

Kamloops Research
&
Assay Laboratory
LTD.



R. G. Blundell
Res. 573-3016

B.C. CERTIFIED ASSAYERS

017395

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Copy to J. O'H. for information only.

July 31, 1978.

Orig back to me.

Mr. Glen Simpson,
Vice-President, Exploration,
Cyprus Anvil Mining Corporation,
330 - 355 Burrard Street,
Vancouver, B. C.
V6C 2G8

Dear Glen:

Recently, samples which were assayed by Kamloops Research and Assay Laboratory (KRAL) were forwarded to your company for submission to an independent laboratory (Cantest) for verification of assay results. A significant difference was noted in the silver assays between the two laboratories and both were contacted by Mr. Jeff Franzen for possible explanations for the difference. KRAL stated that the atomic absorption method was traditionally higher than the fire assay method due to silver losses in the fire assay method. Cantest (1) stated that at most the error in the DY range of values would be 1%, and that atomic absorption assays were higher than fire assays due to a 10% enhancement by iron on silver absorbance. After comparing the silver assays with drill core logs, it was suggested by Mr. Franzen (2) that "KRAL should evaluate this problem and if necessary fire assay all samples for silver". KRAL has completed its investigation and the findings are the subject of this letter.

We would like to discuss the following subjects:

- I The Revision of Recommended Values for Reference Ore MP-1.
- II Losses in Silver by Fire Assay.
- III Corrected vs. Non Corrected Assays.
- IV 10% Enhancement by Iron on Silver Determinations by Atomic Absorption.
- V Accuracy Between Laboratories.
- VI Routine or Specimen vs. Control Assays.

(1) Jeff Franzen, DY Assay Evaluation, Cyprus Anvil Mining Corporation, Vancouver, B.C., June 1, 1978.

(2) *ibid.*

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I The Revision of Recommended Values for Reference Ore MP-1

In 1972 the reference material MP-1 was certified (3) to contain 59.5 ppm silver. In June 1978 a bulletin (4) was issued to all laboratories using MP-1 as a primary reference standard recommending that, due to oxidation, the silver value should be revised downwards to 57.9 ppm. Therefore, the silver assays which were based on a value of 59.5 should be multiplied by a factor of .973 to allow for oxidation. This oxidation was first noticed in late 1976 by the Department of Energy, Mines and Resources and since all DY assays were performed using the value of 59.5 ppm, all should be factored.

II Losses of Silver by Fire Assay

Fulton and Sharwood (5) state that there are many sources of error in the fire assay method for gold and silver:

- "(i) Losses by absorption or solution in the slag of the fusion.
- (ii) Losses by volatilization during fusion.
- (iii) Losses by absorption during cupellation.
- (iv) Losses by volatilization during cupellation.

The chief losses are (i) and (iii)."

Faye (6) states that, "in the lead collection method of fire assay for silver, the average loss of silver is approximately 3%. It is noteworthy that, even if the fire assays are corrected by this amount, the mean value (57.8) is still significantly lower than that of the other methods. A 'corrected' overall mean of 59.5 ppm is obtained when the fire assay results for silver are increased by 3%. This value is probably closer to the true value." The certified value is 6.1% higher than the fire assay value.

- (3) G. H. Faye; Zinc, Tin, Copper, Lead Ore, MP-1: Its Characterization and Preparation for use as a Standard Reference Material, Department of Energy, Mines & Resources, Mines Branch, Ottawa, September 1972, Technical Bulletin TB 155 -- p. 53.
- (4) G. H. Faye and W. S. Bowman; Revision of Recommended Values for Reference Ores MP-1 and KC-1, Department of Energy, Mines & Resources, Ottawa, Canmet Report 78-2.
- (5) Fulton & Sharwood; A manual of Fire Assaying, Third Edition, McGraw-Hill Book Company, Inc. New York and London 1929, p. 209
- (6) G. H. Faye; Technical Bulletin TB 155, p. 56.

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Cantest stated that in the DY range of silver values, the loss of silver would be at most 1% (7). Depending on the weight chosen, one half assay ton or 1 assay ton, the weight of the silver bead obtained would be .5 milligrams to 2.5 milligrams or 1 milligram to 5 milligrams respectively. Fulton (8) states that in this range the loss would be up to 8% and 6% respectively. Furthermore, Bugbee (9) states that the loss would be of the order of 4% on a one milligram silver bead. He also stated p.115 that the silver loss increases as the weight of lead button increases. The 4% loss is observed using a 30 gram button. The 25 gram button would yield a 3.4% loss. This is an interesting point since KRAL used a 0.5 assay ton weight, resulting in a smaller bead than if a 1.0 assay ton were used. The KRAL lead buttons were 45 grams (each button was wrapped to that weight to ensure cupellation of all samples at close to the same time). From the above, the KRAL fire assays should have lost more silver than the stated 4%. This might explain the difference between KRAL atomic absorption and KRAL fire assay corrected figures, Table I.

Table I

Comparison Between Silver Assays by Atomic Absorption, Fire Assay with Silver Correction, Fire Assay without Silver Correction and Fire Assay Cantest.

<u>Sample No.</u>	<u>Atomic Absorption</u>	<u>Fire Assay (Ag Correction)</u>	<u>Fire Assay (No Ag Correction)</u>	<u>Fire Assay Cantest</u>
2686	83.0	85.7	82.3	77.5
2659	74.2	68.6	61.7	59.8
2590	35.3	32.2	28.8	20.9
2735	63.6	55.5	55.5	53.5
2721	74.1	70.0	68.9	66.9
	a) $\bar{x} = 66.0$	$\bar{x} = 62.4$	$\bar{x} = 59.4$	$\bar{x} = 55.7$
	b) $\bar{x} = 64.2$			

- a) Atomic Absorption results based on MP-1 certified value of 59.5 ppm.
 b) Atomic Absorption results based on MP-1 certified value of 57.9 ppm.

For the purposes of accurate comparison only the pulps which were assayed by both Cantest and KRAL were considered. We will also discuss only those results using the revised value of 57.9 ppm, conceding that the original results were high by 2.7%.

The atomic absorption assays averaged 2.9% higher than the fire assay corrected assays and 8.1% higher than fire assay non-corrected assays.

- (7) J. Franzen, DY Assay Evaluation, p. 2.
 (8) Fulton & Sharwood; Manual of Fire Assaying, p. 198
 (9) Edward E. Bugbee; A Textbook of Fire Assaying, Third Edition, John Wiley and Sons, Inc. 1940. p. 116.

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The KRAL fire assay non-corrected assays averaged 6.6% higher than the Cantest fire assay assays. We feel that these results support the findings of Fulton and Sharwood, Bugbee, and Faye, and perhaps the atomic absorption assays were higher than the corrected fire assays due to the small weight of the silver bead and the large weight of the lead button. We cannot claim this to be true, however, as the necessary re-search work was not performed to prove this.

III Corrected vs. Non-Corrected Assays

Due to the losses incurred in the fire assay we recommend correcting silver assays for losses to obtain a result closer to the "true" assay.

Bugbee (10) states that corrected assays give a very close approximation to the actual precious metal contents of a sample.

Fulton and Sharwood (11) state that whenever the highest accuracy is required, corrected assays should always be made.

To substantiate our claims which were based on one set of data, we undertook a further study on six DY samples.

Table II

Comparison Between Silver Assays by Atomic Absorption, Fire Assay with Correction, and Fire Assay with no Correction

<u>Sample No.</u>	<u>Atomic Absorption</u>	<u>Fire Assay (Ag Correction)</u>	<u>Fire Assay (No Ag Correction)</u>
2756	144	141.3	137.2
2757	77	77.5	73.4
2758	17	17.1	13.0
2759	57	56.2	52.0
2760	38	38.4	34.0
2761	42	41.1	37.0
	$\bar{x} = 62.5$	$\bar{x} = 61.9$	$\bar{x} = 57.8$

The atomic absorption results are 1% higher than the fire assay corrected figures, and 8.1% higher than the fire assay non-corrected assays.

Since these values support the observations in Table I the evidence indicates that the losses of silver in the DY range by fire assay are clearly in excess of the 1% claimed by Cantest.

- (10) Edward E. Bugbee; A Textbook of Fire Assaying - p. 216.
 (11) Fulton and Sharwood; Manual of Fire Assaying - p. 209.

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IV Theory of 10% Enhancement of Silver Absorbancy by Iron

We are not aware of the theory subscribed to by Cantest (12) that iron enhances silver absorbance by 10%, and we can find nothing in our textbooks to substantiate this claim. In fact both Slavin (13) and Reynolds and Aldous (14) state quite the opposite.

Slavin states,

"Silver is a particularly convenient atomic absorption determination. The analysis is sensitive and trouble free."

- "500 ug/ml each of Zn, Mg, Cu, Mn, Fe, Ni, Cu, and Ti had no effect on the absorption of solutions containing 10 and 50 ug/ml silver. About 5,000 ug/ml aluminum in 10% HNO₃ solution produced only the small reduction in sensitivity that is associated with physical effects. This work was done with a low temperature flame and thus the effects would be even smaller in an air-acetylene flame."

Reynolds and Aldous state,

"Atomic absorption determinations for silver are remarkably free from interference effects and the following anions and cations, commonly found in association with the element do not affect its absorption, even when present in heavy excess: Al, Ba, Be, Bi, Cd, Ca, Cr, Co, Cu, Fe, La, Pb, Li, Mg, Mn, Hg, Mo, Ni, K, Na, Sr, Sn, Ti, Zn, NH₄⁺, CN⁻."

Conceding that possibly more recent information might be available to substantiate this claim, we contacted Mr. Jack Stanley, Chief Assayer, Newmont Mining, Similkameen Division, and Mr. Rod Hanson, Chief Assayer, Afton Mines Ltd.

Mr. Stanley, formerly Chief Assayer, United Keno Hill Mines, stated that he had not found that iron interfered in the analysis of silver by atomic absorption and in addition corrected assays in the fire assay method should be used. He also stated that for low silver values (DY range) the atomic absorption method was superior to the fire assay method.

Mr. Hanson, formerly Manager of Bondar-Clegg and Chief Assayer at Island Copper, verified the statements of Mr. Stanley and added that the atomic absorption silver method was widely replacing the fire assay method.

- (12) J. Franzen, DY Assay Evaluation, p. 2.
- (13) Walter Slavin; Atomic Absorption Spectroscopy, The Perkin Elmer Corporation, Norwalk, Connecticut, Interscience Publishers, A Division of John Wiley and Sons, New York, London, Sydney, 1968. p. 158-159.
- (14) R. J. Reynolds and K. Aldous; Atomic Absorption, A Practical Guide, Barnes and Noble, Inc. New York, 1970. p. 63.

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Although it would be folly to draw any conclusions regarding the fire assays of Cantest without much more data, we suggest that perhaps they are attributing the loss of silver in the fire assay to iron enhancement of silver absorbance. (Table I and Table II show a difference of 8.1% between atomic absorption and fire assay non-corrected values.) This is only an opinion, however, and should be regarded as such.

We are confident that the data presented in this letter supports the accuracy of our silver assays. As a final note to this we would like to describe the relative differences between the two methods.

The atomic absorption method uses a 1 gram sample weight diluted to 100 ml and aspirated directly.

The fire assay method uses a 14.583 gram weight in which the silver is extracted and physically measured on a precision balance (1/300 milligram can be weighed). The silver correction for these assays was physically measured.

If one considers these factors, the chances of making compensating errors resulting in check assays which are inaccurate would appear to be extremely low.

V Accuracy Between Laboratories Participating in the Certification of MP-1

If Table III (15) is considered it becomes readily apparent that there is a wide range in the assays used to certify MP-1 as a reference standard. The spread of assays, using the atomic absorption method for silver is 25.6% between the high and low value; using the fire assay method is 16.5%, and overall is 30.5%.

The reasons for this spread are numerous and it is not the intention of this letter to elaborate. The facts are presented merely to show what can happen when a number of laboratories are requested to analyse a sample of a complex ore. Similar differences are also observed in the lead assays (22.0%) and copper assays (20.3%). While these are the worst possible cases, nevertheless they are assays reported on the same sample, and it does point out the fact that for ore grade calculations control assays should perhaps be considered.

(15) G. H. Faye; Technical Bulletin TB 155, pages 15-29

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Table III

Comparison Between Laboratories Participating in Certification of
MP-1 as Reference Standard

<u>Laboratory</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>	<u>Range</u>	<u>Number of Observations</u>
1	a.a.	66.62	.36	66.2 - 67.2	10
2	a.a.	58.67	1.72	57 - 62	12
	f.a.	58.0	1.22	57 - 60	5
3	a.a.	57.4	.52	57 - 58	10
	f.a.	56.16	.37	55.6 - 56.6	10
4	a.a.	60.06	2.28	58.3 - 65.9	10
5	colour	63.4	1.65	60 - 65	10
6	a.a.	61.9	.21	61.5 - 62	10
7	f.a.	58.6	.88	56.6 - 60	10
8	f.a.	53.3	1.16	51.5 - 54.9	10
9	a.a.	62.3	.38	61.7 - 62.4	10
10	a.a.	56.06	.07	55.9 - 56.1	10
13	a.a.	64.8	0	0	10
15	a.a.	59.0	.82	58.0 - 60	10
17	a.a.	54.51	1.01	53.5 - 56.6	10
	f.a.	54.68	.97	54.2 - 56.2	10
18	f.a.	56.63	.62	55.8 - 57.0	12

Data not available for missing laboratories.

a.a. = atomic absorption

f.a. = fire assay

colour = colourimetric

VI Control vs. Routine Assays

Bugbee (16) recommends control assays for greater certainty in underground control, a viewpoint that is shared by KRAL. The most economical method of assaying drill core is to perform routine or specimen assays on all of the samples submitted. The samples which are of particular interest in terms of ore grade should then be assayed by control methods. By following this procedure, money is not needlessly spent verifying the waste rock and greater precision is obtained on the ore samples.

Following is a breakdown of the cost of this procedure along with an explanation of the difference between routine and control.

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The cost to your company for the routine assays for lead, zinc, copper and silver, would be \$14.30 per sample. Control assays on selected samples for lead and zinc would be \$7.15 per element and control assays for silver by fire assay would be \$8.50 each with gold an additional \$3.50. This is a considerable saving over the list price, Table IV.

Table IVComparative Cost Between List and Cyprus Anvil Price

	<u>Cyprus Anvil Price</u>	<u>List Price</u>
Cu a.a.	\$ 3.575	\$ 4.50
Pb a.a.	3.575	5.50
Zn a.a.	3.575	5.50
Ag a.a.	3.575	5.00
	<hr/>	<hr/>
Totals	\$14.30	\$20.50
	<hr/>	<hr/>
<u>Control</u>		
Pb a.a.	7.15	11.00
Zn a.a.	7.15	11.00
	<hr/>	<hr/>
<u>Fire Assay</u>		
Ag)	12.00	17.00
Au)	<hr/>	<hr/>
Totals	\$26.30	\$39.00
	<hr/>	<hr/>

Each control assay would be performed in triplicate, with re-assays performed at KRAL's expense if the spread of assays was greater than 0.1% metal on the lead and zinc assays and 0.1 oz/ton on the silver assays. The price would be effective from July 1, 1978 to July 1, 1979. Both corrected silver and uncorrected silver assays would be reported at no additional cost.

We hope that this meets with your approval, and that any questions regarding the differences in the silver assays have been answered.

Yours very truly,

KAMLOOPS RESEARCH &
ASSAY LABORATORY LTD.*Derek A. Blundell*Derek A. Blundell,
Manager.

DAB:d

c.c. Mr. D. Jennings