ASAHI
REFINING

“Sampling of Molten Dore and Scrap Metals”

ASAHI REFINING

A little about Asahi:

Asahi operates 3 locations now in North America:

-Salt Lake City, Utah – Established 1980

-Brampton, Canada – Established 1975

-Miami, Florida – Established 2019

ASAHI REFINING

Refiners face lots of risks from the materials they receive:

Origins of the material.
Environmental impacts of handling & refining.
Health and safety impacts of processing.
&
Sampling risks in the “value” determination process.

The materials that refiners receive everyday are always mixtures of various elements.

Metals, metalloids, and non-metals.

Our job is to first evaluate the material for its content of precious metal.

Then to refine it.

The evaluation process is of course to determine “fair value” for both the refiner and the customer.

There are many impurities that can interfere in that process.

Arsenic, selenium, iron, nickel, bismuth, antimony, lead to name a few.

The main issue with these impurities is that:

Can create significant segregation in the melt and samples.

This can lead to a significantly ***low*** or ***high*** credit for the precious metals present.

Why does this segregation happen?

Not all materials will melt and form homogenous liquids to sample.

Not all materials will solidify into nice, homogenous samples.

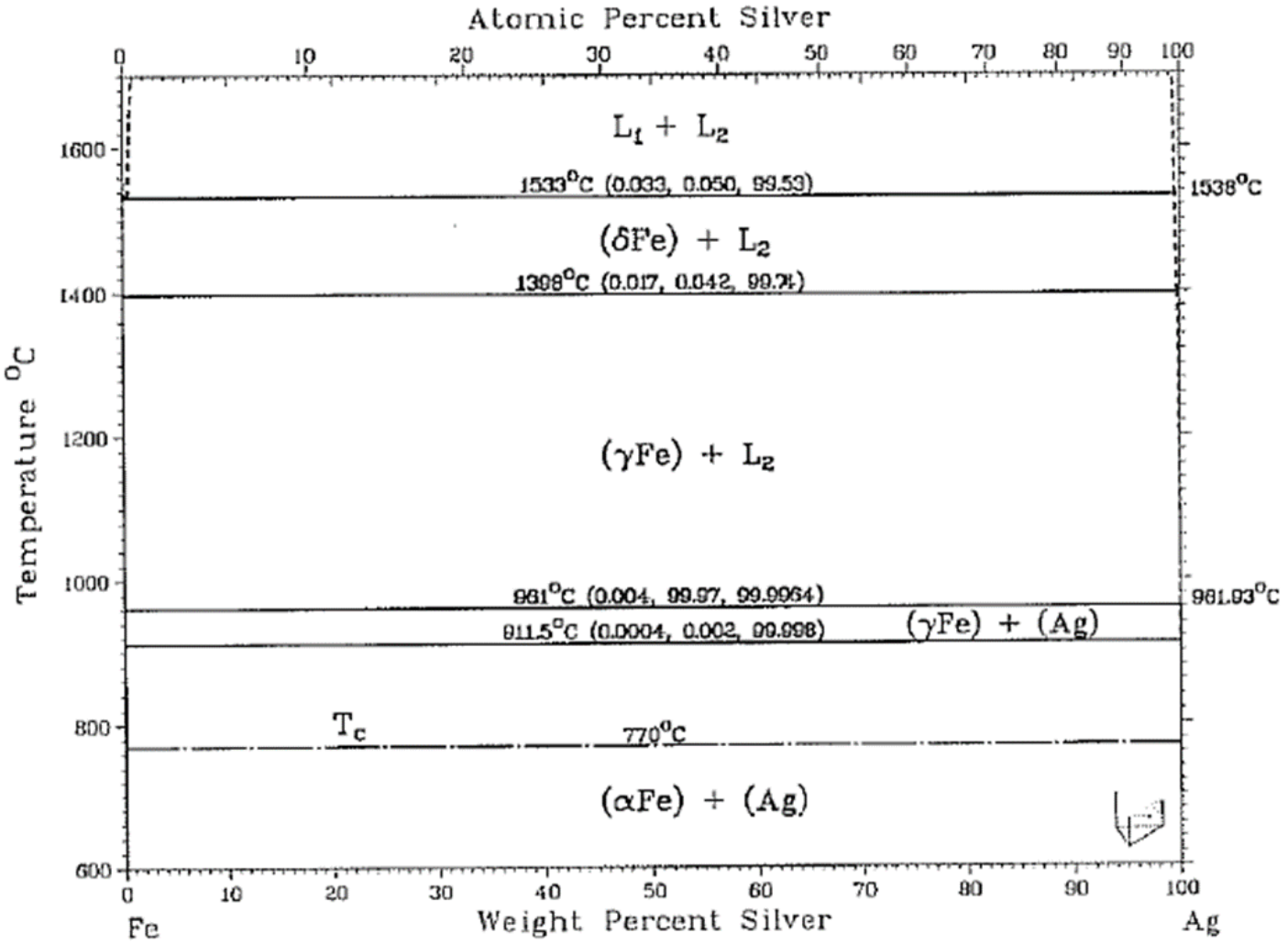
To get any kind of homogeneity we often rely on physical mixing & rapid solidification.

Melts often have more than one “phase” present.

As an example, looking at a binary phase diagram for silver and iron, this extreme situation becomes clear.

The Issue

ASAHI REFINING



L.J. Schwartzendruber, 1984.

No amount of iron/silver is soluble in the other at any temperature!

With induction, in a lower frequency furnace, the field creates a vigorous mixing.

Physically mix the components.

But its not reliable.

Re-separation will occur.

ASAHI REFINING

Get a rapid “salad dressing effect”

Similarly, once the mixing stops, the molten mixture re-segregates.

The more time allowed, the more pronounced the segregation.

Clearly evident in the sample drawn, and even more so in the bar cast as it cools more slowly.

Common sampling methods of precious metal melt-able materials:

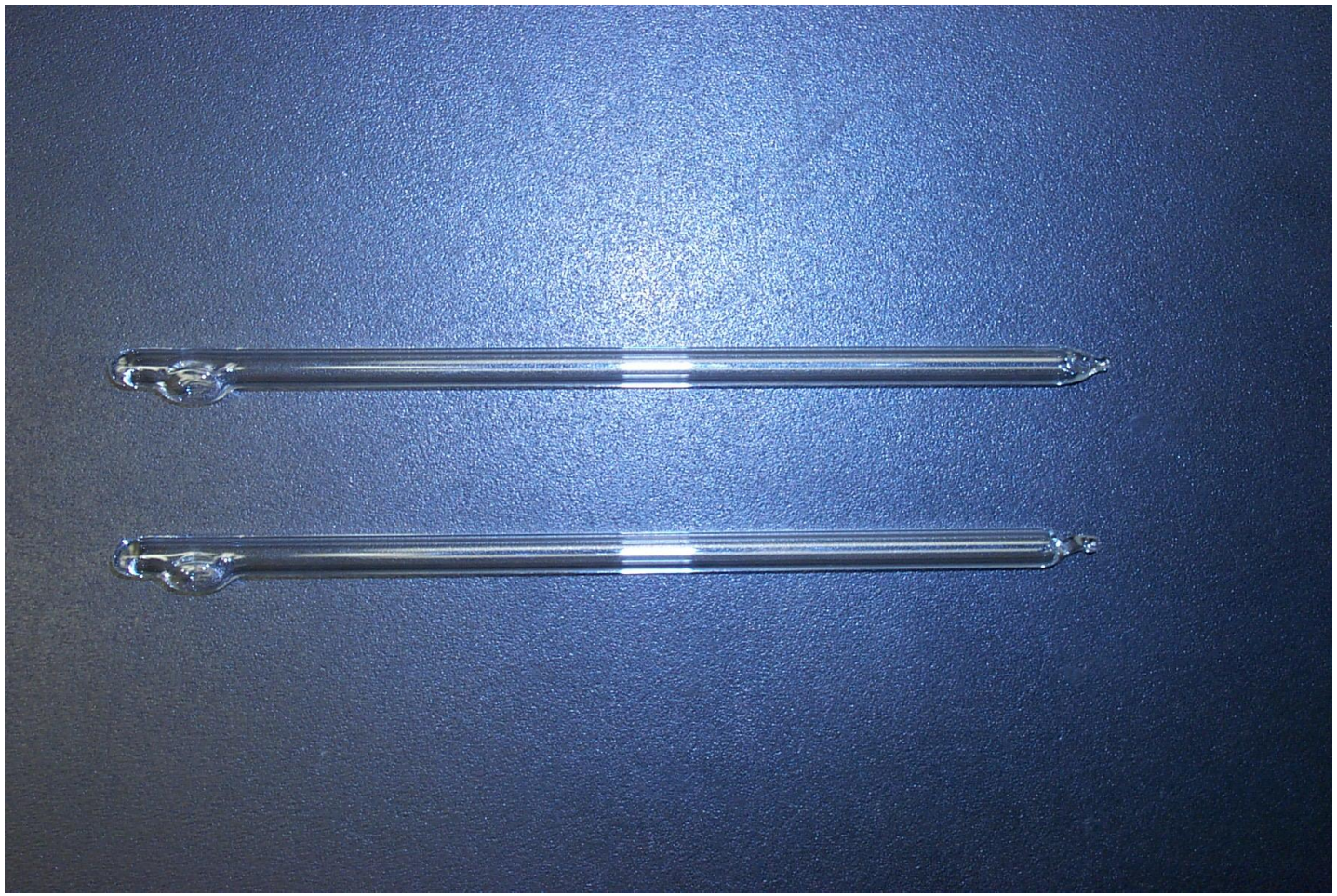
- Vacuum Tube Samples.
- Grain Sample.
- Cast Button.
- Drill Sample (either from small bar/cast bar)

ASAHI REFINING

Asahi favours vacuum pins:

R		(1)		(2)		(3)		(4)	
% Spread (assay)		Drill		Button & Drill		Grain		Vacuum Dip	
		A	B	A	B	A	B	A	B
		%	%	%	%	%	%	%	%
I.	0.00 – 0.03	14	17	42	29	83	84	86	89
II.	0.03 – 0.10	57	43	37	56	14	13	12	10
III.	0.10 – 0.30	19	33	14	12	2	2	1	1
IV.	0.30 – 1.00	8	5	6	3	1	<1	<1	<1
V.	> 1%	2	2	1	<1	<1	<1	<1	<1

The Issue



The Issue

ASAHI REFINING

Time is of the essence:

Obtain a sample that solidifies rapidly.

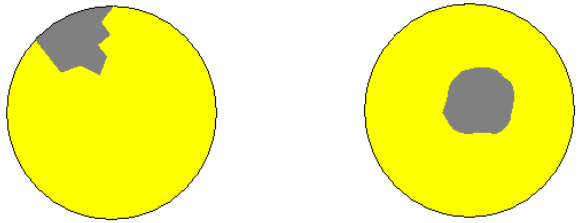
Generally, thin vacuum tube and grain samples are superior when dealing with these types of materials.

Larger cast pieces will segregate more.

ASAHI REFINING

Segregation in the pin sample.

Sometimes more subtle.



Not always completely “random”

ASAHI REFINING

Time is of the essence:

Segregation in the bar:

ASAHI REFINING

What can this problem look like: Good

ASAHI REFINING

What can this problem look like: Bad

ASAHI REFINING

What can this problem look like: Very Bad!

ASAHI REFINING

What can this problem look like: Ugly!!!

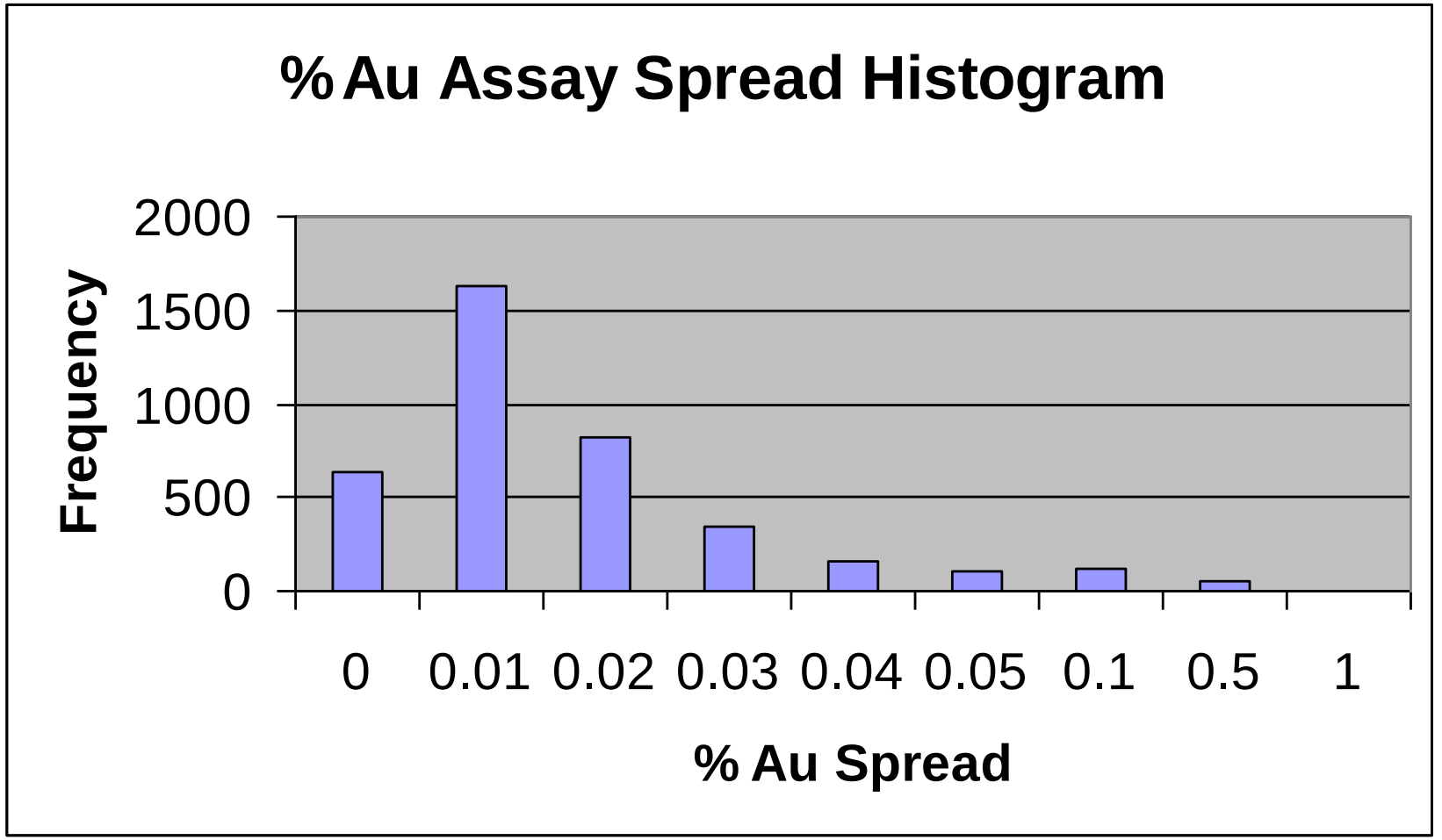
ASAHI REFINING

The question we always ask ourselves is “Can we get a good sample?”

ASAHI REFINING

Typical Fire Assay Data for Gold Dore:

Sampled by vacuum pin tube.



ASAHI REFINING

Typical Fire Assays for Au with Fe and Ag present:

Percent Gold

		Low					High		**Average**
67.82	68.30	67.04	68.13	68.92	68.21	68.21	69.42	68.97	68.333

Ag	12.7%
Fe	8.5%

Lot Wt	Au oz Spread			In Dollars
1200 t oz	29 t oz			$ 43,500

Percent Gold

			Low					High	**Average**
58.60	58.62	58.65	58.33	58.61	58.64	58.54	58.59	58.65	58.582

Ag	20.8%
Fe	4.0%

Lot Wt	Au oz Spread			In Dollars
1080 t oz	3.5 t oz			$ 5,250

ASAHI REFINING

Typical Fire Assay for Au with Fe and Low Ag present:

Percent Gold

	High	Low							**Average**
82.57	82.61	82.53	82.54	82.60	82.56	82.58	82.53	82.56	82.564

Ag	3.2%
Fe	5.1%

Lot Wt	Au oz Spread			In Dollars
2500	2 t oz			$ 3,000

ASAHI REFINING

Fire Assay for Au with Fe and Very Low Ag present:

Percent Gold

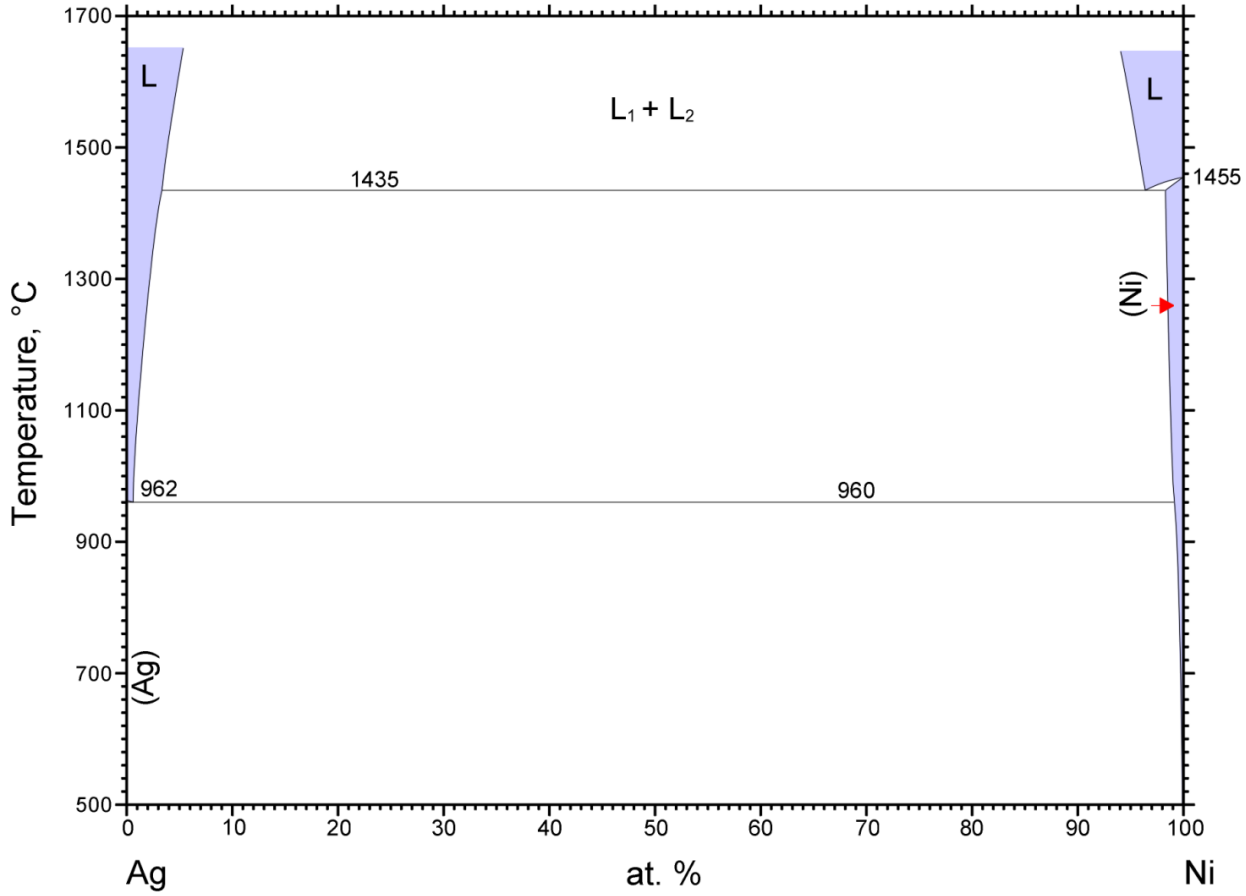
Low		High		Average
50.323	50.323	50.327	50.325	50.325

Ag	0.32%
Fe	9.1%

Lot Wt	Au oz Spread			In Dollars
588 t oz	0.023 t oz			$ 35

ASAHI REFINING

Nickel is a similar problem:



M. Singleton 1990

ASAHI REFINING

Nickel is a similar problem:

The Issue

ASAHI REFINING

	Gold %	Silver %
Laboratory 1	59.602	29.655
Laboratory 2	59.210	29.390
Laboratory 3	57.868	30.151

Ni = 4%

1828 t oz

Re-melt:

	Percent Gold				Average
Top 01	57.683	58.017	58.053	57.889	
	58.023	58.309	58.701	56.583	
	57.950	57.249	58.343	58.310	57.926
Top 02	57.816	58.176	57.789	57.881	
	56.803	57.479	56.494	55.998	
	55.731	56.657	57.733	57.193	57.146
Mid 01	58.165	58.083	58.563	58.114	
	57.941	57.911	58.046	58.399	
	58.413		58.567	58.198	58.218
Mid 02	58.451	58.240	58.003	58.132	
	58.099	57.847	58.267	58.720	
	58.424	58.229	58.378	58.356	58.262

Difference = 31.7 oz or $47,526

Average
57.881

ASAHI REFINING

Nickel/Silver induced variance – high silver:

Lot #	% Nickel	% Silver	% Gold	Assay Standard Deviation
1	3.31	25.61	65.56	0.0586
2	4.97	20.89	65.01	0.2447
3	5.41	18.18	53.81	0.1056
4	5.85	22.48	59.69	0.3592
5	6.92	25.10	61.59	0.6532
6	6.96	18.97	66.56	0.3103
7	7.00	19.00	64.29	0.3431

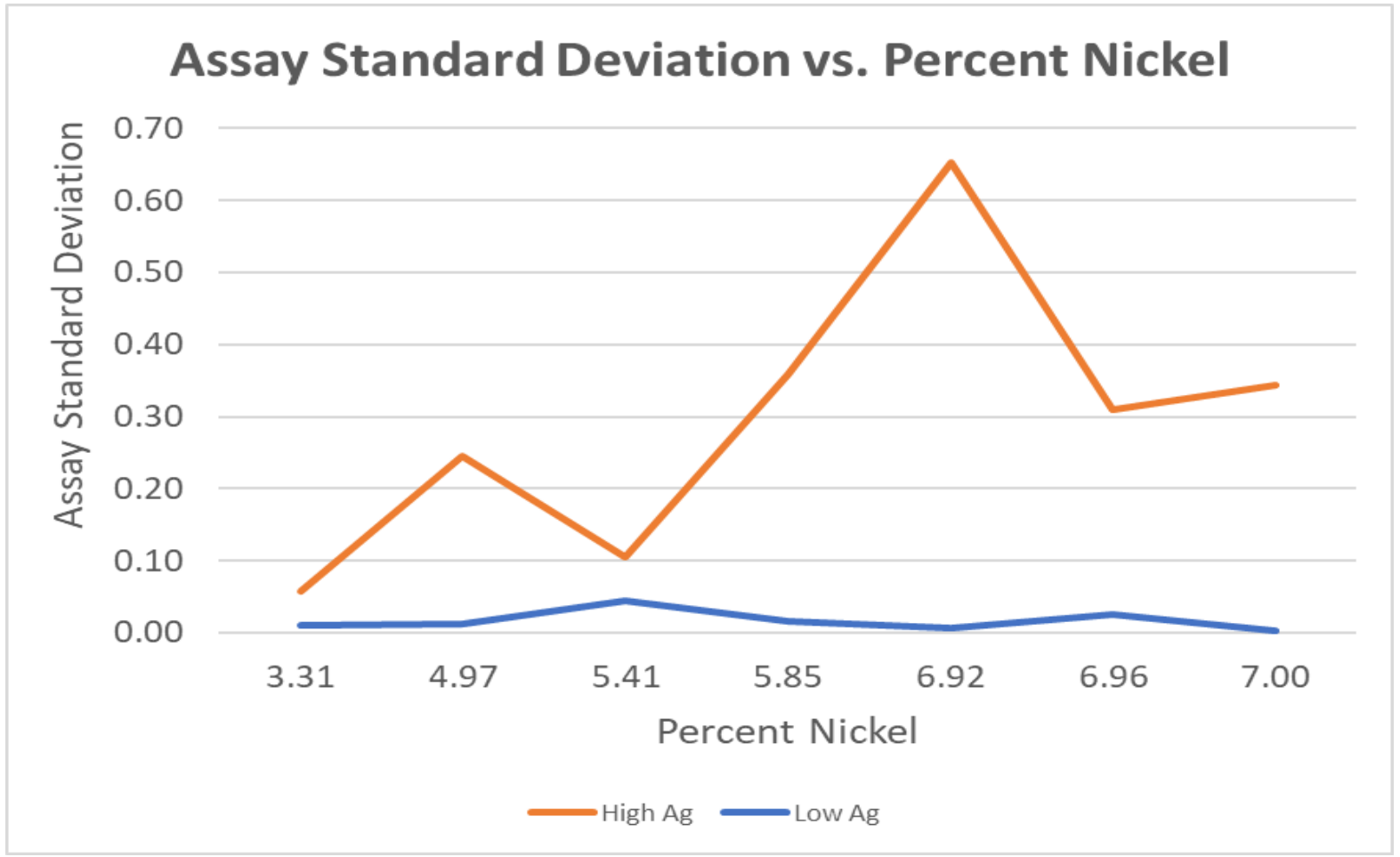
ASAHI REFINING

Nickel/Silver induced variance – Low Silver:

Lot #	% Nickel	% Silver	% Gold	Assay Standard Deviation
1	0.50	4.822	86.05	0.010
2	4.30	4.282	86.89	0.013
3	5.10	4.625	81.74	0.045
4	5.59	4.475	84.85	0.016
5	7.03	4.128	77.68	0.006
6	6.02	4.478	83.58	0.026
7	8.5	3.735	75.11	0.003

ASAHI REFINING

Nickel/Silver induced variance:



ASAHI REFINING

Nickel/Silver Significant Economic Impact

The uncertainty applies for both the refiner and the customer.

For a regular shipper with this problem, the risk is large.

ASAHI REFINING

Arsenic

Common component in many mine gold dore materials.

Relatively easy to make a homogenous liquid.

Segregation all occurs on cooling of the sample.

Lead is common component of many mine and scrap materials.

With low lead contents you can get two phases just at the surface of the melt between 1050^{o} and 1100^{o} C.

Segregation in the sample also occurs on solidification.

ASAHI REFINING

Approaches:

Work with the customer to remove the problematic impurity at source.

This is often technically difficult or not economically feasible.

ASAHI REFINING

Approaches:

Separate the iron and nickel from the melt using the different melting points of the phases present.

Use reagents to remove the impurities from the melt prior to sampling.

Chemically process the metal, recover the precious metals and sample the recovered metal.

ASAHI REFINING

Approaches:

Divide the material and sample/assay enough to statistically reduce the risk.

Dilute the melt with another metal to reduce the impact of the “suspect” impurity (typically with copper).

Homogenize the sample by melting into another metal (typically copper) – but this does not eliminate variance from sample to sample.

Using the melting point differential allows a partial removal – works better with iron than nickel.

Using reagents – sodium sulfite, copper chloride, oxygen, chlorine – works okay with iron, lead, bismuth, arsenic, but very difficult with nickel. Process losses occur.

Dissolution and re-precipitation of the gold and silver – process losses.

Check suspect materials before melting and sampling.

Look at the phase diagram if available: www.asminternational.org has a very extensive library.

Smaller sub-lots and more samples – while workable is often challenging for both the customer and refiner; umpire.

Dilute the material with copper. This often requires quite a large addition and is not always successful.

Homogenize the sample by melting with another metal – copper. But does not eliminate variance from sample to sample.

While we can reduce the risk, it is very difficult to remove it entirely.

Many of these choices put customer metal at risk of loss prior to the sampling.

Balance between that risk and the risk inherent in the sampling of the received materials “as is”.

The risks associated with sampling in the presence of these impurities can be large.

These risks represent significant financial risk to both the refiner and the customer.

Can ameliorate but difficult to eliminate this risk.

ASAHI REFINING

It’s all in the sampling!!!

ASAHI REFINING

Thank you for your time and attention!