cleaning of necessary glassware, etc. required a minimum total of five hundred hours.

4. The goal of this phase of the program was to try and identify the most suitable pre-treatment and type of leach procedure, for use on a single sample collection of the Bad Heart Sandstone. The reason for this was to eliminate variables that would be introduced, and thus skew the data, if samples taken from multiple locations were used for the initial research.

   This standardized procedure would then be used for samples from other sites and depths. This should create an informed decision of the property's potential.

   Due to the importance of identifying the procedures required to accurately analyze materials with the characteristics of the Bad Heart Sandstone, the procedures used must remain proprietary, at this time.

4. Continued

One other aspect of the program, included in the report, is the field trip of late April, 2001. At this time an experienced geologist and myself, contracted Blackhawk Excavating of Spirit River to re-excavate a test pit at Site one - LSD -06-section 26-06-09-79. The pit was sampled at one foot intervals, to the depth of twelve feet. These samples were then dried, pulverized, screened, split and logged.

A split of each sample was forwarded to Auric Metallurgical Laboratories of Salt Lake City, for fire assay with nickle sulphide collection.

This work required approximately one hundred hours, the results of which are included in the body of the report.

Would you please insert the revised "Statement of Expenditures" and "Allocation of Expenditure" and remove the initial submission in the existing copies of the report.

I am including a list setting forth expenses, as well as a list of consulting and custom services utilized, for which receipts can be provided if required.

Also included is a description of work done and conclusions arrived at for inclusion in the Body of the Report.

Respectfully yours,

[redacted]

Ronald T. Owens

N.B. Correct address is: Suite 202, 5201 - 52 Ave.
Ponoka, AB
T4J 1H6;

(not suite 201)

Expendables for which receipts can be provided if required

2001

Jan	Bedrock Supplies	$ 211.86
Feb	Bedrock Supplies	92.57
Feb	Bedrock Supplies	67.23
Feb	Bedrock Supplies	462.45
May	Bedrock Supplies	516.21
June	Bedrock Supplies	40.93
Aug	Bedrock Supplies	91.53
Aug	Bedrock Supplies	70.51
Jan	Petrocraft	103.42
May	Petrocraft	16.45
Jan	Franklin Supply	10.48
Mar	Petrocraft	67.41
Feb	Action Mining Supplies	8.51
Feb	Action Mining Supplies	209.01
Mar	Action Mining Supplies	132.82
Mar	Action Mining Supplies	160.67
Jun	Action Mining Supplies	175.32
Jul	Action Mining Supplies	207.44
Feb	High Valley Chemicals	22.86
Feb	High Valley Chemicals	201.28
Feb	Vopak Chemicals	84.26
May	Vopak Chemicals	41.71
May	Mid North Safety Supply	38.95
May	Sample bags	8.63
Jun	Loomis (sample transport)	28.50
Jun	Alfa Aesar	162.77
Jun	Sample bags	16.41
Jun	U.P.S. (transport of re-agents)	40.11
Aug	U.P.S. " "	48.11
Aug	Greyhound " "	7.72
Aug	Fisher Scientific	97.18
2001	De-ionized water	85.00
2001	Heat and electricity for lab	1,224.00
	Total	$ 4,776.91

Consulting and Custom Services utilized

2000			
Nov	Philip Analytical Services	$	612.25
Dec	Philip Analytical Services		615.25
2001			
Apr	Philip Analytical Services		160.50
Apr	Philip Analytical Services		347.75
2000			
Dec	Maxam Analytical		342.40
Dec	Maxam Analytical		149.80
2001			
Mar	Maxam Analytical		149.80
Feb	Alpha Laboratories		218.21
May	Genalysis		144.00
Aug	Auric Laboratories		2208.04
Feb	Loring Laboratories		96.30
Sept	Loring Laboratories		29.96
April	Blackjack Excavating		386.27
2002			
Feb	[redacted]		779.25
	Total	$	6,239.78

Consulting and Custom Services utilized

BLACKJACK EXCAVATING & PILING LTD.

Box 32, Site 2, RR No. 1
Spirit River, AB T0H 3G0
Phone: (780) 864-0159
Fax: (780) 351-2037
Cell: (780) 864-0159
Email: blackjackpilings@telusplanet.net

TIME TICKET № 02118

DATE April 26/01

P.O. #

AFE

LOCATION Gordondale

CUSTOMER Mineral Recovery Systems

QTY	UNIT	MATERIAL	UNIT PRICE	AMOUNT
		TOTAL MATERIALS		

DESCRIPTION OF WORK

- Excavate pit for soil sampling.
- Backfill pit

HRS	EQUIPMENT (Unit # & Attachments)	RATE	AMOUNT
3	580 SL Hoe	95.00	285.00
1	T101 Deck Truck	95.00	95.00
	TOTAL EQUIPMENT		380.00
	less 5% COD		19.00
			361.00

OTHER CHARGES	AMOUNT

LABOUR		HRS	RATE	AMOUNT
	ST			
	OT			
	ST			
	OT			
	ST			
	OT			
	ST			
	OT			

TOTAL LABOUR	
MATERIALS	
EQUIPMENT & OTHER	361.00
SUBTOTAL	361.00
GST #: 865586580RT GST	25.27
TOTAL DUE ▶	386.27

CLIENT REP.

CONTACT #

CIBC

00077 PONOKA -
PONOKA, ALTA
TRANSIT NO. *N° D'IDENTIFICATION* BRANCH *CENTRE BANCAIRE*

DATE 9/07/2001

RON OWENS
NAME OF REMITTER *DONNEUR D'ORDRE*

PAY TO THE ORDER OF *PAYEZ À L'ORDRE DE* AURIC METALLURIGICAL LABORATORIES,LLC********** USD ***********1,425.00***

AMOUNT IN FIGURES *MONTANT EN CHIFFRES*

THE SUM OF *LA SOMME DE* ONE THOUSAND FOUR HUNDRED TWENTY FIVE******************* UNITED STATES DOLLARS *DOLLARS DES ÉTATS-UNIS*

AMOUNT IN WORDS *MONTANT EN LETTRES*

TO *TIRÉ:*
THE BANK OF NEW YORK
48 WALL STREET
NEW YORK, N.Y.
USA 10286

NOT NEGOTIABLE NON NÉGOCIABLE

CHARGE TO CUSTOMER *À IMPUTER AU CLIENT*

RATE *COURS*	1.5495
EQUIV. CAD *CONTRE-VALEUR EN CAD*	2,208.04
HANDLING CHARGES *COMMISSION DE MANIPULATION*	0.00
TOTAL COST *COÛT TOTAL*	2,208.04

CUSTOMER'S COPY
RETAIN THIS COPY FOR YOUR RECORD
SEE "NOTICE TO PURCHASER" ON REVERSE

COPIE DU CLIENT
CONSERVER CETTE COPIE POUR VOS DOSSIERS
VOIR «AVIS À L'ACHETEUR» AU VERSO

Map 1

Pit #2
Pit #1
RO-07
RO-10
RO-08/09
98-059 1:20K 98-04-30
AS4917
AIR PHOTO SERVICES (403) 427-3520
Edmonton, A

Statement of Expenditures

Metallic and Industrial Minerals Permit Nos 9396110003 and 9396110004

Description	Total Cost
Fifty percent of capital investment carried forward from previous period	$ 13,500.00
Lab materials and reagents	3,733.68
Consulting and Custom Services	6,583.58
Equipment maintenance	[redacted]
Time spent on project [redacted]	[redacted]
	$ 37,407.95

I certify that these expenditures are valid and were incurred in conducting assessment work on the above permits.

Signed

[redacted]

Ronald T. Owens

Signature/Stamp:
Commissioner
For Oaths

KAREN R. DAY
Karen R. Day
A Commissioner for Oaths in
and for the Province of Alberta.
Exp. 23.07.05

Allocation of Expenditures

Permit No.	Ha.	Expenditure Required	Expenditure Assigned
9396110003	1554.048	$ 15,540.048	$ 16,331.18
9396110004	2007.312	20,073.12	21,076.77
	-------	-------	-------
Total	3561.36	$ 35,613.60	$ 37,394.27

Introduction : Program for the Evaluation of the Bad Heart Sandstone

In November of 2000 it was concluded that much of the prior work and expense related to evaluating this property as a precious metal prospect, was not accomplishing that goal.

An in-house wet-chemistry analysis procedure was begun, under the instruction of an accredited chemist.

The focus of this program was twofold:

1. To identify the most suitable pre-treatment and leach procedure for use on sample material containing anomalous iron, nickel, manganese and other potentially interfering elements.
2. To evaluate I.C.P. mass spec. as an accurate, economical way of analyzing the pregnant leach samples produced.

Work Performed:

Over two hundred leach trials were conducted; the first several groups were either partial or total failures, and so are not reported.

The protocol followed was "Standard Addition" utilizing a pulp from Nevada, of proven consistency of AU values as the spike.

This spike was used in all samples submitted for instrumental analysis, to which various ratios of Bad Heart Sandstone pulp was added.

In the interest of reducing as many variables as possible, the Bad Heart Sandstone pulp used was a thoroughly mixed sample from between two feet and four feet of an earlier backhoe pit at Site one LSD -06-section 26-06-09-79
(see air photo map)

After a standardized procedure is established, it would then be rigidly applied to samples from other locations and depths of this property.

On April 26, 2002, a second test pit was excavated at Site one - LSD 06-section 26-06-09-79.

Approximately ten pounds of material was collected at one foot intervals, to a depth of twelve feet. As in the previous pit, a two foot horizon of cemented material was encountered at six feet of depth.

Several hundred pounds of this material was retrieved and transported for future analysis. Each one foot horizon was air-dried, pulverized, split, screened and logged. One thousand gram, representative splits of each aforementioned one foot horizon were forwarded to Auric Metallurgical Laboratories, Salt Lake City, Utah. There a fire assay-nickle sulphide collection was conducted. The results are shown in section seven of this report.

Conclusions:

1. Iron interference was a major hurdle in direct I.C.P. analysis of the leaches that were tested.
2. Weak acid washes (pre-leach) reduced the problems experienced, somewhat.
3. Multi-step wet chemistry is required to obtain repeatable, quantitative results by anyone not having a broad experience in fusion chemistry.
4. It is essential that instrumental analysis be done promptly and consistently (within one hundred hours, or the pregnant leaches that were used started to degrade. (partially precipitate).

Summary:

Progress has been made, and more comprehensive in-house work is to be done in the future. This will involve solvent extraction and gravimetric determination, so that all facets of the analysis can be observed. This should help identify sooner, any deviations from the norm.

AMENDED APPENDIX

TO

METALLIC AND INDUSTRIAL MINERALS PERMIT NO. 9396110003

COMMENCEMENT OF TERM:

1996 NOVEMBER 5

DATE OF AMENDMENT:

1998 NOVEMBER 2

AGGREGATE AREA:

4 608 HECTARES

DESCRIPTION OF LOCATION AND PERMITTED SUBSTANCES:

6-09-079: 19-36

METALLIC AND INDUSTRIAL MINERALS

SPECIAL PROVISIONS:

NIL

Hazel Henson

FOR: MINISTER OF ENERGY

AMENDED APPENDIX

TO

METALLIC AND INDUSTRIAL MINERALS PERMIT NO. 9396110004

COMMENCEMENT OF TERM:

1996 NOVEMBER 5

DATE OF AMENDMENT:

1998 NOVEMBER 2

AGGREGATE AREA:

4 608 HECTARES

DESCRIPTION OF LOCATION AND PERMITTED SUBSTANCES:

6-09-080: 1-18

METALLIC AND INDUSTRIAL MINERALS

SPECIAL PROVISIONS:

NIL

Hazel Henson

FOR: MINISTER OF ENERGY

otal Work one In Period or Time Frame

May 14, 1999

ompany	Permit	Cancelled Date
WENS, RONALD THOMAS	**9396110003**	

Period	Due Date	Hectare	$/Ha	Required Spending	Expenditure	Cash Payment	Previous Credit	Balance
1	Nov 05, 1998	4608.0000	$5.00	$23,040.00	$28,074.23	$0.00		$5,034.23
2	Nov 05, 2000	4608.0000	$10.00	$46,080.00	$0.00	$0.00	$5,034.23	($41,045.77)
3	Nov 05, 2002	0	$10.00	$0.00	$0.00	$0.00		
4	Nov 05, 2004	0	$15.00	$0.00	$0.00	$0.00		
5	Nov 05, 2006	0	$15.00	$0.00	$0.00	$0.00		

Source: Minerals Tenure Branch, Mineral Agreements May 14, 1999

Total Work Done In Period or Time Frame

May 14, 1999

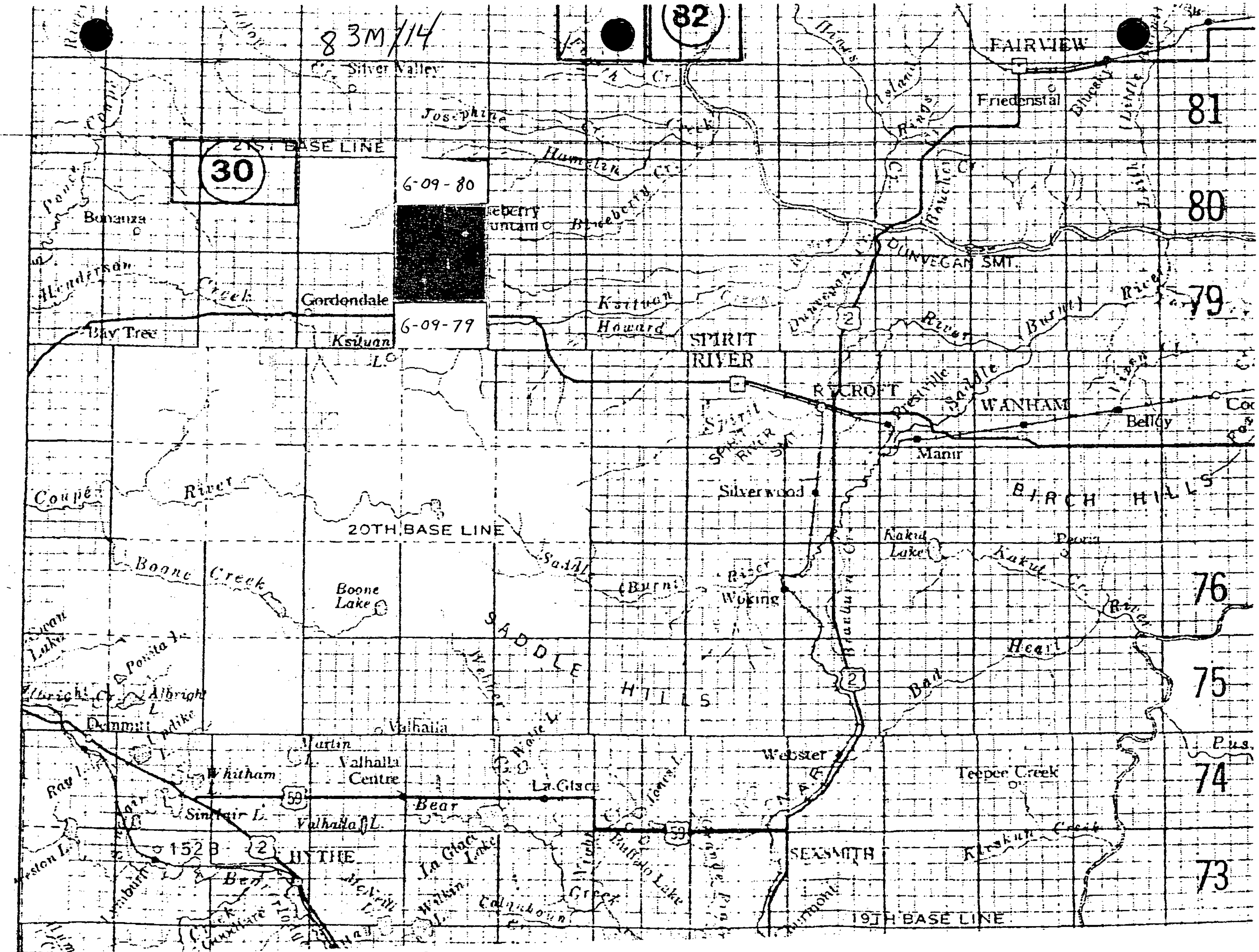
Company	Permit	Cancelled Date
OWENS, RONALD THOMAS	**9396110004**	

Period	Due Date	Hectare	$/Ha	Required Spending	Expenditure	Cash Payment	Previous Credit	Balance
1	Nov 05, 1998	4608.0000	$5.00	$23,040.00	$28,074.22	$0.00		$5,034.22
2	Nov 05, 2000	4608.0000	$10.00	$46,080.00	$0.00	$0.00	$5,034.22	($41,045.78)
3	Nov 05, 2002	0	$10.00	$0.00	$0.00	$0.00		
4	Nov 05, 2004	0	$15.00	$0.00	$0.00	$0.00		
5	Nov 05, 2006	0	$15.00	$0.00	$0.00	$0.00		

Source: Minerals Tenure Branch, Mineral Agreements May 14, 1999

4

83M/14

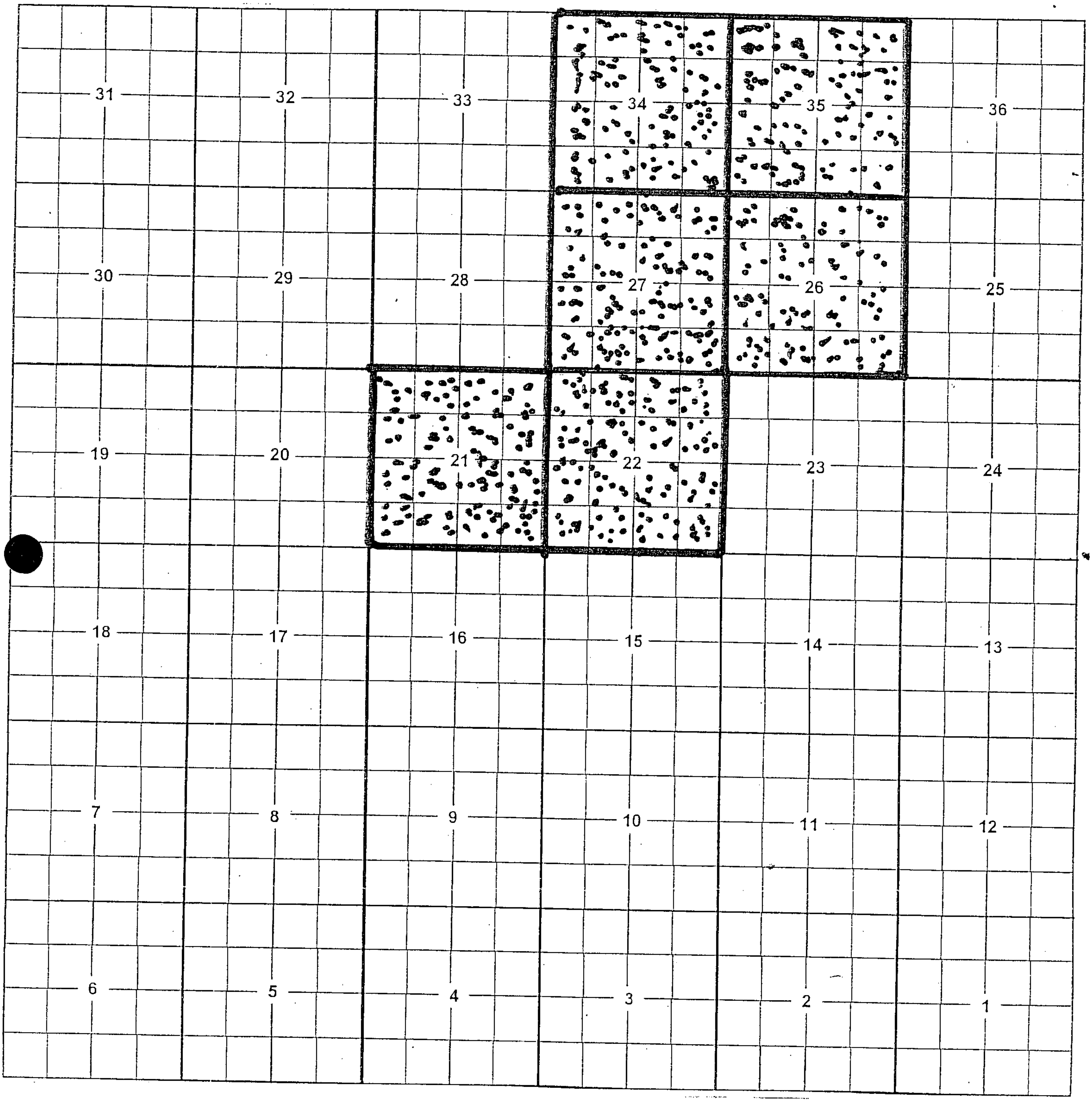


32
FAIRVIEW
Silver Valley
Friedenstal
81
Josephine Cr.
Creek
21ST BASE LINE
30
6-09-80
Hamelin Cr.
Blueberry Cr.
Blueberry Mountain
80
Bonanza
DUNVEGAN SMT.
Henderson Creek
Gordondale
6-09-79
Ksituan Creek
Howard
79
Bay Tree
Ksituan L.
SPIRIT RIVER
2
RYCROFT
Burnt River
Saddle
WANHAM
Belloy
Manir
Spirit River
SPIRIT RIVER SMT.
Silverwood
BIRCH HILLS
Coupé River
20TH BASE LINE
Kakut Lake
Kakut Cr.
Peoria
Boone Creek
Boone Lake
Burnt River
Woking
76
SADDLE HILLS
Heart River
Bad Heart
75
Albright Cr.
Albright L.
Demmitt
Valhalla
Martin L.
Valhalla Centre
Whitham
Webster
Teepee Creek
74
59
Bear
La Glace
Valhalla L.
Sinclair L.
Ray L.
152B
HYTHE
SEXSMITH
Kleskun Creek
La Glace Lake
Buffalo Lake
Bear River
Creek
Calahoun
Wilkins L.
73
19TH BASE LINE

9W6

METALLIC MINERALS PERMIT NO. 9396110003

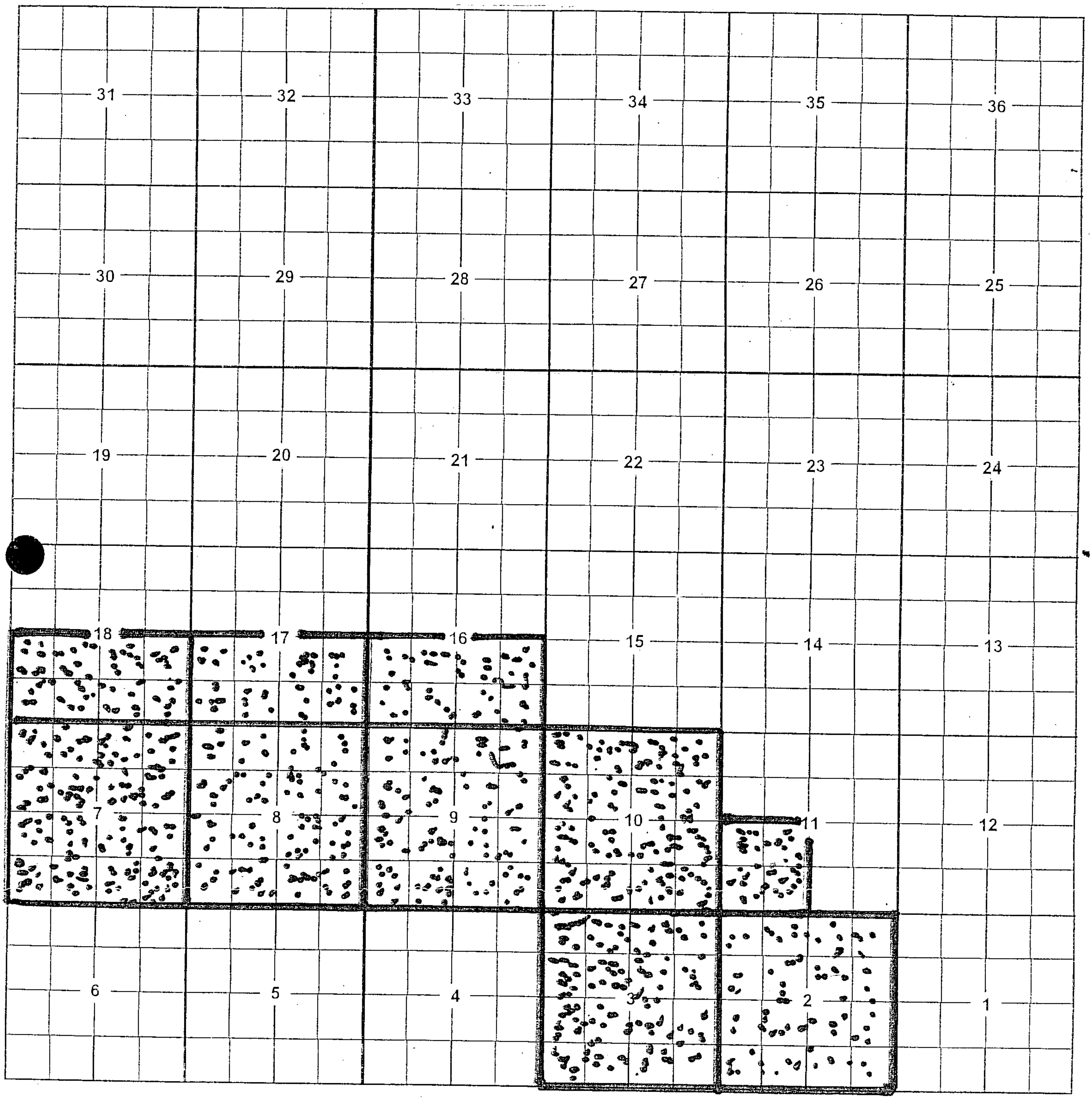
6-09-079



AREA COVERED BY THIS REPORT ---- ▨

METALLIC MINERALS PERMIT NO. 9396110004

6-09-080



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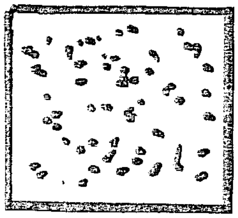

5

Body of Report

Maxxam
Analytics Inc
A Chemex Labs Alberta/NOVAMANN International Partnership

9331 - 48 Street
Edmonton, Alberta, Canada
T6B 2R4

FAX COVER SHEET

Please Deliver the Following Pages To:

NAME: Ron Owens, Mineral Recovery Systems

FAX: 1-403-783-6586

FROM: Maxxam Edm.
TELEPHONE: (780) 468-3500
FAX: (780) 468-3560
TOTAL # of PAGES INCLUDING COVER: 18

MAXXAM Analytics Inc.

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point ID:
Client ID:
Meter Number:
Laboratory Number: 01-23125-03

Company:

Well / Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RO-44 T3

	Gauge Pressures kPa		Temperatures °C	
	Source	As Received	Source	As Received
	N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported:
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.24

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc. DRAFT COPY **CERTIFICATE OF ANALYSIS**

Container Identity: Glass
Sample Point ID:
Client ID:
Meter Number:
Laboratory Number: 01-23125-01

Company:

Well / Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RO-04411

	Gauge Pressure kPa		Temperature °C	
	Source	As Received	Source	As Received
	N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported:
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.17

NA Analysis Not Available ND Not Detected Results relate only to items tested

Remarks:
*No Sample Date

MAXXAM Analytics Inc.

DRAFT COPY

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point ID:
Client ID:
Meter Number:
Laboratory Number: 01-23125-02

Company:

Well / Plant:
Method of Sample:
Company:

Sample Description:

Sample Point: RO-044-T2

Gauge Pressure (kPa)
Source: N/A
As Received: N/A

Temperature (°C)
Source: N/A
As Received: N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported:
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.30

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc.

DRAFT COPY

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point ID:
Client ID:
Meter Number:
Laboratory Number: 01-23125-15

Company:

Well / Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RO-0381/2

Gauge Pressures kPa — Source: N/A — As Received: N/A
Temperatures °C — Source: N/A — As Received: N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported:
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.40

NA Analysis Not Available   ND Not Detected   Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc. DRAFT COPY **CERTIFICATE OF ANALYSIS**

Container Identity: Glass
Sample Point I.D.:
Client I.D.:
Meter Number:
Laboratory Number: 01-23125-11

Company:

Well / Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RC-0371/2

	Gauge Pressures kPa		Temperature °C	
	Source	As Received	Source	As Received
	N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Analyzed:
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax: 403-783-8487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.39

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc. DRAFT COPY

CERTIFICATE OF ANALYSIS

Glass				01-23125-12
Container Identity	Sample Point ID	Client ID	Meter Number	Laboratory Number

Company:

Well / Plant	Name of Sampler	Company

Sample Description:

Sample Point: 80-045

Gauge Pressures kPa		Temperatures °C	
N/A	N/A	N/A	N/A
Source	As Received	Source	As Received

*		2000/12/12			AL
Date Sampled Start	Date Sampled End	Date Received	Date Reported		Analyst

Contact Name:

Contact Phone:

Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.62

NA Analysis Not Available NC Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc.

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point ID:
Client ID:
Meter Number:
Laboratory Number: 01-23125-13

Company:

Well / Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RD-046

Gauge Pressures kPa		Temperatures °C	
Source	As Received	Source	As Received
N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported:
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.62

NA Analysis Not Available   ND Not Detected

Results relate only to items tested

Remarks:
*No Sample Date

MAXXAM Analytics Inc.

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point ID:
Client ID:
Meter Number:
Laboratory Number: 01-23125-14

Company:

Well/Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RC-0411/2

	Source	As Received
Gauge Pressure kPa	N/A	N/A
Temperature °C	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported:
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.30

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc.

DRAFT COPY

CERTIFICATE OF ANALYSIS

Glass
Container Identity

Sample Point I.D.

Client I.D.

Meter Number

01-23125-17
Laboratory Number

Company

Well / Plant

Name of Sampler

Company

Sample Description

RO-043
Sample Point

Gauge Pressure kPa

N/A	N/A
Source	As Received

Temperature °C

N/A	N/A
Source	As Received

*
Date Sampled Start

Date Sampled End

2000/12/12
Date Received

Date Reported

AL
Analyst

Contact Name

Contact Phone

403-783-6487
Contact Fax

PARAMETER	UNITS	RESULT
Gold	mg/l	0.40

NA Analysis Not Available   ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc.

CERTIFICATE OF ANALYSIS

Glass				01-23125-06
Container Identity	Sample Point ID	Client ID	Meter Number	Laboratory Number

Company:

Well Plant: Name of Sampler: Company:

Sample Description:

Sample Point: RC-042T1

Gauge Pressures kPa		Temperatures °C	
N/A	N/A	N/A	N/A
Source	As Received	Source	As Received

*		2000/12/12			AL
Date Sampled Start	Date Sampled End	Date Received	Date Reported		Analyst

Contact Name:

Contact Phone: Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.28

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc. DRAFT COPY

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point ID:
Client ID:
Meter Number:
Laboratory Number: 01-23125-16

Company:

Well, Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RO-016A

	Gauge Pressure kPa		Temperature °C
Source	As Received	Source	As Received
N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported:
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.41

NA Analysis Not Available ND Not Detected Results relate only to items tested.

Remarks:

*No Sample Date

MAXXAM Analytics Inc. DRAFT COPY

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point ID:
Client ID:
Meter Number:
Laboratory Number: 01-23125-07

Company:

Well / Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RC-042 T2

	Gauge Pressures kPa		Temperatures °C	
	Source	As Received	Source	As Received
	N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported:
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.23

NA Analysis Not Available NC Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc. DRAFT COPY

CERTIFICATE OF ANALYSIS

Container Identity: Glass

Sample Point ID:

Client ID:

Meter Number:

Laboratory Number: 01-23125-08

Company:

Well/Plant:

Name of Sampler:

Company:

Sample Description:

Sample Point: RO-04213

Gauge Pressure kPa		Temperature C	
N/A	N/A	N/A	N/A
Source	As Received	Source	As Received

Date Sampled Start: *

Date Sampled End:

Date Received: 2000/12/12

Date Reported:

Analyst: AL

Contact Name:

Contact Phone:

Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.38

NA Analysis Not Available   ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Data

MAXXAM Analytics Inc.

DRAFT COPY

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point I.D.:
Client I.D.:
Meter Number:
Laboratory Number: 01-23125-05

Company:

Well Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RO-036A F1

	Gauge Pressures kPa		Temperatures °C	
	Source	As Received	Source	As Received
	N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported:
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.12

NA Analysis Not Available NC Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc. DRAFT COPY

CERTIFICATE OF ANALYSIS

Glass				01-23125-04
Container Identity	Sample Point I.D.	Client I.D.	Meter Number	Laboratory Number

Company

Well / Plant	Name of Sampler	Company

Sample Description

RO-036D
Sample Point

Gauge Pressures kPa		Temperatures °C	
N/A	N/A	N/A	N/A
Source	As Received	Source	As Received

*		2000/12/12		AL
Date Sampled Start	Date Sampled End	Date Received	Date Reported	Analyst

Contact Name

	403-783-6487
Contact Phone	Contact Fax

PARAMETER	UNITS	RESULT
Gold	mg/l	0.06

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc. DRAFT COPY

CERTIFICATE OF ANALYSIS

Container Identity: Glass

Sample Point I.D.:

Client I.D.:

Meter Number:

Laboratory Number: 01-23125-09

Company:

Well / Plant:

Name of Sampler:

Company:

Sample Description:

Sample Point: RC-036B

Gauge Pressures kPa		Temperatures °C	
N/A	N/A	N/A	N/A
Source	As Received	Source	As Received

Date Sampled Start: *

Date Sampled End:

Date Received: 2000/12/12

Date Reported:

Analyst: AL

Contact Name:

Contact Phone:

Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.19

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc.

DRAFT COPY

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point I.D.:
Client I.D:
Meter Number:
Laboratory Number: 01-23125-10

Company:
Well / Plant: Edmonton
Name of Sampler:
Company:

Sample Description:
Sample Point: RO-036C

	Gauge Pressure kPa		Temperature °C	
	Source	As Received	Source	As Received
	N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported:
Analyst: AL

Contact Name: Terry Christopher
Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.20

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

MAXXAM Analytics Inc.

DRAFT COPY

CERTIFICATE OF ANALYSIS

Container Identity: Plastic
Sample Point ID:
Client ID:
Meter Number:
Laboratory Number: 01-23556-13

Company:

Well / Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RC-032

Gauge Pressures kPa	
Source	As Received
N/A	N/A

Temperatures C	
Source	As Received
N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2001/01/15
Date Reported:
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax:

PARAMETER	UNITS	RESULT
Palladium	mg/l	<0.1

NA Analysis Not Available NC Not Detected

Results relate only to items tested

Remarks

* No Sample Date

RN Samples

Sample No.	Analysis Type	Well Name / Sample ID	Sample Point
01-23406-01	Certificate	Edmonton	RN-001A
01-23406-02	Certificate	Edmonton	RN-001B
01-23406-03	Certificate	Edmonton	RN-001C
01-23406-04	Certificate	Edmonton	RN-001D
01-23406-05	Certificate	Edmonton	RN-008A
01-23406-06	Certificate	Edmonton	RN-008B
01-23406-07	Certificate	Edmonton	RN-009A

Report Distribution

Invoice(s)

1 Report(s) Ron Owens No.: 81994-IE C/C Mineral Recovery Ponoka, AB

Supervisory Approval
Industrial Division

[redacted]

Signature

Mon, Jan 22, 2001

Date of Issue

- RN Samples

Sample No.	Analysis Type	Well Name / Sample ID	Sample Point
01-23406-01	Certificate	Edmonton	RN-001A
01-23406-02	Certificate	Edmonton	RN-001B
01-23406-03	Certificate	Edmonton	RN-001C
01-23406-04	Certificate	Edmonton	RN-001D
01-23406-05	Certificate	Edmonton	RN-008A
01-23406-06	Certificate	Edmonton	RN-008B
01-23406-07	Certificate	Edmonton	RN-009A

Report Distribution
Invoice(s)
1 Report(s) Ron Owens No.: 81994-IE C/O Mineral Recovery Ponoka, AB

Supervisory Approval
Industrial Division

[redacted]

Signature

Mon, Jan 22, 2001
Date of Issue

Maxxam Job #: 01-23125

Maxxam
Analytics Inc

Samples for gold content (00/12/22)

Sample No.	Analysis Type	Well Name / Sample ID	Sample Point
01-23125-01	Certificate	Edmonton	RO-044 T1
01-23125-02	Certificate	Edmonton	RO-044-T2
01-23125-03	Certificate	Edmonton	RO-44 T3
01-23125-04	Certificate	Edmonton	RO-030D
01-23125-05	Certificate	Edmonton	RO-038A T1
01-23125-06	Certificate	Edmonton	RO-042 T1
01-23125-07	Certificate	Edmonton	RO-042 T2
01-23125-08	Certificate	Edmonton	RO-042 T3
01-23125-09	Certificate	Edmonton	RO-038B
01-23125-10	Certificate	Edmonton	RO-038C
01-23125-11	Certificate	Edmonton	RO-037 1/2
01-23125-12	Certificate	Edmonton	RO-045
01-23125-13	Certificate	Edmonton	RO-048
01-23125-14	Certificate	Edmonton	RO-041 1/2
01-23125-15	Certificate	Edmonton	RO-039 1/2
01-23125-16	Certificate	Edmonton	RO-516A
01-23125-17	Certificate	Edmonton	RO-043

Report Distribution
Invoice(s)
1 Report(s) Ron Ostma No.: 8137-IE C/O Mineral Recovery Ponoka, AB

Supervisory Approval
Industrial Division

[redacted]

Signature

Tue, Feb 27, 2001
Date of Issue

CERTIFICATE OF ANALYSIS

Glass
Company Identity

Sample Point I.D. Client I.D.

Company

Meter Number

01-23125-06
Laboratory Number

Well / Plant

Sample Description

Name of Sampler

Company

RO-042 T1
Sample Point

Gauge Pressures kPa
N/A Source
N/A As Received

Temperatures °C
N/A Source
N/A As Received

*
Date Sampled Start
Date Sampled End

2000/12/12
Date Received

2000/12/25
Date Reported

AL
Analyst

Contact Name

Contact Phone

403-783-6487
Contact Fax

PARAMETER	UNITS	RESULT
Gold	mg/l	0.28

NA Analysis Not Available ND Not Detected

Remarks:
*No Sample Date

Results relate only to items tested

CERTIFICATE OF ANALYSIS

Glass
Container Identity

Sample Point I.D.

Client I.D.

Meter Number

01-23125-05
Laboratory Number

Company

Well / Plant

Name of Sampler

Company

Sample Description

RC-036A T1
Sample Point

Gauge Pressures kPa

N/A
Source

N/A
As Received

Temperature °C

N/A
Source

N/A
As Received

*
Date Sampled Start

Date Sampled End

2000/12/12
Date Received

2000/12/28
Date Reported

AL
Analyst

Contact Name

Contact Phone

403-786-6487
Contact Fax

PARAMETER	**UNITS**	**RESULT**
Gold	mg/l	0.12

NA Analysis Not Available   ND Not Detected

Remarks:

*No Sample Date

Results relate only to items tested

CERTIFICATE OF ANALYSIS

Glass
Container Identity

Sample Point I.D. *Client I.D.* *Meter Number*

01-23125-04
Laboratory Number

Company

Well / Plant

Name of Sampler *Company*

Sample Description

RO-038D
Sample Point

Gauge Pressures kPa		*Temperatures °C*	
N/A	N/A	N/A	N/A
Source	*As Received*	*Source*	*As Received*

*
Date Sampled Start *Date Sampled End*

2000/12/12
Date Received

2000/12/28
Date Reported

AL
Analyst

Contact Name

Contact Phone

403-783-6497
Contact Fax

PARAMETER	**UNITS**	**RESULT**
Gold	mg/l	0.03

NA Analysis Not Available ND Not Detected

Remarks:

*No Sample Date

Results relate only to items tested

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point I.D.:
Client I.D.:
Permit Number:
Laboratory Number: 01-23125-03
Company:
Well / Plant:
Name of Sampler:
Company:
Sample Description:
Sample Point: RC-44 T3

Gauge Pressures kPa		Temperatures °C	
Source	As Received	Source	As Received
N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported: 2000/12/28
Analyst: AL
Contact Name:
Contact Phone:
Contact Fax: 403-783-6467

PARAMETER	UNITS	RESULT
Gold	mg/l	0.24

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point I.D.:
Client I.D.:
Meter Number:
Laboratory Number: 01-23125-14

Company:

Well / Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RO-041 1/2

	Gauge Pressures kPa		Temperatures °C	
	Source	As Received	Source	As Received
	N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported: 2000/12/25
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.30

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:
*No Sample Date

CERTIFICATE OF ANALYSIS

Glass
Customer Industry

Sample Point I.D.
Client I.D.
Meter Number

01-23125-13
Laboratory Number

Company

Well / Plant
Name of Sampler
Company

Sample Description

RC-045
Sample Point

	Gauge Pressure kPa		Temperature °C
N/A	N/A	N/A	N/A
Source	As Received	Source	As Received

*
Date Sampled Start
Date Sampled End

2000/12/12
Date Received

2000/12/28
Date Reported

AL
Analyst

Contact Name

Contact Phone

403-783-8487
Contact Fax

PARAMETER	UNITS	RESULT
Gold	mg/l	0.62

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point I.D.:
Client I.D.:
Station Number:
Laboratory Number: 01-23125-12
Company:
Well / Plant:
Name of Sampler:
Company:
Sample Description:
Sample Point: RO-045

	Gauge Pressure kPa		Temperature °C	
	Source	As Received	Source	As Received
	N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported: 2000/12/28
Analyst: AL
Contact Name:
Contact Phone:
Contact Fax: 403-783-6457

PARAMETER	UNITS	RESULT
Gold	mg/l	0.82

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

CERTIFICATE OF ANALYSIS

Container Identity: Glass

Sample Point I.D.:

Client I.D.:

Meter Number:

Laboratory Number: 01-23125-11

Company:

Well / Plant:

Name of Sampler:

Company:

Sample Description:

Sample Point: RO-037 1/2

Gauge Pressures kPa — Source: N/A — As Received: N/A

Temperatures °C — Source: N/A — As Received: N/A

Date Sampled Start: *

Date Sampled End:

Date Received: 2000/12/12

Date Reported: 2000/12/28

Analyst: AL

Contact Name:

Contact Phone:

Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.39

NA Analysis Not Available   ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

CERTIFICATE OF ANALYSIS

Glass
Container Identity

Sample Point I.D.

Client I.D.

Meter Number

01-23125-10
Laboratory Number

Company

Well / Plant

Name of Sampler

Company

Sample Description

RO-036C
Sample Point

Gauge Pressures kPa		Temperatures °C	
N/A	N/A	N/A	N/A
Source	As Received	Source	As Received

Date Sampled Start

Date Sampled End

2000/12/12
Date Received

2000/12/28
Date Reported

AL
Analyst

Contact Name

Contact Phone

403-783-6487
Contact Fax

PARAMETER	UNITS	RESULT
Gold	mg/l	0.20

NA Analysis Not Available   ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

CERTIFICATE OF ANALYSIS

Glass
Container Identity

Sample Point I.D.

Client I.D.

Meter Number

01-23125-C9
Laboratory Number

Company

Well / Plant

Name of Sampler

Company

Sample Description

RO-036B
Sample Point

Gauge Pressure kPa
N/A
Source
N/A
As Received

Temperature °C
N/A
Source
N/A
As Received

Date Sampled Start

Date Sampled End

2000/12/12
Date Received

2000/12/28
Date Reported

AL
Analyst

Contact Name

Contact Phone

403-793-6487
Contact Fax

PARAMETER	UNITS	RESULT
Gold	mg/l	0.19

NA Analyses Not Available ND Not Detected

Remarks:

*No Sample Date

Results relate only to items tested

CERTIFICATE OF ANALYSIS

Container Identity: Glass
Sample Point I.D.:
Client I.D.:
Meter Number:
Laboratory Number: 01-23125-08
Company:
Well / Plant:
Name of Sampler:
Company:
Sample Description:
Sample Point: RC-042 T3

Gauge Pressures kPa		Temperatures °C	
Source	As Received	Source	As Received
N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/12
Date Reported: 2000/12/28
Analyst: AL
Contact Name:
Contact Phone:
Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.38

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

CERTIFICATE OF ANALYSIS

Glass
Container Identity

Sample Point I.D Client I.D

Meter Number

01-23125-07
Laboratory Number

Company

Well / Plant

Name of Sampler
Company

Sample Description

RC-042 T2
Sample Point

Gauge Pressure kPa
N/A Source
N/A As Received

Temperature °C
N/A Source
N/A As Received

*
Date Sampled Start
Date Sampled End

2000/12/12
Date Received

2000/12/28
Date Reported

AL
Analyst

Contact Name

Contact Phone

403-783-6487
Contact Fax

PARAMETER	UNITS	RESULT
Gold	mg/l	0.23

NA Analysis Not Available ND Not Detected

Remarks:

*No Sample Date

Results relate only to items tested

CERTIFICATE OF ANALYSIS

Container Identity: Glass

Sample Point I.D.:

Client I.D.:

Meter Number:

Laboratory Number: 01-23125-02

Company:

Well / Plant:

Name of Sampler:

Company:

Sample Description:

Sample Point: RO-044-T2

	Gauge Pressures kPa		Temperatures °C	
	Source	As Received	Source	As Received
	N/A	N/A	N/A	N/A

Date Sampled Start: *

Date Sampled End:

Date Received: 2000/12/12

Date Reported: 2000/12/28

Analyst: AL

Contact Name:

Contact Phone:

Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.30

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

CERTIFICATE OF ANALYSIS

Container Identity: Glass

Sample Point I.D.

Cabin I.D.

Meter Number

Laboratory Number: 01-23125-01

Company

Well / Plant

Name of Sampler

Company

Sample Description

Sample Point: RO-044 T1

Gauge Pressure kPa — Source: N/A — As Received: N/A

Temperature °C — Source: N/A — As Received: N/A

Date Sampled Start: *

Date Sampled End

Date Received: 2000/12/12

Date Reported: 2000/12/28

Analyst: AL

Contact Name

Contact Phone

Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.17

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

Maxxam Job #: 01-23125

Maxxam Analytics Inc

Samples for gold content (00/12/12)

Sample No.	Analysis Type	Well Name / Sample ID	Sample Point
01-23125-01	Certificate	Edmonton	RO-044 T1
01-23125-02	Certificate	Edmonton	RO-044-T2
01-23125-03	Certificate	Edmonton	RO-44 T3
01-23125-04	Certificate	Edmonton	RO-038D
01-23125-05	Certificate	Edmonton	RO-036A T1
01-23125-06	Certificate	Edmonton	RO-042 T1
01-23125-07	Certificate	Edmonton	RO-042 T2
01-23125-08	Certificate	Edmonton	RO-042 T3
01-23125-09	Certificate	Edmonton	RO-036B
01-23125-10	Certificate	Edmonton	RO-038C
01-23125-11	Certificate	Edmonton	RO-037 1/2
01-23125-12	Certificate	Edmonton	RO-045
01-23125-13	Certificate	Edmonton	RO-046
01-23125-14	Certificate	Edmonton	RO-041 1/2
01-23125-15	Certificate	Edmonton	RO-038 1/2
01-23125-16	Certificate	Edmonton	RO-018A
01-23125-17	Certificate	Edmonton	RO-043

Report Distribution
Invoice(s)
1 Report(s) Ron Owens

No.: 81379-IE

C/O Mineral Recovery

Ponoka, AB

Supervisory Approval
Industrial Division

[redacted]

Signature

Tue, Feb 27, 2001
Date of Issue

CERTIFICATE OF ANALYSIS

Glass
Container Identity

Sample Point I.D. Client I.D. Meter Number

01-23125-17
Laboratory Number

Company

Well / Plant

Name of Sampler Company

Sample Description

RO-043
Sample Point

Gauge Pressures kPa
N/A Source
N/A As Received

Temperatures °C
N/A Source
N/A As Received

*
Date Sampled Start
Date Sampled End
2000/12/12
Date Received
2000/12/28
Date Recorded
AL
Analyst

Contact Name

Contact Phone
403-723-6487
Contact Fax

PARAMETER	UNITS	RESULT
Gold	mg/l	0.40

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

CERTIFICATE OF ANALYSIS

Container Identity: Glass

Sample Point I.D.:

Client I.D.:

Meter Number:

Laboratory Number: 01-23125-16

Company:

Well / Plant:

Name of Sampler:

Company:

Sample Description:

Sample Point: RO-016A

Gauge Pressures kPa — Source: N/A — As Received: N/A

Temperature °C — Source: N/A — As Received: N/A

Date Sampled Start: *

Date Sampled End:

Date Received: 2000/12/12

Date Reported: 2000/12/28

Analyst: AL

Contact Name:

Contact Phone:

Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.41

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:

*No Sample Date

CERTIFICATE OF ANALYSIS

Container Identity: Glass

Sample Point I.D.:

Client I.D.:

Meter Number:

Laboratory Number: 01-23125-15

Company:

Well / Plant:

Name of Sampler:

Company:

Sample Description:

Sample Point: RC-036 1/2

	Gauge Pressure kPa		Temperature °C	
	N/A	N/A	N/A	N/A
	Source	As Received	Source	As Received

Date Sampled Start: *

Date Sampled End:

Date Received: 2000/12/12

Date Reported: 2000/12/28

Analyst: AL

Contact Name:

Contact Phone:

Contact Fax: 403-783-6487

PARAMETER	UNITS	RESULT
Gold	mg/l	0.40

NA Analysis Not Available ND Not Detected

Remarks:

*No Sample Date

Results relate only to items tested

Maxxam Analytics Inc

CERTIFICATE OF ANALYSIS

Container Identity: Glass Bottle
Sample Point I.D.:
Client I.D.:
Meter Number:
Laboratory Number: 01-23406-01
Company:
Well / Plant:
Name of Sampler:
Company:
Sample Description:
Sample Point: RN-001A

Gauge Pressures kPa		Temperatures °C	
Source	As Received	Source	As Received
N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/28
Date Reported: 2001/01/22
Analyst: AL
Contact Name:
Contact Phone:
Contact Fax:

PARAMETER	UNITS	RESULT
Gold	mg/l	0.25

NA Analysis Not Available   ND Not Detected

Results relate only to items tested

Remarks:
* No Sample Date

Maxxam Analytics Inc

CERTIFICATE OF ANALYSIS

Container Identity: Glass Bottle
Sample Point I.D.:
Client I.D.:
Meter Number:
Laboratory Number: 01-23406-02

Company:

Well / Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RN-001B

Gauge Pressures kPa — Source: N/A — As Received: N/A
Temperatures °C — Source: N/A — As Received: N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/28
Date Reported: 2001/01/22
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax:

PARAMETER	UNITS	RESULT
Gold	mg/l	0.27

NA Analysis Not Available   ND Not Detected

Results relate only to items tested

Remarks:

* No Sample Date

Maxxam
Analytics Inc

CERTIFICATE OF ANALYSIS

Container Identity: Glass Bottle

Sample Point I.D.:

Client I.D.:

Meter Number:

Laboratory Number: 01-23406-03

Company:

Well / Plant:

Name of Sampler:

Company:

Sample Description:

Sample Point: RN-001C

	Source	As Received
Gauge Pressures kPa	N/A	N/A
Temperatures °C	N/A	N/A

Date Sampled Start: *

Date Sampled End:

Date Received: 2000/12/28

Date Reported: 2001/01/22

Analyst: AL

Contact Name:

Contact Phone:

Contact Fax:

PARAMETER	UNITS	RESULT
Gold	mg/l	0.25

NA Analysis Not Available   ND Not Detected

Results relate only to items tested

Remarks:

* No Sample Date

Maxxam Analytics Inc

CERTIFICATE OF ANALYSIS

Container Identity: Glass Bottle
Sample Point I.D.:
Client I.D.:
Meter Number:
Laboratory Number: 01-23406-04
Company:
Well / Plant:
Name of Sampler:
Company:
Sample Description:
Sample Point: RN-001D

	Gauge Pressures kPa		Temperatures °C
Source	As Received	Source	As Received
N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/28
Date Reported: 2001/01/22
Analyst: AL
Contact Name:
Contact Phone:
Contact Fax:

PARAMETER	UNITS	RESULT
Gold	mg/l	0.24

NA Analysis Not Available ND Not Detected

Results relate only to items tested

Remarks:
* No Sample Date

Maxxam Analytics Inc

CERTIFICATE OF ANALYSIS

Container Identity: Glass Bottle
Sample Point I.D.:
Client I.D.:
Meter Number:
Laboratory Number: 01-23406-05
Company:
Well / Plant:
Name of Sampler:
Company:
Sample Description:
Sample Point: RN-008A

	Source	As Received
Gauge Pressures kPa	N/A	N/A
Temperatures °C	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/28
Date Reported: 2001/01/22
Analyst: AL
Contact Name:
Contact Phone:
Contact Fax:

PARAMETER	UNITS	RESULT
Gold	mg/l	0.32

NA Analysis Not Available   ND Not Detected

Results relate only to items tested

Remarks:
* No Sample Date

Maxxam Analytics Inc

CERTIFICATE OF ANALYSIS

Container Identity: Glass Bottle
Sample Point I.D.:
Client I.D.:
Meter Number:
Laboratory Number: 01-23406-07

Company:

Well / Plant:
Name of Sampler:
Company:

Sample Description:

Sample Point: RN-009A

	Gauge Pressures kPa		Temperatures °C	
	Source	As Received	Source	As Received
	N/A	N/A	N/A	N/A

Date Sampled Start: *
Date Sampled End:
Date Received: 2000/12/28
Date Reported: 2001/01/22
Analyst: AL

Contact Name:

Contact Phone:
Contact Fax:

PARAMETER	UNITS	RESULT
Gold	mg/l	0.82

NA Analysis Not Available   ND Not Detected

Results relate only to items tested

Remarks:
* No Sample Date

Maxxam Analytics Inc

CERTIFICATE OF ANALYSIS

Glass Bottle				01-23406-06
Container Identity	Sample Point I.D.	Client I.D.	Meter Number	Laboratory Number

Company:

Well / Plant:

Name of Sampler:

Company:

Sample Description:

Sample Point: RN-008B

Gauge Pressures kPa		Temperatures °C	
Source	As Received	Source	As Received
N/A	N/A	N/A	N/A

Date Sampled Start	Date Sampled End	Date Received	Date Reported		Analyst
*		2000/12/28	2001/01/22		AL

Contact Name:

Contact Phone:

Contact Fax:

PARAMETER	UNITS	RESULT
Gold	mg/l	0.28

NA Analysis Not Available   ND Not Detected

Results relate only to items tested

Remarks:

* No Sample Date

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PHILIP SERVICES

PHILIP ANALYTICAL
07-Dec-00
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Client :

ANALYTICAL REPORT
Form 42007782

			Philip ID :	30007984	30007985	30007986	30007987	30007988	30007989
			Client ID :	RO-031A 2/2	RO-030T1 1/2	RO-031B 2/2	RO-031CT1 2/2	RO-034T1 1/2	RO-035 2/2
Sparcode	**Parameter**	**Unit**	**MDL**						
METALS TOTAL									
Au-TMS42	Gold	mg/L	0.0001	0.0037	0.0027	0.0043	0.0016	0.0008	0.0139
			Matrix :	Soil	Soil	Soil	Soil	Soil	Soil
			Sampled on:	00/12/04	00/12/04	00/12/04	00/12/04	00/12/04	00/12/04

PHILIP SERVICES

PHILIP ANALYTICAL

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DUPLICATE SUMMARY
Form 42007782

Parameter	Client ID	Philip ID	Sample Conc.	Duplicate Conc.	MDL	Unit	Relative % Diff.
Gold	RO-030T1 1/2	30007985	0.0027	0.0024	0.0001	mg/L	11.76

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PHILIP SERVICES

PHILIP ANALYTICAL

07-Dec-00
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SPIKE SUMMARY
Form 42007782

Parameter	Client ID	Philip ID	Sample Conc.	Sample & Spike Conc.	Spike Amount	Unit	Percent Recovery
Gold	Blank Spike. Batch :	04201862	< 0.0001	0.0184	.02	mg/L	92
Gold	RO-030T1 1/2	30007985.	0.0027	0.441	.5	mg/L	88

PHILIP SERVICES

PHILIP ANALYTICAL
04-Dec-00
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ANALYTICAL REPORT

Client :
Project :

			Philip ID : **Client ID :**	30007867 RO-024B	30007868 RO-024A	30007869 RO-025A	30007870 RO-025B
Sparcode	**Parameter**	**Unit**	**MDL**				
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	< 0.0010 (1)	< 0.0010 (1)	< 0.0010 (1)	< 0.0010 (1)
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/11/28 16:00	00/11/28 16:00	00/11/28 16:00	00/11/28 16:00

Result comments and/or text results :

(1) MDL RAISED DUE TO DILUTION.

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PHILIP SERVICES

PHILIP ANALYTICAL
04-Dec-00
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ANALYTICAL REPORT

Client :
Project :

Sparcode	Parameter	Unit	MDL	**Philip ID :** 30007871 **Client ID :** RO-026	30007872 RO-027 T1	30007873 RO-027 T2	30007874 RO-027 T3
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	< 0.0010 (1)	0.0001	0.0009	0.0002
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/11/28 16:00	00/11/28 16:00	00/11/28 16:00	00/11/28 16:00

Result comments and/or text results :

(1) MDL RAISED DUE TO DILUTION.

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PHILIP SERVICES

PHILIP ANALYTICAL
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ANALYTICAL REPORT

Client :
Project :

Sparcode	Parameter	Unit	MDL	Philip ID : 30007875 Client ID : RO-027 T6	30007876 RO-028 T2	30007877 RO-029 T1	30007878 RO-029 T2
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	< 0.0001	0.0032	0.0012	0.0011
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/11/28 16:00	00/11/28 16:00	00/11/28 16:00	00/11/28 16:00

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PHILIP ANALYTICAL
04-Dec-00
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ANALYTICAL REPORT

Client :
Project :

Philip ID : 30007879
Client ID : RO-022B

Sparcode	Parameter	Unit	MDL	
METALS TOTAL				
Au-TMS42	Gold	mg/L	0.0001	0.0060

Matrix : Soil
Sampled on: 00/11/28 16:00

PHILIP SERVICES

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DUPLICATE SUMMARY

Parameter	Client ID	Philip ID	Sample Conc.	Duplicate Conc.	MDL	Unit	Relative % Diff.
Gold	RO-027 T1	30007872	0.0001	0.0001	0.0001	mg/L	0.00

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PHILIP SERVICES

PHILIP ANALYTICAL

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SPIKE SUMMARY

Parameter	Client ID	Philip ID	Sample Conc.	Sample & Spike Conc.	Spike Amount	Unit	Percent Recovery
Gold	Blank Spike. Batch :	04201836	< 0.0001	0.0205	.02	mg/L	103
Gold	RO-027 T1	30007872	0.0001	0.0401	.05	mg/L	80

PHILIP SERVICES

PHILIP ANALYTICAL
02-Nov-00
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ANALYTICAL REPORT

Client :
Project :

			Philip ID :	30006630	30006631	30006632	30006633
			Client ID :	RO-008C	RO-008D	RO-008E	RO-008G
Sparcode	Parameter	Unit	MDL				
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	0.0146	0.0043	0.0034	0.0040
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/10/30 16:00	00/10/30 16:00	00/10/30 16:00	00/10/30 16:00

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ANALYTICAL REPORT

Client :
Project :

			Philip ID :	30006634	30006635	30006636	30006637
			Client ID :	RO-008F	RO-008H	B3	RO-008J TI
Sparcode	Parameter	Unit	MDL				
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	0.0028	0.0007	0.505	0.0011
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/10/30 16:00	00/10/30 16:00	00/10/30 16:00	00/10/30 16:00

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ANALYTICAL REPORT

Client :
Project :

Sparcode	Parameter	Unit	MDL				
			Philip ID :	30006638	30006639	30006640	30006641
			Client ID :	RO-008I	B1	RO-006	RO-008J T2
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	0.0149	0.0014	0.0040	0.0019
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/10/30 16:00	00/10/30 16:00	00/10/30 16:00	00/10/30 16:00

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ANALYTICAL REPORT

Client :
Project :

Philip ID : 30006642
Client ID : RO-008J T3

Sparcode	Parameter	Unit	MDL	
METALS TOTAL				
Au-TM542	Gold	mg/L	0.0001	0.0012

Matrix : Soil
Sampled on: 00/10/30 16:00

PHILIP SERVICES

PHILIP ANALYTICAL

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DUPLICATE SUMMARY

Parameter	Client ID	Philip ID	Sample Conc.	Duplicate Conc.	MDL	Unit	Relative % Diff.
Gold	RO-008E	30006632	0.0034	0.0031	0.0001	mg/L	9.23

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PHILIP SERVICES

PHILIP ANALYTICAL

02-Nov-00
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SPIKE SUMMARY

Parameter	Client ID	Philip ID	Sample Conc.	Sample & Spike Conc.	Spike Amount	Unit	Percent Recovery
Gold	Blank Spike. Batch :	04201591	< 0.0001	0.0218	.02	mg/L	109
Gold	RO-008E	30006632	0.0034	5.53	5	mg/L	111

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ANALYTICAL REPORT
Form 42007775

Client :

			Philip ID :	30007191	30007192	30007193	30007194
			Client ID :	RO-009D	RO-013	RO-011F	RO-010A
Sparcode	**Parameter**	**Unit**	**MDL**				
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	0.0266	0.0159	0.0392	0.812
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/11/07 16:00	00/11/07 16:00	00/11/07 16:00	00/11/07 16:00

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Client

ANALYTICAL REPORT
Form 42007775

			Philip ID :	30007195	30007196	30007197	30007198
			Client ID :	RO-010B T2	RO-010B T4	RO-009E	RO-012
Sparcode	Parameter	Unit	MDL				
				0.79	0.34		
METALS TOTAL							
Au-TM542	Gold	mg/L	0.0001	0.132	0.0575	0.0512	0.140
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/11/07 16:00	00/11/07 16:00	00/11/07 16:00	00/11/07 16:00

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Client :

ANALYTICAL REPORT
Form 42007775

Sparcode	Parameter	Unit	MDL			
				Philip ID :	30007199	30007200
				Client ID :	RO-011B	RO-011D
METALS TOTAL						
Au-TM842	Gold	mg/L	0.000		0.0459	0.0339
				Matrix :	Soil	Soil
				Sampled on:	00/11/07 16:00	00/11/07 16:00

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DUPLICATE SUMMARY
Form 42007775

Parameter	Client ID	Philip ID	Sample Conc.	Duplicate Conc.	MDL	Unit	Relative % Diff.
Gold	RO-011F	30007193	0.0392	0.0388	0.0001	mg/L	1.03

PHILIP SERVICES

PHILIP ANALYTICAL

14-Nov-00
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SPIKE SUMMARY
Form 42007775

Parameter	Client ID	Philip ID	Sample Conc.	Sample & Spike Conc.	Spike Amount	Unit	Percent Recovery
Gold	Blank Spike. Batch :	04201693	< 0.0001	0.0207	.02	mg/L	104
Gold	RO-011F	30007193	0.0392	0.502	.5	mg/L	93

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PHILIP SERVICES

PHILIP ANALYTICAL
22-Nov-00
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Client :

ANALYTICAL REPORT
Form 42007776

			Philip ID :	30007524	30007525	30007526	30007527
			Client ID :	RO-014 T1	RO-014 T3	RO-016A T1	RO-016A T3
Sparcode	**Parameter**	**Unit**	**MDL**				
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	0.0011	0.0093	0.866	0.108
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/11/17 16:00	00/11/17 16:00	00/11/17 16:00	00/11/17 16:00

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ANALYTICAL REPORT
Form 42007776

Client :

Sparcode	Parameter	Unit	MDL				
			Philip ID :	30007528	30007529	30007530	30007531
			Client ID :	RO-011-I	RO-011 K	RO-015 A	RO-016B T1
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	0.952	0.111	0.0606	0.152
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/11/17 16:00	00/11/17 16:00	00/11/17 16:00	00/11/17 16:00

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ANALYTICAL REPORT
Form 42007776

Client :

Philip ID : 30007532
Client ID : RO-016B T2

Sparcode	Parameter	Unit	MDL	
METALS TOTAL				
Au-TMS42	Gold	mg/L	0.0001	0.0304

Matrix : Soil
Sampled on : 00/11/17 16:00

PHILIP SERVICES

PHILIP ANALYTICAL

22-Nov-00
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DUPLICATE SUMMARY
Form 42007776

Parameter	Client ID	Philip ID	Sample Conc.	Duplicate Conc.	MDL	Unit	Relative % Diff.
Gold	RO-014 T3	30007525	0.0093	0.0106	0.0001	mg/L	-13.07

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PHILIP ANALYTICAL

22-Nov-00
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SPIKE SUMMARY
Form 42007776

Parameter	Client ID	Philip ID	Sample Conc.	Sample & Spike Conc.	Spike Amount	Unit	Percent Recovery
Gold	Blank Spike. Batch :	04201745	< 0.0001	0.0198	.02	mg/L	99
Gold	RO-014 T3	30007525	0.0093	0.0957	.1	mg/L	86

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PHILIP ANALYTICAL
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ANALYTICAL REPORT

Client :
Project :

Sparcode	Parameter	Unit	MDL				
			Philip ID :	30007638	30007639	30007640	30007641
			Client ID :	RO-015C	17B	RO-017C	RO-015D
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	0.0051	0.0022	0.0013	0.0013
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/11/22 16:00	00/11/22 16:00	00/11/22 16:00	00/11/22 16:00

PHILIP SERVICES

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29-Nov-00
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Client :
Project :

ANALYTICAL REPORT

Sparcode	**Parameter**	**Unit**	**MDL**				
			Philip ID :	30007642	30007643	30007644	30007645
			Client ID :	RO-018A	RO-017A	RO-20	RO-016B.2 T2
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	0.0013	0.0004	0.0013	0.0022
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/11/22 16:00	00/11/22 16:00	00/11/22 16:00	00/11/22 16:00

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PHILIP ANALYTICAL
29-Nov-00
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ANALYTICAL REPORT

Client :
Project :

Sparcode	Parameter	Unit	MDL	Philip ID : 30007646 Client ID : RO-019A T1	30007647 RO-019A T2	30007648 RO-021	30007649 RO-023
METALS TOTAL							
Au-TMS42	Gold	mg/L	0.0001	0.0005	0.0003	0.0041	0.0012
SPECIAL INORGANICS							
MTSPMTSP	Metals Special Analy	None		---	---	--- (1)	--- (2)
			Matrix :	Soil	Soil	Soil	Soil
			Sampled on:	00/11/22 16:00	00/11/22 16:00	00/11/22 16:00	00/11/22 16:00

Result comments and/or text results :

(1) Text results for sample 30007648 sparcode MTSPMTSP follow :

```
Rh = <0.0001 mg/L
```

(2) Text results for sample 30007649 sparcode MTSPMTSP follow :

```
Pd = 0.0058 mg/L
Pt = 0.0103 mg/L
```

PHILIP SERVICES

PHILIP ANALYTICAL
29-Nov-00
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ANALYTICAL REPORT

Client :
Project :

Philip ID : 30007650
Client ID : RO-010A

Sparcode	Parameter	Unit	MDL	
SPECIAL INORGANICS				
MTSPMTSP	Metals Special Analy	None		--- (1)

Matrix : Soil
Sampled on: 00/11/22 16:00

Result comments and/or text results :

(1) Text results for sample 30007650 sparcode MTSPMTSP follow :

```
ENTIRE SAMPLE DIGESTED. Au IS < 0.025 ug.
```

PHILIP SERVICES

PHILIP ANALYTICAL

29-Nov-00
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DUPLICATE SUMMARY

Parameter	Client ID	Philip ID	Sample Conc.	Duplicate Conc.	MDL	Unit	Relative % Diff.
Gold	RO-021	30007648	0.0041	0.0039	0.0001	mg/L	5.00

SPIKE SUMMARY

Parameter	Client ID	Philip ID	Sample Conc.	Sample & Spike Conc.	Spike Amount	Unit	Percent Recovery
Gold	Blank Spike. Batch :	04201772	< 0.0001	0.0201	.02	mg/L	101
Gold	RO-021	30007648	0.0041	0.0464	.05	mg/L	85
Gold	Blank Spike. Batch :	04201807	< 0.0001	0.0201	.02	mg/L	101

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AuRIC
Metallurgical Laboratories

Date: August 3, 2001

ANALYSIS CERTIFICATE:

To: Mr. Ron Owens
Mineral Recovery Systems
201-5201-52 Ave
Ponoka, Alberta, Canada T4J 1H6

Sample No:	Customer Sample ID No.	Method Code1 Code2	Gold Tr oz/ton	Silver Tr oz/ton	Platinum Tr oz/ton	Palladium Tr oz/ton
3498	1	FAN/FAA	0.010	0.084	0.012	0.004
3499	2	FAN/FAA	0.006	N/D	0.001	0.003
3500	3	FAN/FAA	0.006	0.009	0.003	0.004
3501	4	FAN/FAA	0.005	N/D	0.002	0.005
3502	5	FAN/FAA	0.007	N/D	0.003	0.006
3503	6	FAN/FAA	0.005	N/D	N/D	0.004
3504	7	FAN/FAA	0.006	N/D	N/D	0.005
3505	8	FAN/FAA	0.007	0.001	0.003	0.005
3506	9	FAN/FAA	0.006	N/D	N/D	0.004
3507	10	FAN/FAA	0.007	N/D	0.008	0.006

Analysis method:

Code 1	Procedure for Decomposition / Preparation of Solid Samples
ADn	Acid Decomposition (n: the number of acids used)
FAL	Fire Assay with Lead button Collection
FAN	Fire Assay with Nickel Sulfide Collection
FAT	Fire Assay with Tin Button Collection

Code 2	Procedure for Measurement
VOL	Volumetry or Titrimetry
GRV	Gravimetry
FAA	Flame Atomic Absorption Spectrophotometry
GAA	Graphite Furnace Atomic Absorption Spectrophotometry
ICPE	Inductively Coupled Plasma Spectrophotometry

GENERAL DISCLAIMER:

The results reported above are based on well-known, accepted analytical procedures used solely on the sample submitted by the customer. No warranty as to the reproducibility or extractability of the material other than the sample is given. AuRIC Metallurgical Laboratories, LLC makes no representation express or implied on the material other than that represented by the assayed sample.

NEVADA LEGISLATIVE DISCLAIMER:

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim or deposit has been determined based on the results of assays of multiple samples of geological materials collected by the prospective investor or by a qualified person selected by him and based on an evaluation of all engineering data available concerning any proposed project.

Ahmet B. Altinay
Metallurgical Engineer

[redacted]

AuRIC
Metallurgical
Laboratories

Date: August 3, 2001

ANALYSIS CERTIFICATE:

To: Mr. Ron Owens
Mineral Recovery Systems
201-5201-52 Ave
Ponoka, Alberta, Canada T4J 1H5

Sample No:	Customer Sample ID No:	Method Code1 Code2	Gold Tr oz/ton	Silver Tr oz/ton	Platinum Tr oz/ton	Palladium Tr oz/ton
3508	11	FAN/FAA	0.008	N/D	N/D	0.004
3509	12	FAN/FAA	0.006	N/D	N/D	0.004
3510	15	FAN/FAA	0.006	0.047	N/D	0.003
3511	16	FAN/FAA	0.004	N/D	N/D	0.003
3512	17	FAN/FAA	0.027	N/D	0.017	0.006
3513	18	FAN/FAA	0.018	N/D	0.016	0.007
3514	19	FAN/FAA	0.022	0.034	0.037	0.007
2116	1	AD2/GRV	0.013	0.675	0.012	0.009
2117	17	AD2/GRV	0.016	0.977	0.019	0.009

Analysis method:

Code 1	Procedure for Decomposition / Preparation of Solid Samples
ADn	Acid Decomposition (n: the number of acids used)
FAL	Fire Assay with Lead button Collection
FAN	Fire Assay with Nickel Sulfide Collection
FAT	Fire Assay with Tin Button Collection

Code 2	Procedure for Measurement
VOL	Volumetry or Titrimetry
GRV	Gravimetry
FAA	Flame Atomic Absorption Spectrophotometry
GAA	Graphite Furnace Atomic Absorption Spectrophotometry
ICPE	Inductively Coupled Plasma Spectrophotometry

GENERAL DISCLAIMER:

The results reported above are based on well-known, accepted analytical procedures used solely on the sample submitted by the customer. No warranty as to the reproducibility or extractability of the material other than the sample is given. AuRIC Metallurgical Laboratories, LLC makes no representation express or implied on the material other than that represented by the assayed sample.

NEVADA LEGISLATIVE DISCLAIMER:

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim or deposit has been determined based on the results of assays of multiple samples of geological materials collected by the prospective investor or by a qualified person selected by him and based on an evaluation of all engineering data available concerning any proposed project.

Ahmet B. Altinay
Metallurgical Engineer

[redacted]

AuRIC
Metallurgical
Laboratories

Date: February 28, 2001

ASSAY REPORT:

To:
Mr. Ron Owens
Mineral Recovery Systems
201-5201-52 Ave
Ponoka, Alberta
Canada T4J 1HD

AuRIC Sample No.	Customer Sample ID No:	Gold Tr oz/ton	Silver Tr oz/ton	Platinum Tr oz/ton	Palladium Tr oz/ton	Rhodium Tr oz/ton
1643 C	ROA – 04	0.012	0.102	0.064	0.004	N/D
3365 A	ROA – 04	0.014	0.174	0.049	0.003	N/D

Analysis method: (for AuRIC Sample No.'s ending with A - FA/AA)
(for AuRIC Sample No's ending with C: Chemical Assay/ SX/ GFAA spectrophotometer finish)

Ahmet B. Altinay
Metallurgical Engineer

[redacted]

AuRIC
Metallurgical
Laboratories

Date: September 12, 2002

ANALYSIS REPORT:

Mr. Ron Owens
Mineral Recovery Systems
201-5201-52 Ave
Ponoka, Alberta, Canada T4J 1HD

AuRIC Sample No.:	**3926**	
Customer Sample ID No.:	Bead	
Weight: (Bead)	**1.969 mg**	
Method (Code 1 / Code 2)	**AD2/FAA**	
Units:	ppm	
Aluminum		
Bismuth		
Chromium		
Cobalt		
Copper		
Gold	**812.60**	→ 0.002 mg
Iridium	**N/A**	
Iron		
Lead		
Molybdenum		
Nickel		
Osmium	**N/A**	
Palladium	**304.72**	→ 0 001 mg
Platinum	**Trace**	
Rhodium	**N/A**	
Ruthenium	**N/A**	
Silver	**996,476.38**	→ 1.962 mg
Tin		
Titanium		
Vanadium		
Zinc		

Analysis method:

Code 1	**Procedure for Decomposition / Preparation of Solid Samples**
ADn	Acid Decomposition (n: the number of acids used)
FAL	Fire Assay with Lead button Collection
FAN	Fire Assay with Nickel Sulfide Collection
FAT	Fire Assay with Tin Button Collection
Code 2	**Procedure for Measurement**
VOL	Volumetry or Titrimetry
GRV	Gravimetry
FAA	Flame Atomic Absorption Spectrophotometry
GAA	Graphite Furnace Atomic Absorption Spectrophotometry
ICPE	Inductively Coupled Plasma Spectrophotometry

The results reported above are based on well-known, accepted analytical procedures used solely on the sample submitted by the customer. No warranty as to the reproducibility or extractability of the material other than the sample is given. AuRIC Metallurgical Laboratories, LLC makes no representation express or implied on the material other than that represented by the assayed sample.

Ahmet B. Altinay
Metallurgical Engineer

[redacted]

8

To : MR. RON OWENS
201, 5201 - 52nd Avenue
Ponoka, Alberta
T4J 1H6

File No : 44127
Date : September 6, 2001
Samples :
Project :
P.O.#

Certificate of Assay
Loring Laboratories Ltd.

629 Beaverdam Road, NE Calgary Alberta T2K 4W7
Tel: (403)274-2777 Fax: (403)275-0541

Sample No.	Au mg/l	Pd mg/l	Pt mg/l	Rh mg/l
"PGM Analysis"				
01-03-01	< 0.01	< 0.01	< 0.01	< 0.01
01-03-02	1.12	< 0.01	< 0.01	< 0.01

NOTE: High iron content of solutions caused interferences at some wavelengths.

I HEREBY CERTIFY that the above results are those assays made by me upon the herein described samples :

[redacted]
Assayer

Rejects and pulps are retained for one month unless specific arrangements are made in advance.

9

CAL STATE FULLERTON
Department of Chemistry and Biochemistry
(714) 278-3621 / Fax (714) 278-5316

CELEBRATING FORTY YEARS OF EXCELLENCE

February 18, 2002

Ron Owen
Mineral Recovery Systems
201-5201-52 Ave
Ponoka, Alberta
T4J1H6
Phone: 403 783 6487
Fax? 403 783 6586
Mobil: 403 783 0656

Dear Ron,

As I mentioned on the phone, I have completed the assay on the sample you submitted. The analysis is shown below:.

Sample ID	Gold Oz/Ton	Platinum Oz/Ton	Palladium Oz/Ton	Rhodium Oz/Ton
5080	less than 0.02	ess than 0.02	less than 0.02	less than 0.02

This assay is for the sample labeled "Site 01, sample # 03, 3-4 feet. As we discussed, I am now running sample 01, 1-2 feet and will report to you as soon as I have finished. If you have any questions, please feel free to call me at (714) 278 2641.

Sincerely Yours,

[redacted]

Dr. Joseph L. Thomas
Associate Professor of Chemistry

CALIFORNIA STATE UNIVERSITY, FULLERTON P.O. Box 6866, Fullerton, CA 92834-6866
The California State University: Bakersfield / Channel Islands / Chico / Dominguez Hills / Fresno / Fullerton / Hayward / Humboldt / Long Beach / Los Angeles / Maritime Academy / Monterey Bay / Northridge / Pomona / Sacramento / San Bernardino / San Diego / San Francisco / San Jose / San Luis Obispo / San Marcos / Sonoma / Stanislaus

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Genalysis Laboratory Services Pty. Ltd.

ANALYSTS AND CONSULTING CHEMISTS
ABN: 32 008 787 237

Analytical Report

COMMENTS

1. ATTENTION: R OWEN

JOB INFORMATION

JOB CODE : 6.3/0103205
No. of SAMPLES : 3
No. of ELEMENTS : 7
CLIENT O/N : R OWENS
SAMPLE SUBMISSION No. :
PROJECT :
STATE : Pulp
DATE RECEIVED : 08/06/2001
DATE COMPLETED :
DATE PRINTED : 11/07/2001

LEGEND

'X' = LESS THAN DETECTION LIMIT
'N/R' = SAMPLE NOT RECEIVED
'*' = RESULT CHECKED
'( )' = RESULT STILL TO COME
'I/S' = INSUFFICIENT SAMPLE FOR ANALYSIS
'E6' = RESULT X 1,000,000
'UA' = UNABLE TO ASSAY

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ADELAIDE SAMPLE PREPARATION DIVISION

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PO Box 2078, South Plympton 5038, South Australia
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genalysis laboratory services pty. ltd.

ANALYSIS

ELEMENTS	Au	Ir	Os	Pd	Pt	Rh	Ru
UNITS	ppb	ppb	ppb	ppb	ppb	ppb	ppb
DETECTION	5	2	2	2	2	1	2
METHOD	NIS/*MS	NIS/*MS	NIS/*MS	NIS/*MS	NIS/*MS	NIS/*MS	NIS/*MS
SAMPLE NUMBERS							
0001 03	10	X	X	4	2	X	2
0002 03 DUP	10	X	X	4	X	X	X
0003 03 TRIP	10	X	X	4	2	X	2
STANDARDS							
0001 HGMN.1	144	76	118	710	258	86	252
BLANKS							
0001 Control Blank	X	X	X	2	X	X	X

SILVER INQUART METHOD

1. Thoroughly mix ore with flux. (should be done in a metal mixing box)

   5 grams Ore
   20 grams borax
   70 grams litharge
   1 gram silver
   15 grams flour

2. Put in furnace in scorifying dish at 2,000° F for 45 minutes.

3. Pour and cool. Break slag from lead and cupel lead button at 1,700° F.

4. Weigh Ag button.

5. Part in 1:6 HNO_3 to distilled water. Warm until button is in solution.

6. Leave on hot plate until dry. Put crucible in furnace for two hours at 800° F.

7. Remove from furnace and cool. Add 50 to 100 ml distilled water and warm.

8. Filter and wash three times with hot distilled water.

9. Burn filter until ash free and add 25% sulfuric acid and heat for one hour.

10. Filter and wash with hot water.

11. Burn filter until free of ash, cool and weigh.

12. Calculate mixture of metals and analyze on instrument.

12

1. Grind 100 grams of the ore to -100 mesh. Thoroughly mix with 70 grams of borax and 30 grams of sodium carbonate. Place in an unused 40 gram? clay crucible and fuse this mixture for approximately 90 minutes at 1,150C. Pour into a cast iron mold being careful to recover as much of the fusion as possible. Save the crucible. Grind the fusion to -100 mesh.

2. Carefully separate the metallic particles from the glass matrix. This may be done by using one of the following methods:

a. Place the ground fusion into a gold pan and carefully pan away as much of the glass as possible. Remove the concentrate from the gold pan and dry. There should be approximately 5 grams of dried concentrates remaining.

b. Using a hand magnet, carefully remove the magnetic particles from the ground fusion. Place the non-magnetic fraction into a gold pan and, using normal panning procedures, discard as much of the "lights" as possible. Remove the concentrates from the pan and dry. Combine these concentrates with the magnetics.

3. Weigh the concentrates. Add approximately the same weight of a mixture of one-half sodium nitrate and one-half sodium peroxide. Mix thoroughly and place in the above saved clay crucible. Furnace at 1,000C for 30 minutes. It should be noted that sodium peroxide is a strong oxidizer which should be handled with care. Any osmium or ruthenium that is present in the sample may, at this stage, be oxidized and volatized from the roast. Remove from the furnace and, while still hot, add the following premixed flux:

1. 60 grams litharge
2. 8 grams flour
3. 50 grams borax glass
4. 35 grams sodium carbonate
5. 5 grams silica
6. 1 gram analytical-grade silver chloride

Place in furnace and fuse for approximately one hour at 1,150C. Pour into a cast iron mold and let cool. Carefully break away the slag from the Pb button. Save any metal fragments that are removed during the cleaning process. Grind the slag and smelt under the above conditions using the same flux and crucible; do not add additional silver.

4. Place the Pb buttons and recovered metal fragments in a suitably-sized scorifying dish (3.5 inch diameter), cover with borax glass and a small amount of sodium carbonate, and scorify to approximately one-half of the original weight of the Pb buttons. Pour into a cast iron mold.

5. Cupel the Pb button at approximately 950C. If the cupel is discolored, suggesting the presence of small amounts of precious metals, wrap approximately 100 mg of silver in 5 grams of lead foil and "re-cupel".

6. Using standard spectographic procedures the prill(s) may be analyzed for the Au content and the data calculated to Troy ounces of Au per head ore ton. It is recommended that the method of standard additions be used for background correction. The resulting prill(s) may also (again using standard procedures) be parted with dilute nitric acid and the residue annealed and weighed. The above procedure can be modified to analyze either larger or smaller ore samples.

13

Shale-hosted Nickle Zinc Moly PGE - Mineral Deposit Profiles, B.C. Geological Survey

SHALE-HOSTED Ni-Zn-Mo-PGE
E16

by David V. Lefebure* and R.M. Coveney Jr.#
* British Columbia Geological Survey
# University of Missouri - Kansas City, Kansas City, Missouri

Lefebure, D.V. and Coveney, R..M. Jr.(1995): Shale-hosted Ni-Zn-Mo-PGE, in Selected British Columbia Mineral Deposit Profiles, Volume 1 - Metallics and Coal, Lefebure, D.V. and Ray, G.E., Editors, British Columbia Ministry of Energy of Employment and Investment, Open File 1995-20, pages 45-48.

IDENTIFICATION

SYNONYMS: Sediment-hosted Ni-Mo-PGE, Stratiform Ni-Zn-PGE.

COMMODITIES (*BYPRODUCTS*): Ni, Mo, (Zn, Pt, Pd, Au).

EXAMPLES (British Columbia - *Canada/International*): *Nick (Yukon, Canada); mining camps of Tianeshan, Xintuguo, Tuansabao and Jinzhuwoin and Zunyi Mo deposits, Dayong-Cili District (China).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Thin layers of pyrite, vaesite (NiS_2), jordisite (amorphous MoS_2) and sphalerite in black shale sub-basins with associated phosphatic chert and carbonate rocks.

TECTONIC SETTING(S): Continental platform sedimentary sequences and possibly successor basins. All known deposits associated with orogenic belts, however, strongly anomalous shales overlying the North American craton may point to as yet undiscovered deposits over the stable craton.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Anoxic basins within clastic sedimentary (flysch) sequences containing black shales.

AGE OF MINERALIZATION: Post Archean. Known deposits are Early Cambrian and Devonian, however, there is potential for deposits of other ages.

HOST/ASSOCIATED ROCK TYPES: Black shale is the host; associated limestones, dolomitic limestones, calcareous shale, cherts, siliceous shale, siliceous dolomite, muddy siltstone and tuffs. Commonly associated with phosphate horizons. In the Yukon at base of a 10 to 20 m thick phosphatic shale bed and in China the Ni-Mo beds are in black shales associated with phosphorite.

DEPOSIT FORM: Thin beds (0 to 15 cm thick, locally up to 30 cm) covering areas up to at least 100 ha and found as clusters and zones extending for tens of kilometres.

TEXTURE/STRUCTURE: Semimassive to massive sulphides as nodules, spheroids, framboids and streaks or segregations in a fine-grained matrix of sulphides, organic matter and nodular phosphorite or phosphatic carbonaceous chert. Mineralization can be rhythmically laminated; often has thin discontinuous laminae. Brecciated clasts and spheroids of pyrite, organic matter and phosphorite. In China nodular textures (~ 1 mm diameter) grade to coatings of sulphides on tiny 1-10 mm spherules of organic matter. Fragments and local folding reflect soft sediment deformation. Abundant plant fossils in Nick mineralization and abundant fossils of microorganisms (cyanobacteria) in the Chinese ores.

ORE MINERALOGY (Principal and *subordinate*): Pyrite, vaesite (NiS2), amorphous molybdenum minerals (jordisite, MoS2), bravoite, *sphalerite, wurtzite, polydimite, gersdorffite, violarite, millerite, sulvanite, pentlandite, tennanite and as traces native gold, uranitite, tiemannite, arsenopyrite, chalcopyrite and covellite*. Discrete platinum group minerals may be unusual. Some ore samples are surprisingly light because of abundant organic matter and large amount of pores.

GANGUE MINERALOGY (Principal and *subordinate*): Chert, amorphous silica, phosphatic sediments and bitumen. Can be interbedded with pellets of solid organic matter (called stone coal in China). Barite laths are reported in two of the China deposits.

ALTERATION MINERALOGY: Siliceous stockworks and bitumen veins with silicified wallrock occur in the footwall units. Carbonate concretions up to 1.5 m in diameter occur immediately below the Nick mineralized horizon in the Yukon.

WEATHERING: Mineralized horizons readily oxidize to a black colour and are recessive. Phosphatic horizons can be resistant to weathering.

ORE CONTROLS: The deposits developed in restricted basins with anoxic conditions. Known deposits are found near the basal contact of major formations. Underlying regional unconformities and major basin faults are possible controls on mineralization. Chinese deposits occur discontinuously in a 1600 km long arcuate belt, possibly controlled by basement fractures.

GENETIC MODEL: Several genetic models have been suggested reflecting the limited data available and the unusual presence of PGEs without ultramafic rocks. Syngenetic deposition from seafloor springs with deposition of metals on or just beneath the seafloor is the most favoured model. Siliceous venting tubes and chert beds in the underlying beds in the Yukon suggest a hydrothermal source for metals.

ASSOCIATED DEPOSIT TYPES: Phosphorite layers (F07?), stone coal, SEDEX Pb-Zn (E14), Sediment-hosted barite (E17), vanadian shales, sediment-hosted Ag-V, uranium deposits.

COMMENTS: Ag-V and V deposits hosted by black shales have been described from the same region in China hosted by underlying late Precambrian rocks.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Elevated values of Ni, Mo, Au, PGE, C, P, Ba, Zn, Re, Se, As, U, V and S in rocks throughout large parts of basin and derived stream sediments. In China average regional values for host shales of 350 g/t Mo, 150 g/t Ni, several wt % P2O5 and 5 to 22% organic matter. Organic content correlates with metal contents for Ni, Mo and Zn.

GEOPHYSICAL SIGNATURE: Electromagnetic surveys should detect pyrite horizons.

OTHER EXPLORATION GUIDES: Anoxic black shales in sub-basins within marginal basins. Chert or phosphate-rich sediments associated with a pyritiferous horizon. Barren, 5 mm to 1.5 cm thick, pyrite layers (occasionally geochemically anomalous) up to tens of metres above mineralized horizon.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE : The thin sedimentary horizons (not economic) represent hundreds of thousands of tonnes grading in per cent values for at least two of Ni-Mo-Zn with significant PGEs. In China, Zunyi Mo mines yield ~ 1000 t per year averaging ~4 % Mo and containing up to 4 % Ni, 2 % Zn, 0.7 g/t Au, 50 g/t Ag, 0.3 g/t Pt, 0.4 g/t Pd and 30 g/t Ir. The ore is recovered from a number of small adits using labour-intensive mining methods.

ECONOMIC LIMITATIONS: In China the Mo-bearing phase is recovered by roasting followed by caustic leaching to produce ammonium molybdate. Molybedenum-bearing phases are fine grained and dispersed, therefore all ore (cutoff grade 4.1% Mo) is direct shipped to the smelter after crushing.

IMPORTANCE: Current world production from shale-hosted Ni-Mo-PGE mines is approximately 1000 t of ore with grades of approximately 4 % Mo. Known deposits of this type are too thin to be economic at current metal prices, except in special conditions. However, these deposits contain enormous tonnages of relatively high grade Ni, Mo, Zn and PGE which may be exploited if thicker deposits can be found, or a relevant new technology is developed.

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ACKNOWLEDGEMENTS: Larry Hulbert of the Geological Survey of Canada introduced the senior author to this deposit type and provided many useful comments. Rob Carne of Archer, Cathro and Associates Limited reviewed a draft manuscript.

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November 22, 1994

[E03] [E04] [E05] [E13] [E14] [E15] [E16] [Published Profile Index]
[Deposit Profiles]

This page was last updated: February 11, 2000.

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New Chloride Leaching Process for Gold Extraction from Refractory Ores

From certain gold ores, known as refractory gold ores, the gold cannot be fully recovered by direct cyanide leaching. A major cause of this is the occurrence of much of the gold in such ores in highly disseminated form in sulfide, arsenide and sometimes antimonide minerals. Three methods have been developed for treatment of such refractory ores, each of which involves breaking down the sulfide and arsenide minerals by oxidation before cyanide extraction.

In one method, the sulfide and related minerals containing the gold are recovered by flotation, and roasted. The residues (S- and As-free) are then leached with cyanide. In a second, recently developed process, the flotation concentrates are aerated in slurry form in a medium containing S- and As-oxidizing microorganisms before being leached with cyanide. In the third method, breakdown of the S- and As-minerals is achieved by oxidative treatment of the concentrate in an autoclave, followed by cyanide leaching.

Method 1 is gradually being abandoned because of environmental pollution problems, and new plants in the USA, South Africa, Australia and elsewhere tend to employ Method 2 or Method 3, which produce less severe problems of this type.

Over the past 10 years, however, there have been a number of publications which indicate that the direct oxidative chloride leaching of gold from refractory gold ores may prove to be an improvement on the methods now in use.

These new developments were reviewed by F K Letowski of the University of Witwatersrand in Johannesburg, at the International Conference on the Science and Technology of Gold at Hanau in Germany in June 1996 (1). They include:

1 The use of less volatile 'chloride ion carriers'

In the past, HCl has been used as the main chloride ion carrier in leaching solutions and HNO_3 (or Cl_2) as the oxidant. This has limited leaching temperatures because high partial pressures of HCl lead to loss of Cl^- from the leaching solution. Partial substitution of HCl by $AlCl_3$ or $ZnCl_2$ has been found to decrease dramatically these partial pressures of HCl, apparently as a result of the formation of Al and Zn chlorocomplexes. This has made the attainment of higher leaching temperatures and higher efficiencies possible. Decomposition of the refractory sulfides and arsenides occurs in the chloride leach solutions and their gold content made susceptible to cyanide leaching.

2 The regeneration, in process, of nitric acid used as oxidant

In the chloride leaching reaction, the nitric acid is reduced to NO, the conversion of which back to HNO_3 is costly by conventional methods. A 'leaching in froth' (L/F) process has been devised, however, which has been successfully applied on a laboratory scale for mineral graphite purification (2), zinc concentrate processing (3) and more recently for gold extraction from refractory gold ores.

In this process, oxygen and oxides of nitrogen are the flotation carriers and a chloride solution containing HNO_3 is the reactive medium in which the hydrophobic particles of the ore are suspended. In operation, the outer walls of the froth cells are quickly saturated with oxygen and oxides of nitrogen, entering them from both their sides.

Instantaneous hydrolysis and disproportionation of NO_2 through intermediate species regenerates a substantial fraction of the HNO_3 fed to the system, which implies that the main oxidant in the process is oxygen.

Gold is recoverable by adsorption on carbon from the chloride leach solutions, which can be recycled.

The foundations appear to have been laid for a pilot plant evaluation of this process.

WS Rapson

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1 see D. Thompson, *Gold Bull.*, 1996, **29**, 105, no *Proceedings* are to be published

2 F.K. Letowski, 'Separation Processes: Heavy Metals, Ions and Minerals', The Minerals, Metals and Materials Society, Warrendale Pa, USA, 1995, p. 135

3 F.K. Letowski and D.P. Obeng, *Proc. XIX Int. Mineral Processing Congr., Soc. Min. Metall. and Exploration Inc., Littleton, Colorado*, 1995, 2, 251

Issues Concerning the Quality of Assay Results

Phillip L Hellman[1]

Hellman & Schofield Pty Ltd, Suite 6, 3 Trelawney St, Eastwood NSW 2122 Australia

> *"It is necessary that the assayer who is testing ore or metals should be prepared and instructed in all things necessary in assaying, and that he should close the doors of the room in which the assay furnace stands, lest anyone coming at an inopportune moment might disturb his thoughts when they are intent on the work."*
> Agricola[2]

Abstract

It should not be assumed that assays of samples collected during activities associated with mineral exploration, drilling and metallurgical testwork will be either accurate or precise. The onus of responsibility of monitoring quality should be on those who submit samples.

Assumptions of quality that depend upon, inter alia:
- certification or affiliation of the laboratory,
- use of internal standards by the laboratory,
- apparent accuracy of internal standards as reported by the laboratory,
- agreement between original assays and repeat assays by a second, third or subsequent laboratory,
- agreement between Calculated Heads and Head Assays in metallurgical testwork

should not be made.

Numerous examples are presented highlighting problems such as:
- cross contamination of gold,
- incorrect assay technique leading to under-statement of gold,
- background analytical error resulting in delineation of waste as ore,
- assay bias induced by lithology and presence of coarse gold and
- incorrect calibrations.

These issues reinforce the need for the submission of control samples such as blanks and standards, as well as properly designed check assay campaigns, to:
- provide proof of accuracy and precision,
- provide early warning signals of assay problems,
- identify or eliminate the source of error when issues arise such as poor reconciliations (eg between resource model vs grade control, grade control vs mill),
- minimise risks associated with resource development.

Introduction

The areas of exploration, resource delineation and mine development that come under the general responsibility of geologists and are subject to the greatest risk are, in decreasing importance[3]:
- resource estimation,
- sampling and

---

[1] Ph 61 2 9858 3863 Fax 61 2 9858 4057 email plh@hellscho.com.au
[2] Agricola (1556) pp 223-224
[3] In the experience of Hellman & Schofield Pty Ltd

- assaying.

The potential for **resource estimates** to be seriously in error is enormous. It is not uncommon for different estimates using the same data to vary by over 30% in grade and/or in tonnes[4]. **Sampling bias** will directly impact on both resource estimates and on the discrimination between ore and waste in the production environment. Issues of **assay quality** affect all steps from exploration to production and include environmental monitoring. They also impinge directly on areas subject to the responsibility of metallurgists both at the Feasibility testing stage and also during production.

Importance of Quality Control

A recent example[5] of the importance of Quality Control comes from a gold mine. The mine geology department had been complaining that the resource model was over-estimating grade. A detailed inspection of several months of blast hole assay results from the mine laboratory showed few assays less than 0.5 g/t. The author then submitted a blank pulp and a standard pulp with known gold concentration to the laboratory.

The blank returned an assay of 0.6 g/t. It should have returned a "less-than-detection" value. The standard returned a value of 1.6 g/t and had a recommended value of 0.9 g/t. Ore zones were being defined on the basis of a 1.5 g/t cut-off. Thus whole "ore blocks" with a true grade of between 0.9 and 1.5 g/t were being mined on the assumption that they exceeded 1.5 g/t. The identification of assay bias in the mine laboratory ended a cycle of confusion and blame of the innocent. The view that Quality Control is the responsibility of the laboratory, and not also of those who submit the samples, is a common justification for not using control samples such as standards or blanks.

Mines that are generally the only source of cash generation for mining companies usually have no effective Quality Control systems for monitoring assay accuracy in their laboratories. Paradoxically, the accounting firms that audit these companies, however, have sophisticated systems, often ISO stamped, to audit the books and financial results.

In the production environment where there is ineffective quality control there is no basis for taking informed remedial action when problems arise. A typical example[6] of how unsolved problems compound follows:

- the metallurgical department complains to the mine geology department the gold head grade is lower than predicted in the ore being delivered to the plant,
- the mine geology department replies that they are probably losing gold in the tails or in plant lock-up,
- the tanks are cleaned out to find the gold,
- the mine geologists point out that the hard ore that contains the good grade is not being processed,
- management becomes suspicious that gold is being stolen,
- a large batch of samples is sent to another laboratory
- extra security is placed in the gravity circuit,
- an "audit" of the laboratory commences,
- the mineralisation is regarded as being unique and hostile to resource estimation,

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[4] For example, V Snowden (1994, p335) discusses Snowden Associates' re-estimation of the resources at the Girilambone copper deposit, NSW, Australia and reports a doubling of the reserve tonnage at a similar grade to previous estimates.

[5] Further discussed in Example 2, below.

[6] Based on several real examples.

- the results of the check assays are received but they are so different from the original results that there is a big debate about which laboratory is correct,
- the resource model is re-run to try to better control the spatial variability of the high grades with the same result as before,
- private investigators are called in to detect fraud,
- an audit of the grade-control procedures is commissioned,
- everyone is suspicious that the external consultant has delivered a defective resource model but because terms such as "sequential indicator kriging" or "uniform conditioning" are used (that few understand) they feel powerless to argue,
- management requests all resource estimation and ore blocking to be undertaken by polygonal methods
- an audit of the resource estimate commences,
- the new polygonal estimates clearly do not match reality,
- still there is no answer,

All of the above possibilities for explaining why the mill feed grade is below the predicted grade may be true, but without having credible assays of unbiased samples, there is no basis for coming to any firm conclusion as to what is the cause (s) of the problem. There is also no basis for quickly eliminating possible causes for the short-fall in gold production.[7]

Terminology

In this paper the term "***standard***(s)" is used instead of the more technically correct term "***standard reference material***" (or "SRM"). Sometimes, the *term* "***house reference material***" (or "HRM") is used to refer to standards made for particular internal purposes by a company or laboratory. The term "***precision***" is used to denote the spread of assay data obtained from replicate determinations and is often used synonymously with "***relative standard deviation***" ("RSD" = standard deviation/mean) and "***coefficient of variation***" or "CV". These terms are often expressed as a percentage.

If commercial laboratories quote a precision, it only relates to a concentration level above some multiple of the "***lower detection limit***" ("LD" or "LLD"). This multiple is usually 20 to 50 and refers to a level above which the precision is reasonably stable. The precision value usually refers to twice the RSD expressed as a percentage based on multiple analyses. A quoted precision of 10% for base-metal analysis and 15% for fire-assay gold are typical quoted levels. In reality these obviously depend upon many factors such as difficulty of matrix, element (it cannot be assumed that silver for example will have the same precision as copper), etc. Assays become more imprecise as the lower detection limit is approached. Precision levels from actual examples are provided in this paper.

The "***upper detection limit***" ("UD" or "ULD") is a level beyond which the analysis is recommended to be repeated by a more appropriate technique usually because the concentration is beyond the normal limits of calibration.

The term "***precision***"[8] is also commonly applied to the spread of assay data as determined by duplicate pairs. This information is usually more readily available than replicate analyses of individual samples. Pairs of assay results, such as two determinations of gold from the same pulp, that comes out of a pulveriser provide estimates of one type of precision whereas an

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[7] It is the experience of H&S that, despite audits and reviews of operations and Feasibility Studies by high profile consulting groups, fundamental flaws may remain undiscovered.

[8] The precision value that appears in the figures in this paper refers to $\sigma(A-B)/(\sqrt{2} \times m(A))$ where A & B refer to original and repeat assays and m(A) is the mean of A.

original assay paired to a check assay of a split of the same pulp carried out by a different laboratory provides another type of precision. In these cases the absolute value of the difference between the two results divided by the pair mean[9] is often used to estimate precision and is commonly expressed as a percentage. This has been referred to as the "***Absolute Mean Percent Difference***" or **AMPD** (eg Bumstead, 1984). The average of these values for a number of pairs is often reported.

AMPDs from duplicate determinations of pulps by different laboratories are recommended by Francois-Bongarcon et al (1996) to be better than 10% (ie the value returned from duplicate of assays of 1.000 and 0.905 g/t). This level increases to 20% when assays from coarse rejects[10] are considered. These levels are somewhat arbitrary and depend upon the commodity of interest (eg silver typically returns higher AMPDs than base-metals) and concentration level. AMPDs from concentrations near the LLD will obviously be considerably higher than at higher concentrations.

"***Accuracy***" of analyses or assays refers to closeness to the true value. Consistent and significant departure from accuracy is termed "***bias***" and can be expressed in a variety of ways such as an absolute difference or as a percentage. Thus an average value of 0.8 g/t from several assays of a standard with a "***Recommended Value***" (***RV***) of 1.0 g/t indicates a ***negative*** bias of 20%. ***Positive*** bias refers to results from unknowns that are consistently higher than accepted values. Bias is only "***relative***" unless results from samples are referenced against results for which there is proof of accuracy.

Benchmark papers that discuss this terminology in relation to geochemical analysis include Howarth & Thompson (1976), Thompson & Howarth (1978), Thompson (1992) and Ramsey, et al (1992).

A number of actual examples from exploration, feasibility studies and grade control are described below. The Walker Lake data set has been used to depict a mining bench to illustrate the impact that sampling and assay errors may have on resource estimates and mining operations. This approach has been used here rather than by using actual sections or bench plans from operations or prospects to preserve anonymity.

The Walker Lake data consists of 78,000 data points from a digital elevation model and has been studied in detail by Isaaks and Srivastava (1989). The distribution of the "U" variable in the data set has close similarities with natural gold distributions (eg skewed shape, high coefficient of variation of 1.8). One hundredth of its value is used in this paper to achieve a mean "grade" of 2.66 g/t (with a standard deviation of 4.88, minimum of 0 and maximum of 95). Data points closest to the nodes of a 10 metre grid have been used as a reduced data set.

Examples of Bias

Example 1. Low grades biased high and high grades biased low

Cause: Poor sample preparation procedures with samples containing coarse gold leading to cross contamination as well as the wrong choice of assay technique

The evaluation of this deposit was flawed due to a choice of assay technique that proved to be imprecise and partial rather than near-total as would have been achieved by the use of fire assay. The interpretation of check assay results was made difficult by the presence of coarse gold resulting in a considerable scatter when original and check assays are plotted (Figure 1). The use of a sub-set of the check assays that had been performed by screen fire assays from a

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[9] ie [assay1 – assay2]/[avge] or as 200[assay1 – assay2]/[assay1 + assay2] (expressed as a percentage)
[10] Eg RC chips

proven laboratory revealed an interesting feature depicted in Figure 2. The increasing bias with increasing grade is obvious.

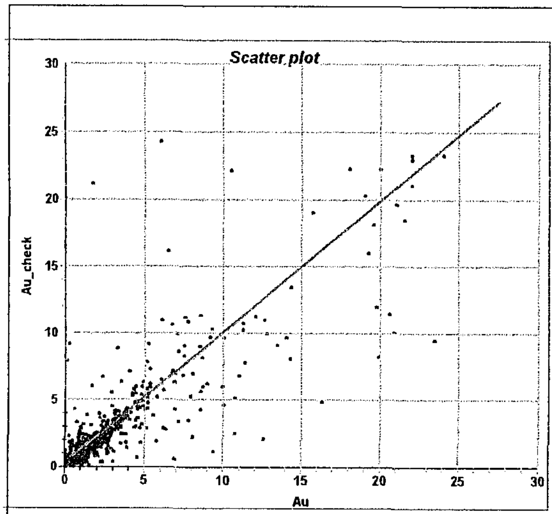

Figure 1. Complete Check-Assay Data Set

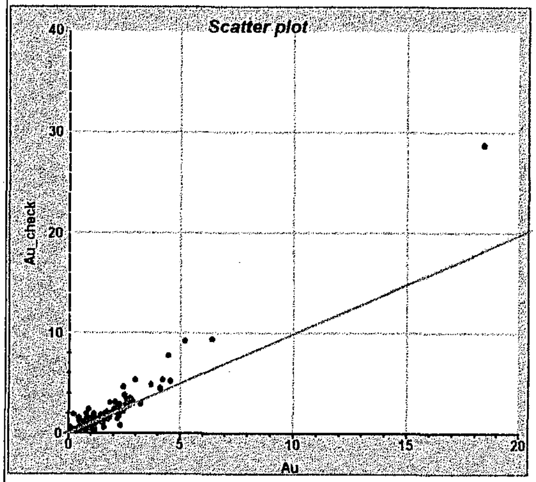

Figure 2. Screen Fire Check-Assay Sub-Set of Data Depicted in Figure 1

Approximately ~~one third~~ of ~~the~~ check assays from the data set in Figure 2, however, were of low grade assays less than 0.5 g/t. There is little value in check assaying such a high proportion of low grade samples. An examination of the check assays that followed samples with high amounts of free gold indicated that low grade (less than 1 g/t) were being significantly contaminated with gold that had plated on the pulverising equipment. This caused the positive bias at low grades that are evident in Figure 4.

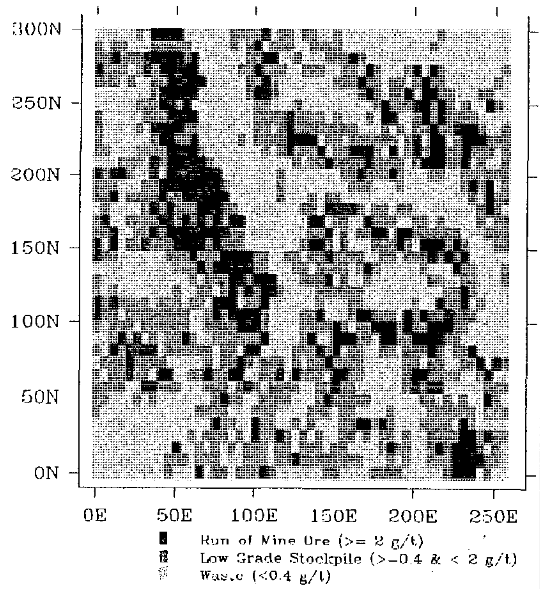

Figure 3. Distribution of Biased Grades on a Mining Bench (ROM ore is biased low and Low Grade Stockpile is biased high)

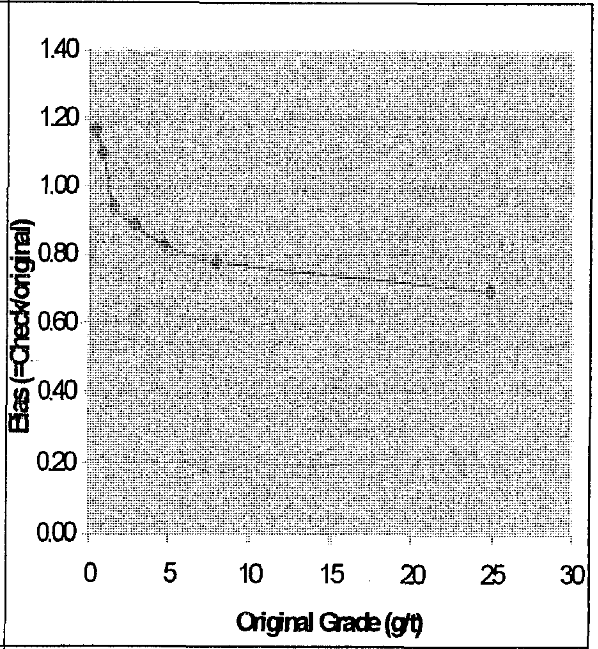

Figure 4. Bias – Grade Relationship as Determined by Correct Checks

The impact of the variable bias on the spatial distribution of grades is depicted in Figure 3 by using the bias-grade relationship of Figure 4.

The presence of coarse gold requires a careful consideration of sampling and assaying protocols. The use of large bowl pulverisers to obtain the largest possible fine sample before splitting off the sample for assaying is commendable. Even this process, however, may induce bias (Johansen, 1997) in mineralisation containing coarse gold such as is found in Bendigo, Victoria, Australia. Scoops taken from the top of the mound of pulp in the pulveriser for conventional fire assaying having an average 30% less than gold assays determined by either cyanidation of the whole pulp or by screen fire assaying of a large sample. In this case, assaying the whole sample effectively eliminates any possibility of bias resulting from "extraction error". The low bias of the fire assays, however, had not arisen due their low (50 grams) sample weights, *per se*, compared to the larger weights employed by the other techniques but rather because the samples were intrinsically biased due to segregation of gold particles in the pulveriser.

The situation is not helped by laboratories taking short-cuts in their screen-fire methodologies. The author has found it necessary to specify that the sieve cloth used in screening be assayed. This was once accepted practice. It is also necessary to specify that the wash (eg felspar) used between samples to clean the pulveriser bowl be assayed to weight-average with the unknown in order to prevent assays being diminished by gold plating onto the discarded wash. Melnbardis (1991) documented the loss of up to 50% of gold on to disk pulveriser plates and 15% on to ring pulverisers from 1/8 inch crushed samples containing visible gold.

Example 2. All grades biased high

Cause: Assay error arising from poor checking of standard solutions

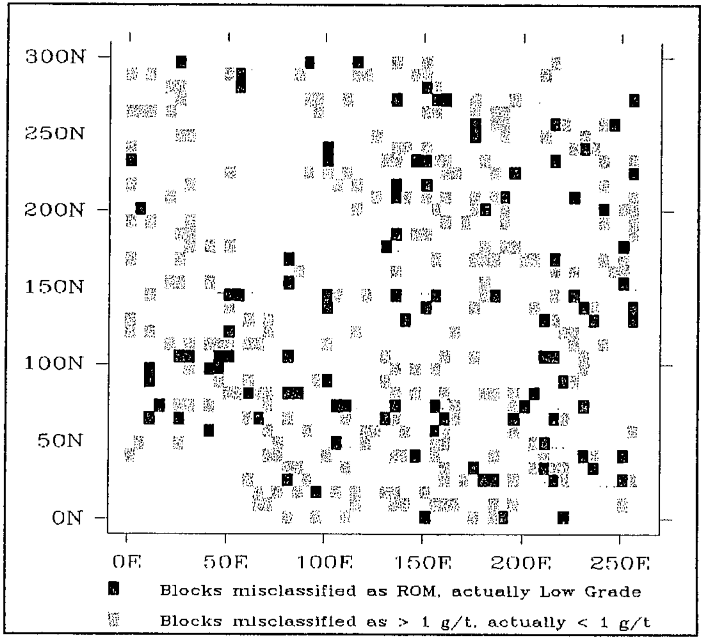

Figure 5. Blocks with Biased Grades due to Mine Laboratory Background Error

This example was referred to in the Introduction (above). 24% of the tonnage with a true grade less than 1.5 g/t has been mis-classified as ROM (blocks marked with filled squares, Figure 5). 22% of the tonnage with a true grade less than 1.0 g/t has been mis-classified as having a grade exceeding 1.0 g/t. As with many reconciliation issues (resource or grade control vs mill) the identification of the major component of the problem was hindered by the presence of both assay bias and also sampling bias. The most likely explanation for the constant "background error" is the deterioration of standard solutions used to calibrate the AAS readings.

Example 3. Assay bias exacerbated by lithology and presence of coarse gold

Cause: Presence of clay causing dispersion problems and solubility problems of gold grains

Discrepancies between grade prediction from mine grade control procedures and back-calculated mill head grades at a gold mine with a significant level of gravity-recoverable gold led to a number of check assaying campaigns. The check assay results, however, were equivocal when doubt was cast on the veracity of the assays due to serious data handling errors and an inconsistent explanation for some of the assay discrepancies. The absence of included standards did not help establish which laboratory should be believed.

This example was interesting because the cyanide-soluble assays from the grade control samples were positively biased (of the order of 10%) compared to a number of checks by aqua regia and a smaller number of checks by fire assay. The mineralisation, however, has no known characteristics that should prove problematical for aqua regia (eg presence of electrum, high sulphide contents, carbonate, etc). Intuitively, the cyanide results should have been lower than the aqua regia assays. Coincidentally[11], the magnitude of the bias between the cyanide results and the aqua regia corresponded to the mismatch between milled grade and grade control predicted grade.

The mine laboratory used "off-the-shelf" standard pulps that had an uncertain relevance to the mineralisation so it was felt that the quality of the assaying should be re-investigated. The following course of action was taken in collaboration with mine staff:

1. Several hundred kilograms from a range of rock types and grades were comminuted, blended and homogenised.
2. A set (10 pulps in each set) of approximately 70 gram samples were dispatched to two laboratories for fire assay (30g) of gold in duplicate, a third set of 20 pulps (with included standards) were sent for analysis by neutron activation to establish homogeneity.
3. The results from all three laboratories were examined:

Assaying of Candidate Standards						
Standard	Lab 1 (n=20)		Lab 2 (n=20)		NAA Lab (n=20)	
	Mean	CV%	Mean	CV%	Mean	CV%
LG	1.19	4.3	1.39	2.2	1.24	1.3
MG	2.59	7.0	3.06	3.3	2.92	1.6
HG	8.70	3.5	10.17	3.1	9.14	1.3

Table 1: Homogeneity check assaying of standards

The variation between the three laboratories in the author's experience is typical with an average 17% difference between the lowest and the highest average for each standard. This variation is, however, unacceptable by any reasonable criteria. The two laboratories that returned the lowest and highest value have good reputations and were advised that the samples represent potential standards so it is assumed that particular care was taken with their assay.

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[11] This remained a coincidence

The results for the certified standards supplied to the NAA laboratory are:

Assaying of Certified Standards		
Standard	**Recommended Value (g/t)**	**NAA Result (N = 3)**
2PA	0.85	0.85
7PA	3.00	3.00
10P	6.81	6.82
6PA	1.65	1.66

Table 2: Assaying of included standards by NAA

The results in Table 2 are within 1% of Recommended Values and indicate that the values from the NAA laboratory in Table 1 can be used with confidence.

4. The three standards were then provided to the mine geology department as large samples (~800 g) ~~to use with the large grade control samples for cyanide soluble gold~~ and as smaller samples (100 g) for use as controls for conventional assaying by fire assay and aqua regia.
5. Blank pulps and coarse blanks were also prepared.
6. To resolve the historic and ongoing assay discrepancies a retrospective check assay program commenced using approximately 200 previously assayed residue pulps in combination ~~with the newly prepared standards and blanks~~.
7. Several coarse gold standards were made by using high purity separates from the gravity plant. These were weighed and added to selected standard samples. Coarse blanks (several grams) prepared to mimic typical +106 micron fractions obtained during screening (for screen fire assay) were also added to the standards that had spiked gold. The coarse blank was also added to several blank pulps submitted for screen fire assaying.
8. The prepared batch was submitted to a different laboratory from those tabulated above for cyanide-soluble gold analysis and screen fire assay (~800 grams, 150 mesh, two 30 gram fire assay undersize and fire assay of oversize, sieve cloth assayed). The "whole" submitted sample was assayed.
9. The results of the control samples were examined:

Standards and Blanks					
Standard (g/t)	**Recommended Value (g/t)**	**Assay Method**	**Mean**	**CV%**	**N**
Blank	<0.01	SFA	0.03		4
Blank	<0.01	CN	0.03		4
LG	1.24	SFA	1.25	6.1	7
MG	2.92	SFA	2.80	4.1	6
HG	9.14	SFA	8.98	1.87	7
LG	1.24	CN	1.25	0.7	7
MG	2.92	CN	2.70	12.2	6
HG	9.14	CN	8.82	1.95	5

Table 3: Summary statistics for the assaying of standards

These results compare well with recommended values. Although the laboratory was not informed that the batch contained standards, it performed better than the two other laboratories whose results are reported in Table 1. The cyanide-soluble results are lower than the RVs for the MG and HG standards (by 92% & 97% respectively).

10. The results from the spiked samples were useful despite potential inaccuracies in weighing in small amounts of physical gold into the standard samples. The CN-soluble results were consistently low (average of 78% of predicted values) whilst the SFA results were, on average, within 10% of the predicted values. The average predicted grade for the spiked samples assayed by SFA is 17.4 g/t and the average for the CN-soluble assays is 13.5 g/t. Thus at higher grades, in the presence of coarse gold, there is evidence that the CN-soluble grades are significantly low.
11. An examination of the assay results of the unknowns commenced. The original pulps of the samples had previously been assayed twice at different times using the mine laboratory's CN-soluble methodology. Thus for each sample there were two original assays. There were also two new assays - a screen fire assay and a CN-soluble assay, by the check laboratory. It quickly became clear that one set of the earlier CN-soluble results were biased high by an overall 6% compared to the check laboratory's CN results. The other set had a close agreement with the check laboratory. When the grade ranges were considered, however, by sub-setting the grades into intervals from 0-1, 1-5, 5-10 and 10-50 g/t a positive bias at low grades and a negative bias at higher grades became apparent (Figure 6):

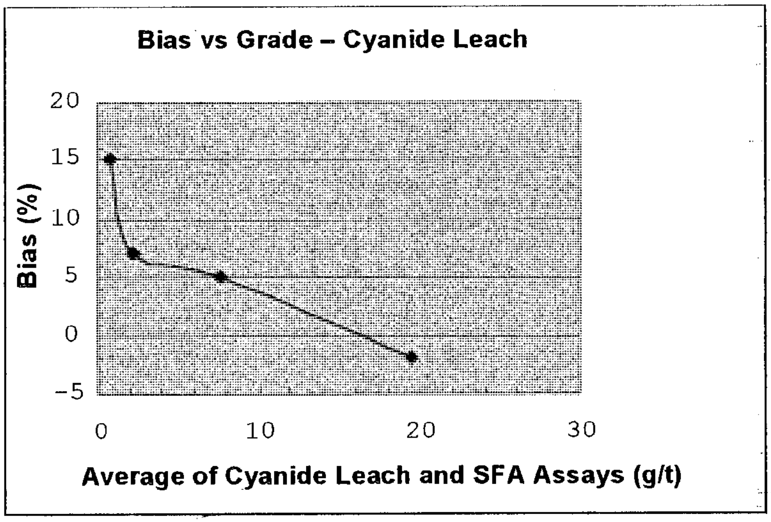

Figure 6. Bias – Grade Relationship for Cyanide Leach Used in Assaying of Grade Control Samples.

This result was consistent with previously acquired internal check assay data.

12. The reason for the bias grade relationships became clear when the data was split on the basis of lithology. The lithologies containing the highest amounts of layer silicates had the highest positive biases suggesting that problems of dispersion in the pregnant solution were contributing to the problem. The check laboratory commented that the dispersion problems were extreme for some of the samples with settling of the solutions for hours required in some cases.

The presence of high clay contents is a well known contributor to high bias for both aqua regia and cyanide gold determinations.

The procedures outlined above for preparation of standards have proved effective over many years. Unless every batch of samples submitted to a laboratory contains a standard sample there is no means to determine the accuracy of the results. This applies to stream sediments, BLEG samples, soils, ferruginous lags, rock chips, drill core, reverse circulation chips, grade control samples, waters, metallurgical samples and any other samples. The common assumption that assay results are in some way guaranteed because the laboratory uses its own standards is clearly unsupported and unjustified .

Useful papers describing the use and preparation of standards are James and Radford (1988) and Davis and Windham (1995).

Example 4. *Low bias in copper-rich but high iron samples from Girilambone, NSW.*

Cause: Incorrect gas mixture resulting in inadequate temperature in flame for AAS determinations.

The evaluation[12] that led to the successful development of the Girilambone Copper Mine, N.S.W. took place from 1989 to 1992. As part of the drilling program a number of pulps were prepared from the actual mineralisation and were distributed to ten Australian laboratories to check the copper content of oxide and chalcocite samples with a variable Fe content. It became immediately apparent that the results formed two populations. Seven laboratories agreed on a lower set of Cu values, three gave results variably higher.

The view that the majority is likely to be right is a common[13] but flawed approach when dealing with check assays. In this case the majority was wrong and the exercise resulted in the identification of a poor choice of AAS gas mixture resulting in an incorrect flame temperature by the majority of the laboratories. A re-assay program of samples with high Fe[14] contents (~> 5% Fe) and low copper contents (~>0.3 - < 1.5% Cu) resulted in an average 15.4% lift in copper grade of the re-assayed samples. The relationship between bias and iron content is depicted in Figure 7.

An earlier check assay program had not revealed any bias but had supported the original laboratory's results. Such is the danger of check assay programs uncontrolled by appropriate standard pulps.

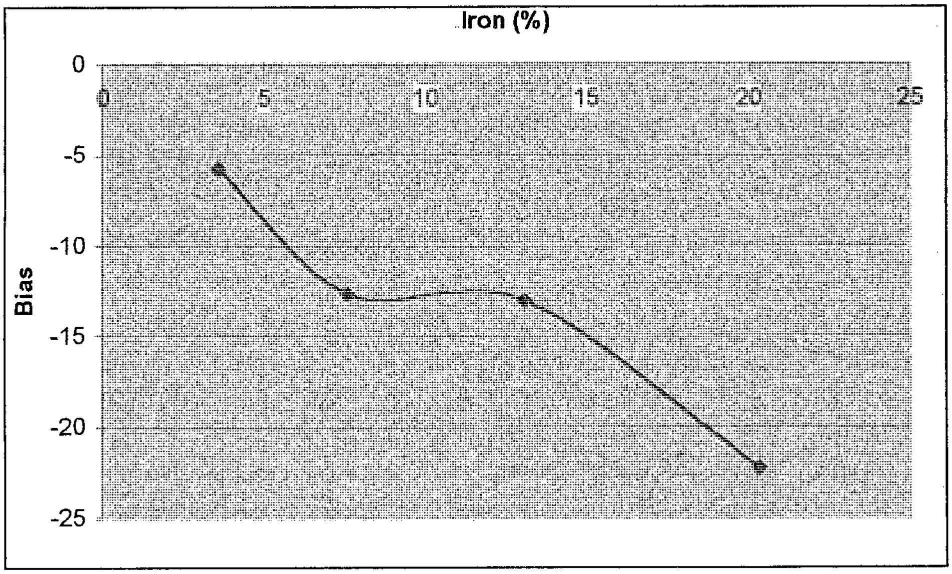

Figure 7. Bias – Iron Relationship, Copper Mineralisation, Girilambone, NSW

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[12] By Nord Resources (Pacific) Pty Ltd

[13] Not only in the mining industry but in most areas of human endeavour. A recent example of this concerned results for a nickel laterite from three laboratories two of which agreed and the third differed by reporting lower concentrations of Ni and Mg. The results from the third were unjustifiably rejected.

[14] The identification of high iron samples for re-assay was made possible by the diligent, detailed and quantitative geological logging that was available as a computerised database.

Example 5. Fire assay with AAS finish

Cause: Incorrectly calibrated AAS procedure

Five standards with various grades were made up of Lebong Tandai (Bengkulu Province, Sumatera, Indonesia) ore in the early 1980s. These were submitted with underground channel samples and drill core to an Australian laboratory for fire assay (followed by AAS) gold determinations. The results from submitted standards in numerous batches indicated a 15% low bias. A check laboratory with included standards was also used. A simple scatter plot of gold concentration of the two laboratories with the results of the standards was sufficient to convince the laboratory to re-assay, at their expense, all samples from the previously assayed batches. The use of included standards prevented arguments between the two laboratories as to which laboratory was correct.

The original laboratory maintained that the problem arose from the AAS equipment though no other laboratory had this problem with the same equipment. It appears that a fundamental problem existed either with standardisation or with the actual fire assay technique. This laboratory was subsequently sold to another group. If that low bias carried through to other projects how many projects may have been similarly undervalued?

Examples of Incorrect Assay Techniques

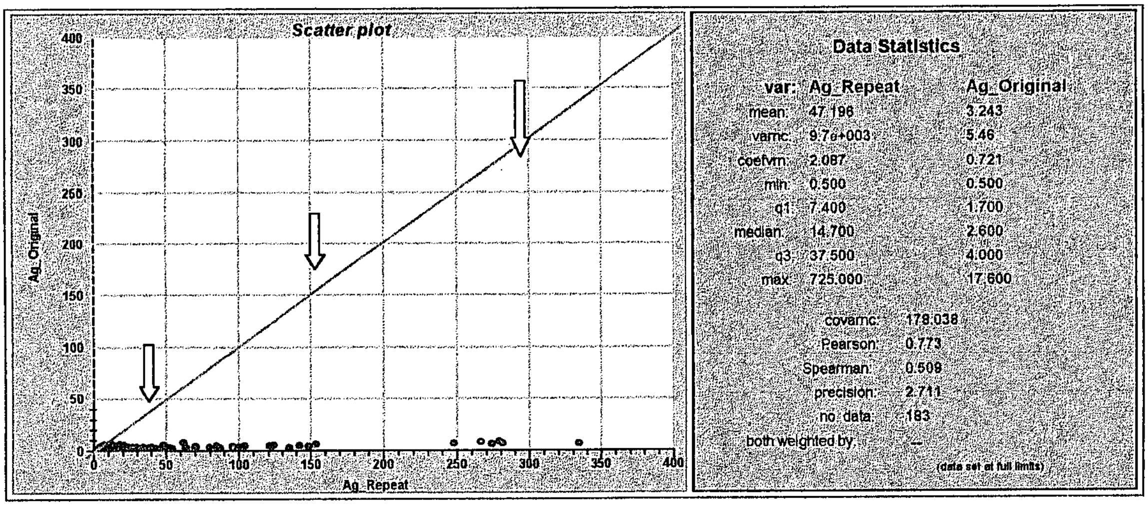
Example 6. Disappearance of grade

Cause: Unconvincing explanation from the branch laboratory that "we forgot to add the acid"—the wrong technique was used.

The spectacular example of a whole batch of silver results reporting low as is depicted in Figure 8 was discovered by the routine use of blind standards. The curious feature of this example is that lead and zinc assays performed in the same batch as the silver assays showed close to expected values. Rather than having discovered a new Ag-poor Pb/Zn-rich ore type the results from the standards demonstrated that the silver assays had considerably been undervalued. The laboratory (a branch laboratory of a major international minerals analytical company) initially indicated that the results were as reported. The standard results were then shown to the laboratory which then conceded that a mistake had been made. The forthcoming explanation of forgetting to add acid was, however, less than convincing due to the fact that the Pb and Zn assays are derived from the same solution.

The check assays for Pb are, on average, 8% lower than the originals (Figure 9) and illustrate a convincing uniform bias. The Zn repeats show a close agreement with the originals.

The samples in this example constitute approximately 170 metres of drilled intervals from two holes. If undiscovered, the low grades (mean of 3 g/t) in the original batch would have resulted in a significantly understated resource estimate compared to the re-assayed batch (mean of 47 g/t). In a preliminary exploration setting the low results could conceivably have led to the down-grading of a promising prospect.



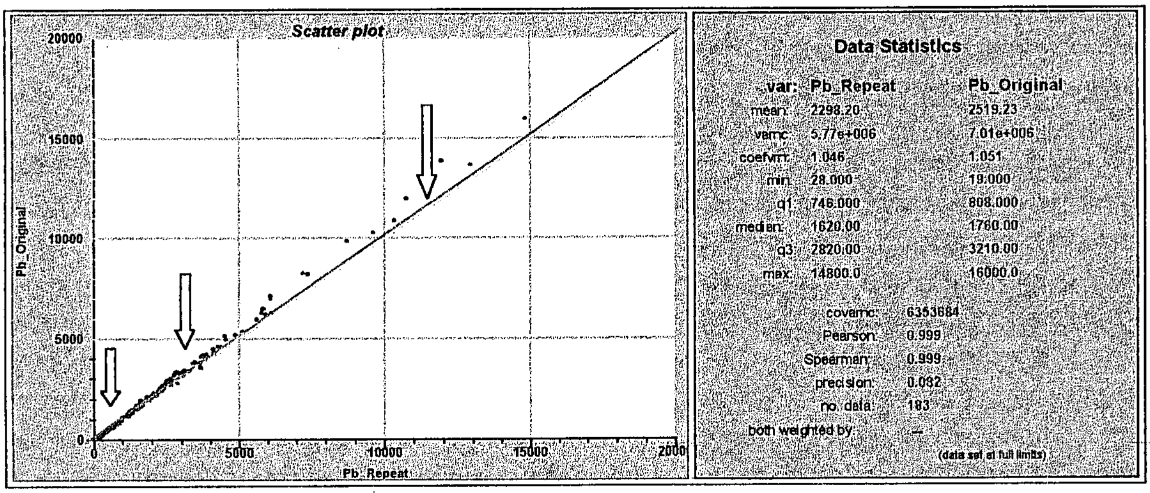
Data Statistics

var:	Ag_Repeat	Ag_Original
mean:	47.196	3.243
varnc:	9.7e+003	5.46
coefvm:	2.087	0.721
min:	0.500	0.500
q1:	7.400	1.700
median:	14.700	2.600
q3:	37.500	4.000
max:	725.000	17.600

covarnc: 178.038
Pearson: 0.773
Spearman: 0.509
precision: 2.711
no. data: 183
both weighted by: --

(data set at full limits)

Figure 8. Original vs Repeat Silver Assays – Entire Batch of Results
(arrows mark position of standards)



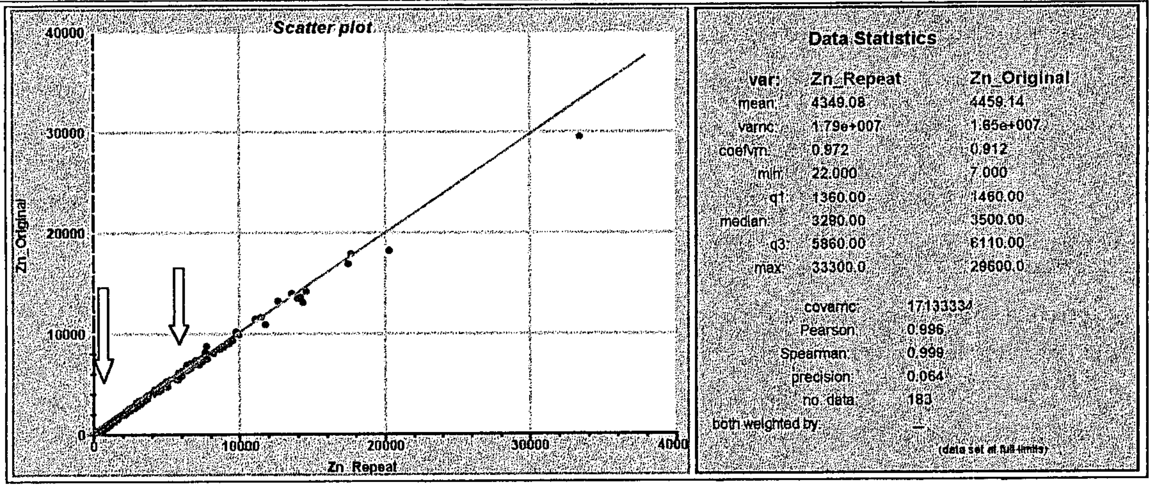
Data Statistics

var:	Pb_Repeat	Pb_Original
mean:	2298.20	2519.23
varnc:	5.77e+006	7.01e+006
coefvm:	1.046	1.051
min:	28.000	19.000
q1:	746.000	808.000
median:	1620.00	1760.00
q3:	2820.00	3210.00
max:	14800.0	16000.0

covarnc: 6353684
Pearson: 0.999
Spearman: 0.999
precision: 0.082
no. data: 183
both weighted by: --

(data set at full limits)

Figure 9. Original vs Repeat Lead Assays – Entire Batch of Results
(arrows mark standards)



Data Statistics

var:	Zn_Repeat	Zn_Original
mean:	4349.08	4459.14
varnc:	1.79e+007	1.65e+007
coefvm:	0.972	0.912
min:	22.000	7.000
q1:	1360.00	1460.00
median:	3290.00	3500.00
q3:	5860.00	6110.00
max:	33300.0	29600.0

covarnc: 17133334
Pearson: 0.996
Spearman: 0.999
precision: 0.064
no. data: 183
both weighted by: —
(data set at full limits)

Figure 10. Original vs Repeat Zinc Assays – Entire Batch of Results (arrows mark standards)

A more considered explanation of the disappearance of the silver in the original batch came from the laboratory where the actual analysis was performed. The branch laboratory acted as a receiving depot and forwarded the pulps to the main laboratory for analysis. A partial leach was stated to have been mistakenly used instead of a multi-acid digestion that would have involved HCl, HNO_3, $HClO_4$ and HF resulting in a "total" result. This second explanation is still hard to understand in view of the "partial" results for Pb and Zn having higher mean results than the repeats.

Example 7. Inappropriate ICP technique for iron-rich laterite samples

Cause: Inappropriate assay technique that failed to report As and Sb resulting from iron-rich nature of matrix

An example of the complete failure of an ICP technique for analysis of Sb and biased results for As comes from a laterite sampling survey in West Africa. Sb results from all the initial batches of results for surface laterite samples were reported by the laboratory as being "less-than-detection" by a large sample aqua regia technique. Prior to selecting the technique the laboratory had been contacted to check the appropriateness of the particular technique.

Checking by INAA showed these results to be clearly in error with the true results returning values in excess of 10 times the detection limit. Repeat analyses by the same laboratory using a larger ratio of solution to sample resulted in more acceptable results.

Examples of Cross Contamination

Example 8. Cross contamination of an entire batch of samples

Cause: Previously assayed metallurgical test products and failure by client and laboratory to assay coarse blanks

The formative experience by the author early in his career of a whole batch of surface rock-chips having suffered irreversible laboratory contamination from coarse gold originating from previously assayed metallurgical samples in the laboratory has left a lasting memory. With such exciting results there was keen interest in following[15] up the initial samples. This led to a new batch of submitted samples returning values less than detection.

Example 9. Cross contamination tails

Cause: High amounts of coarse gold reporting to oversize in screened assays

An examination of successive assays following high grade intercepts was carried out to test the extent of cross contamination that may have resulted during the fine pulverising stage. Two examples are provided in Figure 11.

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[15] One week of field-work in mid summer

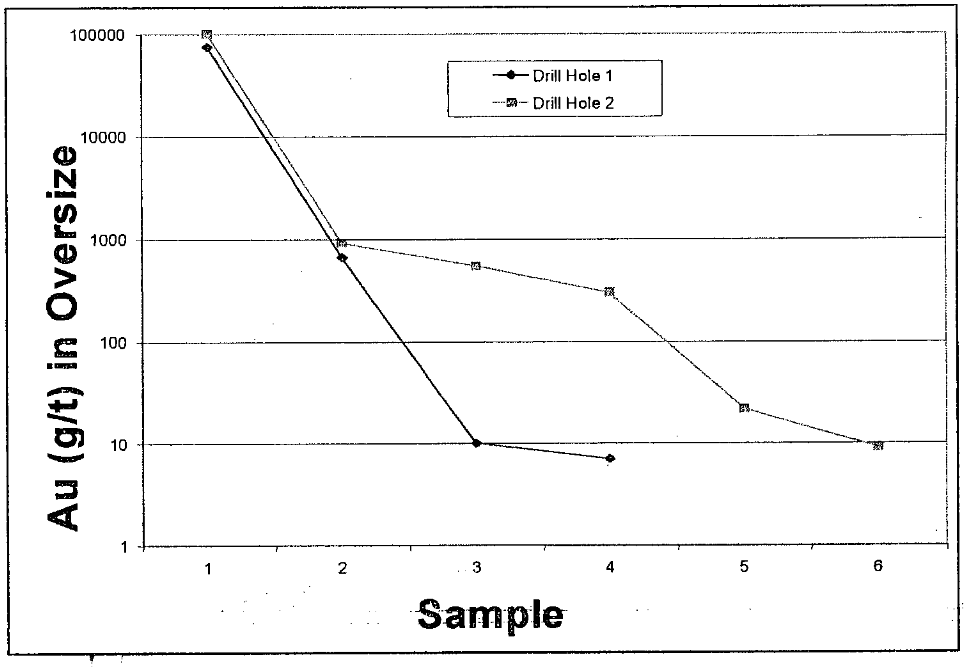


Figure 11. Diminution of grades in screened oversize following a high grade intercept.

The fall off in grade following the intervals with exceptionally high gold in the coarse fraction is a testimony to the ability of gold to plate on to pulverising equipment and carry-over to subsequent samples. Evidence for such effects can be found by closely examining the behaviour of gold grades following high grade intervals either by assessing the amount of gold that reports to the oversize in the case of screened assays (eg screen fire assays) or by looking for decay-type diminution of grade.

Coarse blanks (eg waste gravel, coral, limestone, etc) should be submitted as anonymous samples especially after suspected high grade mineralisation to test for cross contamination. Cross contamination in samples containing coarse gold may be severe and may have the effect in resource evaluation drilling of falsely enhancing lower grades to levels above cutoffs of interest.

A useful practice is to find out how many pulverisers are being used in the laboratory and what order the samples are being processed. The same number of coarse blanks should then be placed at the start of every submitted batch. This ensures that, if the previously prepared batch at the laboratory contained unusually high concentrations of elements (eg Mo, Au) that have a tendency to plate onto pulverisers, early detection of the problem is likely.

A recent inspection of a laboratory revealed the selective non-use of inter sample cleaning agents (such as quartz wash). This was justified by the laboratory manager on the basis of the visual impression by laboratory assistants that the pulveriser bowls appear clean. It is impossible, however, to visually detect gold plated onto pulverising equipment that may contribute parts per million cross contamination.

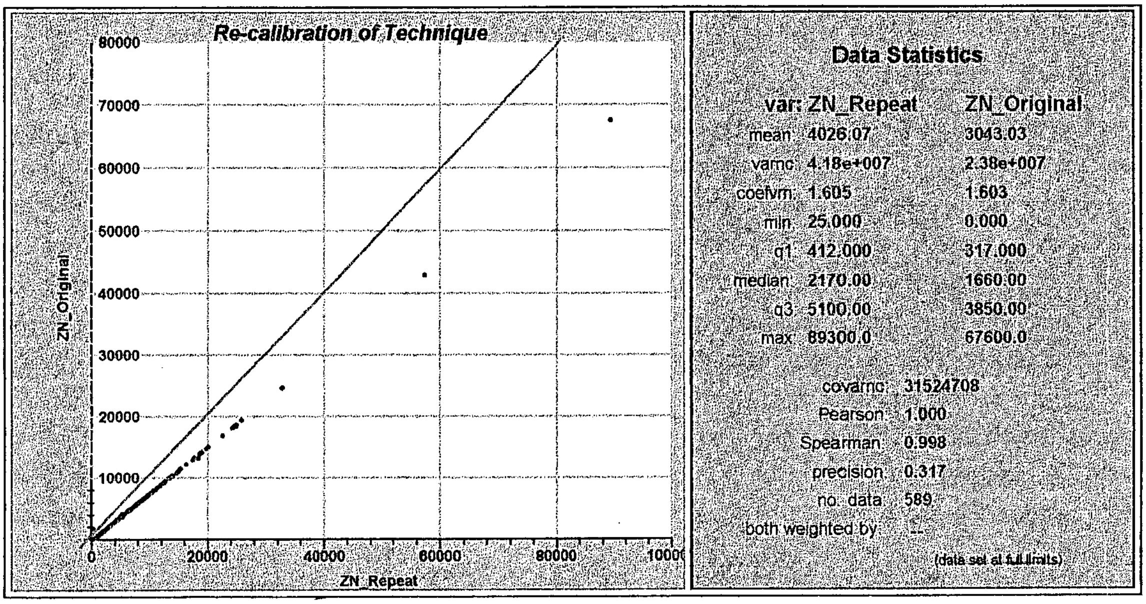
Cross contamination of gold in the context of resource estimation will result in exaggerated mineralised intercepts leading to the impression that mineralised widths are wider than reality. This will, in turn, affect geostatistical studies of spatial continuity resulting in artificially induced measures of continuity. Blanks cost nothing and are easily obtainable and may provide indispensable information regarding the quality of sample preparation.

Blanks that by-pass the sample preparation system are also valuable. These are typically pre-pulverised material (eg silica flour or residue pulps) and yield information relating to background analytical levels and the possibility of cross contamination by virtue of solution carry-over or other sources of non-sample-preparation-type contamination.

Example of Re-Calibration

Example 10. ***Discrepancy between Zn assays by different techniques from the same laboratory***

Cause: Incorrect calculation of assays due to incorrect calibration



Data Statistics

var:	ZN_Repeat	ZN_Original
mean	4026.07	3043.03
varnc	4.18e+007	2.38e+007
coefvm	1.605	1.603
min	25.000	0.000
q1	412.000	317.000
median	2170.00	1660.00
q3	5100.00	3850.00
max	89300.0	67600.0

covarnc: 31524708
Pearson: 1.000
Spearman: 0.998
precision: 0.317
no. data: 589
both weighted by: 1

(data set at full limits)

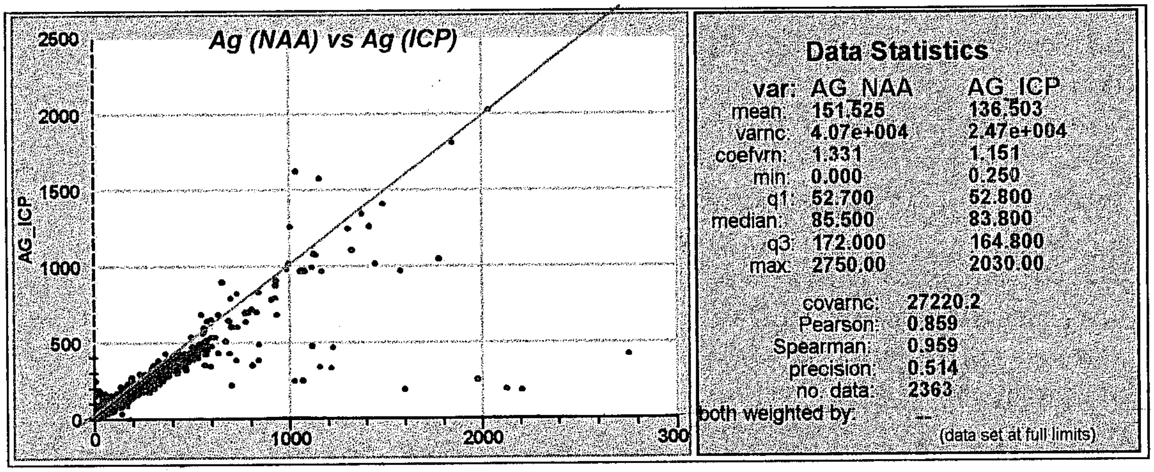
Figure 12. Effect of Recalibration upon Repeat Assays

This is an unusual example and was discovered by standards submitted by the client being used to document discrepancies between assays based on different methods. The result was pleasing with an approximate lift by 33% of zinc grades.

Importance of Detection Limits

Example 11. Illustration of the wisdom of taking note of laboratory's guidelines for assay method's upper limits

Many laboratory Schedules of Services quote Upper Detection Limits ("**UD**") in addition to Lower Detection Limits ("**LD**"). These should be taken seriously as the example depicted in Figure 13 illustrates. In this case the laboratory's Schedule of Services specifies a LD between 2-5 ppm and an UD of approximately 80 - 120[16] ppm.

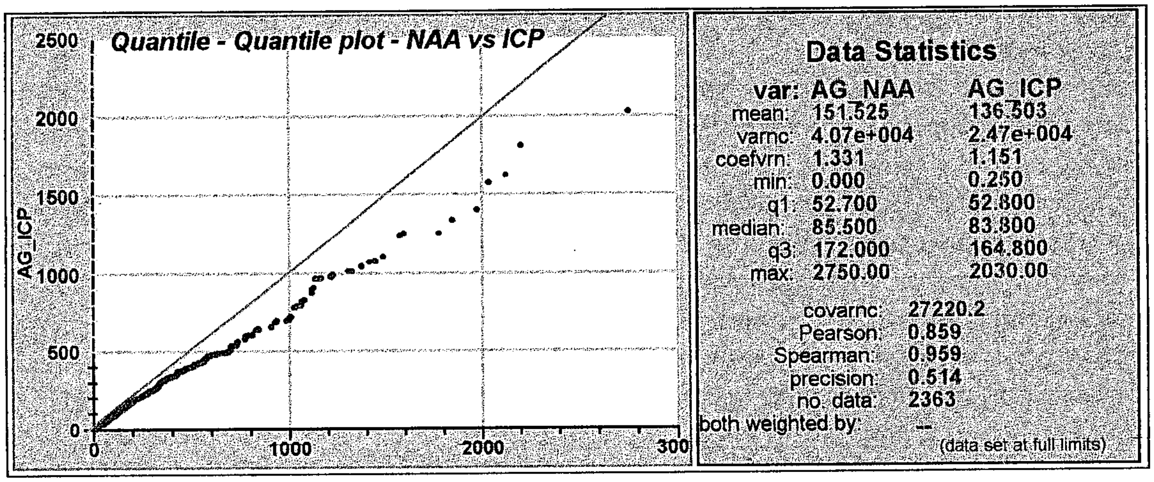


Data Statistics

var:	AG_NAA	AG_ICP
mean:	151.525	136.503
varnc:	4.07e+004	2.47e+004
coefvrn:	1.331	1.151
min:	0.000	0.250
q1:	52.700	52.800
median:	85.500	83.800
q3:	172.000	164.800
max:	2750.00	2030.00

covarnc: 27220.2
Pearson: 0.859
Spearman: 0.959
precision: 0.514
no. data: 2363
both weighted by: --
(data set at full limits)

Figure 13. Scatter Plot of Silver by Neutron Activation (x axis) vs ICP



Data Statistics

var:	AG_NAA	AG_ICP
mean:	151.525	136.503
varnc:	4.07e+004	2.47e+004
coefvrn:	1.331	1.151
min:	0.000	0.250
q1:	52.700	52.800
median:	85.500	83.800
q3:	172.000	164.800
max:	2750.00	2030.00

covarnc: 27220.2
Pearson: 0.859
Spearman: 0.959
precision: 0.514
no. data: 2363
both weighted by: --
(data set at full limits)

Figure 14. QQ Plot of Silver by Neutron Activation (x axis) vs ICP

Inspection of a scatter plot of the data at lower concentrations (Figure 15) shows a trend of negative bias of the ICP results compared to the NAA results with increasing grade. The QQ plot highlights this more distinctly (Figure 16) and indicates that the quoted UD is in fact too high, on the basis that the NAA results are more accurate at these levels and that the ICP results deteriorate from about 75 ppm rather than the higher UD indicated by the laboratory. This assumption is supported by included silver standards that demonstrated the accuracy of NAA at

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[16] Actual quoted detection limits are not provided in order to preserve anonymity.

levels above 100 g/t. As indicated by Figure 16 there is a positive bias in the ICP results at grades below ~50 g/t compared to NAA. This accords with results from a standard with a RV of 48 ppm for which the ICP results average 48 and the NAA results average 41. This bias is reversed at grades in excess of ~70 g/t Ag.

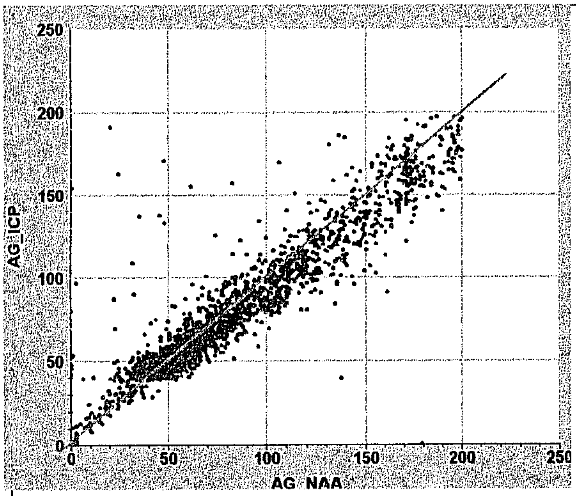

Figure 15. Scatter Plot of Silver by Neutron Activation (x axis) vs ICP (sub-setted data less than 200 ppm)

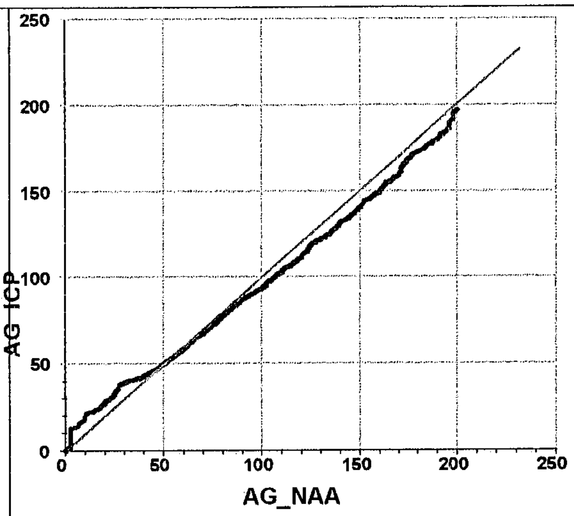

Figure 16. QQ Plot of Silver by Neutron Activation (x axis) vs ICP (sub-setted data less than 200 ppm)

Further evidence for the performance of the ICP and NAA techniques at various concentration levels can usefully be obtained by a consideration of the variation of precision with concentration level. Results from two blanks (a pulp and a coarse blank) as well as three standards are available from numerous batches assayed over a period of two years. In addition to these, results from duplicate pulps and duplicate rig splits (in the case of reverse circulation drill samples) are also available. The relationship between CV and concentration is provided in Figure 17 and Figure 18 for the two methods for silver and zinc. The asymptotic relationship between the two is typical and is a reflection of the rapid deterioration of precision at low concentration levels and only a modest gain in precision at higher levels. The deterioration in the ICP results for silver in Figure 17 in the standard at the ~300 ppm level is consistent with the bias at these levels noted above and reflects the instability of the method above the UD. In contrast, the precision of zinc remains stable at elevated concentrations (Figure 18).

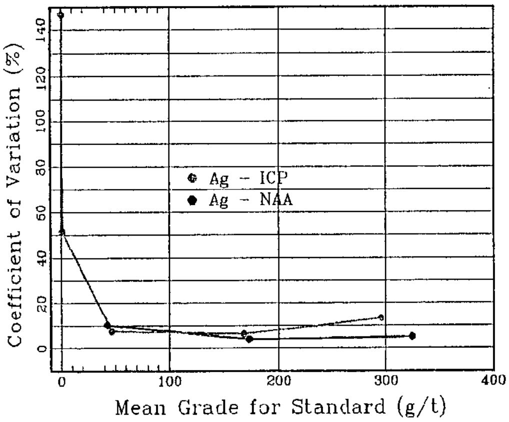

Figure 17. CV vs Grade for ICP and NAA Results

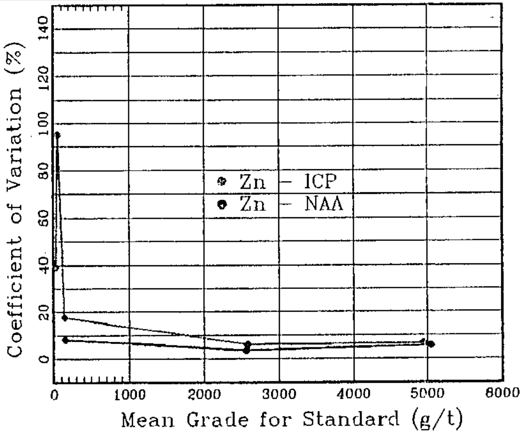

Figure 18. CV vs Grade for ICP and NAA Results

The results from duplicate rig splits analysed in various batches over a period of two years are provided in Figure 19 and Figure 20.

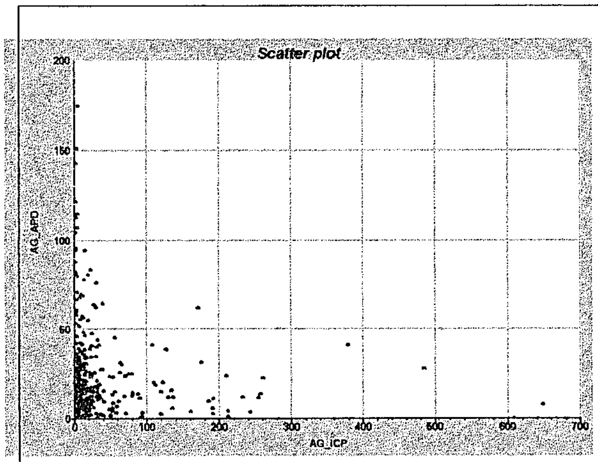

Figure 19. AMPD for ICP Ag Results – RC Rig Splits

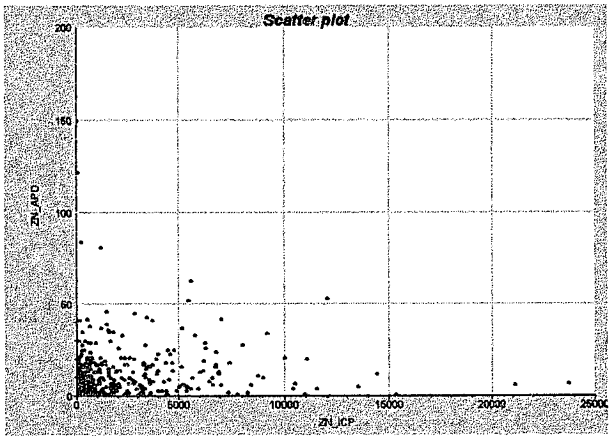

Figure 20. AMPD for ICP Zn Results – RC Rig Splits

It is immediately obvious that the comparison of duplicate pairs based on different splits of coarse RC chips introduces a significant deterioration in precision as illustrated by the average AMPD for Ag values over 20 g/t being 19.8% and that of Zn being 12.4%. The CVs from the standards for these two elements are illustrated in Figure 17 and Figure 18. The poorer precision is due to the introduction of a sampling error which was minimal in the case of the results based on splits of finely pulverised standards. This illustrates the importance of ensuring that discussions of analytical precision are based on samples that have minimal sampling error.

Multiple Problems Within a Laboratory

Example 12. *Poor precision of low level gold determinations using aqua regia digestion*

Cause: Incorrect calibration at gold levels over 100 ppb and no corrections used for actual sample weights in cases when low weight samples were submitted.

Precise low level gold determinations are required for geochemical exploration techniques that utilise media such as stream sediments, soils and laterite. Aqua regia[17] digestion followed by AAS is ideally suited to these requirements by virtue of its lower cost compared to fire assay and its ability to achieve low limits of detection that are usually quoted at the part-per-billion level. The media quoted above are usually oxidised and lack high levels of problematical components such as sulphides and carbonate that preclude the technique as a general method for resource delineation. Aqua regia assaying for resource-type levels of interest invariably report lower average results with greater variability when compared with "total" techniques such as neutron activation or fire assay. At low levels, however, aqua regia may achieve good precision.

The results depicted in Figure 21 were a disaster to both the laboratory and client. Suitable standards had been routinely submitted to the laboratory along with the soil and stream sediment samples. The client had assumed, however, that there was something wrong with the submitted standard after having been reassured by the laboratory that the internal laboratory standards

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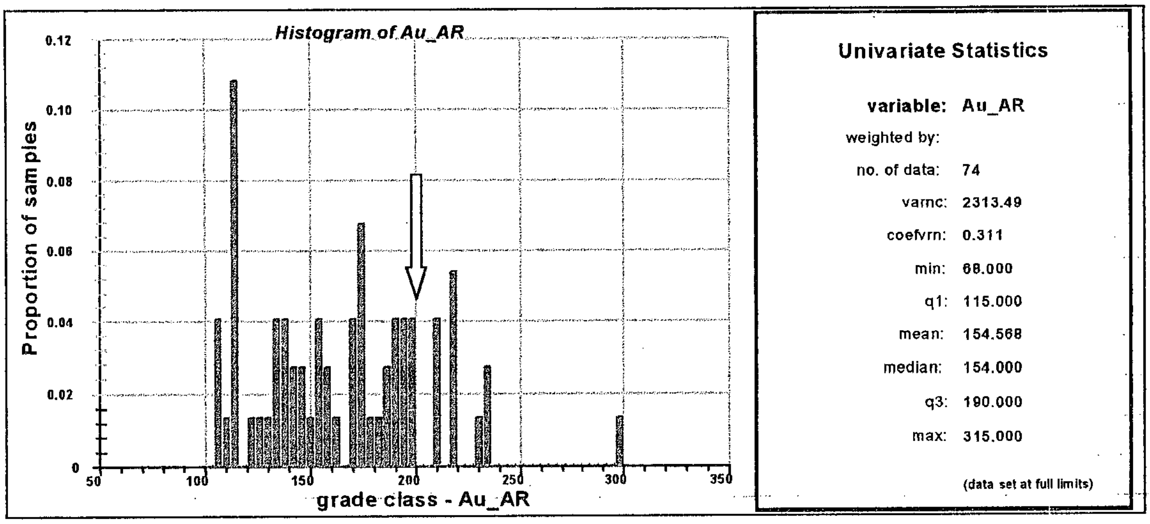
[17] For a discussion of its relative performance refer to Hall et al (1989, 1990)

were effective monitors of accuracy and thus guaranteed acceptable quality of assaying. The internal standards used by the laboratory showed no bias.



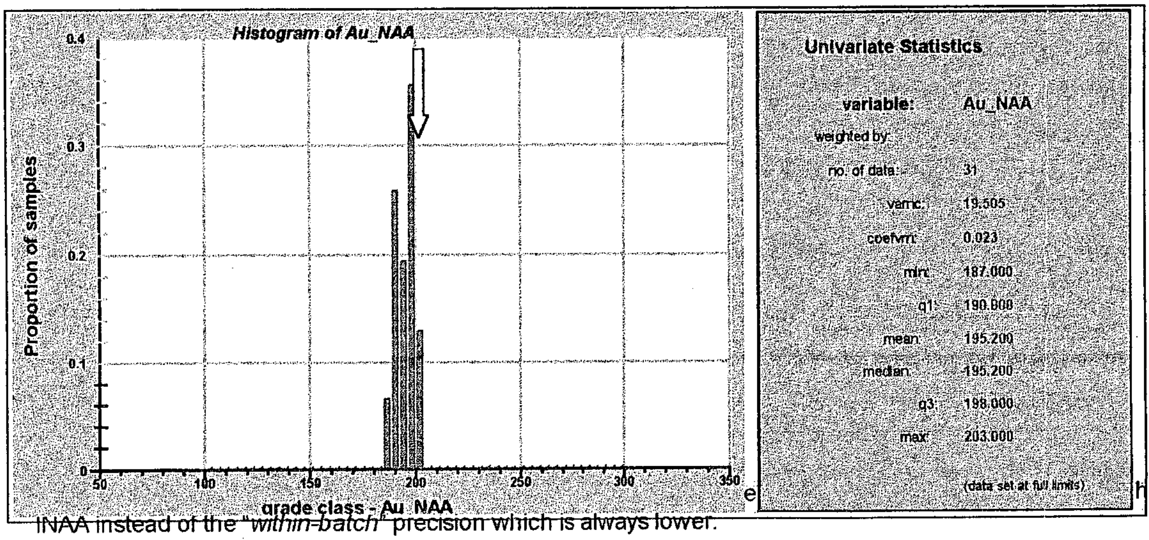
```
Univariate Statistics

  variable:  Au_AR
weighted by:
 no. of data:  74
       varnc:  2313.49
     coefvrn:  0.311
         min:  68.000
          q1:  115.000
        mean:  154.568
      median:  154.000
          q3:  190.000
         max:  315.000

            (data set at full limits)
```

Figure 21. Aqua regia assays for gold of low level gold standard (same standard as in Figure 22)

H&S had been responsible for setting up the original sampling and QC system and were approached to resolve the situation. The first step was to submit approximately 15 splits of the same standard sample to three laboratories for replicate assaying by NAA, aqua regia and fire assay. A histogram of the NAA results is provided in Figure 22. The coefficient of variation (CV) is 2.3% which is an excellent precision and could only be achieved if the original sample splits reflected a homogeneous parent. Furthermore, the mean of 195 is within 1.5% of the Recommended Value of 200 ppb. The CV of the same standard depicted in Figure 21 is 31.1%, approximately 20 times the NAA result[18]. The mean of 155 ppb would be acceptable in the context of discovering anomalies provided some semblance of acceptable precision was achieved.



```
Univariate Statistics

  variable:  Au_NAA
weighted by:
 no. of data:  31
       varnc:  19.505
     coefvrn:  0.023
         min:  187.000
          q1:  190.000
        mean:  195.200
      median:  195.200
          q3:  198.000
         max:  203.000

            (data set at full limits)
```

e hes of

INAA instead of the "*within-batch*" precision which is always lower.

Figure 22. Homogeneity check by INAA of low level gold standard with Recommended Value of 200 ppb (marked by arrow)

The homogeneity tests using aqua regia and fire assay by an independent laboratory showed CVs of 3% and 4%, respectively. These NAA, AR and FA results prompted the laboratory to investigate the source of the poor precision. This led to the discovery of two problems:

Firstly, the results of samples with weights less than 30 grams had a low bias in proportion to the sample weight (eg a 10 gram sample had one third of the correct concentration). The use of small (ie less than 30 grams) samples of –200# hand sieved stream sediments may be common in samples from streams of high relief (due to the rapid loss of fine silt due to high energy drainages). *Secondly*, since the purchase of a new AAS unit, suppression of results by 30% occurred due to incorrect calibration at gold levels above approximately 100 ppb.

Actual original and repeat gold values (ppb) in pairs of samples analysed by the same laboratory are:

	30 grams	30 grams	<30 gram	<30 gram
Original	130	108	27	28
Repeat	217	180	270	280

(Weights refer to original submitted sample weight)

A plot of gold concentration vs Batch Number is provided in Figure 23. These types of plots are useful in highlighting deterioration of quality with time, bad batches within discrete time intervals and overall performance. It is clear that the quoted precision of 10% for the technique was never achieved over the entire period.

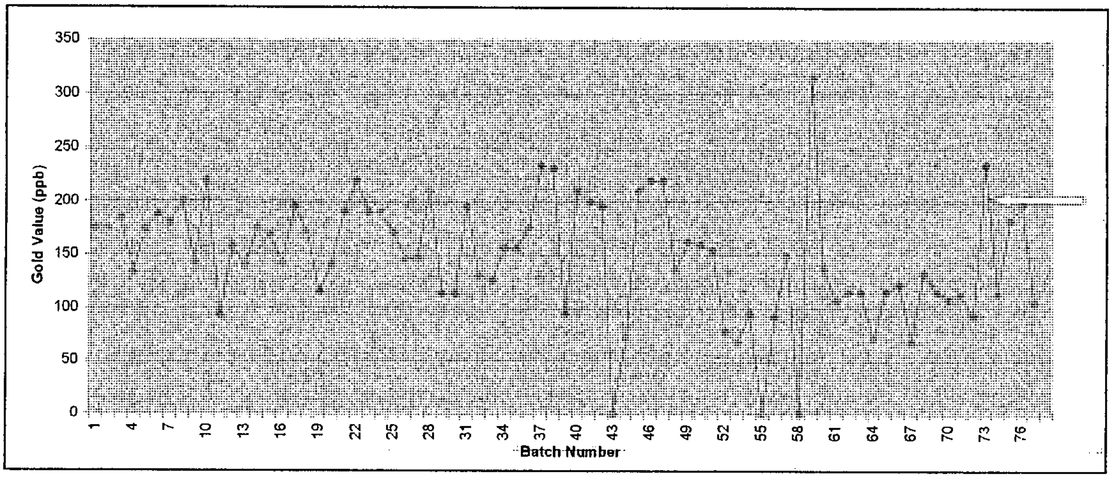


Figure 23. Variation in Gold Concentration of Standard Sample with Batch Number. (Arrow marks recommended value).

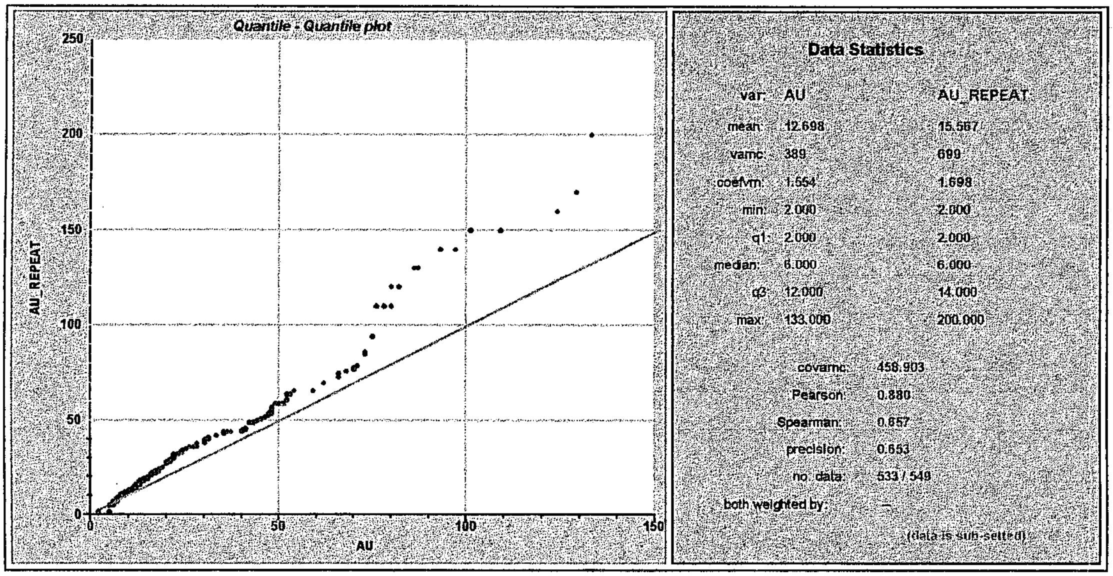
This example demonstrates the inadequacy of relying on the performance of a laboratory's own internal standards as a guide to assaying accuracy. In this case a false sense of security would have resulted due to a fixed weight of 30 grams being used by the laboratory for the standards. Many of the unknowns, however, had weights less than 30 grams and therefore had understated grades due to the lack of the weight correction factor.

The laboratory was obliged to have over 1000 exploration samples re-assayed and, due to the lack of confidence of the client in the laboratory, an independent laboratory was, justifiably, requested. The results of the re-assays are depicted in Figure 24, Figure 25 and Figure 26. Bias is particularly pronounced in the soil re-assays at levels above about 75 ppb. Better agreement in the –200 mesh stream sediments is presumably related to the "cleaner" matrix and particulate nature of the gold in the sediments compared to the soils.

The –80 stream sediments (Figure 26) show poor agreement due both to the poor quality of the original assays and also to the sampling errors associated with particulate gold. The high sampling error associated with the –80 mesh sediments is reflected in an AMPD of 47%, the –200 mesh sediments have an AMPD of 16% and the soils an AMPD of 27% (all for values over 20 ppb).

The cost of the laboratory's errors is not simply confined to the cost of re-assaying all the samples which in this case was borne by the original laboratory. The poor precision of the original analyses resulted in considerable mis-classification of geochemical anomalies. Imprecisely understated stream sediment results will result in the down grade of potentially large drainage basin areas (to several square kilometres). The occasional artificial anomaly (see Figure 23) causes the unnecessary follow-up of falsely high results. The combined costs of helicopter hire and logistical support to follow-up laboratory-induced anomalies is considerable.

The detection of bias and poor precision of either original or check assays is difficult to impossible in samples that have high sampling errors due to particulate gold. In these cases, inserted standards are the only means by which quality of assaying can be unambiguously assessed.

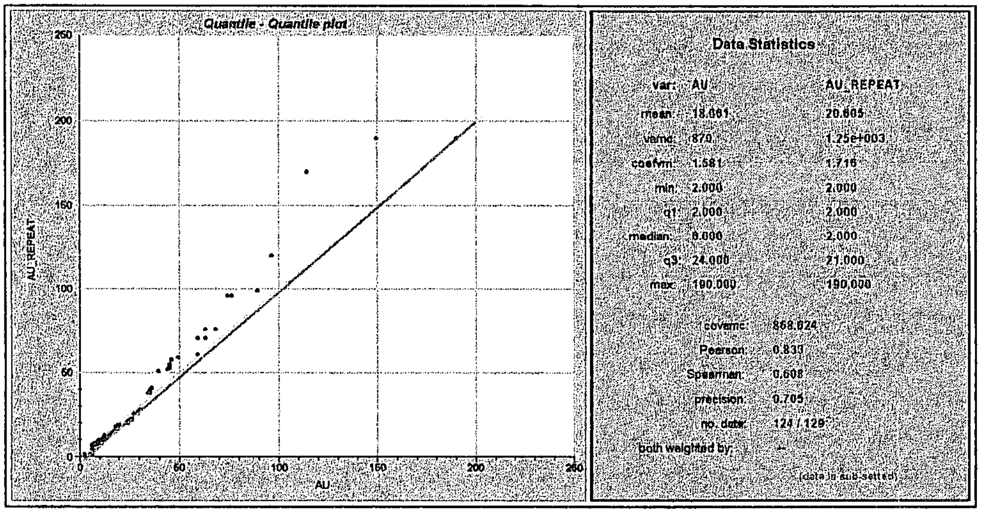


Data Statistics

var:	AU	AU_REPEAT
mean:	12.698	15.567
varnc:	389	699
coefvn:	1.554	1.698
min:	2.000	2.000
q1:	2.000	2.000
median:	6.000	6.000
q3:	12.000	14.000
max:	133.000	200.000

covarnc: 458.903
Pearson: 0.880
Spearman: 0.857
precision: 0.653
no. data: 533 / 549
both weighted by: —
(data is sub-setted)

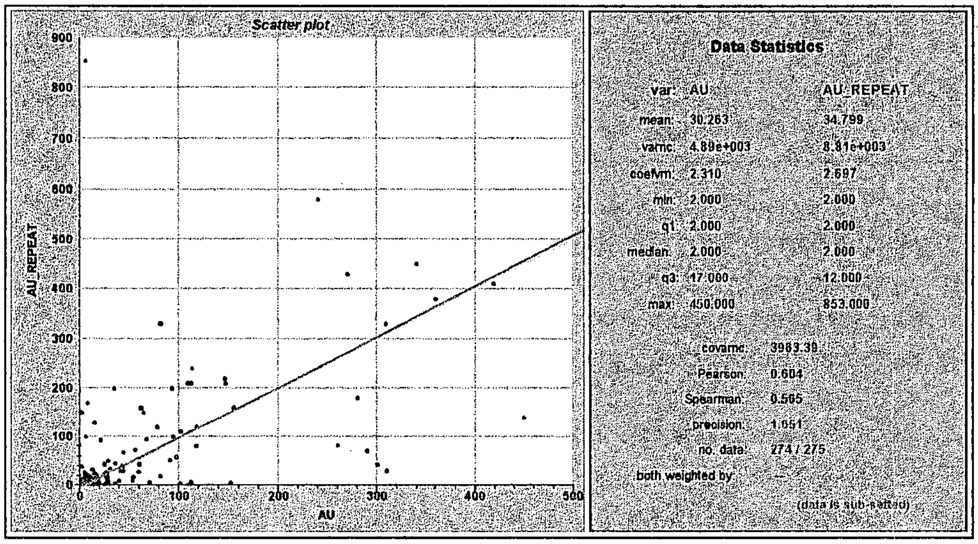
Figure 24. QQ Plot of Original vs Repeat Gold Analyses in Soils.



var:	AU	AU_REPEAT
mean:	18.061	20.605
varnc:	870	1.25e+003
coefvn:	1.581	1.716
min:	2.000	2.000
q1:	2.000	2.000
median:	8.000	2.000
q3:	24.000	21.000
max:	190.000	190.000

covarnc:	868.024
Pearson:	0.833
Spearman:	0.608
precision:	0.705
no. data:	124 / 129
both weighted by:	—

Figure 25. QQ Plot of Original vs Repeat Gold Analyses in –200 Mesh Stream Sediments.



var:	AU	AU_REPEAT
mean:	30.263	34.799
varnc:	4.89e+003	8.81e+003
coefvn:	2.310	2.697
min:	2.000	2.000
q1:	2.000	2.000
median:	2.000	2.000
q3:	17.000	12.000
max:	450.000	853.000

covarnc:	3983.39
Pearson:	0.604
Spearman:	0.565
precision:	1.051
no. data:	274 / 275
both weighted by:	—

Figure 26. Scatter Plot of Original vs Repeat Gold Analyses in –80 Mesh Stream Sediments.

Assaying of Metallurgical Samples

Example 13. *Interpretation of assay results of metallurgical samples by multiple laboratories using typical criteria*

Cause: Reliance on agreement between Calculated Heads and Actual Heads as an indicator of accuracy without having submitted standards.

Interpretation of metallurgical results is often difficult as a consequence of the absence of effective QC protocols. Metallurgical test products are susceptible to problems of precision and accuracy resulting from the partitioning nature of the actual testwork which produces extremes in element concentrations. Inclusion of appropriate control samples is mandatory in such work due to the high cost of the testwork and significance of the results to the evaluation of mineral projects.

Samples were submitted to five laboratories. The results in Table 4 (below) concern silver and are based on the same metallurgical sample and come from two of the five laboratories:

Assay Results of Metallurgical Sample from Laboratory 1			
	Weight (%)	**Ag (ppm)**	**Ag (%)**
Product 1	0.49	3900	33.9
Product 2	0.65	2500	28.7
Product 3	0.66	340	4.0
Product 4	4.56	35	2.8
Product 5	1.62	100	2.9
Tail	92.02	17	27.7
Total	**100.0**		**100.0**
Calc Head		**56.6**	
Actual Head		**199**	

Assay Results of Metallurgical Sample from Laboratory 2			
	Weight (%)	**Ag (ppm)**	**Ag (%)**
Product 1	0.49	35125	78.8
Product 2	0.65	3115	9.2
Product 3	0.66	303	0.9
Product 4	4.56	33	0.7
Product 5	1.62	94	0.7
Tail	92.02	23	9.6
Total	**100.0**		**99.90**
Calc Head		**219**	
Actual Head		**207**	

Table 4: Assay results of the same metallurgical products by two laboratories

Assays for the tails by five laboratories varied from 14 to 27 ppm and for Product 1 varied from 2800 to 37,700 ppm. Excluding Laboratory 1, assays of Ag for the tails varied from 18 to 27 ppm and for Product 1 from 32,300 to 37,700 ppm.

Results for internal standards assayed in the same batches as the metallurgical samples were reported by the laboratories. Laboratory 1 reported these results:

	Recommended Value (ppm)	**Reported Value (ppm)**
Standard 1	138	138
Standard 2	626	600
Standard 3	70	68

The apparent good performance of these results is inconsistent with the total failure of the laboratory's performance with respect to the samples of interest. This illustrates the inadequacy of using laboratories' own internal standard data as a monitor of accuracy.

Agreement between calculated heads and actual heads is a common method used to validate assays in metallurgical tests. It is easy to demonstrate that the introduction of a variable bias (eg assays at high levels too low and assays at low levels too high) will produce a close agreement (within 5%) between these two values. The results from Table 4 have been used to generate a set of biased assays from a hypothetical laboratory:

Hypothetical Laboratory 3				
	Weight (%)	Factored Ag (ppm)	Bias Factor	Ag (%)
Product 1	0.49	30,000	0.854	74.7
Product 2	0.65	2660	0.854	8.1
Product 3	0.66	333	1.10	1.12
Product 4	4.56	39.6	1.20	0.92
Product 5	1.62	105	1.15	0.86
Tail	92.02	30.6	1.35	14.3
Total	**100.0**			**100.0**
Calc Head		**198**		
Actual Head		**207**		

Table 5: Artificially introduced variable bias to assay results

The agreement between the Calculated and Actual Heads for the artficially biased results is actually better than the real results provided in Table 4. This feature may lead to the erroneous conclusion that the biased results given in Table 5 are superior to to the real results in Table 4.

The early detection of bias without the time consuming submission of residue samples to check laboratories is only possible by the use of control samples such as internal standards and blanks. The consequences of having no control samples may include the following:

- discrepancies between Calculated vs Actual Heads being blamed on sampling problems such as "spotty" gold rather than assay error,
- incorrect estimation of metallurgical recoveries leading to over- or under-valuation of the project,
- extra expense associated with numerous check assays that may produce equivocal results,
- masking of assay bias by poor precision.

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Acknowledgments

Helpful comments on various drafts of the paper by Ron Butler, Dr David Garnett, Ed Malone and Neil Schofield are acknowledged. Luke Burlet assisted with preparation of the layout of the document.

Numerous people have participated on a collaborative basis in many of the projects represented in the examples. These include, Dr Russell Fountain, Dr David Garnett, Sam Garrett, Dr Paul Hamlyn, Greg Hall, Dr Mal Jansen, Nic Johnson, Dr Michael Leggo, Jane MacKay, Ian Neuss, Dr Ian Pringle, Neil Schofield and Graeme Sheldon. Many laboratory managers and chemists, by virtue of their commitment to solving problems, have also substantially contributed to the assembling of these case studies.