

F A R O M I N E

G E O L O G Y R E V I E W

Final report

*D.E.J.*

Sept 1986

FARO GEOLOGY DEPARTMENT  
FINAL REPORT & RECOMMENDATIONS

In fulfilment of contract  
Re Purchase Order # 082983

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Scope of assignment:

The scope was not strictly specified but was indicated to be broad, including advising on operational procedures, and assessing the reliability of current geological modeling.

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FARO MINE



Aerial view of pit July 29/86  
looking north east

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## Executive Summary

### i) Observations

1) The geological model on which the computer mine model is based, cannot be expected to give reliable detailed forecasts of tonnage and grade on the scale of a single mining bench twenty feet in height. This is because of the heterogeneity of the orebody which precludes detailed accurate geological interpretation from the current drillhole density.

#### 2) Grade control

Selective mining is limited by truck shovel method of ore and waste removal. Horizontal or subhorizontal layers of ore and waste are not separable. Waste and ore are designated in vertical columns 20' high, on the basis of blast hole chip sampling grade. Columns are bounded by blast hole spacing. Since the waste and ore boundaries tend to be subhorizontal, this system is inefficient in separating ore from waste.

Initial benching patterns based on a computer block model, were not optimized for reducing dilution.

3) Bench blasthole data is closely enough spaced to allow a considerable improvement in detailed interpretation if the data obtained is accurate. The accuracy of the current blasthole sampling method is not good enough for reliable grade control. It is certain that some of the columns are designated for waste, low grade, or direct to crusher ore, in error.

4) The logging of blasthole chips gives only a rough idea of lithology and contacts. Bench face mapping can help fill in the geological picture but exposures are always limited. Geophysical logging of blastholes may locate some contacts accurately and greatly facilitate geological interpretation.

5) Timely and accurate forecasting of bench production requires rapid gathering and processing of data from blast holes and bench faces. Processing should include the highest possible application of geological interpreta-

tion as well as obtaining high quality data.

The current level of geological staffing doesn't allow for more than data gathering and recording. There is not time for plotting and geological analysis which is required to project information and make predictions for the next bench.

## ii) recommendations

1) Bring geology staff up to allotment as quickly as possible.

2) Find an accurate method of sampling blast holes. A system of collecting chips during drilling may be best. A separate sample of subbench material would be useful for forecasting a bench ahead. I recommend a test comparing the chip sampling method with a diamond drill core drilled close by on the same bench. I further recommend that the comparison be made for 12 pairs of holes and the data be analyzed statistically, including a geostatistical search for variograms describing the distribution of lead and zinc.

3) Consider the possibility of using a mining method such as front end loaders loading trucks, to enhance selective mining and improve grade control.

4) All geological staff should be impressed with the importance of using the data collected to improve their understanding of the geological situation (especially metal distribution) to facilitate accurate forecasting of bench tonnage and grade.

4) It should also be understood that the opportunity to obtain data and refine the geological understanding of the Faro deposit will be of great importance for the early accurate interpretation of the other ore bodies in the Anvil Range.

## 1.1) Faro Orebody

The orebody is considered to be a sediment hosted, synsedimentary, strataform, exhalative massive sulfide deposit. In its formative state it is thought to have been a layered strataform body in which individual layers would have had distinctive characteristics of sulphide mineralogy and gangue materials. The geologic model would predict the layers to have been fairly uniform over large areas.

possible but not necessarily true. (Exp? P2

Subsequent to deposition the orebody has been subjected to several periods of deformation in which the rocks and ore have been folded and faulted. In addition the ore body has been subjected to regional metamorphism that has undoubtedly added further complexity by changing details of ore mineralogy.

Geologists who have worked out the current geological model on cross sections, created and used a remarkably comprehensive nomenclature for rock and ore types. These units were then treated as stratigraphic horizons and a model was made which attempted to correlate these "strata" from drill hole to drill hole. An impressive picture with a lot of detail was built up. Closer examination reveals that there was much that there was much interpretive material incorporated to account for large differences between adjacent drill holes.

rather unimportant structure so facies changes must interpret something!

## Personal observations

My impression of the Faro orebody is that it consists of a very heterogenous distribution of sulphide minerals within a zone of altered rocks that is a reasonably well defined distinguishable unit.

The distinguishing features of the unit include the sulphides, development of graphite, sericitic alteration, talc, and the rock type designated D4. (muscovite sericite envelope).

newspack?

Lateral variations have been observed to occur rapidly. For example the iron sulfide mineral of massive sulphides in a bench face in the JB zone changed from pyrite to pyrrhotite over a distance of 5 to 10 feet. Pb & Zn grade contours also show rapid lateral changes with patchy areas of high grade.

why

Observations I have made in the pit and information proffered by Lee Pigage and Greg Jilson have given me the strong impression that the breccia cap and the various dikes are intrusive elements that form part of a subvolcanic suite. I suggest that the structural effects of the intrusion of these elements may be irregular radial tension cracks, (some filled with dikes), and some underthrusting of material being dragged up on the flanks of the intrusive material. In addition I expect that permeation of volcanic steam and other gasses along fractures would produce gouge-like alteration material far exceeding the amount normally expected from fracturing alone. This scenario may explain some of the difficulties in correlating fault traces in current pit mapping. I suggest that the idea is worth some investigation by someone with expertise in volcanic environments.

The highly variable distribution of ore minerals is a result of original variability of deposition complicated by post depositional folding and faulting. This variability is indicated on the geology cross sections by showing rock units as discontinuous lenses and blocks separated by faulting. These methods of illustration result from the fact that there is often too little resemblance between adjacent drill holes to allow for confident correlation of details of mineralization.

I believe that the geological interpretation has one unfortunate effect;- that of indicating more reliability of detail than is warranted by the drillhole framework.

#### 1.2) Suggestions

- i) A strong effort should be made to keep pit mapping up to date and plotted on current work plans.
- ii) Grade distribution plots and contours should be kept current.
- iii) Continual effort to relate new data to geology should be maintained. Bench plots should be interpolated onto geological sections regularly.
- iv) Grade distribution should be examined statistically, both in the classical sense and in the geostatistical sense. The object is to quantify variability and evaluate the reliability of grade and tonnage estimates.

## 2.1)General

The operational task of the Geology Department at Faro is;-

- 1) to determine where ore is located and to guide the mining operation to it.
- 2) to predict tonnages and grades for various production units of ore as required by mine planning.
- 3) to guide the mining operation in selecting ore and discarding waste.(Grade Control)
- 4) to predict various ore types and conditions of oxidation of ore available for milling.

## 2.2)Comments

Accomplishing the tasks efficiently requires the best knowledge obtainable of the geology of the deposit. A very considerable body of data and interpretation exists and has been used to construct a computer model of the ore body. This in turn has been utilized for long range production planning.

Bench blast hole information allows detailed evaluation of ore distribution in the bench but it is obtained so close in time to the actual mining of the bench that there is little scope for adjusting mining plans to any surprises that appear.

It might be considered worthwhile to do infill diamond drilling from a bench at or near the ore hangingwall, to allow for intermediate planning revisions.

## 2.3)Reccommendations

- 1)Continuous updating of the geology using all data provided by operations.
- 2)Determine the best method of obtaining grade data from blast holes.
- 3)Determine the best methods of using computer for data handling and plotting.

3)

## DATA GATHERING

### 3.1) Pit Mapping

Lee Pigage developed pit mapping methods which he has described. The following conditions are critical in my opinion.

i) Geologists going into pit should always be equipped and ready to take notes and record geological data.

ii) A method of quickly locating one's position in the pit should be devised. Preferably it should be usable by geologists without recourse to surveyors, be accurate to +/- 3 feet, and not require bulky equipment. My suggestion is to check out optical range finders as a partial solution, to be used with a set of permanent visual markers.

iii) A vehicle for geology department use should be provided.

### 3.2) Analytical Data

The important points about gathering analytical data are:-

i) Sampling procedure must produce a representative sample. The sampling procedure should be checked until users of the data are confident in the results.

Further tests of tube sampling the blast hole chip pile may show that it is possible to get representative samples by this method. If not, it may be necessary to test a method of collecting samples while the holes are being drilled. The system must be capable of taking a representative sample from the stream of chips.

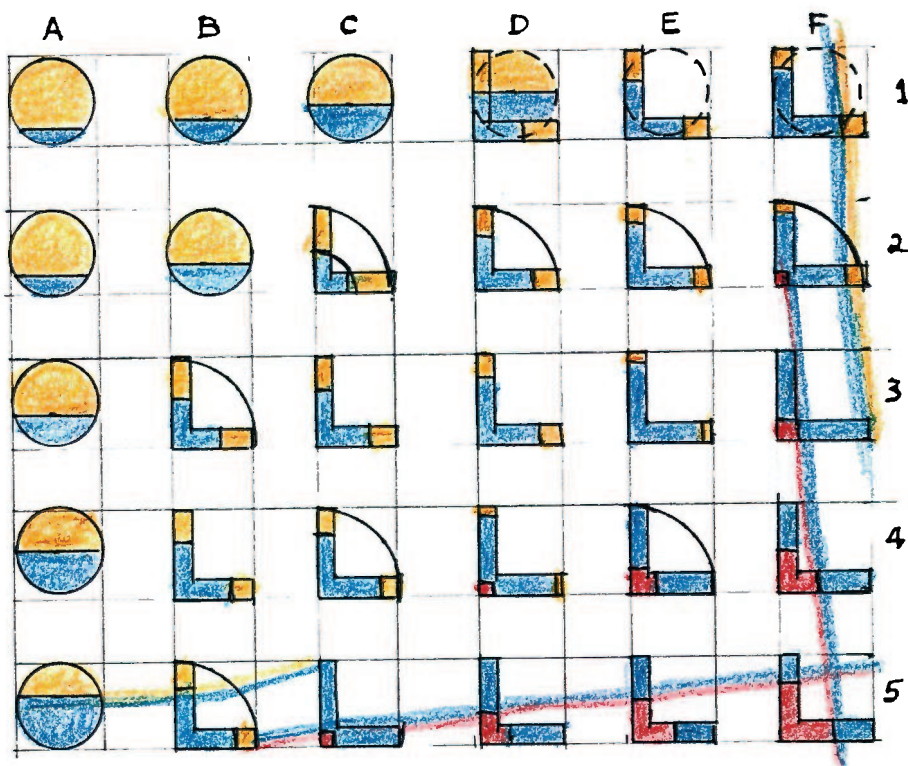
ii) Samples should be analyzed to get the optimum amount of information. For example, analyses for iron and sulphur would allow estimation of ore sulphide types, specific gravity, and the condition of oxidation.

### 3.3) Data Recording

a) Entry of data into a computer data base which records the sample location and allows plotting and statistical analyses of data, should occur at the earliest possible moment to eliminate manual transcription and plotting.

b) Methods of plotting data for better illustration should be investigated. For example the current bench plot of circles with color codes representing rock types determined from blast hole chips is confusing. I suggest that it might be improved by plotting only one or two of the dominant lithologies on an L shaped diagram. The two legs of the L would be the same, and could be read as an element in a fence diagram along either of the grid lines of the blast hole pattern that pass through the hole.

The following diagram illustrates the method proposed and it's relationship to current practise.



c) Working drawings such as bench plans and the geology sections pertaining to an active pit area, should be on standard sized sheets and have a home in a labeled file drawer.

d) Information worked up on current drawings should periodically be transferred to the permanent geology base maps and sections. Non current working drawings could then be discarded.

FARO MINE



Looking west from east wall August 8/88  
Mining in progress

FARO MINE



View from east wall August 8/86  
looking north west

FARO MINE



View from north wall of pit August 8/86  
looking south, reservoir in background

FARO MINE



View from west wall of pit August 12/86  
looking east

**Appendix A**  
**The Breccia Cap as an Intrusive Breccia Column**

Some of the characteristics of the breccia cap are summarized following:-

- 1) Clasts are mainly metasediments similar to the metasedimentary country rocks of the region.
- 2) Clasts have been found to have deformations and crenulations typical of the late stages of regional deformation.
- 3) The breccia contains scattered clasts of igneous dike rocks similar to dikes that have intruded the breccia and have sent small apophyses anastomosing among the breccia fragments
- 4) One strong crosscutting dike mapped in the breccia did not crosscut the breccia boundary.
- 5) Clasts of sulphides have not been observed in the breccia.
- 6) The upper contact of the breccia is overlain by steeply dipping schistose metasediments. However the contact does not conform to the primary layering of the metasediments, and could be considered intrusive.

Magmatic stoping and breccia columns described following:-

The process is thought to act in the following manner. Magma under pressure begins to invade its cover rocks in areas of weakness such as fault intersections. Pressure in the magma varies resulting in surges followed by relaxations. Surges produce fracturing and relaxation allows the broken material to loosen and fall back. a column of breccia builds up in advance of the invading magma.

Brecciation at the advance end of the column may consist merely of fractured rock, and gradually downward becomes more comminuted, rotated and mixed. Good reviews of breccia and pebble columns and mineralized breccia pipes are given by Leonard Bryner (1961) and Vincent D. Perry (1961)

Perry states that- "repeated magma advances at various points and resultant slumpage in the chimneys would eventually extend the breccias to or near the surface.

Leech (G.S.C. Paper 64-1 p30) reports diatreme breccia columns occurring in the Rocky Mountains. He has this to say (Leech personal communication)

At the highest levels the rock is fractured but not displaced. At a lower level the rock is brecciated with some rotation of fragments, then brecciated and containing some "foreign" but local sedimentary fragments. There is an increase in the proportion of matrix and a range of fragment shapes from angular to partially rounded by abrasion. <----->Going deeper the igneous components increase and also dikes may appear.

There are also various references in the literature to Rheomorphic Breccias referring to breccias which become fluidized and can be intruded into surrounding rocks.

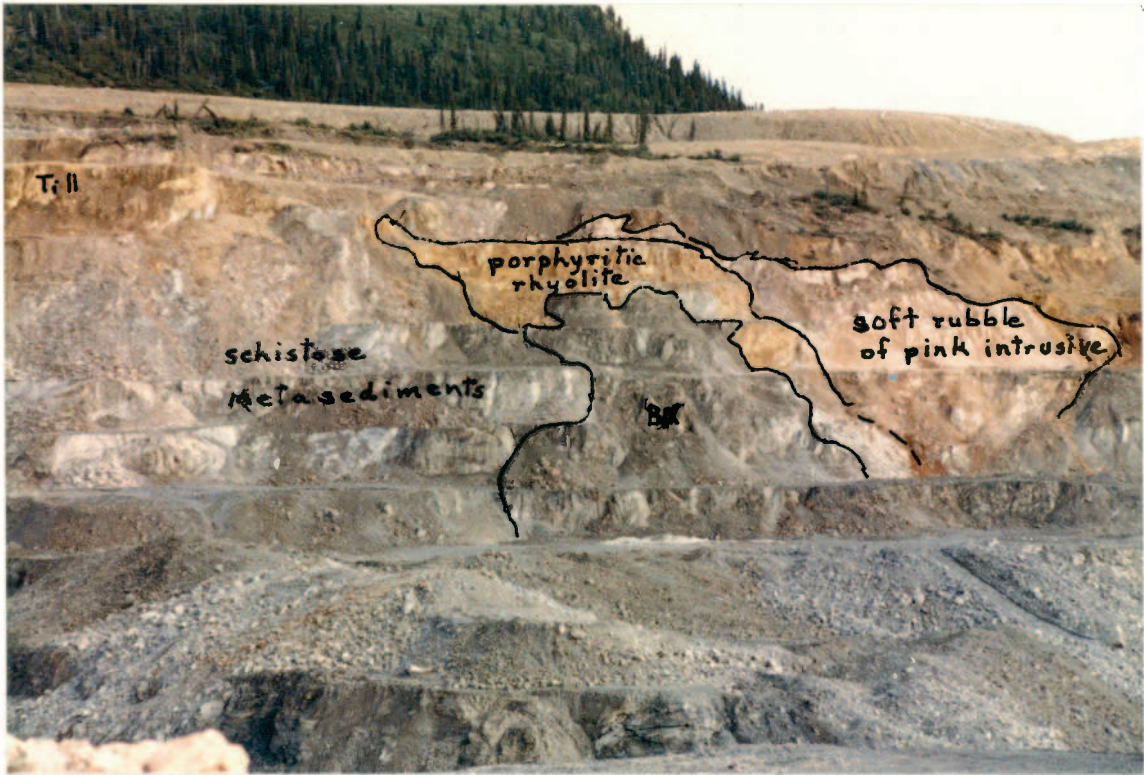
#### Comments

There are fairly obvious similarities between the Breccia Cap and some of the described breccia columns. Particularly interesting is the association of igneous clasts and intrusive dikes within the breccia indicating breccia formation and igneous activity occurring together. Large scale batholith emplacement has occurred in the Anvil range, and volcanic flows are also present. The igneous setting seems to have been appropriate for a subvolcanic suite to have developed. The relative timing is not however known to me.

#### References

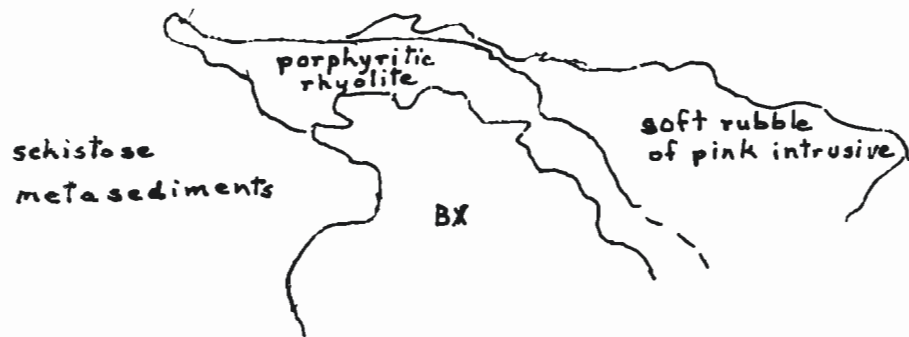
- Bryner, Leonid 1961. Breccia & Pebble Columns Associated with Epigenetic Ore Deposits, Ec.Geol. Vol. 56 p488-508.
- Perry, Vincent D. 1961. The Significance of Mineralized Breccia Pipes. Mining Engineering April 1961.

FARO MINE



View of east wall showing subvolcanic complex

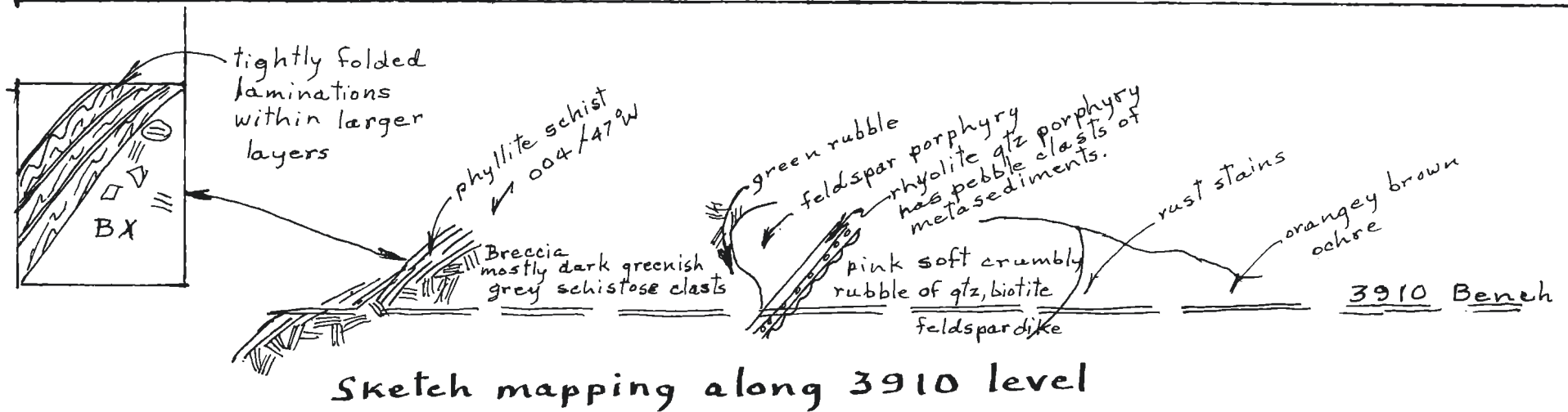
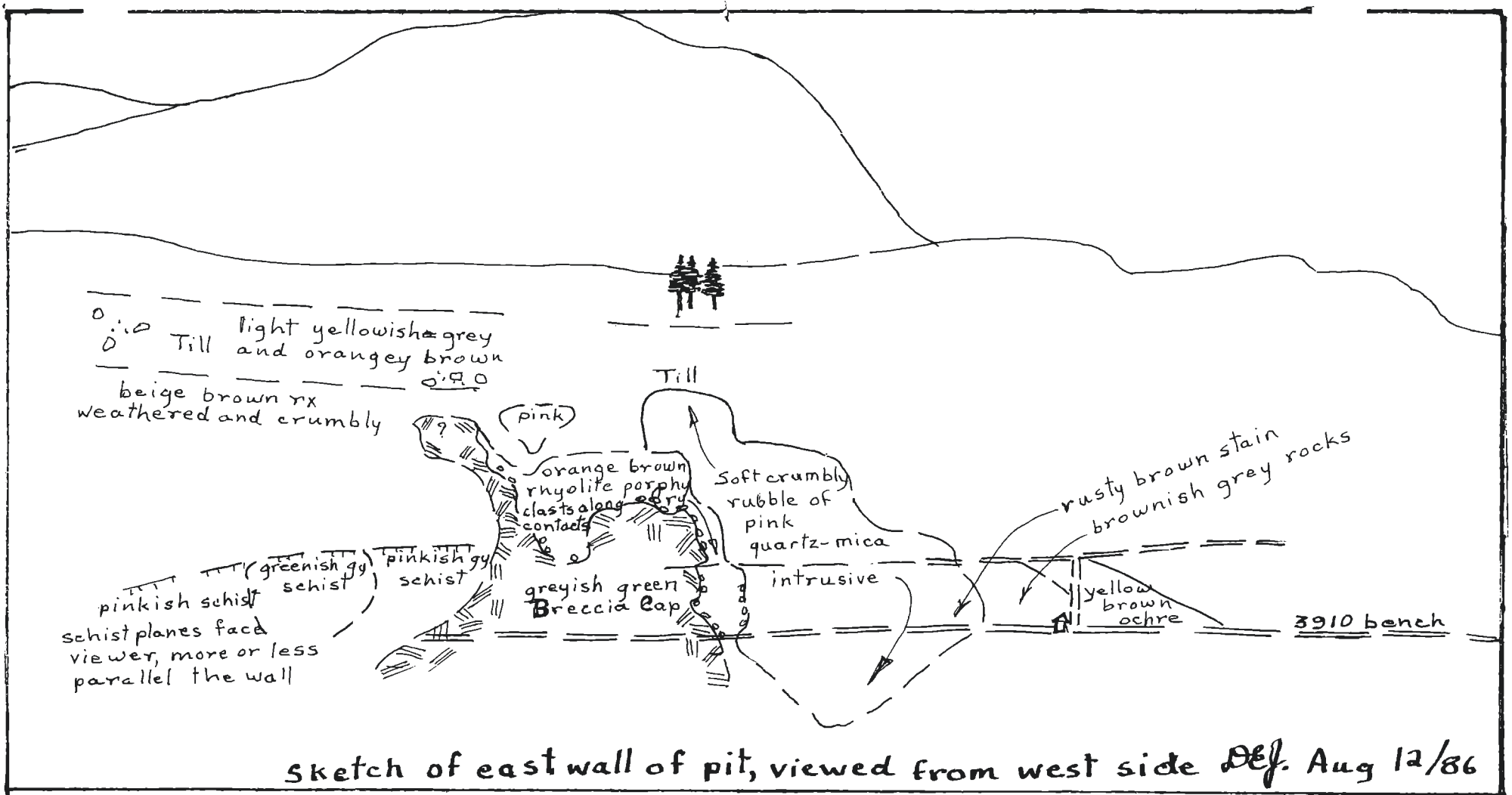
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FARO MINE



View of east wall showing subvolcanic complex



FARO MINE



Breccia Blocks  
dislodged from adjacent bedrock



Breccia Blocks



FARO MINE



Breccia Blocks  
dislodged from adjacent bedrock



Breccia Blocks

## Appendix B

### BLAST HOLE SAMPLING TEST

A proposed program to investigate the reliability of blast hole cuttings sampling.

**Problem** There is a certain lack of confidence in the reliability of assay grades obtained from sampling blasthole cuttings. Comparison of pairs of samples from 13 blastholes indicates that a fairly high proportion of the pairs differ by an unacceptable amount.

It is proposed to further check the reliability of the current sampling method, and evaluate two other methods of sampling the blasthole cuttings.

The aim of the exercise is to find a method that inspires confidence at the lowest cost and inconvenience.

**Present practice** The cuttings cone is approached, and a narrow slot is dug into the cone until the stratified structure of the chips can be seen.

A sample is taken from the narrow end of the slot from top to bottom. The amount taken is a shovelful which would weigh roughly 1-3 lbs depending on the amount of sulfide material in the sample

### Proposed test

#### a) Shovel Method

Sample 30 cuttings piles by the present method in conjunction with tube and quarter sampling. Compare assays.

#### b) Tube Sample Method

A tube with an I.D. of 3" will be worked down into the cuttings cone to bring out a sample.

Assuming a sample 18" long the sample volume will be  $r^2 * h = 1.5^2 * 18 = 127.2$  cu in = .07 cu ft.

Assuming an SG of 3 the sample will weigh about  $3 * .07 * 62.4 = 13.1$  lb

### Problems anticipated

- i) Stopping the sample at the base of the pile
- ii) Dropping some sample during retrieval
- iii) Eliminating the portion of the cuttings from the part of the hole that went below bench depth.

### Advantages

- i) A larger volume of sample is taken than the shovelfull which increases the statistical validity of the sample
- ii) Presumably it will be easier to take two or more samples with the tube than by the shovel method.

### Test procedure

Sample 30 piles, two tube samples from each. Remove the top 3" of cuttings from the sample area before inserting the tube. Gauge depth to base of pile. Tip tube sideways to remove without dropping sample. Bag and tag 2 samples. Compare assays between tube samples, vs shovel sample, and vs quarter samples.

Proposed test continued

c) Quartering Method

- i) Place quartering divider in place
- ii) Scrape a thin layer of sub bench cuttings from the surface of quarters A&B
- iii) Shovel the whole of quarter A onto a mixing board
- iv) Reduce the sample to aprox. 1 kg by riffling
- v) Bag & tag 1
- vi) Repeat process for quarter B

Advantage

- i) A large sample is taken and reduced by approved sampling methods to a manageable representative sample.
- ii) Sampling two quarters separately will test whether sulfides are distributed evenly in the pile.

Problems

- i) A lot of equipment has to be moved around
- ii) There will be some difficulty in eliminating the sub-bench chips
- iii) It will be time consuming

Test Procedure

- i) Quarter and sample 30 piles
- ii) Bag tag & assay 2 samples per pile
- iii) Compare A vs B
- iv) Compare avge of A+B with tube samples
- v) Compare avge of A+B with shovel samples

Notes

Steve notes that the cuttings pile typically has a somewhat rectangular base and would look somewhat asymmetrical in profile.

Also there are often ruts under the pile making an uneven base.

Suggestions

- i) Orient the quarter dividers to be along the diagonals of the rectangle or try to bisect irregular lobes
- ii) Circumscribe a circular sampling limit around the blast hole
- iii) Lay a plastic base to catch cuttings before drilling

D.E.J. aug 3 /86

Grade control

a) The program to test blast hole sampling methods nearly drowned in the rain, but four blast holes were sampled by the proposed test methods. the results showed large variations between the different samples taken from the same cone of chips. the following conclusions arise from the results so far:- i) Grade is distributed non uniformly in the chip pile.

ii) A single small sample from the chip pile has little chance of representing the grade accurately.

In addition there is a strong suggestion that the quartering method of sampling is getting consistently higher pb & zn values than the other methods. [ four out of four]. I think it may be because the heavier minerals drop out closest to the hole and the quartering method of sampling is the only one that samples the cone at the edge of the hole.

b) An ex blast hole sampler has proferred a design for a tube sampler and sampling method used by himself at a Placer Development mine. This system will be tested. I suggest that an extra tube sample be taken adjacent to the blast hole to test my theory that this portion of the pile collects more of the highgrade than the rest.

c) I conclude that the current method of blast hole sampling is not adequate and may well be assigning ore to the low grade stock pile. In addition the bench grades calculated from this data are not reliable.

d) In as much as an improved sampling method is bound to increase the load of work, and as the testing program has already increased the load for the immediate future, I reccomend the immediate hiring of a chief blast hole sampler and grade control technician to work closely with Steve and Cam. I suggest that the chap who gave us the information about the sampler is worth trying.

D.E.J. Aug.17 /86