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ORE RESERVE ESTIMATION
SILVER QUEEN VEIN
OWEN LAKE BRITISH COLUMBIA

By

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CHAPTER X BLOCK KRIGING

Using the autocorrelation models described in Chapter 5 block kriging of thickness and for five metals was performed on the Central and Southern vein segments separately. It should be noted here that the problem of necessary dilution due to minimum mining width will be addressed in Chapter 11. Because of the writer's belief that the vein is continuous from the Central to the Southern segment a narrow band of data (150 ft wide) adjacent but in the Central segment was used for kriging the southern segment, and vice versa. Thus, 21 composite values from the Southern segment were used in kriging the Central segment (see Fig. IV.3) and 12 values from the Central segment were used for kriging the Southern segment (Fig. X.1). Furthermore, several drill holes in which the vein was not recognized, thus no assays, (four in Central and seven in South) were all assigned a thickness of 0.01 ft while the grade was assumed to be unknown. It was felt it would be unjustifiable to assume zero grade values in those cases bearing in mind substantial variability of thickness at small distances as well as the presence of mineralization greater than zero in wall rock (see Chapter V).

The 2-d block size selected 200x150 ft^2 was chosen to approximate future mining stope size. It was felt that stopes higher than 150 ft. may cause ventilation problems and 200 ft along strike could be a possible minimum for any type of

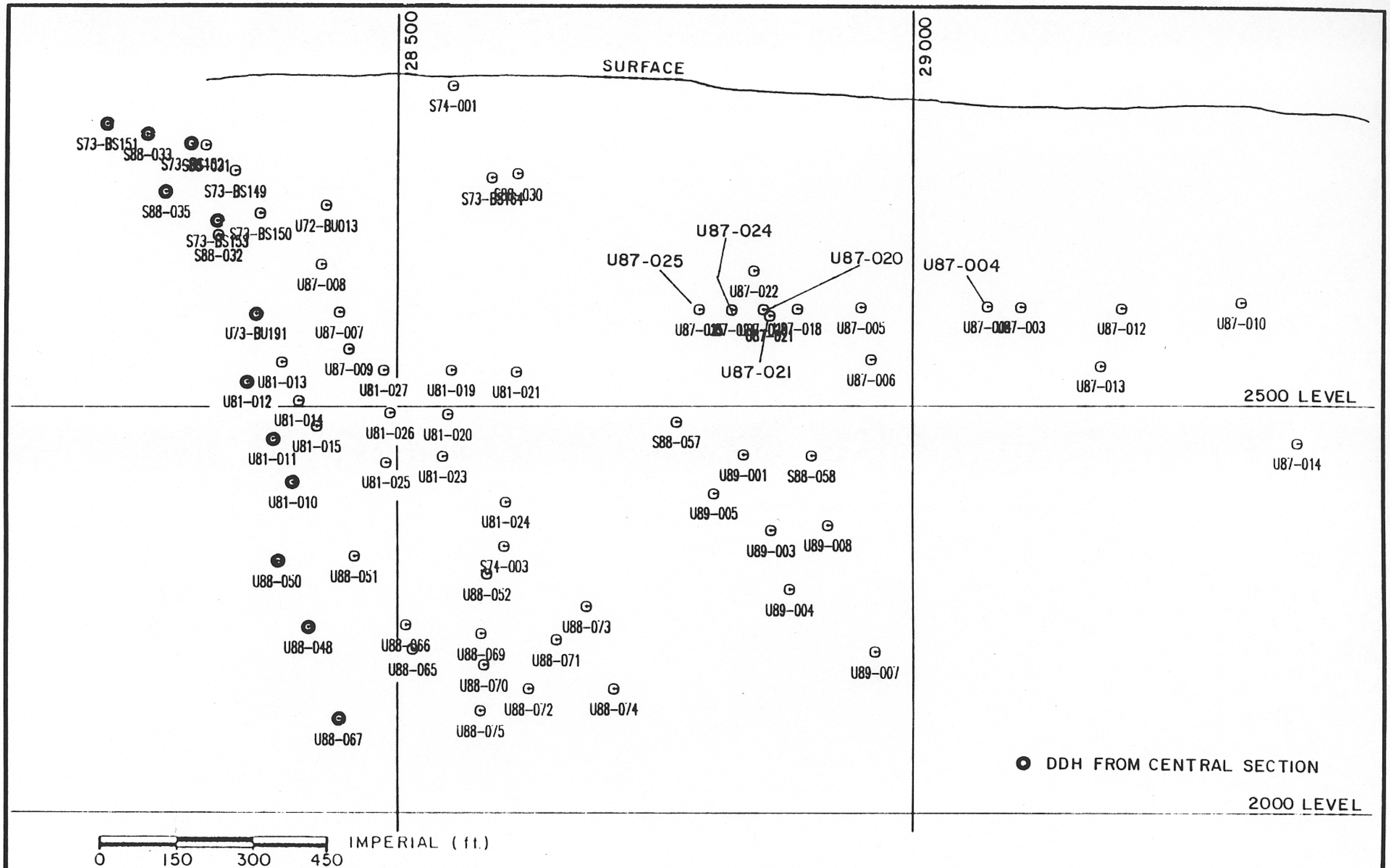

Fig. X.I Drill holes used for reserve estimation, Southern section mechanization introduced. Only the blocks which could be estimated with at least four drill holes (search radius was 200 ft) were estimated.

Average thickness and accumulations for each block were calculated by ordinary kriging. Average grade for each block then was calculated according to the formula:

$$Avgr=Avacc/Avth$$

where:

Avacc - average accumulation for a block, and

Avth - average thickness of the same block.

Figures X.2-X.5 show blocks with the various average Au and Ag grade and thickness calculated by ordinary kriging. Other metals are given in Appendix IX.

Total in situ reserves were estimated, taking into account the Pulaskite dyke cutting through the vein (see Fig. IV.1), and the mined out portion of the vein. A constant specific gravity of 10 ft^3/st was assumed. Table X.1 shows the outcome of the analysis.

Further these reserves were redefined by taking into account the mineability of the vein:

1. Only reserves below Pulaskite dyke between section 26625-27600 are considered;

2. Crown pillars for #2600 and #2880 level and surface are taken into account (20 ft. wide); and

3. Blocks which are above the stoped out area are excluded; starting from section 27700 no blocks above 2600 level are taken into account.

Table X.2 shows the potentially minable in situ resources for a cutoff of zero.

METAL	CENTRAL			SOUTH		
	SHORT TONS	GRADE	THICK-NESS	SHORT TONS	GRADE	THICK NESS
Au	43,647	0.110	4.71	130,615	0.271	2.79
Ag	519,890	6.32	4.34	130,615	14.48	2.79
Cu	519,890	0.24	4.34	130,615	0.93	2.79
Pb	519,890	1.06	4.34	130,615	1.60	2.79
Zn	519,890	6.87	4.34	130,615	10.07	2.79

TABLE X.1 Estimated in situ resources. Units are as follows: thickness in feet, Au and Ag in oz/st, other metals are given in %

METAL	CENTRAL			SOUTH		
	SHORT TONS	GRADE	THICK-NESS	SHORT TONS	GRADE	THICK NESS
Au	403,679	0.110	4.95	122,785	0.285	2.76
Ag	441,233	6.00	4.75	122,785	14.54	2.76
Cu	441,233	0.21	4.75	122,785	0.90	2.76
Pb	441,233	1.05	4.75	122,785	1.67	2.76
Zn	441,233	7.11	4.75	122,785	10.38	2.76

TABLE X.2 Possible minable resources. Units are as follows: thickness in feet, Au and Ag in oz/st, other metals are given in %

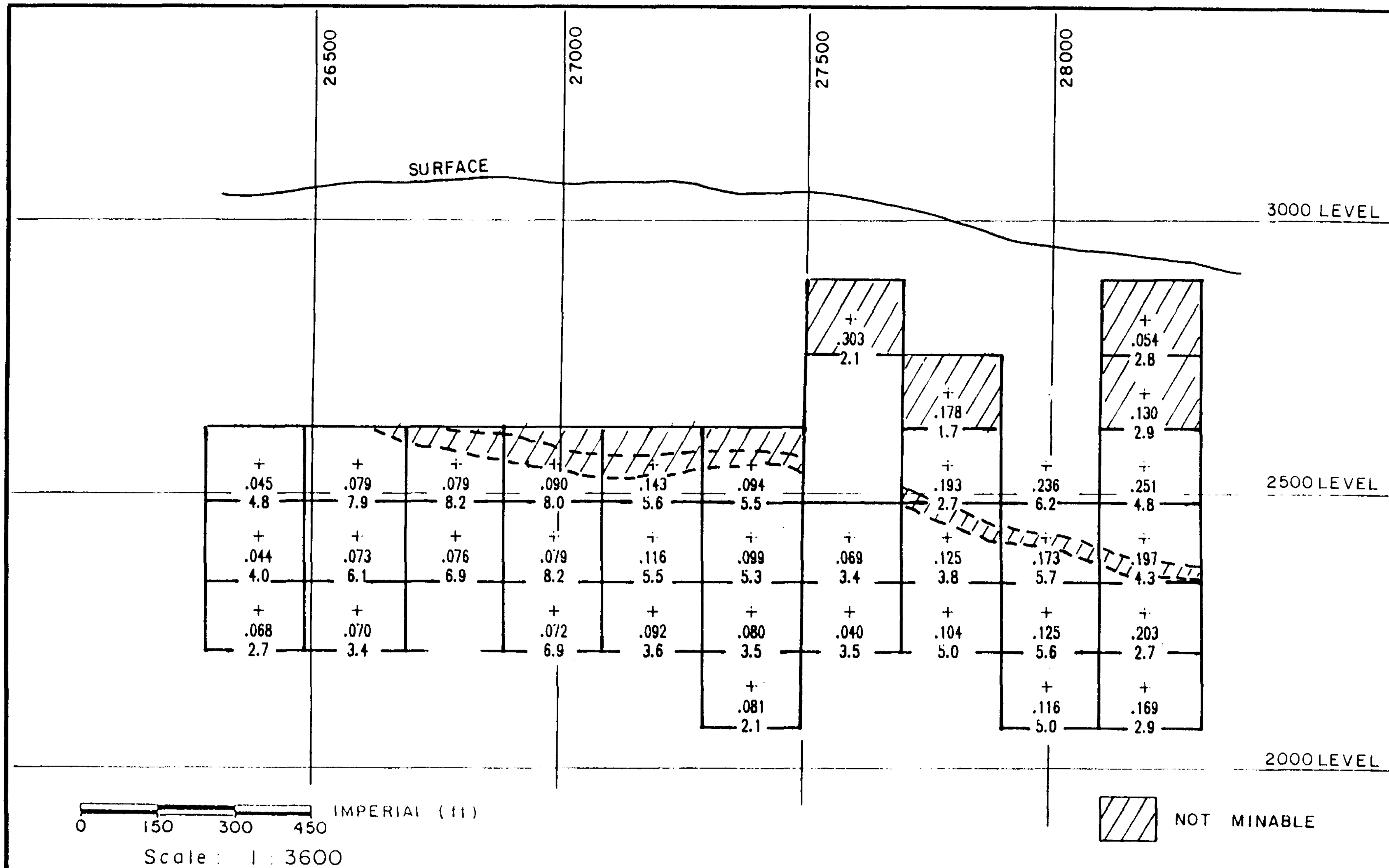

Fig X.2 Estimates of average thickness and Au grade of blocks 200 x 150 ft [2] by ordinary kriging method, central section of No. 3 vein.

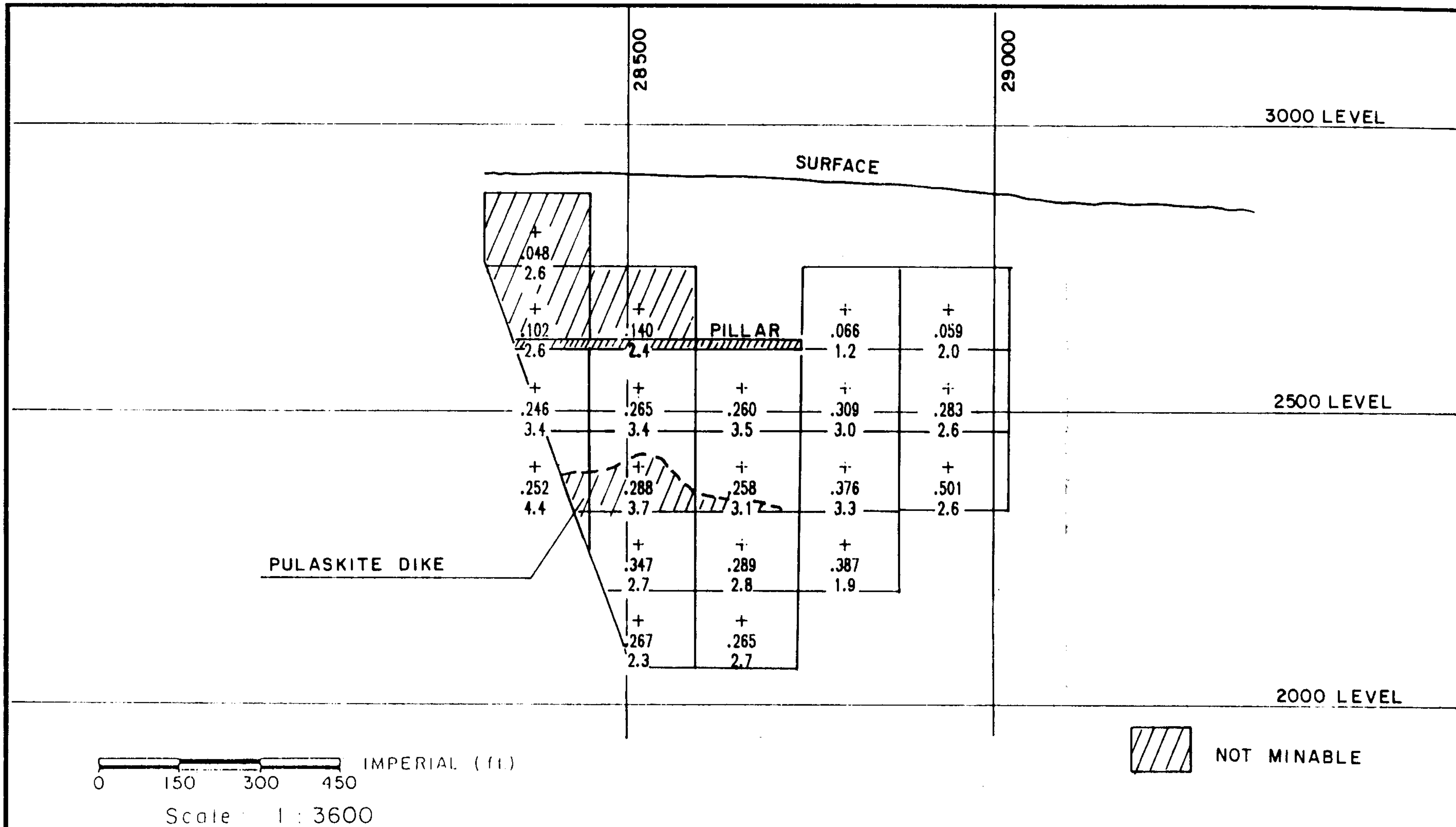

Fig. X.3 Estimates of average thickness and Au grade of blocks 200 x 150 ft^2, by ordinary kriging method, southern section of No. 3 vein.

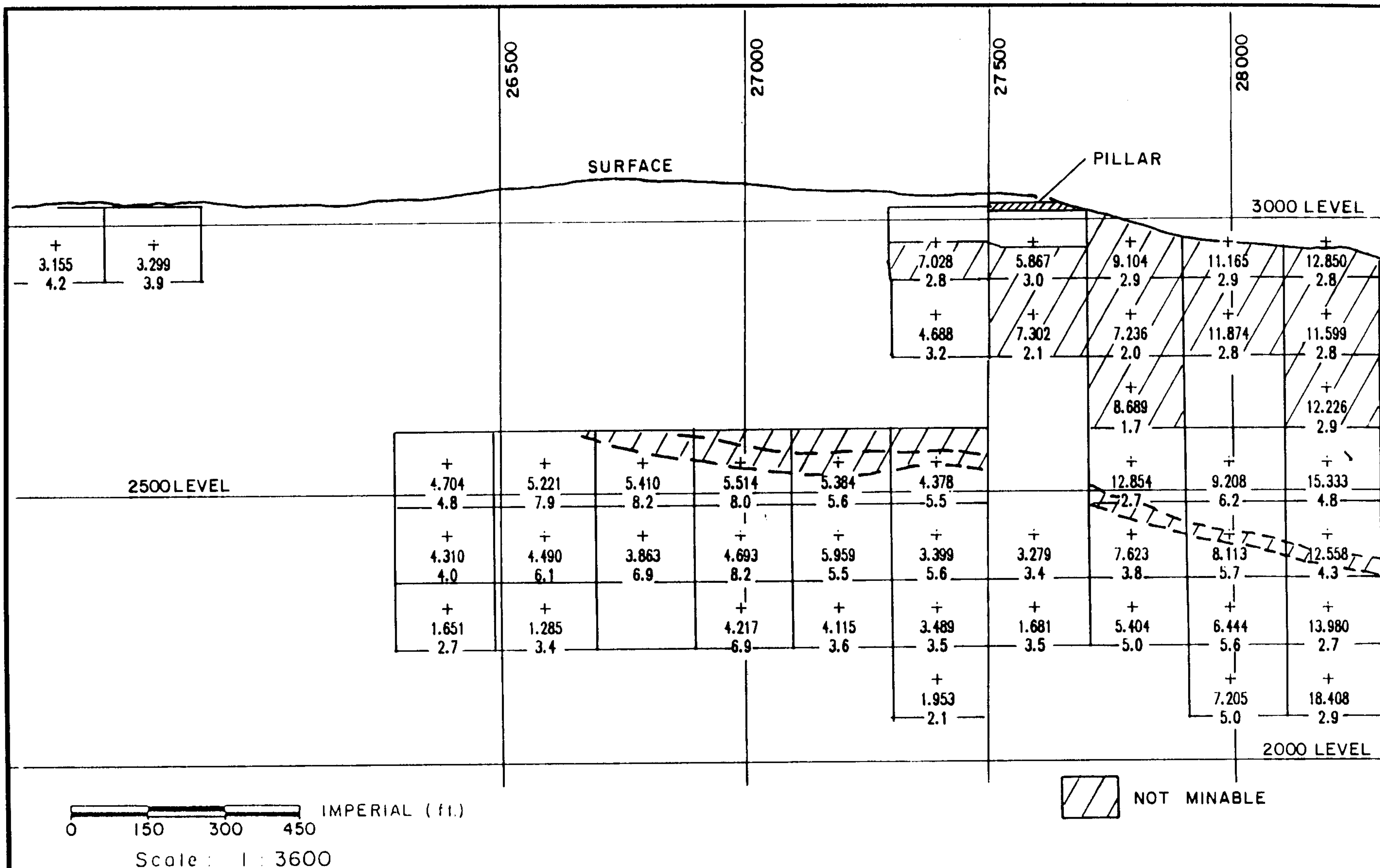

Fig. X.4 Estimates of average thickness and Ag grade of blocks 200×150 ft^2, by ordinary kriging method, Central section of No. 3 vein.

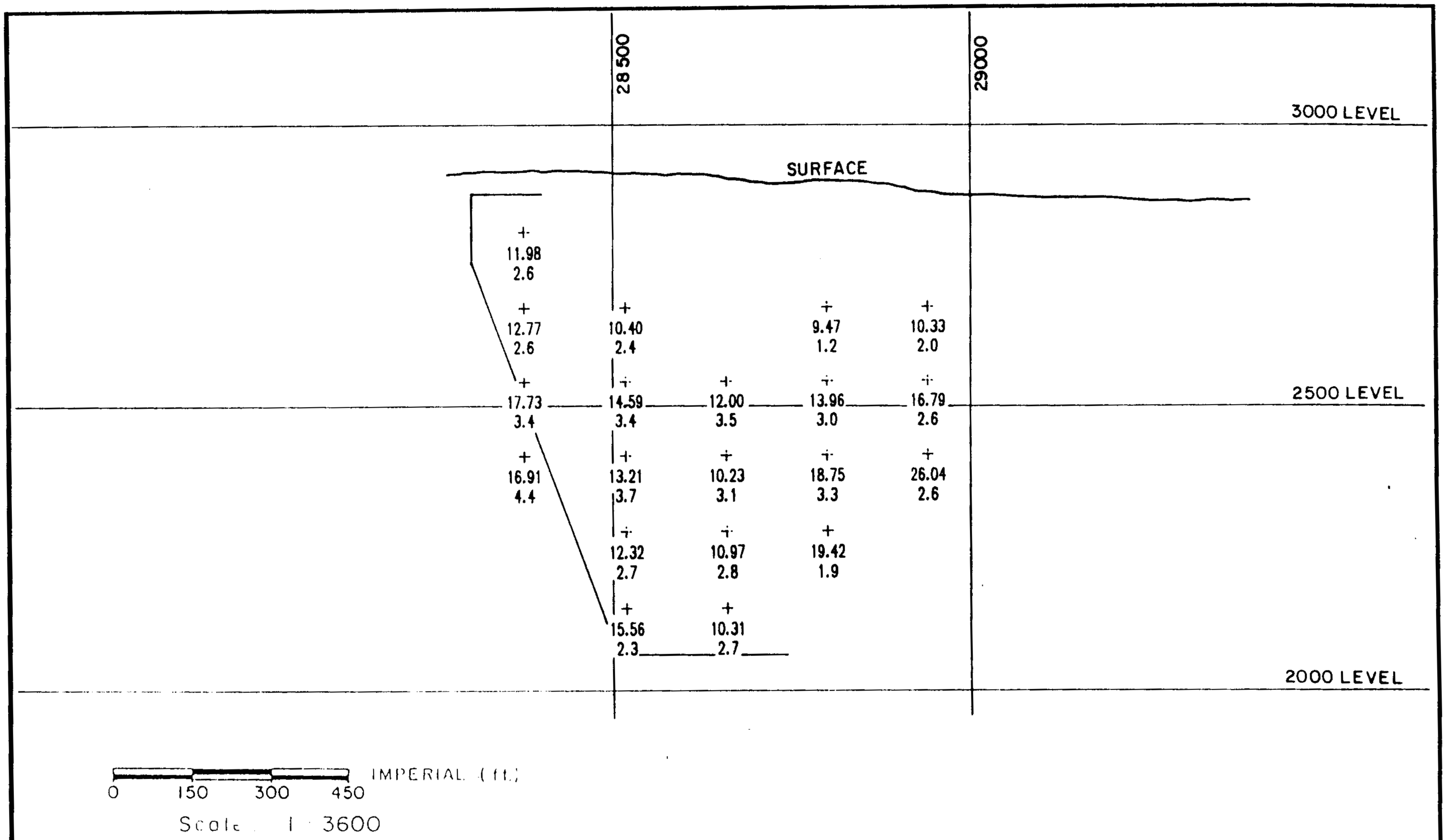

Fig. X. 5 Estimates of average thickness and Ag grade of blocks $200 \times 150\ ft^2$ by ordinary kriging method, Southern section of No. 3 vein.

CHAPTER XII ESTIMATION OF RESERVES FOR MINIMUM MINING WIDTH

XII.1 BASIC ASSUMPTIONS

As shown in Chapter IV the mineralization of interest is not necessarily confined to the vein. There are cases where mineralization can be found both in the hangingwall and the footwall. Appendix XII shows a few examples of mineralization found outside the vein. Furthermore, from the mining point of view narrow intersections have to be diluted to some predefined minimum mining width. Based on the above one can expect an increase in the quantity of metal considered for mining, as well as an increase in tonnage.

In order to calculate mining reserves it was assumed that:

1. Minimum mining width is 4.0 ft;
2. Grade across the minimum width is a composite of best assays found in the neighborhood of the vein, or it is diluted by 0 grade if there are none;
3. The tenor of gold, silver, and zinc mineralization as measured by assays is the basis for the choice of best intersection in the above order;
4. Even if the vein exceeds 4.0 ft the mining width can be increased in case there is good mineralization present in the footwall or hangingwall of the vein (see Appendix XI);
5. If there is additional vein present separated from the major vein by the low grade waste material which would substantially dilute the grade, it is omitted;
6. In places were vein was not found, the minimum mining width is retained with 0.00 grade for gold and 0.01 for other metals for reserve estimation;

7. DDH S72-NGV3 with composite grade entered as unknown in the previous analysis where vein thickness is much less than the assay interval was entered with known values.

In addition three intersections (U74-4, U74-5, U74-6) which were not considered so far were added and included in reserve estimation.

XII.2 CHOICE OF MODIFIED CORRELOGRAM MODELS

- Thickness

The modified correlogram of thickness based on drill hole intersections appears, at the scale considered, to represent pure nugget effect with the exclusion of the first two lags (Fig. XII.1a).

If we analyze drift data diluted to the minimum mining width the modified correlogram (Fig. XII.1b) does not differ from the function calculated in Chapter VI. Thus, the model chosen in previous analysis will again be used in estimation of mining reserves. It may be surprising that the modified correlogram of thickness of the vein where all variables less than 4.0 are considered as 4.0 does not show better continuity for smaller distances.

Naturally the relative variance is much smaller but it does not show in the sill of the modified correlogram which scales all covariances for distances greater than range to zero, or in our case to one. Otherwise at the scale considered the structural relationship is still not present.

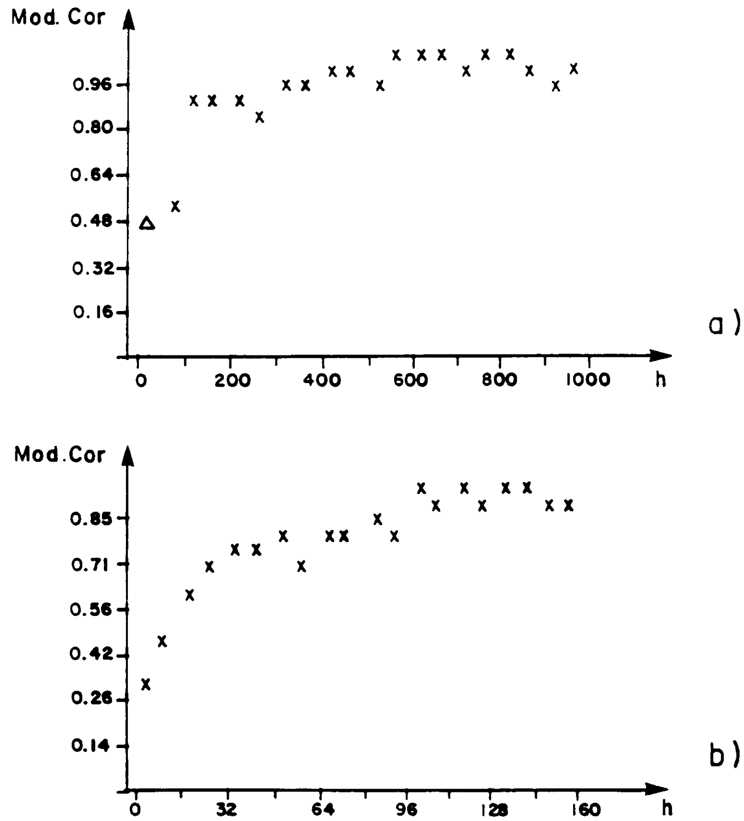

Fig.XII.1 Correlogram of vein thickness from a) drill hole data, minable widths b) drift data, minable widths.

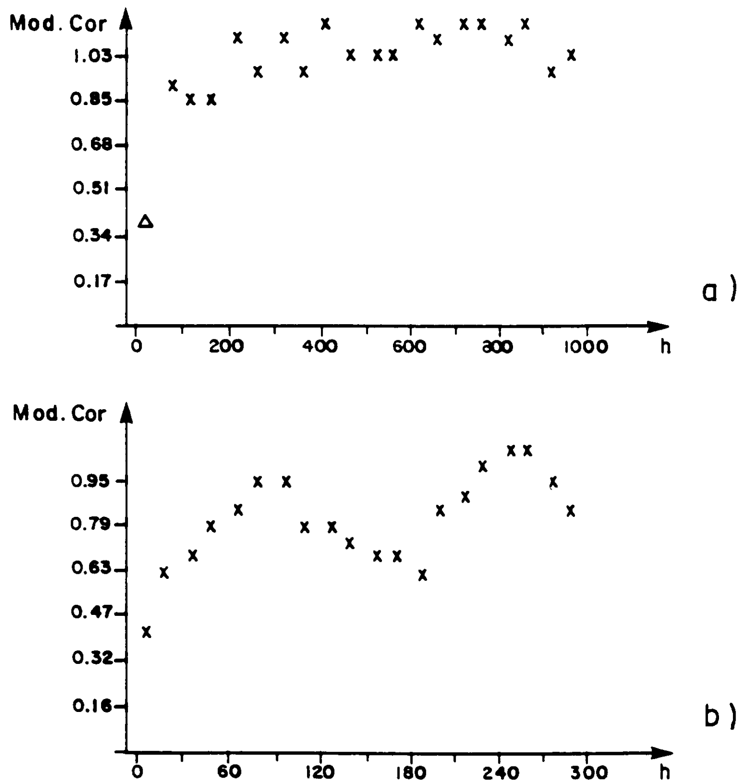

Fig.XII.2 Correlogram of gold accumulations, a) drill hole assays, minable widths b) drift assays, minable widths.

△ – denotes less than 30 pairs

- Gold accumulation

Modified correlograms of gold accumulation for drill hole intersections (fig. XII.2 a) and for drift data (fig. XII.2 b) do not appear to differ from the modified correlograms calculated for the vein.

Therefore the model given in Chapter 5 is going to be used in further calculations.

- Lead accumulation

The modified correlogram of lead accumulation as given in fig. XII.3a returns lower values for the first few lags than the ones encountered when the vein was analyzed. Surprisingly, this structural behavior is not evident when the classical variogram is calculated. One must bear in mind that the correlogram is affected by the covariance function which for the first lags is substantial. The covariance function in this case is affected by a few aberrant large value pairs. To check for the behavior of the function the covariance was calculated on a subset of data and it turned out not to differ so much when compared with other lags.

The modified correlogram of drift data again is comparable with the same function for the vein accumulations (fig. XII.3b).

Although the model chosen in Chapter VI returns slightly higher values than given in figure XII.3a it was felt that the difference is negligible for the purpose of estimation, and this model is going to be used in further analysis.

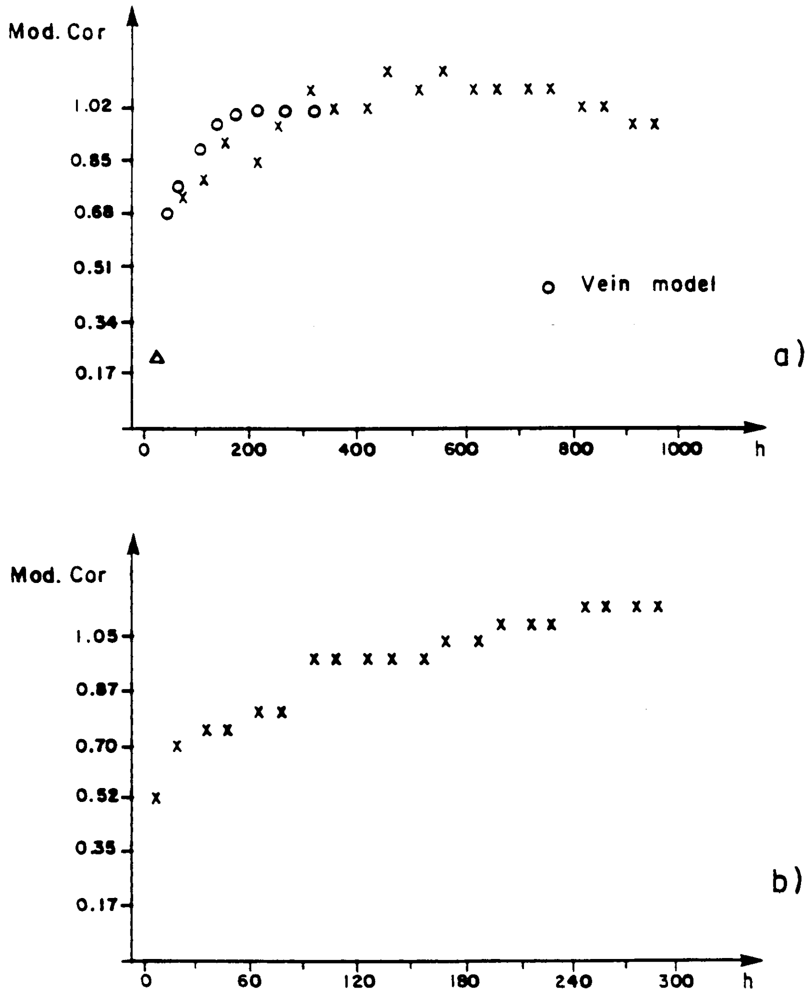

Fig.XII.3 Correlogram of lead accumulations, a) drill hole assays, minable widths b) drift assays, minable widths.

Δ - denotes less than 30 pairs

Modified correlograms of accumulations of other metals as given in appendix XIII are not different from experimental functions given in Chapter VI. Therefore, the models derived for these variables from vein analysis are going to be used again.

XII.3 ORE RESERVE ESTIMATION

The approach towards the mining ore reserve estimation is exactly as described in Chapter X when the reserves were based on the vein mineralization.

The only difference is in assigning the 0.00 values for gold and 0.01 for other metals were the vein was not found and the assays were not given in the interval of interest.

Table XII.1 shows the in situ mining resources and Table XII.2 gives minable resources:

METAL	CENTRAL			SOUTH		
	SHORT TONS	GRADE	THICK-NESS	SHORT TONS	GRADE	THICK-NESS
Au	592,467	0.086	6.33	220,266	0.152	4.6
Ag	708,134	4.78	5.95	220,266	8.15	4.6
Cu	708,134	0.19	5.95	220,266	0.54	4.6
Pb	708,134	0.82	5.95	220,266	0.89	4.6
Zn	708,134	5.43	5.95	220,266	5.67	4.6

Table XII.1 Diluted in situ resources. Units are as follows: thickness in feet, Au and Ag is in oz/st, other metals are given in %.

METAL	CENTRAL			SOUTH		
	SHORT TONS	GRADE	THICK-NESS	SHORT TONS	GRADE	THICK-NESS
Au	530,607	0.088	6.54	202,106	0.163	4.6
Ag	583,137	4.71	6.31	202,106	8.33	4.6
Cu	583,137	0.18	6.31	202,106	0.53	4.6
Pb	583,137	0.84	6.31	202,106	0.94	4.6
Zn	583,137	5.81	6.31	202,106	5.93	4.6

Table XII.2 Diluted Possible Minable Resources. Units are as follows: thickness is in feet, Au and Ag is in oz/st, and other metal are given in %.

Diluted possible minable resources are based on minimum width 4.0 ft., somewhat idealized approach, with no consideration to additional dilution from the strongly altered and often incompetent wallrock.

Previous production data during the period January-June 1973 indicate additional dilution averaging approximately 20% (Cominco, 1988). Furthermore, the recovery of precious and base metals has been known to be quite low due to the complex metallurgy averaging 29% for Au, 56% for Ag, Cu, and Pb, and 81% for Zn. Based on Lakefield Research test work (1988) the recoveries of paying metals by the process of flotation, bioleaching, and roasting, were found to be much higher.

Table XII.3 shows the estimated value of recovered metals.

Variable	Short Tons 20% dil.incl.	Aver. Grade	% * Recov.	Spot Metal Prices Oct. 24/90	$ US Value of Metal
Au	879,255	0.086	63	371.10/oz	18,597,185
Ag	942,291	4.66	90	4.23/oz	16,877,069
Cu	942,291	0.22	85	1.24/lb	4,431,311
Pb	942,291	0.71	87	0.35/lb	4,143,098
Zn	942,291	4.79	96	0.61/lb	53,728,649
				TOTAL	97,777,312

Table XII.3 Estimated fully diluted tonnage, average grade, and gross value of metals recovered from the No. 3 vein. Metal prices are quoted from The Northern Miner
* Based on laboratory tests by Lakefield Research

XII.4 COMPARISON OF RESULTS WITH UNPUBLISHED COMINCO ESTIMATES

In order to check the estimated mining reserves with the estimates from the past, two areas in Central section were compared. These areas of polygonal shape given in the unpublished report by Cominco, were estimated only by the data within their boundaries.

The first polygon with a total of 22 drill holes included, between section 26250 and section 27250 (see Fig. IV.1, POL1) returned average thickness 0.8 ft. higher and the quantity of metals up to 10% greater (zinc) than that given by Cominco.

Larger thickness appears to show because of two drill holes: U88-027 and U88-028 which show the true mineralized to be 10 ft. wider. The difficulty of determining the limits of the vein has been well recognized in this area and some of the drill holes like U88-027 were cut to 15.0 ft by Cominco.

The silver accumulation is only 95% of the Cominco estimates. The main reason appears to be the interpretation of vein attitude in the area. There are a few drill holes (U88-20, U88-21, U88-22, U88-31) which show the vein to be narrower than estimated by Cominco. Average silver grade within considered intersections is similar but the quantity of metal is larger. Because a number of drill holes were not drilled perpendicular to the strike direction the assumed attitude of the vein will have an effect on the calculated true thickness of the vein and in turn on the quantity of metal.

The fact that close to 10% more quantity of zinc was estimated when wider sections were included may suggest the possibility of some kind of mechanization for wider stopes.

The second polygon included 13 drill holes (see Fig. IV.1, POL2). Estimated average thickness is approximately the same in both cases. There are large discrepancies though in the estimate of average grade excluding gold.

Table XII.4 compares the calculations.

VARIABLE	AUTHOR	COMINCO
THICKNESS	5.36 ft	5.40 ft
Au	0.176 oz/st	0.178 oz/st
Ag	8.49 oz/st	10.21 oz/st
Cu	0.20 %	0.283 %
Pb	1.11 %	1.48 %
Zn	8.15 %	9.07 %

TABLE XII.4 Comparison of estimates of average thickness and grade of a polygon (POL2) in Central section of No. 3 vein.

These large discrepancies are because of the following:

- averages from four stopes as well as U81-17 and U81-18 are included in Cominco estimation (total 17 data included in estimates);
- Two drill holes BU-191 and U81-09 of very low grade (BU-191 carries only trace values) are included in the present analysis.

If we exclude the stope data and two low grade holes the estimates will be as given below:

VARIABLES	AUTHOR		COMINCO	
	GRADE	ACCUMULATION	GRADE	ACCUMULATION
Ag	9.41	51.60 ft*oz/st	8.98	51.9 ft*oz/st
Cu	0.222	1.22 ft*%	0.249	1.43 ft*%
Pb	1.23	6.76 ft*%	1.38	7.97 ft*%
Zn	8.94	49.00 ft*%	9.23	53.30 ft*%
	THICKNESS = 5.48		THICKNESS = 5.78	

TABLE XII.5 Comparison of estimates of average thickness and grade of a polygon (POL2) where stope averages (Cominco) and low grade drill holes (Author) are excluded. Units are as follows: thickness is in feet, Ag is in oz/st, other metals are in %.

As noted, the differences are not that large any more although lead and copper still represent only 85% of the quantity of metal calculated by Cominco.

It is concluded that in general, true thickness of the vein is slightly larger in Cominco estimates due to probably different assumption of the dip of the No. 3 zone which may affect also the estimates of accumulations.