

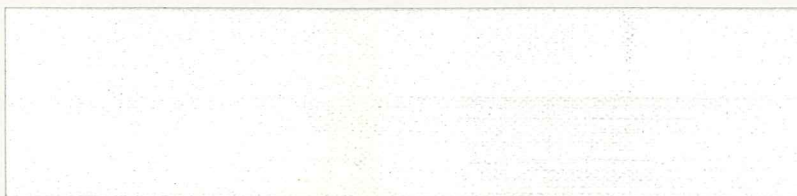
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COMMODITY If not obvious	gold; silver
NOTES	Review of sampling practices; handwritten notes  17 p.

Keep docs at about 250 pages if no oversized maps attached  
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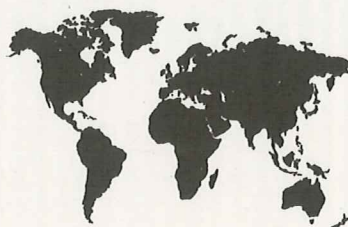
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**REVIEW OF MINING AND PROCESSING  
SAMPLING PRACTICES AT THE  
ROSEBUD MINING COMPANY**

June 23, 1998

Prepared for

**Rosebud Mining Company LLC**

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## **EXECUTIVE SUMMARY**

Sampling practices at the Rosebud Project were reviewed by Mr. Francis Pitard in order to identify the causes of reconciliation problems between the Rosebud Mine and the Pinon Mill in March, April, and May 1998. The main areas of concern are summarized below, then further analyzed in more elaborate discussions.

### **UNDERGROUND FACE AND RIB SAMPLING**

1. Some operators collect increments with their hand. Such practice tends to eliminate many fines that are sifting between the fingers. Then, the sample over-represents the coarser, hard blocks.
  - ⇒ Use the peak side of the hammer to dislodge increments that should fall in a square bucket held against the wall.
2. Some operators collect increments from the pile of material accumulated on the ground and against the bottom of the walls. You don't know where that material came from.
  - ⇒ Always collect all increments from undisturbed, in-situ material.
3. The number of collected random increments and the weight of samples seem to be correct. Overall, operators do a good job on these issues.

### **LOSS OF GOLD AND SILVER**

4. On page 6 of my Heterogeneity Test report written in August 1996 [1], a tremendous enrichment of gold is shown in the fine size fractions. This clearly suggests that any losses of fines would instantly result into a severe loss of gold.
5. A huge amount of fines is lost on the ground, at the mine stopes. This fine material should be checked for its gold content.
6. Fines are lost on the storage pad for stockpiles at the mine. These losses are greatly amplified during the rainy season, especially if running water on stockpiles is lost to the nearby creek.
7. Fines are further lost on the storage pad at the Pinon Mill, especially during the rainy season.

### **PINON MILL METALLURGICAL BALANCE**

8. The primary sampling station for the head of the mill is in perfect working condition, and under no circumstances should this station be responsible for the missing ounces during March, April, and May 1998.
9. The tail sampler is still incorrect, biased, and in very poor condition. But, because of the excellent condition of the sampler for the CIL Feed, a huge bias introduced by the Tail sampler should be quickly noticed: It is not the case.
10. The accuracy of the moisture content of the ore is drastically deteriorating during the rainy season. Therefore it is expected that metallurgical accounting would not be as good during this period.

## **NEWMONT GOLD REFINERY**

11. Mr. Dale R. Dean showed convincing evidence that bookkeeping at the gold refinery "Laisse a desirer", besides the point that people here are reliable and dedicated to perform a good job. Such problem may not explain for the missing ounces, but it is certainly an area to watch more carefully in the future.

## **DATA COMPARISONS**

12. You performed an enormous amount of comparisons between laboratories, between duplicate samples, etc... I suggest you systematically use Relative Difference Plot associated with a Moving Average, to easily detect biases and their evolution as a function of time, or as a function of grade. It is a pragmatic, powerful tool that can help you tremendously.
13. In the East and North areas, you started to perform Heterogeneity Tests. It is an excellent thing to do prior to the start of production, so you can adjust all your sampling protocols, if necessary.
14. In the East zone the ore is likely to be extremely hard, therefore, I would suggest you develop a SAMPDRILL as illustrated in my August 25, 1997 report, on page 9 and Appendix #2, [2].

## **LABORATORY RELIABILITY**

15. The sample preparation and fire assay with gravimetric finish seems to be well done, as during my August 1997 visit. I don't think you have any problem that could explain the loss of gold ounces in this area.
16. Mr. Dale R. Dean showed convincing evidence that metallic screen assays performed by American Assay in Reno are not as reliable as they should be. Such assays should provide a reference as the best possible assays: It is not the case.

## **A NECESSARY, LONG OVERDUE TEST**

17. Collect about 200 pounds of material from the discharge point (any of them) at the Tailing pond of the Pinon Mill. Make reasonably sure that all the material is indeed coming from the Rosebud project. Separate the heavy minerals with a laboratory shaking table. Then, perform a careful mineralogical investigation of the heavy minerals.

## UNDERGROUND FACE AND RIB SAMPLING

During my underground visit with Mr. Kurt Allen, sampling operators did a good job overall. However, as we well know, sampling faces or ribs, by hand, is a very operator dependent operation. Therefore, attention to details is important, so we don't obviously bias samples. Such bias may take place under the following conditions:

- The material on the face or rib is very friable. If the operator sweeps the in-situ rock with his hands, searching for something loose as a potential increment, then the sample instantly becomes non-probabilistic. Why is it that some rocks are hard, and some others are tender and loose? Both categories don't necessarily have the same gold and silver content. Furthermore, when sweeping with hands, fines tend to pass between fingers and get lost, while the hand would most certainly grab a bigger fragment.
  - ⇒ It is essential to keep the sample reasonably probabilistic. So, I suggest the operator use a square bucket that he or she apply against the wall with the left hand, while the right hand hammers the wall using the sharp side of the geologist hammer. Always use the hammer. Do not sweep with hands. Everything falling in the bucket must remain as part of the sample. Under no circumstances should the content of the bucket be subsampled by hand.
- Another detail, which is an unacceptable mistake, is to collect some material from what has been accumulated on the ground near the face or the rib. Who knows where that material came from. It may indeed come from the wall you want to sample. But, it may as well come farther back, brought by the bucket of the front-loader that extracted the material after the blast. In other words, this material may have nothing to do with the face or rib above. Why take a risk?
  - ⇒ As a rule, never take material from the ground to represent a face or a rib at a given point. Always take increments from the in-situ material.

The number of increments the operators took at random is good, and samples were of a respectable size: There was no problem here at all.

## LOSS OF GOLD AND SILVER DURING THE MINING OPERATION

### LOSSES DURING UNDERGROUND BLASTHOLE DRILLING

Underground blasthole drilling, often horizontal, and performed with percussion hammers, pulverizes all the material very fine, which is lost either as airborne dust, or as running slurry if water injection is used. It is very clear that all the volume drilled is a total loss. If a high density of holes are drilled within the mineralized veins, the loss may be considerable.

**Conclusion:** Underground blasthole drilling does not take mineral recovery into consideration. Whatever is practical to do to perform the job, this is what is done. There is not enough dialogue between mining engineers and ore grade control engineers.

- ⇒ It is not to your advantage to drill much within the mineralized vein. You don't want the mineralized vein to be broken very fine. There should be negotiation with the mining engineer to concentrate most blastholes around the vein, within the waste material, every time possible. Minimize the amount of explosive used. Drilling dry is not advisable, as it is an environmental hazard for the operators. If using water, all slurries must be collected, and



drained to a recovery tank. These slurries will be recovered later with other slurries when cleaning other areas with water guns, as explained later in this report.

## **LOSSES DURING UNDERGROUND BLASTING and RECLAIMING**

### **Loss #1: Natural segregation during the blast**

During the blast, a large amount of fines go airborne and are redeposited faraway on the ground, on the walls, and on the ceiling. Also, a large amount of fines slowly sifts between large fragments and boulders, finding their way to the bottom part of the pile in holes, cracks, fractures beyond reach for the reclaiming front loader.

### **Loss #2: Dust suppression using water**

The use of water is often a necessity to suppress environmentally hazardous dust. This introduces the strongest segregation of all. Most fines, rich in gold and silver minerals, find their way into the ground, in inaccessible areas for the reclaiming process.

### **Loss #3: The reclaiming process**

It is impossible, first to have a perfectly flat working area prior to blasting, second to reclaim any material in holes, cracks, and fractures. As a result, most fines generated by the blast are lost. And, this may happen every time the material is transferred to a stockpile.

None of these problems can be minimized in a practical way. The solution is to accept the facts the way they are, and find a way to reclaim fines on ceiling, on walls, in holes, in cracks, in fractures, etc... There are only two ways to do this, either by vacuum, or by using water guns. There is no time constraint to perform these operations, as they can be performed a long time after the reclaiming of the material has been performed, as long as the area is still easily accessible. Let's analyze the advantages and disadvantages of both techniques.

## **RECLAIMING OF FUGITIVES FINES USING VACUUM**

Vacuuming has been used in underground mines to recover tiny gold nuggets liberated and lost during drilling, blasting, and ore transferring. Usually, such task is performed by independent contractors. The advantages of vacuuming are as follows:

- It generates the minimum of material to handle and transport.
- It prevents precious metals nuggets from getting deeper and deeper into holes, cracks, and fractures, making their recovery more likely.
- The technology of the equipment required is well known and relatively cheap.
- The training of the necessary manpower is simple.
- Access to working areas is quick and simple.

But, there are many disadvantages:

- The volume of material that can be vacuumed is limited.
- The access to upper parts of walls and ceiling is difficult.

- The process is slow, and manpower consuming.
- Fragments between 1 inch and 5 inches interfere with the good functioning of the equipment.
- The equipment is noisy.
- The large volume of air going through the filters releases huge amounts of very fine dust in the air.

**Conclusion:** I am not impressed by this approach, which seems to be incompatible with the huge scale of the problem. Vacuuming a few hundred square meters is one thing, vacuuming several acres is another thing. It is my opinion that you need something that could be done on a larger scale, and something cleaner for the operators.

### RECLAIMING OF FUGITIVE FINES USING WATER GUNS

If water is easily available, the use of water guns may facilitate the recovery of fugitive fines. Depending on local conditions, this can be done in several ways. If you have natural drainage, leaving the underground mine, you may install a pilot plant size Ball Mill, thickener, and floatation facility to recover valuable losses. If a lot of water is available, you may not recycle the water from the thickener. If limited supply of water is available, you may recycle the water from the thickener.

If such natural drainage does not exist, you may consider installing such pilot plant size facility at the lowest underground development. In this case, it is necessary to recycle the excess water from the thickener.

The advantages of using water guns are:

- It is far more effective to wash walls and ceiling.
- 1-inch to 5-inch fragments do not interfere as much as for vacuuming.
- Natural drainage can carry the slurry to a common collecting point.
- There is no hazardous dusting problem.
- It is less noisy for the operators.
- Much bigger tonnage of material can be quickly handled.
- Water pumps can be much farther away from the cleaning point than vacuuming systems.

There are disadvantages:

- Sufficient water may not be available.
- If drainage goes the wrong way, ground resurfacing may become necessary.
- Water may force precious material particles deeper into inaccessible holes, cracks, and fractures.
- A huge volume of slurry needs to be sent to a thickener, which is a large unit underground.
- The final Tail needs to be pumped back to the surface.

⇒ I suggest you perform a test, estimating a 100 feet long area where you know the content of the material that was excavated, from the face and rib samples. Wash the entire area with water guns, and recover the slurry carefully. Sample the slurry and estimate its gold and silver content. Then, draw your conclusions.



## **ASSAY RESULTS FROM SAMPLES COLLECTED IN STOPE LOW SPOTS**

Recent samples collected in the stope low spots does not seem to indicate the presence of the rich, fine material. Yet, I suggest caution on this observation, as you collected only 3 samples. I would suggest you collect at least 30 of these samples.

## **LOSS OF GOLD AND SILVER AT THE STOCKPILES**

### **LOSS OF GOLD AND SILVER AT THE MINE STOCKPILE**

The accumulation of water around the mine stockpile may be a logistic problem during the rainy season, creating poor working conditions for front loaders and trucks. The temptation is to naturally drain the water away. But, loosing this water may also drain away considerable amount of very rich fines.

- ⇒ I suggest you take a few samples in the creek below the stockpile, so you would have an idea about the gold and silver grade of the lost slurries.
- ⇒ Depending on your findings, I would suggest you dig a pond somewhere below the stockpile area, in which the water would decant. At the end of rainy season, you would completely pump the excess water out, then let the pond dry during the dry season. At the end of the dry season, you may reclaim sediments accumulated at the bottom of the pond.

A few samples recently collected in the creek seem to indicate that there is no problem.

Rich fines may also sift to a certain depth on the storage pad itself. You already have evidence that the top 6-inches of the pad, which is not supposed to contain much gold, may contain 0.5 opt. Your sampling campaign may tell you how much of that material you may reclaim and send to the Pinon Mill as ore.

Recent samples collected on the storage pad shows about 0.367 opt gold. Considering that most of the material collected in these samples should not contain gold, it means that fines making up a 0.367 opt average must have a very high grade, as observed in the Heterogeneity test.

### **LOSS OF GOLD AND SILVER AT THE PINON MILL STOCKPILE**

Recent samples collected on the storage pad at the Pinon Mill also show a substantial amount of gold. Nevertheless, adding all these losses does not seem to explain all the missing gold ounces. But, it may explain half of these losses. So, where is the other half: Perhaps, relative plots may help us to find it.

## **INVESTIGATING DUPLICATE ASSAYS USING A RELATIVE PLOT AND A MOVING AVERAGE**

### **APRIL 1998 DUPLICATE CHECK ASSAYS FOR GOLD**

The relative plot is shown in figure 1. A 10-point Moving Average has been drawn in red along the X-axis where the 45 pairs are sorted chronologically. The duplicates are on average about

7.67% higher than the original assays. Over 45 pairs, this is a huge difference, and something to worry about. As shown in figure 1, the bias becomes clear and consistent above pair #20, which means the laboratory is not consistently accurate over time. We may also have a bias in the other direction at the beginning of the chronology. My opinion is that you have segregation in the sample bags, or the laboratory needs to be checked with Standard Reference Materials on a regular basis.

#### **APRIL 1998 UNDERGROUND DUPLICATE SAMPLING**

A much bigger problem is shown in figure 2 with the underground duplicate sampling. A drastic change occurs at pair #39: Is this a change of operators? Under pair #39, the duplicate samples were about 40% higher than the originals. But above pair #39 the duplicate samples were about 40% lower. Such huge discrepancy is certainly enough to generate reconciliation problems between the mine and the mill. I suggest you build a Sampdrill as suggested in my August 25, 1997 report, so sampling would not be so operator dependent.

#### **COMMENTS ABOUT C.H. BUCKNAM MEMORANDUM DATED JUNE 10, 1998**

A conventional statistical analysis is presented using Student's T tests and removal of outliers. Though such approach is almost a standard throughout the mining industry, it has limitations and weaknesses. The relative plot as shown in figures 1 and 2 is far more powerful to show problems.

The Student's T test is not capable of showing the evolution of a sampling bias as a function of gold grade. So, my advise is keep doing the Student's T test but always add the relative plot with it: It would be good complementary information. Remember, in sampling there no such thing as a constant bias, and the Student's Test is powerless to analyze this fact.

As far as the elimination of outliers is concerned, I disagree with it. Outliers tend to be eliminated when they become embarrassing or when we don't know how to deal with them statistically. I understand the logic used by C.H. Bucknam, which is practically a standard approach in Geostatistics. The point is that the removal of the outlier systematically eliminates something that needs an explanation. Therefore, the new proposition is not any better than the one using the outlier: Both are wrong. So, what would be the right thing to do? Make sure you always have access to an estimation using the all data, including outliers. Then, and only then, you may proceed with manipulations of your choice. An underground duplicate sample showing an outlier is trying to say that there was a tiny structure that was hit by chance: Shall we ignore these tiny structures? It would be unwise to do so.

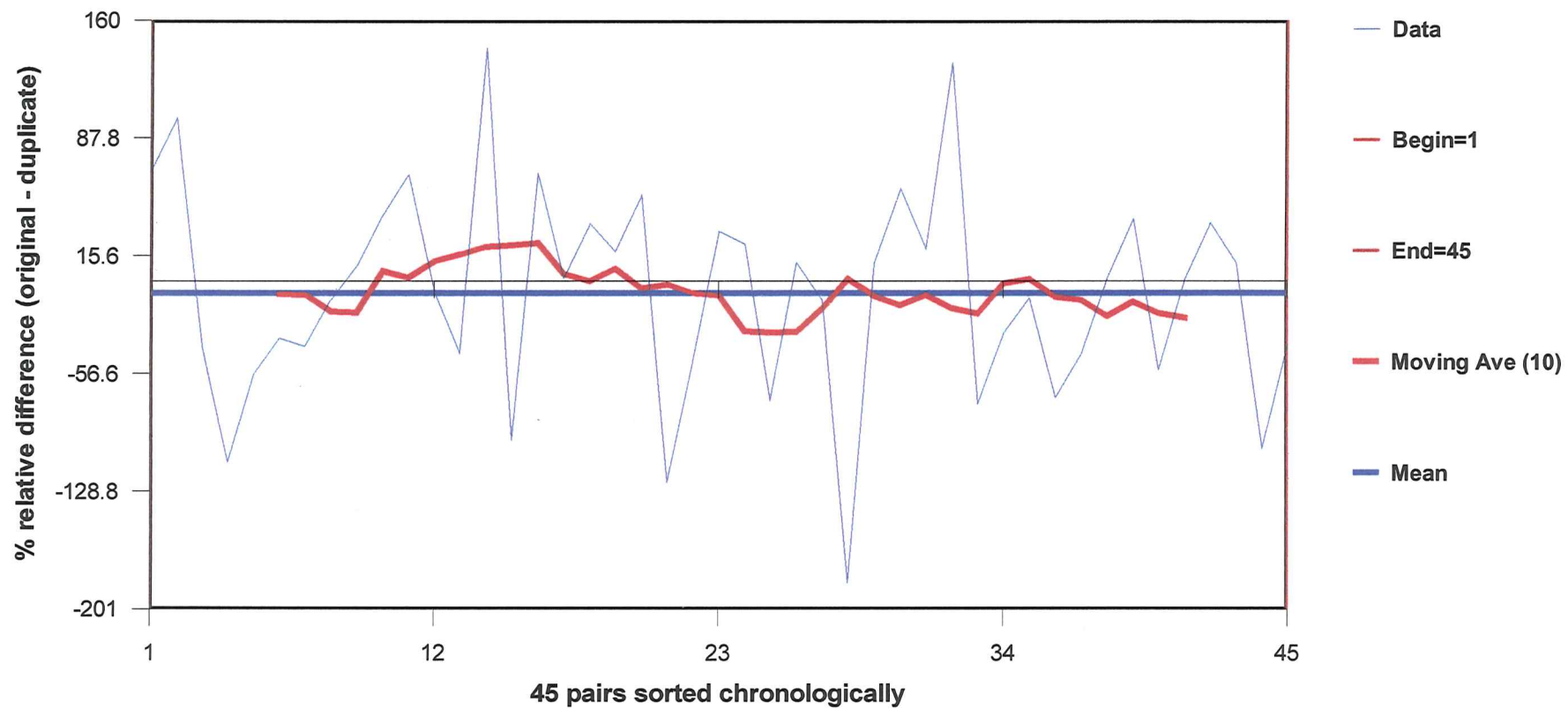
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Data from the Pinon Mill for the April 1998 Head samples are investigated. A relative difference is calculated between the Leachwell Lab Split and the 24 hour Bottle Roll. As shown in figure 3, most of the time, the 24 hour Bottle Roll is about 8 to 10% higher than the Leachwell Lab Split. This is a very large difference: The question is: Who is right?

#### **RELATIVE PLOT OF THE APRIL 1998 TAIL GRADE**

The same exercise is performed for the April 1998 Tail grade. As shown in figure 4, there was a period when the 24 hour Bottle Roll was about 20% lower than the Leachwell Lab Split. These

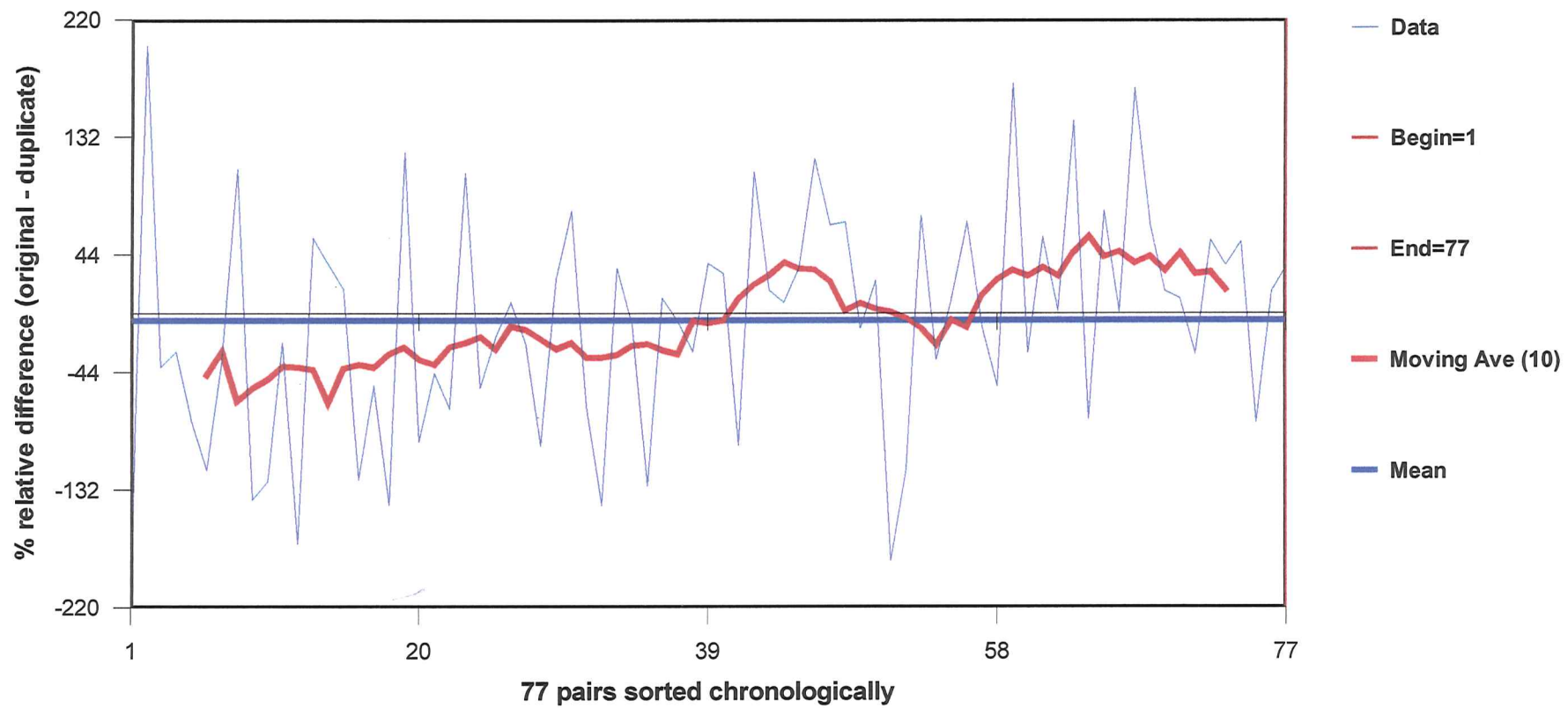
**Figure 1. Rosebud Project April 1998 Duplicate Check Assays for Gold**



Mean = -7.67      Median = 7.31E-01      Std. = 8.59

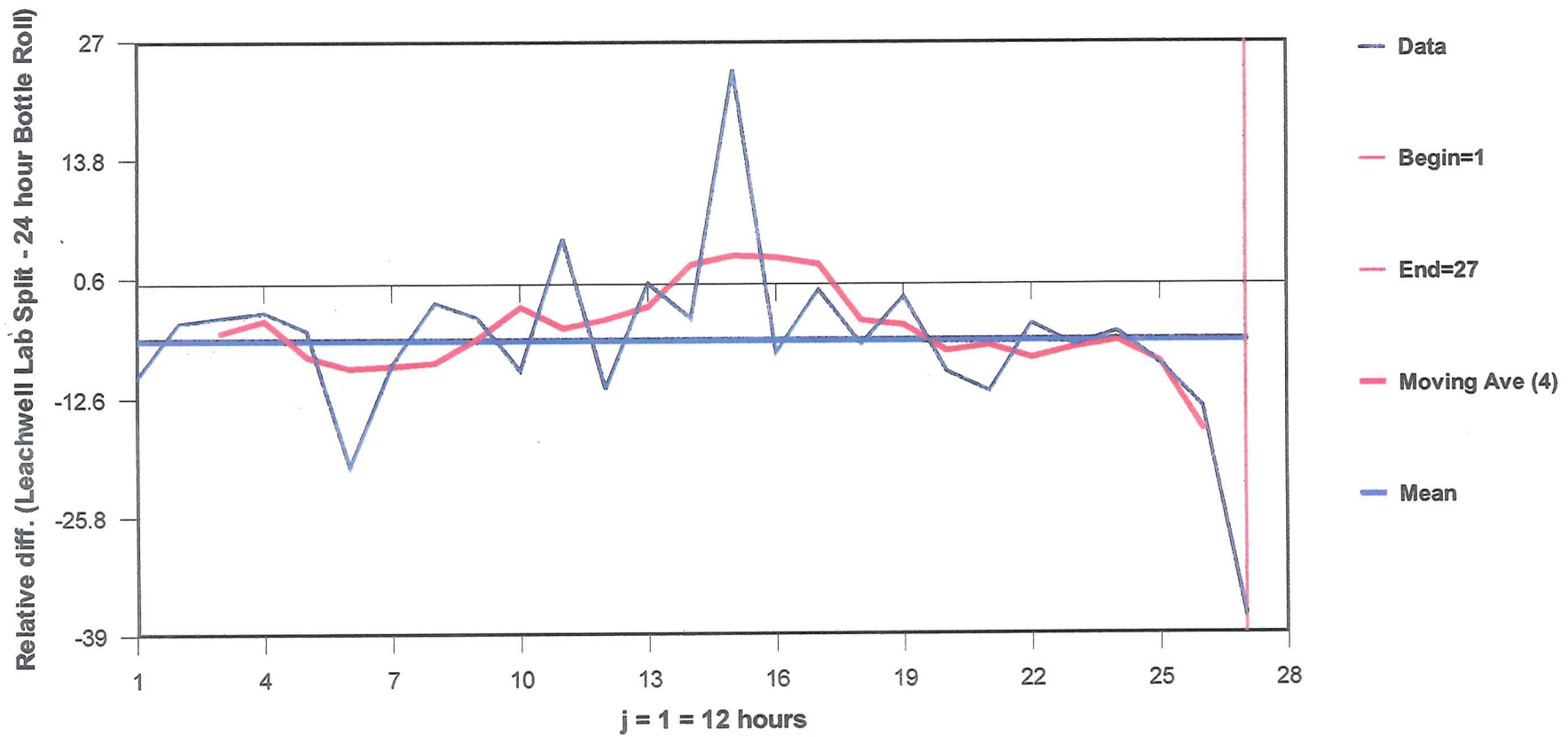


Figure 2. Rosebud Project April 1998 Underground Duplicate Sampling



Mean = -5.78      Median = 1.41      Std. = 1.48E+01

Figure 3. Rosebud Head Relative Plot

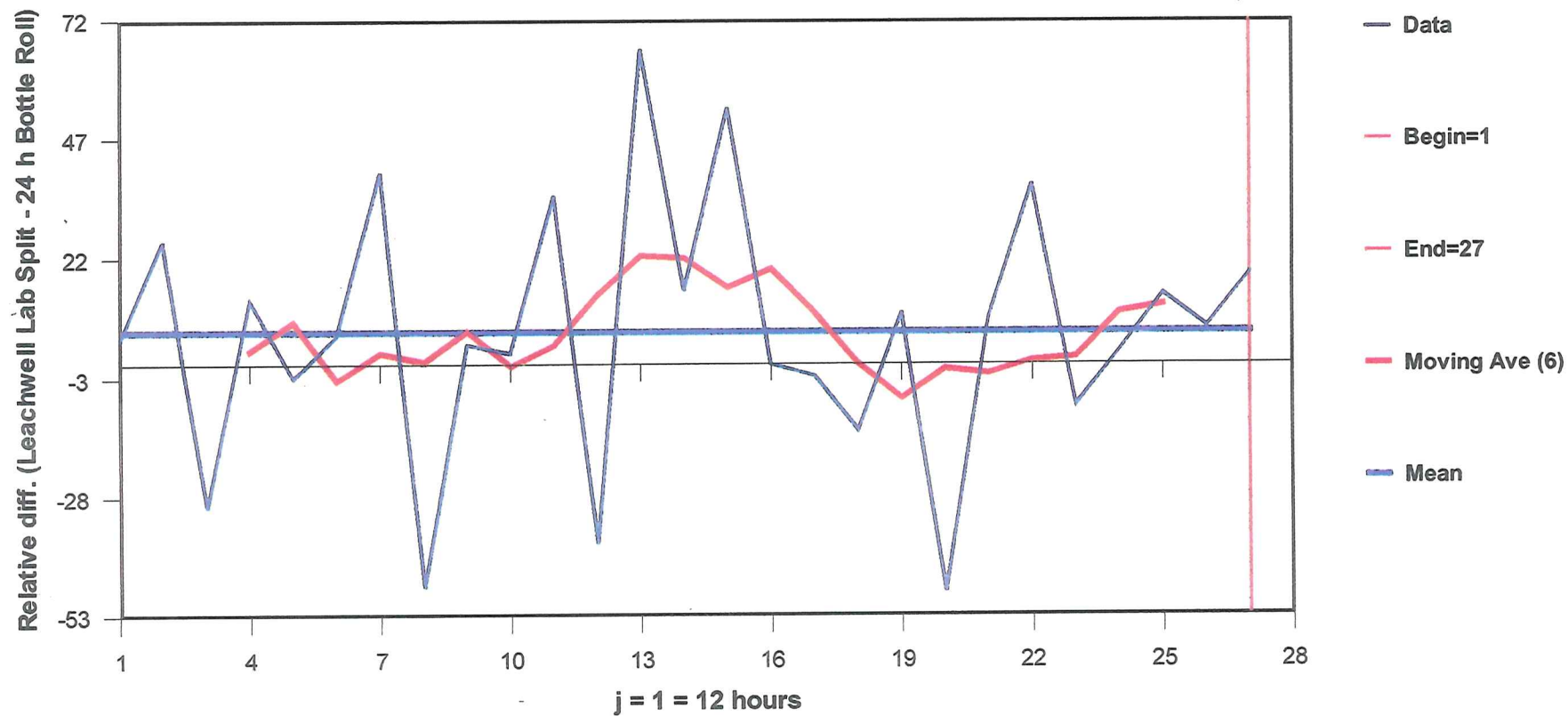


Mean = -6.35

Median = -5.34

Std. = 1.54

Figure 4. Rosebud Tail Relative Plot



Mean = 6.56

Median = 6.01

Std. = 4.17



differences may go a long way to explain discrepancies between the Mine and the Mill. You must find out how reliable the Bottle Roll is, using standard additions.

### CONCLUSIONS AND RECOMMENDATIONS

All these relative plots show major discrepancies that are mostly responsible for the reconciliation problem between the Rosebud Mine and the Pinon Mill. My recommendations are:

1. Find a way to make the underground sampling less operator dependent. The use of a 1-inch diameter Sampdrill may help you. Such Sampdrill must be fabricated by yourself using the information sent to you in my August 25, 1997 report.
  2. Very carefully check the accuracy of the Leachwell Lab Split assays and the 24 hour Bottle Roll assays using standard additions on unknown samples and on blanks. You cannot work properly with the present discrepancies.
  3. We don't know what the gold content of the Pinon Mill Tails is, as the present sampling station is not working properly. This was supposed to be fixed a long time ago.
-

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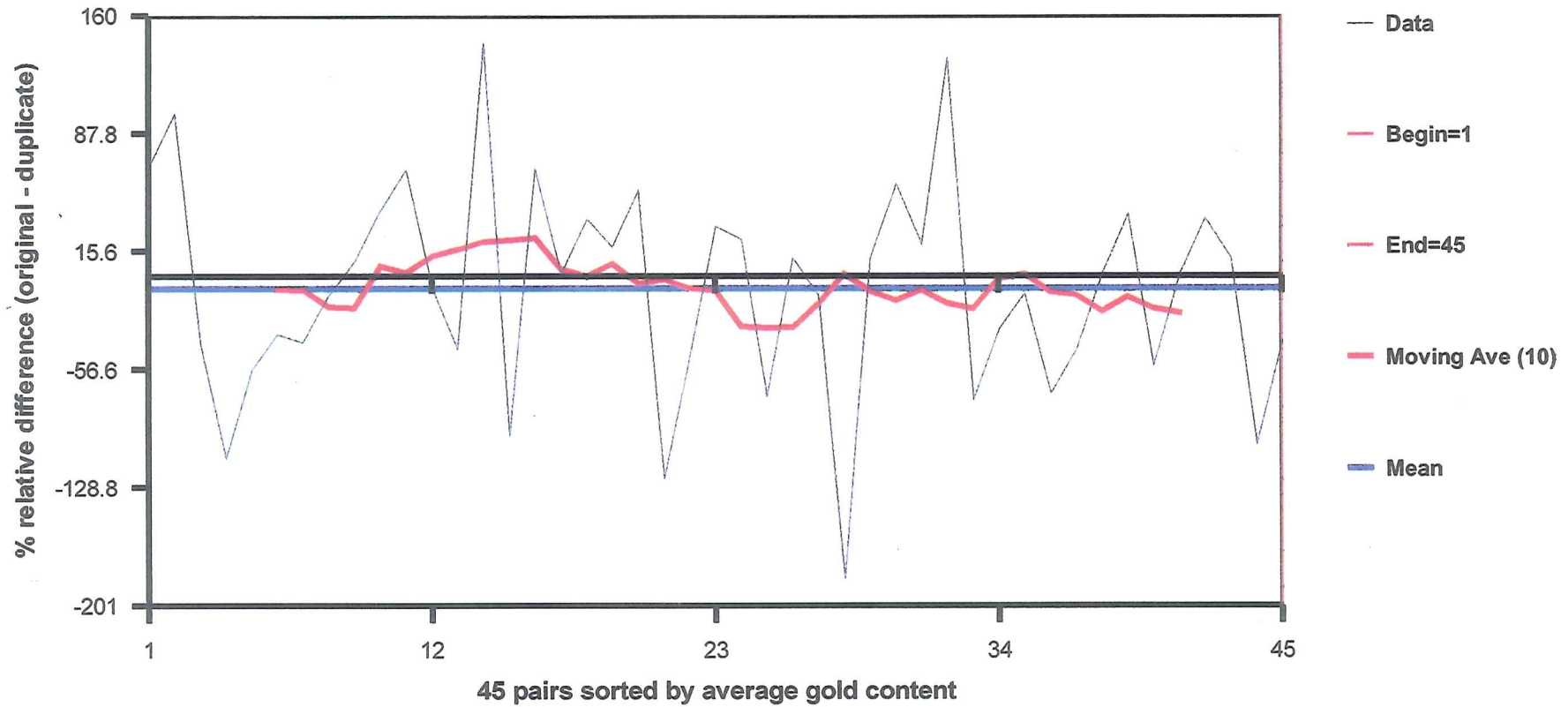
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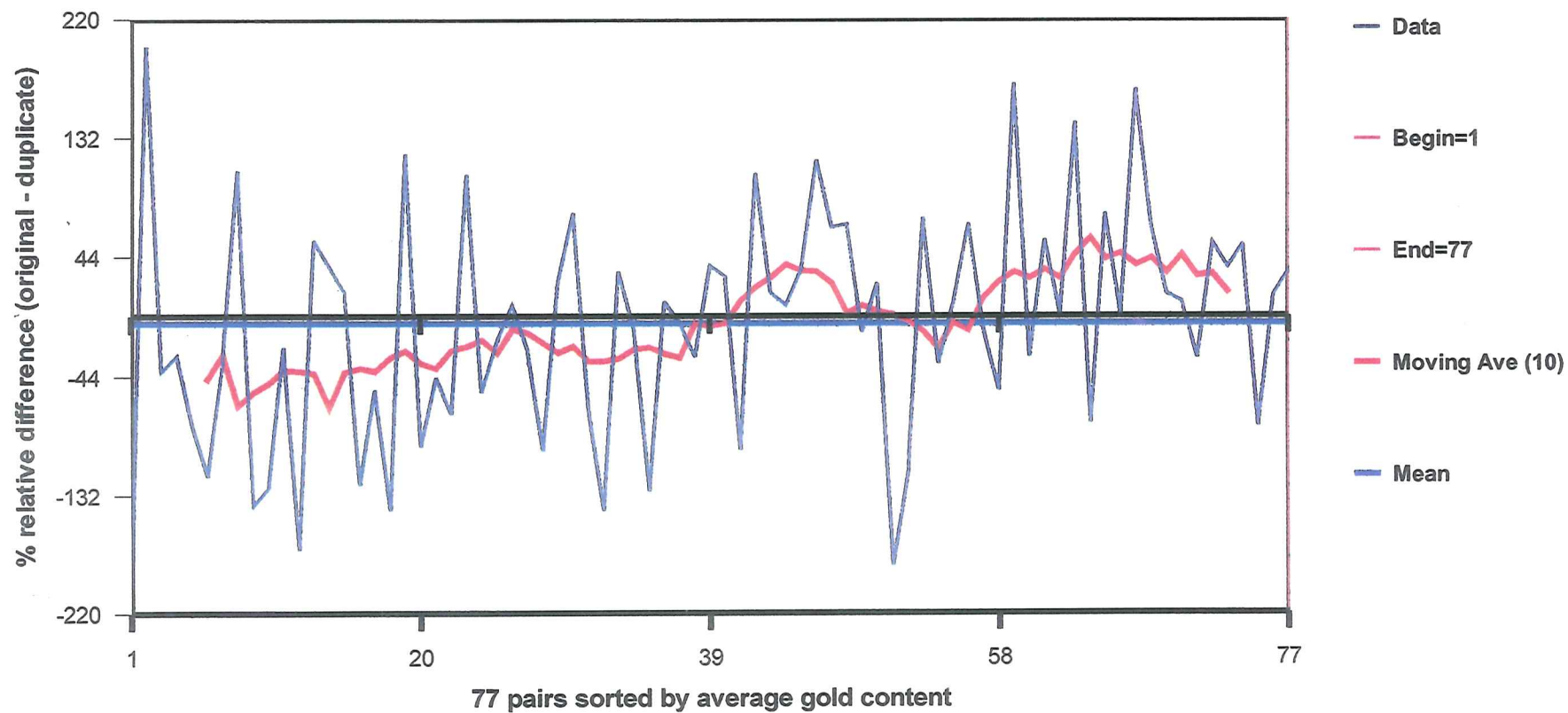
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