6000 1880

Mining District File Summary Sheet

DISTRICT	Rosebud
DIST_NO	4010
COUNTY If different from written on document	Pershing
TITLE If not obvious	Rosebud - Resource/Reserve Due Diligence
AUTHOR	Cameron D; Muerhoff, C; Ristorcelli, S Knudsen H; Hendrickson R.; Clayton, R
DATE OF DOC(S)	1996 - 1997
MULTI_DIST Y / (N?) Additional Dist_Nos:	
QUAD_NAME	Sulphur 7½'
P_M_C_NAME (mine, claim & company names)	Rosebud Mine; Rosebud Mining Co LLC; Hecla Mining Co.; Mine Development Associates Santa Fe Pacific Gold
COMMODITY If not obvious	gold; silver
NOTES	correspondence; handwritten notes; variograms; statistics 70p

Keep docs at about 250 pages if no oversized maps attached (for every 1 oversized page (>11x17) with text reduce the amount of pages by ~25)

SS: DD (Initials) 8/1/08 (Date)

DB: ______ Initials ______ Date

SCANNED: ______ Initials ______ Date

Revised: 1/22/08

SFPG RESOURCE/RESERVE
DUE DILIGENCE

60001880 4010

60001880 4010

The Rosebud Mining Company LLC

P.O. Box 2610
Winnemucca, NV 89446
Phone (702) 623-6912
Fax (702) 623-6967
Hecla Mining Co. - Manager of Mining

FACSIMILE COVER SHEET

DATE: Feb 4, 1997

TO: Don Cameron
Hecla Mining Company

FROM: Charlie Muerhoff

NUMBER OF PAGES INCLUDING COVER: 6

MESSAGE: This is really all I have from Pete Knudsen. Remember - he worked on the south zone only. If you need info on the North & East zones, let me know.

We talked to Pete today - he said he would be happy to beef-up the report if you wish to see more documentation.

Charlie

IF YOU DO NOT RECEIVE LEGIBLE COPIES OF ALL PAGES, PLEASE CALL BACK AS SOON AS POSSIBLE.

Fax

To: Steve Ristorcelli

Of: Mine Development Associates

Fax: 702-856-6053

Phone: 702-856-5700

Pages: 1, including this cover sheet.

Date: September 28, 1996

Steve;

The basic data used in this analysis consisted of the five foot composites. The short lengths that Charlie has classified as string #2 were not used. In all cases the variograms were calculated using a maximum assay value of 4 opt. Correlograms were calculated and then converted to variograms.

Methodology

Zones 1 and 2 were initially analyzed separately. As in the previous work, useful variograms can be obtained, but the variograms are fairly fuzzy. By combining zones 1 and 2, better variograms were obtained. Both mineralization in both zones appears to have the same spatial characteristics. Zone 1 is higher grade than zone 2, but they have the same coefficient of variation. The grouping of the data made the variograms much easier to interpret and model.

Results for Zone 1&2

Zone 11 and 21 were combined. The mineralization in zones 11 and 21 is roughly tabular with a strike of N5E and dip of about 35 to the SE. Within the tabular body the continuity of mineralization is anisotropic. The greatest continuity is along the strike of the zone.

From the desk of...

H. Peter Knudsen
Dean
Montana Tech
School of Mines
Montana Tech
1330 West Park St.
Butte, Montana 59701
406-496-4395

The variograms for zone 11 & 21 has the following parameters;

Nested Spherical Model					
Nugget Effect	=	0.60			
C1 value	=	0.30	Range	=	20 feet
C2 value	=	.10	Range	=	80 feet
Bearing of major axis	=	5	Dip	=	0.0
Tilt	=	30			
Anisotropy factors					
Semi-major	=	1.33	Minor	=	1.67

Zones 12 to 15 and 22 to 25 were also grouped together. This variograms is actually quite similar to the variograms for zones 11 and 21, except the direction of greatest continuity is along the direction of the dip. The variograms for these zones has the following parameters;

Nested Spherical Model					
Nugget Effect	=	0.55			
C1 value	=	0.30	Range	=	25 feet
C2 value	=	.15	Range	=	100 feet
Bearing of major axis	=	95	Dip	=	30.
Tilt	=	0.0			
Anisotropy factors					
Semi-major	=	1.33	Minor	=	2.00

Zone 3

Zone 3 proved to be more of a challenge than zones 1 &2. This is probably mostly due to the smaller number of samples available. Zones 31 to 35 were grouped together in order to get a useable variograms. While the variograms are somewhat fuzzy, the variograms show that the mineralization in zone 3 has different directions of continuity than the mineralization in zones 1 and 2. In zone 3 the mineralization has the greatest continuity in the vertical direction. In the horizontal plane the mineralization appears to be isotropic.

The parameters of the variograms are;

Nested Spherical Model					
Nugget Effect	=	0.30			
C1 value	=	0.40	Range	=	100 feet

From the desk of...

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C2 value	=	0.30	Range	=	200 feet
Bearing of major axis	=	0.0	Dip	=	90.0
Tilt	=	0.0			
Anisotropy factors					
Semi-major	=	2.00	Minor	=	2.00

Zone 4

Zone 4 is a challenge. Variograms were calculated in a direction of N45E with a 35 degree dip, N45W with a zero dip, and S45W with a 60 degree dip. The first two variograms are fuzzy and there from these the mineralization appears to be isotropic. The third direction which is perpendicular to the zone gives a 2 to 1 Anisotropy.

The parameters are;

Spherical Model					
Nugget Effect	=	0.35			
C1 value	=	0.65	Range	=	70 feet
Bearing of major axis	=	45.0	Dip	=	35.0
Tilt	=	0.0			
Anisotropy factors					
Semi-major	=	1.00	Minor	=	2.00

Comments

The more that I look at this data, the more that I think Indicator kriging is a better way to estimate the grades of this deposit. The indicator variograms that I have looked at are much easier to interpret. This would be a plus in helping unravel the question of which directions have the best continuity in each zone. Indicator kriging would also be the best way to handle the high grades, rather than the arbitrary cutting that is now being practices.

From the desk of...

H. Peter Knudsen
Dean
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School of Mines
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Butte, Montana 59701
406-496-4395

Variograms for Rosebud

Zones 11&21 combined.

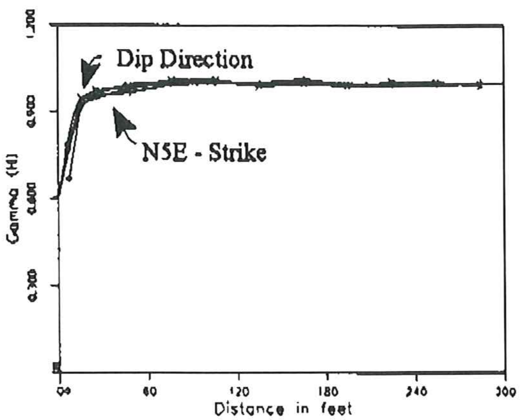


Figure 1. Zones 11&21 - dip and strike directions.

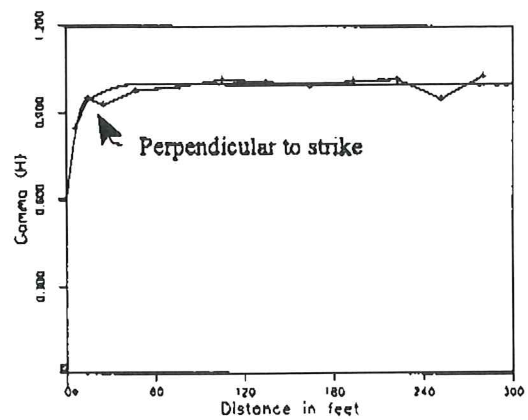


Figure 2. Zones 11&21 - perpendicular to structure.

Zones 12 to 25 combined.

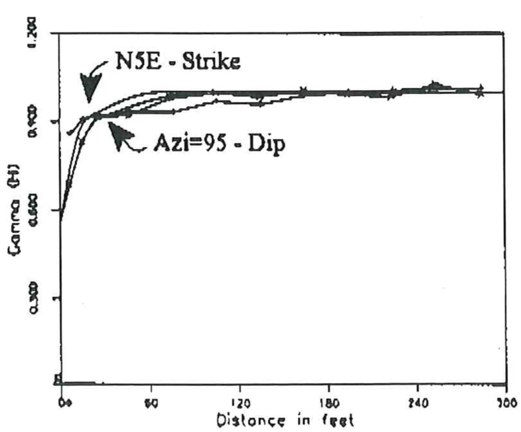


Figure 4. Zones 12 to 25 - dip and strike directions.

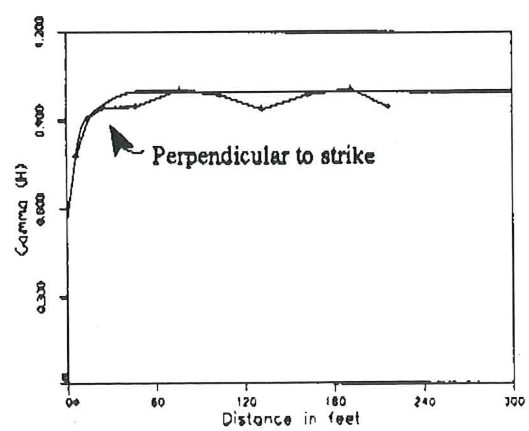


Figure 3. Zones 12 to 25 - perpendicular to structure.

Zone 3 Variograms

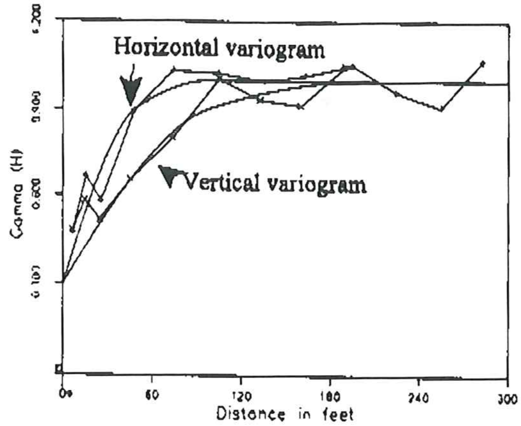


Figure 5. Zone 3 - Horizontal and vertical variograms.

Zone 4 variograms.

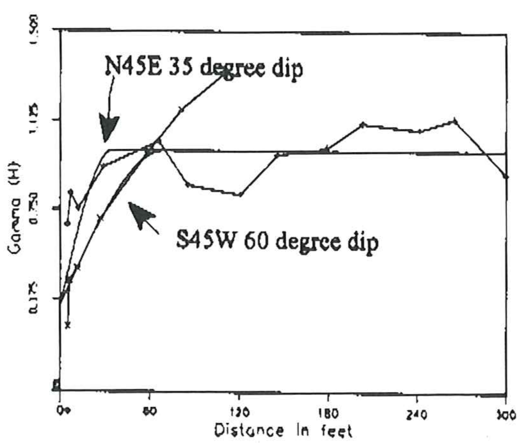


Figure 6. Zone 4 variograms.

7/8/96 charlie: FYI

see [illegible] 11[30] am today

Geostatistical Analysis of the Rosebud Deposit

by

H. Peter Knudsen, Ph.D., P.E.
Professor
Montana Tech
of the
University of Montana
Butte, Montana 59707

VERY ROUGH

July 18, 1996

Prepared for

Mine Development Associates.

1.0 Introduction

Mine Development Associates contracted H. Peter Knudsen to determine the variography of the Rosebud Deposit. Work performed includes calculation of basic statistics and variogram models for four geologic/mineralogic zones of the deposit.

2.0 Data

The basic data used in this analysis consisted of 5ft composites prepared by Mine Development Associates. The data was grouped by MDA into four zones and within each major zone the data was further separated into five separate grade zones.

2.1 Zone 1

Many different attempts were made to model the mineralization in zone 1. The high grade samples in this zone cause the (traditional) variograms calculated to be erratic and unusable. To limit the influence of the high grades on the variogram calculation, only grades less than 4 opt were used. In addition, there are too few samples in the x4 and x5 zones to calculate variograms.

Grouping 13,14,and 15 together gives enough data to obtain an useable variogram. Adding in zone 12 improves the variogram enough so that anisotropy can be determined. The range of influence appears to be the same between the variograms calculated for 13,14 and 15, as it is for the grouping of 12,13,14, and 15. The variograms are shown in Figure 1 and 2.
The variogram parameters for the grouped data from zones 12,13,14, and 15 are listed below.

Spherical Model			
Nugget Effect	=	0.02	
C Value	=	0.35	
Range	=	30 feet	(On strike - N5E)
Range	=	50 feet	(Down dip)
Range	=	20 feet	(Perpendicular to zone)

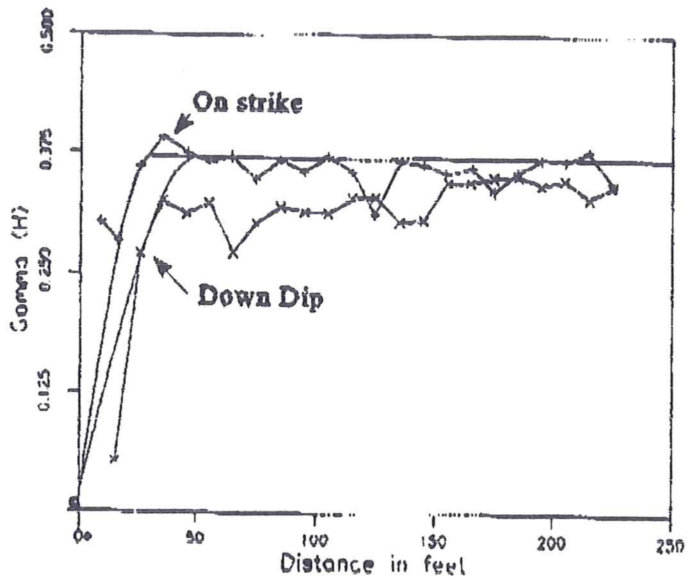


Figure 1. Zone 1 Variograms (12,13,14,15).

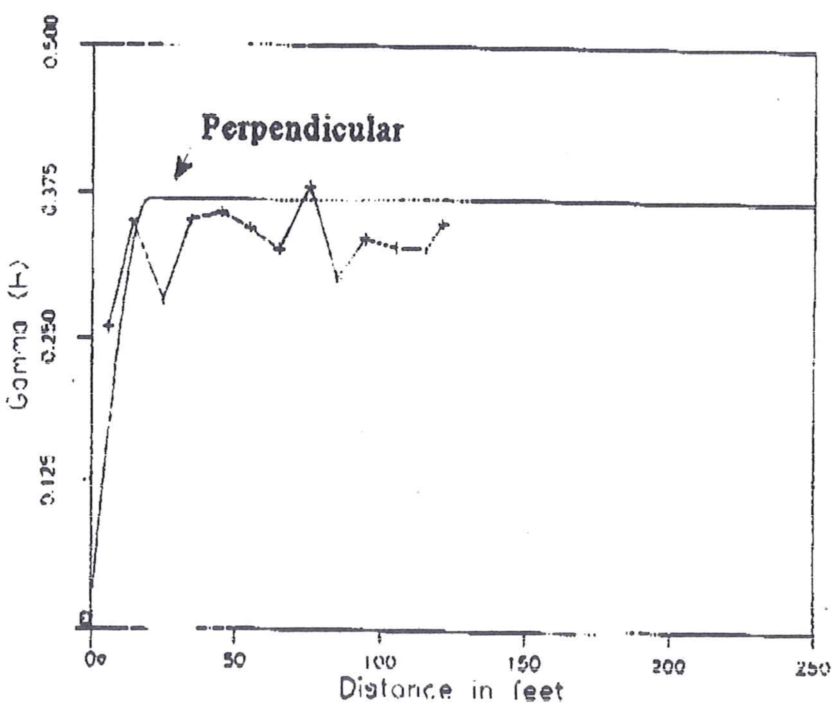


Figure 2. Zone 1 variogram (perpendicular to zone)

2.2 Zone 2

The zone 2 variograms are similar to zone 1. Again only grades less than 4 opt were used in the calculation. The resulting variograms are shown in Figure 3 and 4. The variogram parameters for the grouped data from zones 22,23,24, and 25 are listed below.

Spherical Model		
Nugget Effect	=	0.07
C Value	=	0.18
Range	=	50 feet (On strike)
Range	=	50 feet (Down dip)
Range	=	15 feet (Perpendicular to zone)

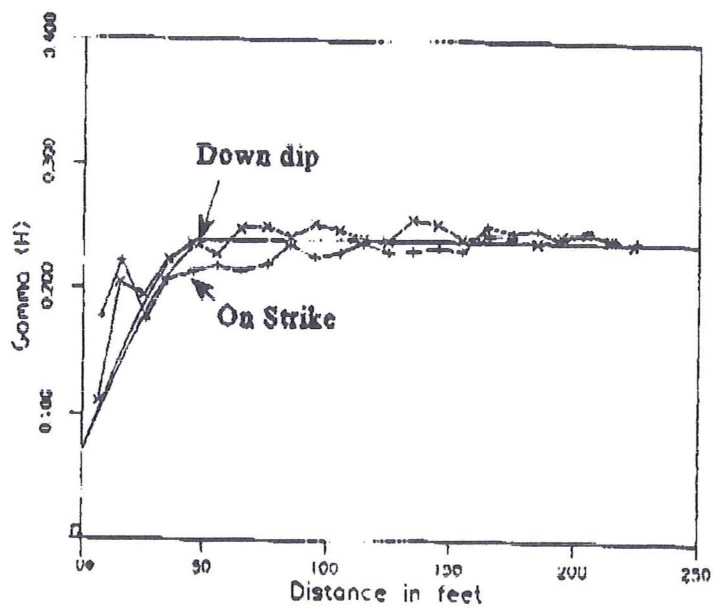


Figure 3. Zone 2 Variograms.

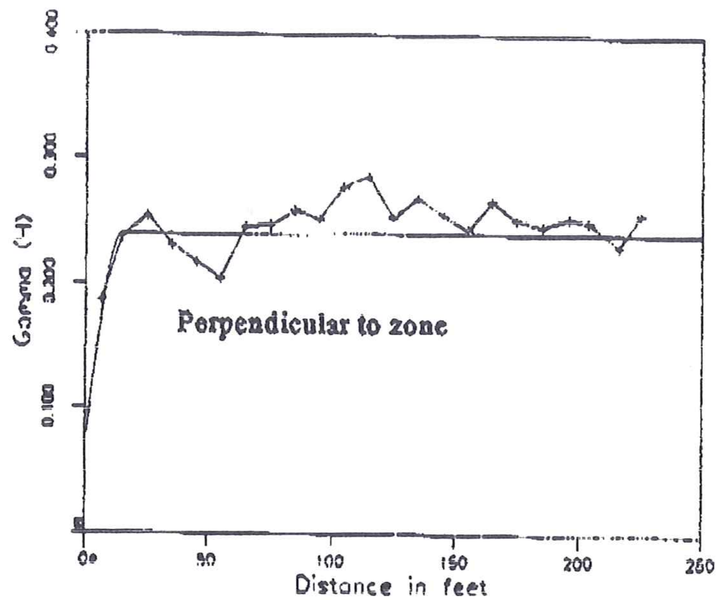


Figure 4. Zone 2 variogram (perpendicular).

2.3 Zone 3

The mineralization in zone 3 has a strong near vertical continuity. The range in the dip direction is 90 feet. The variograms are shown in Figures 5 and 6. The variogram parameters for the grouped data from zones 32,33,34, and 35 are listed below.

Spherical Model		
Nugget Effect	=	0.08
C Value	=	0.21
Range	=	60 feet (On strike)
Range	=	90 feet (Down dip)
Range	=	15 feet (Perpendicular to zone)

When the data from zones 31,32,33,34,and 35 where grouped together, the variograms were smoother and better defined, but the ranges and anisotropy remained the same.

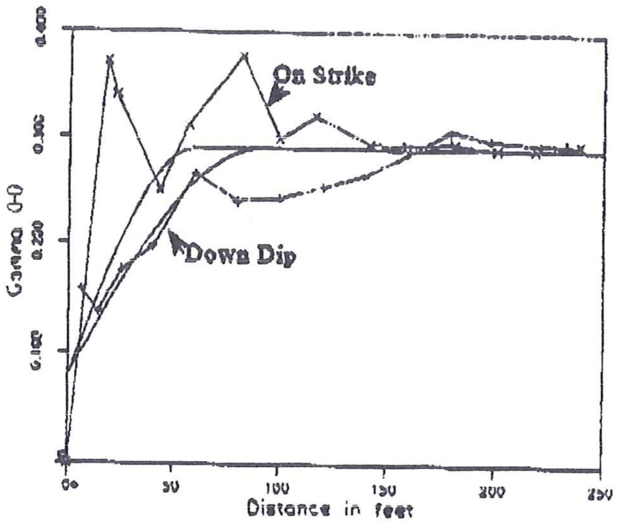


Figure 5. Variograms for zone 3 (32,33,34,35).

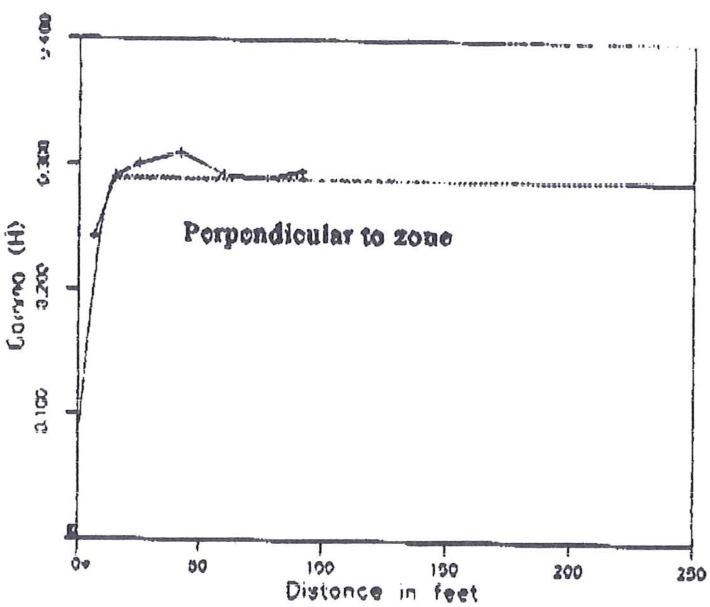


Figure 6. Zone 3 variogram (perpendicular to zone).

2.4 Zone 4

All the data in zone 4 was grouped together to get enough samples to calculate a variogram, yet only the omni-directional variogram had any observable structure. There are not enough samples to determine anisotropy. The omni-directional variogram is shown in Figures 7. The variogram parameters are shown below.

Nested Spherical Model		
Nugget Effect	=	0.010
C1 Value	=	0.015
Range 1	=	20 feet
C2 Value	=	0.015
Range 2	=	90 feet

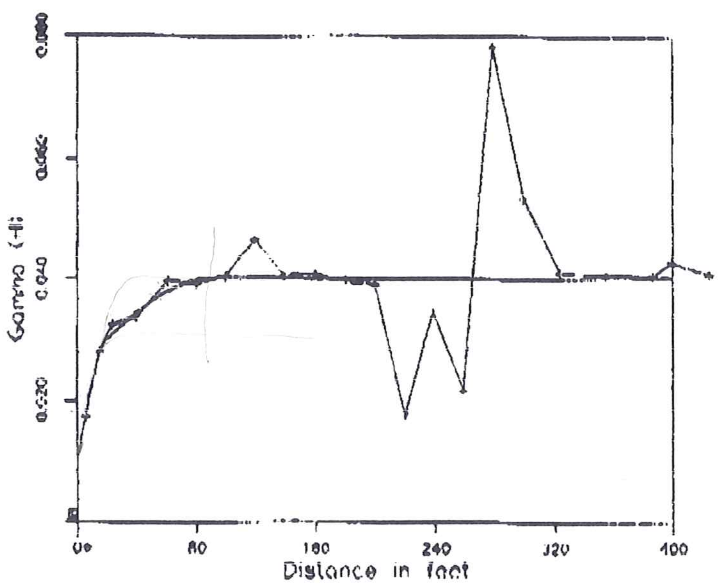


Figure 7. Omni-directional variogram for zone 4.

3.0 Indicator Variograms

Indicator variograms were calculated for zone 1 using all the data and using only the data from 12, 13,14,and 15. The variograms for the second grouping are better behaved than when zone 11 is added to the data set. In general the variograms are very smooth and easy to interpret and I believe can be used to better define the anisotropy of the mineralization. Selected printouts of the variograms are attached. I have not fit models to any of the indicator variograms.

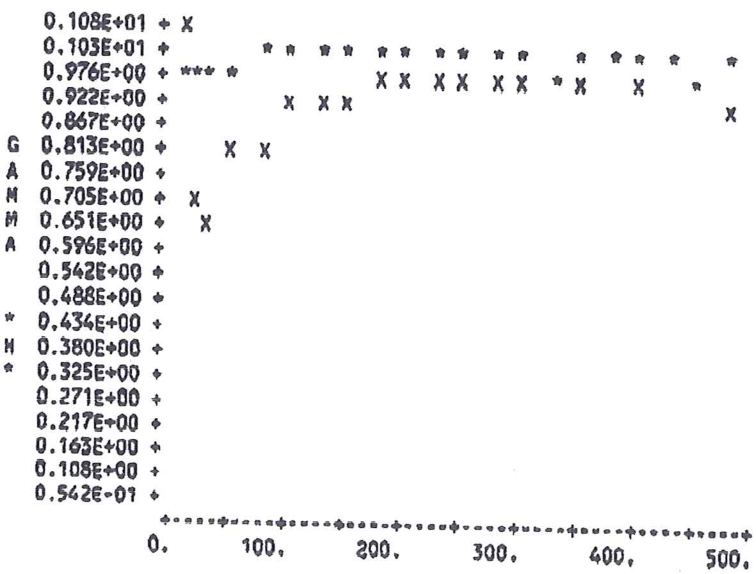
AM

FOR CUTOFF = 0.100E-01

Zone 1 GOLD DATA

		DATA USED IN CALCULATIONS	
ANGLE = 85. DIP = 0. WINDOW = 35.		MEAN	= 0.205
CLASS SIZE =	25.	VARIANCE	= 0.162
MAX DISTANCE =	545.	STD DEVIATION	= 0.402
LOGARITHMS -NO		NO.OF SAMPLES =	1699

DISTANCE	# PAIRS	DRIFT	GAMMA (H)	X_GAMMA(H)	AVER DIST
0 - 15	131	-0.763E-01	1.08	0.967	11.6
15 - 30	567	-0.882E-02	0.659	0.934	23.8
30 - 45	2349	0.468E-02	0.643	0.956	39.0
45 - 70	9247	0.106E-01	0.774	0.971	58.5
70 - 95	14285	0.588E-02	0.770	0.989	83.5
95 - 120	19471	-0.678E-02	0.893	0.993	107.8
120 - 145	23144	0.115E-01	0.914	0.988	132.4
145 - 170	23379	-0.211E-01	0.885	0.984	157.6
170 - 195	25339	-0.236E-01	0.963	1.00	182.8
195 - 220	26949	-0.805E-02	0.945	0.993	207.6
220 - 245	25652	-0.425E-01	0.973	1.02	232.4
245 - 270	25462	-0.100E-01	0.942	1.00	257.2
270 - 295	21667	-0.336E-01	0.944	0.985	282.4
295 - 320	21827	-0.277E-01	0.939	1.01	307.5
320 - 345	18195	-0.187E-01	0.934	0.970	332.1
345 - 370	14534	0.537E-02	0.946	0.989	357.7
370 - 395	13780	0.203E-02	0.996	1.00	382.3
395 - 420	12751	-0.341E-01	0.953	0.989	407.3
420 - 445	11336	-0.140E-01	0.978	0.991	432.4
445 - 470	10925	-0.641E-02	0.968	0.975	457.2
470 - 495	9049	0.198E-01	0.913	0.990	481.8
495 - 520	7990	0.472E-01	0.928	0.975	508.2
520 - 545	7688	0.356E-01	0.874	0.985	531.1



1 INDICATOR VARIOGRAM
FOR CUTOFF = 0.500E-01

Zone 1 GOLD DATA

DATA USED IN CALCULATIONS

ANGLE = 85. DIP = 0. WINDOW = 35.	MEAN	= 0.620
CLASS SIZE = 25.	VARIANCE	= 0.236
MAX DISTANCE = 545.	STD DEVIATION	= 0.485
LOGARITHMS -NO	NO.OF SAMPLES =	1699

DISTANCE	# PAIRS	DRIFT	GAMMA (H)	X_GAMMA(H)	AVER DIST
0 - 15	131	0.687E-01	0.664	0.604	11.6
15 - 30	567	-0.564E-01	0.711	0.667	23.8
30 - 45	2349	0.643E-01	0.846	0.783	39.0
45 - 70	9247	0.554E-01	0.939	0.875	58.5
70 - 95	14285	0.951E-01	0.978	0.907	83.5
95 - 120	19471	0.806E-01	1.04	0.972	107.8
120 - 145	23144	0.767E-01	1.02	0.960	132.4
145 - 170	23379	0.296E-01	1.03	0.975	157.6
170 - 195	25339	0.345E-01	1.04	0.990	182.8
195 - 220	26949	0.346E-01	0.997	0.950	207.6
220 - 245	25652	-0.317E-01	1.02	0.984	232.4
245 - 270	25462	0.441E-01	1.05	1.01	257.2
270 - 295	21667	0.826E-02	1.02	0.984	282.4
295 - 320	21827	0.317E-01	1.05	1.02	307.5
320 - 345	18195	0.238E-01	1.01	0.996	332.1
345 - 370	14534	0.755E-01	1.01	1.01	357.7
370 - 395	13780	0.823E-01	0.980	1.01	382.3
395 - 420	12751	0.220E-01	0.988	1.02	407.3
420 - 445	11336	-0.181E-01	1.01	1.02	432.4
445 - 470	10925	-0.824E-03	0.988	1.01	457.2
470 - 495	9049	0.119E-01	1.01	1.00	481.8
495 - 520	7990	0.651E-01	0.898	0.919	508.2
520 - 545	7688	0.611E-01	0.936	0.919	531.1

```
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    0.100E+01 +       X *  * *  * *  *    *    *    X X   X  *
    0.949E+00 +     X  *
    0.897E+00 +   X *
    0.844E+00 +
G   0.791E+00 +   *
A   0.738E+00 +  X
M   0.686E+00 + X*
M   0.633E+00 + *
A   0.580E+00 +
    0.527E+00 +
    0.475E+00 +
*   0.422E+00 +
H   0.369E+00 +
*   0.316E+00 +
    0.264E+00 +
    0.211E+00 +
    0.158E+00 +
    0.105E+00 +
    0.527E-01 +
              +--------+---------+---------+---------+---------+------
              0.      100.      200.      300.      400.      500.
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1 INDICATOR VARIOGRAM
FOR CUTOFF = 0.100

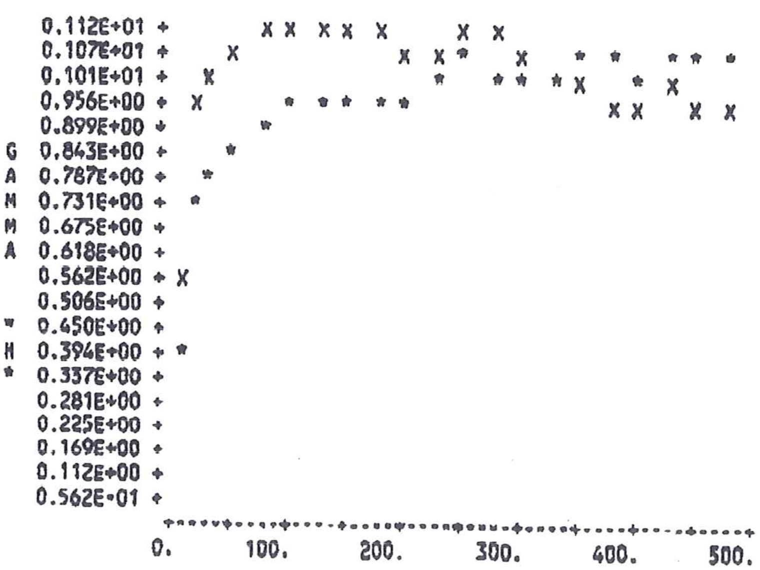
Zone 1 GOLD DATA

DATA USED IN CALCULATIONS

ANGLE = 85. DIP = 0. WINDOW = 35.
CLASS SIZE = 25.
MAX DISTANCE = 545.
LOGARITHMS =NO

MEAN = 0.725
VARIANCE = 0.200
STD DEVIATION = 0.447
NO.OF SAMPLES = 1699

DISTANCE	# PAIRS	DRIFT	GAMMA (H)	X GAMMA(H)	AVER DIST
0 - 15	131	0.763E-02	0.554	0.367	11.6
15 - 30	567	-0.670E-01	0.927	0.675	23.8
30 - 45	2349	0.438E-01	0.975	0.750	39.0
45 - 70	9247	0.552E-01	1.02	0.818	58.5
70 - 95	14285	0.977E-01	1.12	0.887	83.5
95 - 120	19471	0.837E-01	1.11	0.940	107.8
120 - 145	23144	0.763E-01	1.12	0.945	132.4
145 - 170	23379	0.468E-01	1.10	0.938	157.6
170 - 195	25339	0.524E-01	1.09	0.947	182.8
195 - 220	26949	0.445E-01	1.06	0.933	207.6
220 - 245	25652	-0.213E-01	1.06	0.975	232.4
245 - 270	25462	0.514E-01	1.12	1.03	257.2
270 - 295	21667	0.909E-02	1.07	1.00	282.4
295 - 320	21827	0.103E-01	1.05	1.01	307.5
320 - 345	18195	0.137E-01	1.01	1.01	332.1
345 - 370	14534	0.642E-01	0.991	1.02	357.7
370 - 395	13780	0.673E-01	0.905	1.02	382.3
395 - 420	12751	0.604E-02	0.930	1.01	407.3
420 - 445	11336	-0.243E-01	0.974	1.02	432.4
445 - 470	10925	-0.423E-01	0.948	1.03	457.2
470 - 495	9049	-0.619E-02	0.946	1.02	481.8
495 - 520	7990	0.161E-01	0.841	0.980	508.2
520 - 545	7688	0.260E-03	0.898	0.972	531.1



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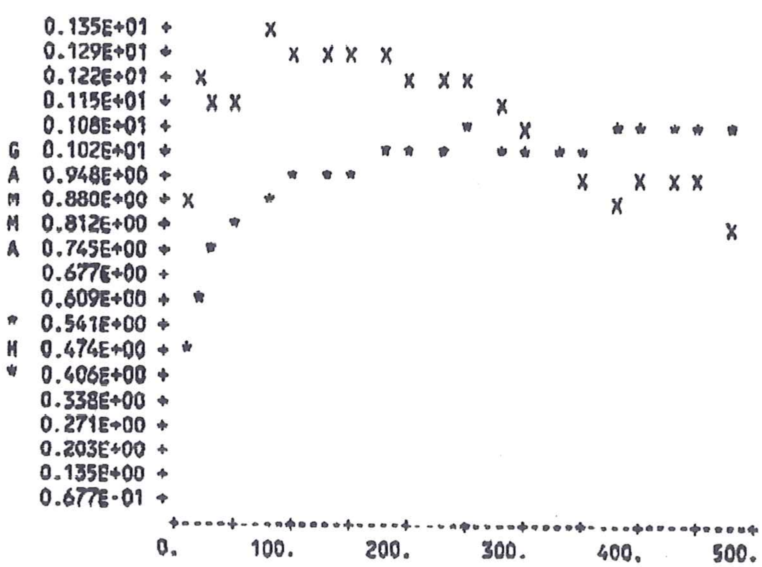
Zone 1 GOLD DATA

DATA USED IN CALCULATIONS

ANGLE = 85. DIP = 0. WINDOW = 35.
CLASS SIZE = 25.
MAX DISTANCE = 545.
LOGARITHMS -NO

MEAN = 0.830
VARIANCE = 0.141
STD DEVIATION = 0.375
NO.OF SAMPLES = 1699

DISTANCE	# PAIRS	DRIFT	GAMMA (H)	X_GAMMA(H)	AVER DIST
0 - 15	131	-0.229E-01	0.840	0.437	11.6
15 - 30	567	-0.265E-01	1.17	0.574	23.8
30 - 45	2349	0.187E-01	1.15	0.728	39.0
45 - 70	9247	0.454E-01	1.14	0.772	58.5
70 - 95	14285	0.752E-01	1.35	0.861	83.5
95 - 120	19471	0.776E-01	1.28	0.944	107.8
120 - 145	23144	0.716E-01	1.28	0.929	132.4
145 - 170	23379	0.474E-01	1.26	0.907	157.6
170 - 195	25339	0.433E-01	1.26	0.971	182.8
195 - 220	26949	0.374E-01	1.21	0.960	207.6
220 - 245	25652	-0.209E-01	1.17	1.01	232.4
245 - 270	25462	0.337E-01	1.20	1.06	257.2
270 - 295	21667	0.909E-02	1.11	1.01	282.4
295 - 320	21827	-0.994E-02	1.04	0.998	307.5
320 - 345	18193	-0.198E-02	1.01	1.01	332.1
345 - 370	14534	0.325E-01	0.918	1.01	357.7
370 - 395	13780	0.403E-01	0.851	1.03	382.3
395 - 420	12751	-0.132E-01	0.888	1.04	407.3
420 - 445	11336	-0.531E-01	0.946	1.05	432.4
445 - 470	10925	-0.667E-01	0.912	1.06	457.2
470 - 495	9049	-0.194E-01	0.806	1.02	481.8
495 - 520	7990	-0.476E-02	0.658	0.965	508.2
520 - 545	7688	-0.134E-01	0.784	0.937	531.1



1 INDICATOR VARIOGRAM
FOR CUTOFF = 0.500

Zone 1 GOLD DATA

ANGLE = 85. DIP = 0. WINDOW = 35.	**DATA USED IN CALCULATIONS**
CLASS SIZE = 25.	MEAN = 0.903
MAX DISTANCE = 545.	VARIANCE = 0.877E-01
LOGARITHMS -NO	STD DEVIATION = 0.296
	NO.OF SAMPLES = 1699

DISTANCE	# PAIRS	DRIFT	GAMMA (H)	X_GAMMA(H)	AVER DIST
0 - 15	131	-0.305E-01	1.22	0.458	11.6
15 - 30	567	0.106E-01	1.61	0.728	23.8
30 - 45	2349	0.200E-01	1.30	0.795	39.0
45 - 70	9247	0.269E-01	1.31	0.800	58.5
70 - 95	14285	0.412E-01	1.55	0.867	83.5
95 - 120	19471	0.553E-01	1.36	0.915	107.8
120 - 145	23144	0.454E-01	1.36	0.932	132.4
145 - 170	23379	0.431E-01	1.36	0.921	157.6
170 - 195	25339	0.269E-01	1.32	0.942	182.8
195 - 220	26949	0.262E-01	1.36	0.991	207.6
220 - 245	25652	-0.838E-02	1.21	0.994	232.4
245 - 270	25462	0.249E-01	1.20	1.02	257.2
270 - 295	21667	-0.106E-02	1.15	1.02	282.4
295 - 320	21827	-0.118E-01	0.995	0.987	307.5
320 - 345	18195	-0.324E-02	0.974	1.01	332.1
345 - 370	14534	0.131E-01	0.845	1.00	357.7
370 - 395	13780	0.166E-01	0.776	1.01	382.3
395 - 420	12751	-0.247E-01	0.807	1.02	407.3
420 - 445	11336	-0.367E-01	0.825	1.03	432.4
445 - 470	10925	-0.471E-01	0.842	1.03	457.2
470 - 495	9049	-0.167E-01	0.818	1.03	481.8
495 - 520	7990	-0.165E-01	0.582	0.969	508.2
520 - 545	7688	-0.287E-01	0.603	0.990	531.1

```
     0.161E+01 +  X     X
     0.153E+01 +
     0.145E+01 +
     0.137E+01 +  X X   X  X X  X X
     0.129E+01 + X                    X
G    0.121E+01 +                        X  X
A    0.113E+01 +
M    0.105E+01 +                  *  * *  * *  * *  * *  * *  *
M    0.965E+00 +        *  * *  *
A    0.884E+00 +      *
     0.804E+00 +  ** *                          X    X  X X  X
     0.724E+00 +                                   X
*    0.643E+00 +
H    0.563E+00 +
*    0.482E+00 + *
     0.402E+00 +
     0.322E+00 +
     0.241E+00 +
     0.161E+00 +
     0.804E-01 +
               +----+----+----+----+----+----+----+----+----+----+
               0.       100.      200.      300.      400.      500.
```

COPY

MINE DEVELOPMENT ASSOCIATES

MINE ENGINEERING SERVICES

SURPAC MINING SYSTEMS

DATE: September 11, 1996

TO: Charlie

FAX: 702-623-6967

FROM: Steven Ristorcelli

THIS TRANSMISSION CONSISTS OF 17 PAGES INCLUDING THIS COVER PAGE.

IF ALL PAGES ARE NOT RECEIVED, PHONE (702) 856-5700.

FAX NUMBER: (702) 856-6053

Charlie,

This fax is to paraphrase the conversation w/ Pete K. today and give you some more "support" data. Basically, the only valid point Santa Fe has is the estimation from variable length samples.

1. If there is a bias in the data, then there will be a bias in the kriging. The weighted averages by zone did not change significantly based on the fax I sent to you this morning. I am sending several sheets on the zones showing the statistics of all samples less than 2.5 ft in length (the point at which Pete K. starts to get concerned). I have looked at them and found that they are not terribly different from the stats of the corresponding zones in total. Don't forget, once we move out and cut the outliers it will result in lower means. As we stated, send Pete both files (assay and composite - down hole by rock type) and he will be the judge as to whether we should use 5 ft composites or assays. Consider compositing to 5 ft just to avoid having to constantly deal with these sorts of headaches. I don't feel it will materially affect the outcome, just the perception. And finally, there is no reason to work with 10 ft composites over 5 ft composites. Kriging will put valid grades in 10 ft blocks from 5 ft samples.
2. Pete used correlograms.
3. The comment on sub-blocking by Santa Fe is not applicable and therefore does not warrant a comment. However, Santa Fe's note on this is nonsense. Sub-blocking is for geometry only.
4. On his comment no. 5 in the Conclusions, Pete just shrugged it off as nonsense. I have asked him to comment on it in writing for you or to call you today. My comments are: kriging takes into account and compensates for clustered data. Second, we used zones because there is a radical change in local means. The zoning takes this into account and therefore in all our estimation domains we do have "stationarity of mean". And of coarse, the second half of this paragraph is also moot because we used the correlogram.

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_1:11

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	67	.064701	-.021620	.151023	4.3350	0.000000	2.90700	2.90700
AGAVG	67	2.535821	-.509497	5.581139	169.9000	0.000000	75.05000	75.05000
LENGTH	67	1.770149	1.624600	1.915699	118.6000	.300000	2.50000	2.20000

TOTAL Z11 0.019

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_1:11

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.1252	.35389	.043235	8.088548	.292836	65.90396	.577996
AGAVG	155.8739	12.48495	1.525279	5.624617	.292836	30.71450	.577996
LENGTH	.3561	.59671	.072900	-.769735	.292836	-.22525	.577996

			$\bar{m}$	SD
Z11	total	Au	0.019	0.679
		Ag	0.35	2.75
		Length	4.78	1.07

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_2:12							
Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	30	.134600	.074664	.194536	4.03800	0.000000	.80700	.80700
AGAVG	30	1.573667	.279591	2.867743	47.21000	0.000000	14.63000	14.63000
LENGTH	30	1.886667	1.705125	2.068208	56.60000	.600000	2.50000	1.90000

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_2:12						
Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.02576	.160511	.029305	2.788296	.426892	10.20313	.832746
AGAVG	12.01038	3.465599	.632729	3.105729	.426892	9.25076	.832746
LENGTH	.23637	.486177	.088763	-.798526	.426892	.45625	.832746

Z12	0.115	0.329
	1.45	2.81
	4.67	0.95

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_3:13

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	22	.652545	.005558	1.299533	14.3560	.004000	7.08500	7.08100
AGAVG	22	5.195000	1.032625	9.357375	114.2900	.040000	33.14000	33.10000
LENGTH	22	1.677273	1.332494	2.022051	36.9000	.200000	2.50000	2.30000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_3:13

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	2.12936	1.459233	.311110	4.456865	.490962	20.47442	.952780
AGAVG	88.13321	9.387929	2.001513	2.260857	.490962	4.17403	.952780
LENGTH	.60470	.777623	.165790	-.599855	.490962	-1.09765	.952780

Z13 0.409 0.503

4.36 8.05

4.65 1.16

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_4:14

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	14	1.086714	.512210	1.66122	15.21400	.013000	2.65500	2.64200
AGAVG	14	6.994286	-.099181	14.08775	97.92000	.160000	42.97000	42.81000
LENGTH	14	1.471429	1.085482	1.85737	20.60000	.400000	2.50000	2.10000

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_4:14

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.9901	.99501	.265929	.475894	.597380	-1.62392	1.154050
AGAVG	150.9348	12.28555	3.283452	2.455401	.597380	5.81033	1.154050
LENGTH	.4468	.66844	.178648	.132272	.597380	-1.03856	1.154050

Z 14 1.202 0.918
7.44 12.57
4.37 1.16

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_5:15							
Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	3	19.34133	-41.6631	80.34579	58.02400	2.975000	47.57900	44.60400
AGAVG	3	22.56333	-13.7702	58.89682	67.69000	8.770000	37.90000	29.13000
LENGTH	3	1.56667	-.0874	3.22069	4.70000	1.000000	2.30000	1.30000

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_5:15						
Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	603.0756	24.55760	14.17834	1.666996	1.224745	--	--
AGAVG	213.9256	14.62620	8.44444	.469546	1.224745	--	--
LENGTH	.4433	.66583	.38442	1.055832	1.224745	--	--

Z15 7.292 10.178
15.08 13.07
4.35

STAT. BASIC STATS — Descriptive Statistics (al19999.sta) by ZONE: G_6:21

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	40	.014575	.007683	.021467	.58300	0.000000	.114000	.114000
AGAVG	40	.456000	-.058947	.970947	18.24000	0.000000	7.950000	7.950000
LENGTH	40	1.785000	1.609150	1.960850	71.40000	.600000	2.500000	1.900000

STAT. BASIC STATS — Descriptive Statistics (al19999.sta) by ZONE: G_6:21

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.000464	.021549	.003407	2.973792	.373783	11.20121	.732600
AGAVG	2.592542	1.610137	.254585	4.319718	.373783	17.77601	.732600
LENGTH	.302333	.549848	.086939	-.573342	.373783	-.81862	.732600

Z 21 0.027 0.282
0.210 0.592
4.896

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_7:22

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	17	.163529	.055634	.271425	2.78000	.001000	.82200	.82100
AGAVG	17	2.248824	-.932085	5.429732	38.23000	.040000	25.94000	25.90000
LENGTH	17	1.935294	1.632783	2.237805	32.90000	.600000	2.50000	1.90000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_7:22

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.04404	.209852	.050897	2.25489	.549747	5.65850	1.063198
AGAVG	38.27528	6.186701	1.500496	3.94781	.549747	15.93977	1.063198
LENGTH	.34618	.588368	.142700	-1.05138	.549747	.09321	1.063198

Z 22 0.100 0.119

0.715 1.701

5.00

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_8:23

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	11	.512091	.116777	.907405	5.63300	.003000	2.055000	2.052000
AGAVG	11	1.232727	.394708	2.070746	13.56000	.060000	4.440000	4.380000
LENGTH	11	1.581818	1.074775	2.088861	17.40000	.200000	2.400000	2.200000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_8:23

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.346252	.588432	.177419	2.012456	.660687	4.789305	1.279416
AGAVG	1.556022	1.247406	.376107	1.883283	.660687	4.160826	1.279416
LENGTH	.569636	.754743	.227563	-.932233	.660687	.043244	1.279416

Z 23 0.364 0.453
1,86 3.59
4.68

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_9:24

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	2	.572000	-5.52698	6.670979	1.144000	.092000	1.052000	.960000
AGAVG	2	.640000	-.63062	1.910620	1.280000	.540000	.740000	.200000
LENGTH	2	2.000000	--	--	4.000000	2.000000	2.000000	0.000000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_9:24

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.460800	.678823	.480000	--	--	--	--
AGAVG	.020000	.141421	.100000	--	--	--	--
LENGTH	0.000000	0.000000	0.000000	--	--	--	--

Z 24 1.250 0.992
3.561 4.046
4.778

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_10:31

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	14	.024286	.010981	.037590	.34000	.001000	.073000	.072000
AGAVG	14	.150714	.035227	.266201	2.11000	.030000	.770000	.740000
LENGTH	14	1.850000	1.581322	2.118678	25.90000	.900000	2.500000	1.600000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_10:31

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.000531	.023043	.006159	.882547	.597380	-.229038	1.154050
AGAVG	.040007	.200018	.053457	2.731652	.597380	7.714764	1.154050
LENGTH	.216538	.465337	.124367	-.863027	.597380	.506188	1.154050

Z 31 0.020 0.022
0.15 0.32
4.75

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_11:32

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	5	.080200	.023331	.137069	.401000	.029000	.147000	.118000
AGAVG	5	.212000	.113681	.310319	1.060000	.140000	.340000	.200000
LENGTH	5	1.660000	.757762	2.562238	8.300000	.800000	2.500000	1.700000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_11:32

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.002098	.045801	.020483	.688155	.912871	-.20590	2.000000
AGAVG	.006270	.079183	.035412	1.324727	.912871	1.63298	2.000000
LENGTH	.528000	.726636	.324962	-.273938	.912871	-2.34440	2.000000

Z 32 0.075 0.063
0.471 1.444
4.767

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_12:33

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	2	.447000	-1.10316	1.997157	.894000	.325000	.569000	.244000
AGAVG	2	.695000	-.89328	2.283276	1.390000	.570000	.820000	.250000
LENGTH	2	1.600000	-3.48248	6.682482	3.200000	1.200000	2.000000	.800000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_12:33

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.029768	.172534	.122000	--	--	--	--
AGAVG	.031250	.176777	.125000	--	--	--	--
LENGTH	.320000	.565685	.400000	--	--	--	--

Z33 0.355 0.439
1.02 1.89
5.03

STAT. BASIC STATS	Descriptive Statistics (al19999.sta) by ZONE: G_13:34							
Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	1	1.753000	--	--	1.753000	1.753000	1.753000	--
AGAVG	1	2.440000	--	--	2.440000	2.440000	2.440000	--
LENGTH	1	1.000000	--	--	1.000000	1.000000	1.000000	--

STAT. BASIC STATS	Descriptive Statistics (al19999.sta) by ZONE: G_13:34						
Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	--	--	--	--	--	--	--
AGAVG	--	--	--	--	--	--	--
LENGTH	--	--	--	--	--	--	--

Z 34 1.399 1.547
2.95 4.00
4.79

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_14:41

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	14	.027643	-.004257	.059542	.38700	0.000000	.218000	.218000
AGAVG	14	.205714	.068002	.343427	2.88000	0.000000	.870000	.870000
LENGTH	14	1.642857	1.339259	1.946455	23.00000	.400000	2.500000	2.100000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_14:41

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.003052	.055249	.014766	3.632359	.597380	13.42695	1.154050
AGAVG	.056888	.238512	.063745	2.067220	.597380	4.29740	1.154050
LENGTH	.276484	.525817	.140531	-.878563	.597380	1.31034	1.154050

Z 41   0.017   0.028

0.18   0.363

4.62

no samples
for Z 42

STAT. BASIC STATS

Descriptive Statistics (all9999.sta)
by ZONE: G_15:43

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	1	.492000	--	--	.492000	.492000	.492000	--
AGAVG	1	.810000	--	--	.810000	.810000	.810000	--
LENGTH	1	1.100000	--	--	1.100000	1.100000	1.100000	--

STAT. BASIC STATS

Descriptive Statistics (all9999.sta)
by ZONE: G_15:43

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	--	--	--	--	--	--	--
AGAVG	--	--	--	--	--	--	--
LENGTH	--	--	--	--	--	--	--

Z 43 0.314 0.219
1.17 3.19
5.07

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_16:44

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	1	1.517000	--	--	1.517000	1.517000	1.517000	--
AGAVG	1	3.940000	--	--	3.940000	3.940000	3.940000	--
LENGTH	1	2.300000	--	--	2.300000	2.300000	2.300000	--

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_16:44

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	--	--	--	--	--	--	--
AGAVG	--	--	--	--	--	--	--
LENGTH	--	--	--	--	--	--	--

Z 44 0.747 0.851
1.95 2.14
3.90

COPY

School of Mines
Montana Tech
Memorandum

September 13, 1996

To:	Charlie Muerhoff, Steve Ristorcelli
From:	Pete Knudsen , Dean
Re:	Geostat questions

Concerns expressed by Santa Fe

1. Use of assay data violates Santa Fe's standard practices.
Comment;

It is important that all samples have the same support, ie., length. It is acceptable to use assay data as long as they have the same lengths. There is always some samples that will have shorter lengths, usually at the end of the hole. These can be ignored if they are very small, or used in the analysis if they are at least one half the length of the other samples. What must be avoided is the use of short samples that were expressly taken to sample a high grade structure. This will lead to a bias.

The resolution to this problem is to composite use down-the-hole composites of 5 feet length.

2. A relative variogram or correlogram may be more appropriate.
Comment;

Correlograms were calculated and converted to variograms.

3. Block Size. Santa Fe seems to worry that the sub - blocking ability of SURPAC2 will change the "variance". Also, Santa Fe seems to feel the composite length must be the same as the block height.
Comment;

Kriging can be done with composites hat are a different size than the block. Most software is not written for the case of the composites being longer than the block, but all of the software that I know of will correctly calculate the Kriging weights for samples that are a shorter length. What must be done is to use the correct block descritization. In the case of a 10 ft high block and 5 ft samples, the vertical descritization must be two!

Santa Fe's worries about sub-blocking revolve about a 'change of support'. The purpose of Kriging is to make optimal estimates of the grade of each block. A block that is on the edge of an ore zone should correctly model the geometry of the zone. That is why sub-blocks are used. We are not violating any principle of geostatistics by keeping and using on a portion of a block. Assume the original kriged block is say 25'x25'x10' but only 25'x12'x10' of the block is in the zone. If we use the same composites to estimate the full block, and then use them again to krige only the partial block, the kriged estimates will be very similar. The kriging variance will be almost the same in each case, because the main determinate of the kriging variance is the samples and their locations. In each case the same samples are used, hence the kriging variance will be nearly identical.

Santa Fe also makes the assumption that if the block size should change, a new size composite should be computed. This assumption is not true.

Hecla
MINING COMPANY

Post-it® Fax Note 7671	Date 9/18	# of pages ▶ 4
To Steve R.	From Charlie	
Co./Dept.	Co.	
Phone #	Phone #	
Fax #	Fax #	

Robin Hendrickson
SFPG Reno Exploration Office
250 South Rock Blvd.
Suite 100
Reno Nv. 89502

Sept. 16, 1996

Dear Robin:

We have reviewed your comments of September 4, 1996 and asked both Peter Knudsen and Steve Ristorcelli to review and comment on the same. Both of these gentlemen have been significantly involved in the Rosebud Mineral Resource estimation process. Charlie Muerhoff has summarized and consolidated those comments and our response.

Hecla, as well as many other mining companies, has experienced the ill effects of mineral resource models which give little attention to the geologic features which control mineralization. There are numerous examples of "reserve busts" resulting from mathematical models which don't attempt to represent controlling geologic features. Accurately interpreting and modeling the geologic controls has been a main focus of the delineation drilling and modeling employed at the Rosebud Project from the outset. Numerous in-house and outside experts have been involved in this program since inception. These techniques are not new in the broad sense but have been advanced to the needs of this particular ore body and underground mining methods. The model and techniques have been audited formally by two consulting firms one of which specializes in performing audits for financial institutions for the purposes of project financing and valuation.

Throughout this entire process the Rosebud Staff has been very open to constructive criticism and the model has significantly improved through the efforts, talents, and experience of the vast resource of people which have been a part of this effort. In continuing this process we are making a change in response to one of your suggestions and have supplied comments to the remainder as attachments to this letter.

Sincerely,
Ronald W. Clayton
Ronald W. Clayton
Rosebud Project General Mgr.

cc: George Johnson
Ron Parrat

HECLA MINING COMPANY
ROSEBUD PROJECT

September 16, 1996

Memorandum to: Ron Clayton

From: Charlie Muerhoff *Charlie*

RE: Response to SFPG Letter Regarding Rosebud Project Modeling, Dated 9/4/96

This memorandum is intended to address the conclusions and recommendations included in the letter sent to you by Skip McIntosh, SFPG regarding Rosebud Project Modeling, dated September 4, 1996. The letter was forwarded to Pete Knudsen and Steve Ristorcelli for their review; their comments have been incorporated into my response.

1. *SFPG: The modeling strategy currently being adopted (sub-blocking, assay based variograms and assay based interpolation) for the Rosebud model will most likely lead to an overestimation of the grade and ounces when applying a cutoff grade for mining.*

   Response: The use of assay data in geostatistics and for block estimation (regardless of the method) is acceptable as long as each sample has the same support, i.e., length. To resolve this problem, we will weight-average downhole assays to five-foot composites within gold domains. Since this will undoubtedly result in composites less than five-feet in length occurring at the margin of the domains, Pete Knudsen recommends using the composites which are at least one-half the length of the other samples (i.e., at least 2½ feet) and discarding those samples which are less than one-half the length of the other samples. Sub-blocking is addressed in item 3 below.

   In their examination of the data, SFPG uses the global population of South Zone drill samples rather than samples from the mineralized zone. Sample data from surface drill holes which include up to 600 feet of unmineralized rock has been included in their analysis. This affects the perceived bias to higher grades in the shorter assay intervals and unfairly accentuates this relationship. Steve Ristorcelli examined the relationship between shorter assay intervals and grades on a domain by domain basis and found the bias to be very minimal. In fact, in some of the higher grade zones, samples that are shorter than five feet actually have a lower average grade, rather than higher.

   SFPG: This is the problem which Lauren Roberts has described as being his experience at other operations i.e., the model has predicted more ounces than mining demonstrated.

   Response: I believe Lauren's comments have been taken out of context. This particular methodology has not been used at any of Hecla's operations until Rosebud. I used a very simplified version when modeling the GP Blanket at Republic and the model compared favorably to actual production, with an overall tonnage variance of -8% and gold ounce variance of +4% as compared to the actual tonnage and ounces produced.

   SFPG: The best way to eliminate the problems of changing support variograms and block sizes is to focus on "internal dilution" or the Volume Variance: change in support issues.

Response: As stated above, we will composite the data to five-foot sample lengths, negating the change in support issue. Block size is addressed in item 3 below.

2. *Composites should be used in the interpolation process. Grades should be estimated by Kriging, Inverse Distance power (...) and Nearest Neighbor methods. All three methods should be evaluated as a basis for mine planning.*

   Response: Ten-foot composites were used in previous resource calculations, and we will use five-foot composites for the current model. Surpac (and MEDS) will correctly calculate the Kriging weights for sample composites that are shorter than the size of the block. As far as the estimation method is concerned: just as we did for the 1995 Mineral Inventory, several estimation methods will be used as to evaluate the current model. For the 1995 model, six different iterations of the resource estimate were generated by Kriging, nearest neighbor, and manual polygonal methods. The Kriged model was selected for inclusion in the 1995 RMI and was used for the feasibility mine planning.

3. *SFPG: The block size should be held constant at a size equal to the appropriate SMU for an underground mining project.*

   Response: In general, I do not agree with this argument. Given the proper understanding of the deposit, combined with the ability to mine at highly variable widths and heights, block sizes should not be held constant for an underground mining situation. The block size should take into account the differing styles and geometry of the mineralization within a given deposit and the differing mining methods to be employed for the most efficient extraction.

   In regards to the current model, we are not planning to use sub-blocking (yet), but we are using partial blocks at the individual domain boundaries. The resultant whole block will receive the weighted average grade of those partial blocks which comprise it. Sub-blocking or partial blocking is for geometry purposes only and change of support is not an issue. Pete Knudsen described this to me as follows: "The purpose of Kriging is to make optimal estimates of the grade of each block. A block that is on the edge of an ore zone should correctly model the geometry of the zone. That is why sub-blocks are used. We are not violating any principle of geostatistics by keeping and using only a portion of a block. Assume the original kriged block is say 25'x25'x10' but only 25'x12'x10' of the block is in the zone. If we use the same composites to estimate the full block, and then use them again to krige only the partial block, the kriged estimates will be very similar. The kriging variance will be almost the same in each case, because the main determinate of the kriging variance is the samples and their locations. In each case the same samples are used, hence the kriging variance will be nearly identical."

4. *SFPG: Simplify the interpolation strategy minimum number of statistically supported mineral domains within 4 area domains instead of 19 different domains. Let the modeling define the grade distribution boundaries rather than trying to visually estimate them from the assays. There are inherent errors in the assays which could lead to bias in the grade zoning.*

   Response: We are currently using four area domains, with each subdivided into four or five grade population domains (total of 19 domains). The grade population domains are individually modeled to reflect their respective occurrences as they relate to style of mineralization and geologic control or their spatial relationship to particular stratigraphic units. If grade population boundaries coincide with recognizable geologic boundaries and controls, why let these boundaries be defined by geostatistics where grades will smear across their respective geologic boundary? GEOLOGY MUST BE HONORED. Our approach all along has been to model the grade populations (low-grade as well as high-grade) to the geology. The result is often sharp contrasts in grade at boundaries between high-grade and low-grade mineralization (the use of partial block composites at domain boundaries actually create a 'transitional' grade boundary over a block width), but this approach is applicable to the observed distribution and occurrence of mineralization in the Rosebud Deposit.

As you are aware, it has always been our intention to perform several estimations of the model using different types of methods, just as we did for the 1995 RMI model. We will include a model where the grade domain boundaries internal to the area domains will be disregarded.

As far as 'inherent errors in the assays' is concerned, I don't understand this statement. Any error that is inherent to the assays would also be included in the subsequent composite. Given the sample protocol used for core, and the minimal variance found in original assays vs. check assays vs. metallic screen assays vs. CN bottle roll results, I don't believe there are inherent errors in the core sample assays. In regards to LAC's reverse-circulation drilling, we have identified some downhole smearing, especially where high inflows of water were encountered. This has been taken into account when modeling the grade domains (assays from several holes were either restricted or eliminated completely based on conflicting data from nearby core holes).

5. *SFPG: The highly clustered spatial distribution of drilling samples and the high grade outliers in the distribution of values in the South Zone raises the problem of different local mean values within the densely drilled zones compared with the distal (lower grade zones). This condition would render the assumption of stationarity of the mean invalid. Hecla does not decluster the data before calculating variograms. The effect of clustering and non stationarity may be minimized by calculating the variogram using a method which reduces the effect of the local mean on the variogram curve. These methods include calculating a relative variogram, or using either the covariance or correlogram function to characterize the spatial continuity of the mineralization.*

   Response: One of the reasons the grade domain methodology was chosen was because of the observed radical changes in local means. Again, instead of smoothing data, we chose to model the variability of grades by separating recognized grade populations and modeling them individually. The use of grade domains takes the change in local means into account; there is a stationarity of the mean within each grade domain.

   Pete Knudsen did use correlograms and converted them to variograms.

Let me know if you have any questions.

enclosures: Pete Knudsen correspondence
Steve Ristorcelli correspondence & statistical analysis

Indicator Kriging Model of the the Rosebud Deposit

by

H. Peter Knudsen, Ph.D., P.E.

January 6, 1997

Prepared for

Mine Development Associates.

1.0 Introduction

Mine Development Associates contracted H. Peter Knudsen to develop a indicator krigingin model of the Rosebud Deposit. Work performed includes calculation of basic statistics, calculation and modeling of indicator variograms, and indicator kriging for four geologic/mineralogic zones of the deposit.

2.0 Data

The basic data used in this analysis consisted of 5ft composites prepared by Mine Development Associates. The data was grouped by MDA into four zones. Each zone was analyzed independently.

2.1 Zone 1

All data in zone 1 were grouped together. Indicator cutoffs were chosen based on the likely economic cutoffs and the need to retain definition in the high grade tail of the distribution. The cutoffs chosen are listed below.

Number	Cutoff Value	Cumulative Percent
1	0.05	63.7%
2	0.10	74.4%
3	0.15	80.0%
4	0.25	85.3%
5	0.40	89.2%
6	0.60	92.8%
7	1.00	95.9%
8	2.00	98.3%
9	3.00	99.3%
10	10.00	99.99%

Indicator variograms were calculated and modeled for each indicator cutoff. In general the variograms were well behaved and fairly easy to model. Anistropy was found in the lower cutoffs but as the cutoff increased the anisotropy became less apparent. The anistropy ellipsoid in oriented with the major axis at N5E with a dip of 30 degrees.

The variogram parameters for the grouped data from 12 to 15 are listed below. A nested spherical model was used as the variogram model.

Variogram Parameters for Zone 1

#	Co	C1	R1	C2	R2	Bearing	Dip	Tilt	Major AF	Minor AF

1	0.2	.45	30'	.35	150.’	5	0	30	1.5	1.5
2	0.2	.45	30'	.35	150.’	5	0	30	1.5	1.5
3	0.2	.4	30'	.4	150.’	5	0	30	1.5	1.5
4	0.2	.4	30'	.4	150.’	5	0	30	1.5	1.5
5	0.2	.4	30'	.4	150.’	5	0	30	1.5	1.5
6	0.25	.5	30'	.25	100'	5	0	30	1.0	1.0
7	0.5	.35	20'	.15	120'	5	0	30	1.0	1.5
8	0.6	.25	10'	.15	100'	5	0	30	1.0	1.0
9	0.6	.4	25'	0	0	5	0	30	1.0	1.5
10	1.0	0	0	0	0	0	0	0	1.0	1.0

The variogram for the 0.05opt cutoff is shown in Figure 1.

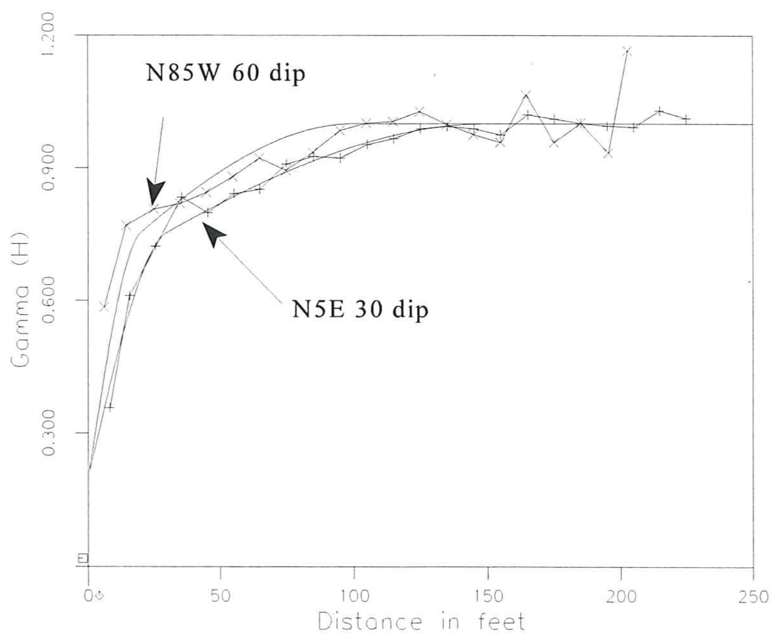


Figure 1. Zone 1 variograms for 0.05 opt cutoff.

2.2 Zone 2

For consistency in the modeling the same cutoffs were used for all zones. All the data from Zone 2 (21,22,23,24,and 25) were used. The zone 2 variograms are similar to zone 1, except the ansistropy between the plane of the structure and perpendicular to it is much stronger than in

Zone 1.

Variogram Parameters for Zone 2

#	Co	C1	R1	C2	R2	Bearing	Dip	Tilt	Major AF	Minor AF
1	0.4	.20	40'	.40	167.’	5	0	30	1.0	3
2	0.4	.20	30'	.40	167.’	5	0	30	1.0	3
3	0.2	.4	30'	.4	140.’	5	0	30	1.0	3.75
4	0.2	.45	25'	.35	150.’	5	0	30	1.25	5
5	0.2	.55	25'	.25	140.’	5	0	30	1.20	4.66
6	0.4	.4	15'	.20	100'	5	0	30	1.0	4.0
7	0.4	.4	15'	.20	100'	5	0	30	1.0	4.0
8	0.8	.20	30'	0	0	5	0	30	1.0	1.0
9	1.0	0	0	0	0	5	0	30	1.0	1.0
10	1.0	0	0	0	0	0	0	0	1.0	1.0

Figure 2 shows the variogram for the 0.05 cutoff.

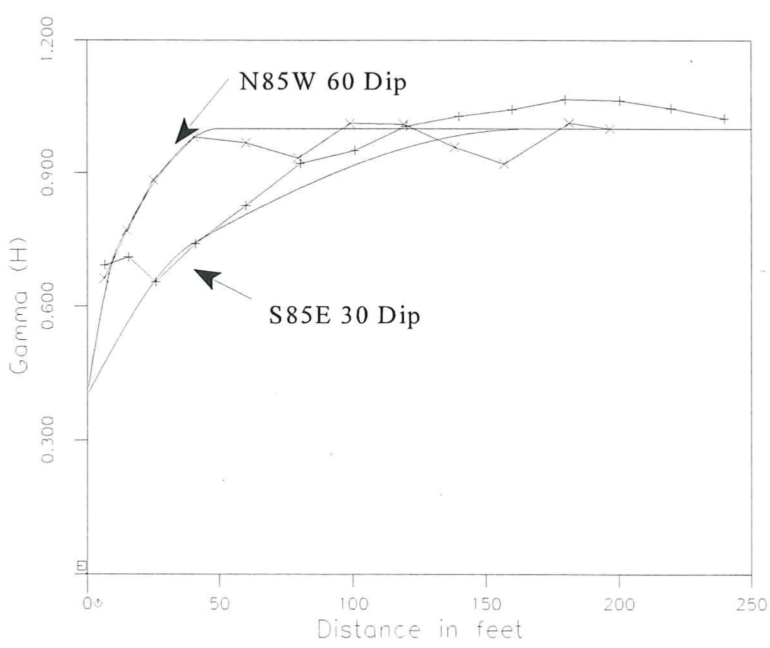


Figure 2. Zone 2 variogram for 0.05 opt cutoff.

2.3 Zone 3

The same cutoffs were used in zone 3 as in zones 1 and 2, with the exception that the highest cutoff used was 2.00 opt. The mineralization in zone 3 has a strong vertical continuity.

Variogram Parameters for Zone 3

#	Co	C1	R1	C2	R2	Bearing	Dip	Tilt	Major AF	Minor AF
1	0.4	.25	30'	.35	120.'	0	90	0	1.33	1
2	0.4	.25	30'	.35	120.'	0	90	0	1.33	1
3	0.3	.7	130	0	0	0	90	0	2.0	1
4	0.3	.7	130	0	0	0	90	0	2.0	1
5	0.3	.7	130	0	0	0	90	0	2.0	1
6	0.3	.6	115	0	0	0	90	0	2.0	1.0
7	0.7	.3	60'	0	0	0	90	0	2.0	1.0
8	0.8	.20	30'	0	0	0	90	0	1.0	1.0

The zone 3 variogram for cutoff 0.05 opt is shown below.

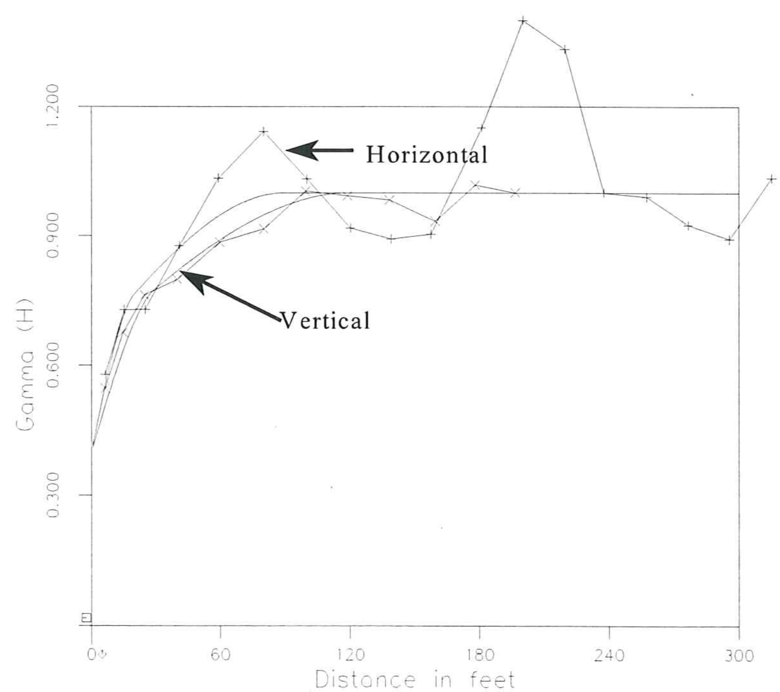


Figure 3. Zone 3 variogram for 0.05 opt cutoff.

2.4 Zone 4

The cutoffs used in zone 4 are different than in the other zones, because there are fewer high values in this zone.

Number	Cutoff Value	Cumulative Percent
1	0.025	63.7%
2	0.050	77.2%
3	0.100	83.1%
4	0.150	88.4%
5	0.250	93.3%
6	0.500	98.5%

Variogram Parameters for Zone 4

#	Co	C1	R1	Bearing	Dip	Tilt	Major AF	Minor AF
1	0.4	.60	160'	0	0	0	1.0	2.66
2	0.4	.60	80'	0	0	0	1.0	2.66
3	0.4	.60	80'	0	0	0	1.0	2.66
4	0.4	.60	80'	0	0	0	1.0	2.66
5	0.4	.60	80'	0	0	0	1.0	2.66
6	1.0	0	0	0	0	0	1.0	1.0

The zone 4 variogram for cutoff 0.025 opt is shown below.

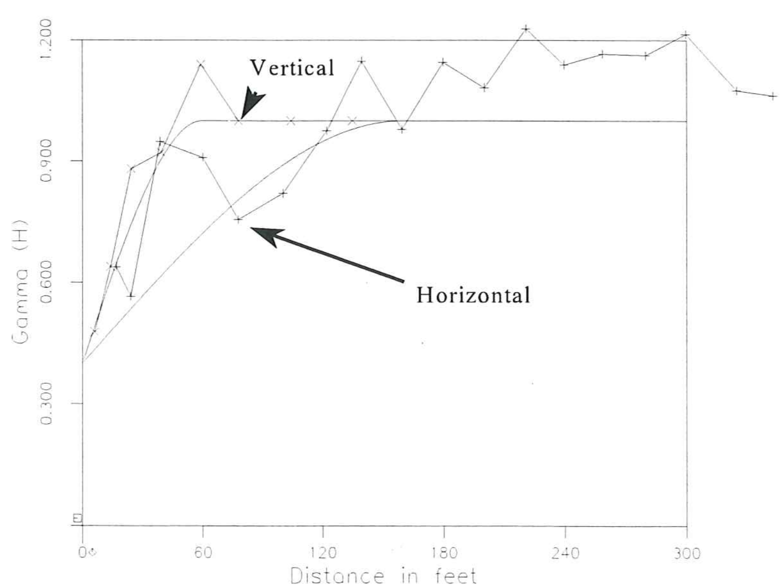


Figure 4. Zone 4 variograms for 0.025 opt cutoff.

3.0 Search Parameters Used

The maximum search radius used in all kriging runs was 150 ft and the vertical search distance was limited to 60 ft. The maximum number of samples used per block was 30 and the minimum used was 10.

Charlie
623-6967

facsimile
TRANSMITTAL

to: Steve Ristorcelli
fax #: 702-856-6053

re: Geostat comments
date: September 13, 1996
pages: 3, including this cover sheet.

Steve
Here are my comments about the questions raised by Santa Fe.
Thanks

From the desk of...

H. Peter Knudsen
Professor and Head, Mining Department
Montana Tech
1300 West Park St.
Butte, MT 59701 USA

1-406-496-4395
Fax: 1-406-496-4133

School of Mines
Montana Tech
Memorandum

September 13, 1996

To: Charlie Muerhoff, Steve Ristorcelli
From: Pete Knudsen . Dean
Re: Geostat questions

2.4
5 | 12

Concerns expressed by Santa Fe

1. Use of assay data violates Santa Fe's standard practices
Comment:

It is important that all samples have the same support,ie., length. It is acceptable to use assay data as long as they have the same lengths. There is always some samples that will have shorter lengths, usually at the end of the hole. These can be ignored if they are very small, or used in the analysis if they are at least one half the length of the other samples. What must be avoided is the use of short samples that were expressly taken to sample a high grade structure. This will lead to a bias.

The resolution to this problem is to composite use down-the-hole composites of 5 feet length.

2. A relative variogram or correlogram may be more appropriate.
Comment:

Correlograms were calculated and converted to variograms.

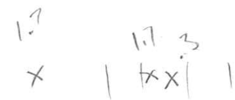
3. Block Size. Santa Fe seems to worry that the sub - blocking ability of SURPAC2 will change the "variance". Also, Santa Fe seems to feel the composite length must be the same as the block height.
Comment;

Kriging can be done withcomposites that are a different size than the block. Most software is not written for the case of the composites being longer than the block, but all of the software that I know of will correctly calculate the Kriging weights for samples that are a shorter length. What must be done is to use the correct block descritization. In the case of a 10 ft high block and 5 ft samples, the vertical descritization must be two!

inside the block, you can estimate any # of pts.
→ estimating two layers

Santa Fe's worries about sub-blocking revolve about a 'change of support'. The purpose of Kriging is to make optimal estimates of the grade of each block. A block that is on the edge of an ore zone should correctly model the geometry of the zone. That is why sub-blocks are used. We are not violating any principle of geostatistics by keeping and using on a portion of a block. Assume the original kriged block is say 25'x25'x10' but only 25'x12'x10' of the block is in the zone. If we use the same composites to estimate the full block, and then use them again to krige only the partial block, the kriged estimates will be very similar. The kriging variance will be almost the same in each case, because the main determinate of the kriging variance is the samples and their locations. In each case the same samples are used, hence the kriging variance will be nearly identical.

Santa Fe also makes the assumption that if the block size should change, a new size composite should be computed. This assumption is not true.



Meltin 1:00-2:00

MINE DEVELOPMENT ASSOCIATES
MINE ENGINEERING SERVICES
SURPAC MINING SYSTEMS

DATE: September 11, 1996
TO: Charlie
FAX: 702-623-6967
FROM: Steven Ristorcelli

THIS TRANSMISSION CONSISTS OF __17 PAGES INCLUDING THIS COVER PAGE.
IF ALL PAGES ARE NOT RECEIVED, PHONE (702) 856-5700.
FAX NUMBER: (702) 856-6053

Charlie,

This fax is to paraphrase the conversation w/ Pete K. today and give you some more "support" data. Basically, the only valid point Santa Fe has is the estimation from variable length samples.

1. If there is a bias in the data, then there will be a bias in the kriging. The weighted averages by zone did not change significantly based on the fax I sent to you this morning. I am sending several sheets on the zones showing the statistics of all samples less than 2.5 ft in length (the point at which Pete K. starts to get concerned). I have looked at them and found that they are not terribly different from the stats of the corresponding zones in total. Don't forget, once we move out and cut the outliers <u>it will result in lower means.</u> As we stated, send Pete both files (assay and composite - down hole by rock type) and he will be the judge as to whether we should use 5 ft composites or assays. Consider compositing to 5 ft just to avoid having to constantly deal with these sorts of headaches. I don't feel it will materially affect the outcome, just the perception. And finally, there is no reason to work with 10 ft composites over 5 ft composites. Kriging will put valid grades in 10 ft blocks from 5 ft samples.
2. Pete used correlograms.
3. The comment on sub-blocking by Santa Fe is not applicable and therefore does not warrant a comment. However, Santa Fe's note on this is nonsense. Sub-blocking is for geometry only.
4. On his comment no. 5 in the Conclusions, Pete just shrugged it off as nonsense. I have asked him to comment on it in writing for you or to call you today. My comments are: kriging takes into account and compensates for clustered data. Second, we used zones because there is a radical change in local means. The zoning takes this into account and therefore in all our estimation domains we do have "stationarity of mean". And of coarse, the second half of this paragraph is also moot because we used the correlogram.

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_1:11

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	67	.064701	-.021620	.151023	4.3350	0.000000	2.90700	2.90700
AGAVG	67	2.535821	-.509497	5.581139	169.9000	0.000000	75.05000	75.05000
LENGTH	67	1.770149	1.624600	1.915699	118.6000	.300000	2.50000	2.20000

TOTAL Z11 0.019

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_1:11

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.1252	.35389	.043235	8.088548	.292836	65.90396	.577996
AGAVG	155.8739	12.48495	1.525279	5.624617	.292836	30.71450	.577996
LENGTH	.3561	.59671	.072900	-.769735	.292836	-.22525	.577996

Z11 total		$\bar{m}$	SD
	Au	0.019	0.679
	Ag	0.35	2.75
	Length	4.78	1.07

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_2:12

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	30	.134600	.074664	.194536	4.03800	0.000000	.80700	.80700
AGAVG	30	1.573667	.279591	2.867743	47.21000	0.000000	14.63000	14.63000
LENGTH	30	1.886667	1.705125	2.068208	56.60000	.600000	2.50000	1.90000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_2:12

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.02576	.160511	.029305	2.788296	.426892	10.20313	.832746
AGAVG	12.01038	3.465599	.632729	3.105729	.426892	9.25076	.832746
LENGTH	.23637	.486177	.088763	-.798526	.426892	.45625	.832746

Z12

Z12	0.115	0,329
	1.45	2,81
	4.67	0,95

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_3:13							
Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	22	.652545	.005558	1.299533	14.3560	.004000	7.08500	7.08100
AGAVG	22	5.195000	1.032625	9.357375	114.2900	.040000	33.14000	33.10000
LENGTH	22	1.677273	1.332494	2.022051	36.9000	.200000	2.50000	2.30000

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_3:13						
Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	2.12936	1.459233	.311110	4.456865	.490962	20.47442	.952780
AGAVG	88.13321	9.387929	2.001513	2.260857	.490962	4.17403	.952780
LENGTH	.60470	.777623	.165790	-.599855	.490962	-1.09765	.952780

Z13 0.409 0.503
4.36 8.05
4.65 1.16

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_4:14

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	14	1.086714	.512210	1.66122	15.21400	.013000	2.65500	2.64200
AGAVG	14	6.994286	-.099181	14.08775	97.92000	.160000	42.97000	42.81000
LENGTH	14	1.471429	1.085482	1.85737	20.60000	.400000	2.50000	2.10000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_4:14

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.9901	.99501	.265929	.475894	.597380	-1.62392	1.154050
AGAVG	150.9348	12.28555	3.283452	2.455401	.597380	5.81033	1.154050
LENGTH	.4468	.66844	.178648	.132272	.597380	-1.03856	1.154050

Z 14 1.202 0.918
7.44 12.57
4.37 1.16

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_5:15

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	3	19.34133	-41.6631	80.34579	58.02400	2.975000	47.57900	44.60400
AGAVG	3	22.56333	-13.7702	58.89682	67.69000	8.770000	37.90000	29.13000
LENGTH	3	1.56667	-.0874	3.22069	4.70000	1.000000	2.30000	1.30000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_5:15

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	603.0756	24.55760	14.17834	1.666996	1.224745	--	--
AGAVG	213.9256	14.62620	8.44444	.469546	1.224745	--	--
LENGTH	.4433	.66583	.38442	1.055832	1.224745	--	--

Z15 7.292 10.178
15.08 13.07
4.35

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_6:21

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	40	.014575	.007683	.021467	.58300	0.000000	.114000	.114000
AGAVG	40	.456000	-.058947	.970947	18.24000	0.000000	7.950000	7.950000
LENGTH	40	1.785000	1.609150	1.960850	71.40000	.600000	2.500000	1.900000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_6:21

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.000464	.021549	.003407	2.973792	.373783	11.20121	.732600
AGAVG	2.592542	1.610137	.254585	4.319718	.373783	17.77601	.732600
LENGTH	.302333	.549848	.086939	-.573342	.373783	-.81862	.732600

Z 21 0.027 0.282
0.210 0.592
4.896

STAT. BASIC STATS	Descriptive Statistics (al19999.sta) by ZONE: G_7:22

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	17	.163529	.055634	.271425	2.78000	.001000	.82200	.82100
AGAVG	17	2.248824	-.932085	5.429732	38.23000	.040000	25.94000	25.90000
LENGTH	17	1.935294	1.632783	2.237805	32.90000	.600000	2.50000	1.90000

STAT. BASIC STATS	Descriptive Statistics (al19999.sta) by ZONE: G_7:22

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.04404	.209852	.050897	2.25489	.549747	5.65850	1.063198
AGAVG	38.27528	6.186701	1.500496	3.94781	.549747	15.93977	1.063198
LENGTH	.34618	.588368	.142700	-1.05138	.549747	.09321	1.063198

Z 22 0.100 0.119
0.715 1.701
5.00

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_8:23

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	11	.512091	.116777	.907405	5.63300	.003000	2.055000	2.052000
AGAVG	11	1.232727	.394708	2.070746	13.56000	.060000	4.440000	4.380000
LENGTH	11	1.581818	1.074775	2.088861	17.40000	.200000	2.400000	2.200000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_8:23

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.346252	.588432	.177419	2.012456	.660687	4.789305	1.279416
AGAVG	1.556022	1.247406	.376107	1.883283	.660687	4.160826	1.279416
LENGTH	.569636	.754743	.227563	-.932233	.660687	.043244	1.279416

Z 23 0.364 0.453
1.86 3.59
4.68

STAT. BASIC STATS — Descriptive Statistics (all9999.sta)
by ZONE: G_9:24

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	2	.572000	-5.52698	6.670979	1.144000	.092000	1.052000	.960000
AGAVG	2	.640000	-.63062	1.910620	1.280000	.540000	.740000	.200000
LENGTH	2	2.000000	--	--	4.000000	2.000000	2.000000	0.000000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta)
by ZONE: G_9:24

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.460800	.678823	.480000	--	--	--	--
AGAVG	.020000	.141421	.100000	--	--	--	--
LENGTH	0.000000	0.000000	0.000000	--	--	--	--

Z 24 1.250 0.992
3.561 4.046
4.778

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_10:31

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	14	.024286	.010981	.037590	.34000	.001000	.073000	.072000
AGAVG	14	.150714	.035227	.266201	2.11000	.030000	.770000	.740000
LENGTH	14	1.850000	1.581322	2.118678	25.90000	.900000	2.500000	1.600000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_10:31

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.000531	.023043	.006159	.382547	.597380	-.229038	1.154050
AGAVG	.040007	.200018	.053457	2.731652	.597380	7.714764	1.154050
LENGTH	.216538	.465337	.124367	-.863027	.597380	.506188	1.154050

Z 31 0.020 0.022
0.15 0.32
4.75

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_11:32							
Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	5	.080200	.023331	.137069	.401000	.029000	.147000	.118000
AGAVG	5	.212000	.113681	.310319	1.060000	.140000	.340000	.200000
LENGTH	5	1.660000	.757762	2.562238	8.300000	.800000	2.500000	1.700000

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_11:32						
Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.002098	.045801	.020483	.688155	.912871	-.20590	2.000000
AGAVG	.006270	.079183	.035412	1.324727	.912871	1.63298	2.000000
LENGTH	.528000	.726636	.324962	-.273938	.912871	-2.34440	2.000000

Z 32 0.075 0.063
0.471 1.444
4.767

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_12:33

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	2	.447000	-1.10316	1.997157	.894000	.325000	.569000	.244000
AGAVG	2	.695000	-.89328	2.283276	1.390000	.570000	.820000	.250000
LENGTH	2	1.600000	-3.48248	6.682482	3.200000	1.200000	2.000000	.800000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_12:33

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.029768	.172534	.122000	--	--	--	--
AGAVG	.031250	.176777	.125000	--	--	--	--
LENGTH	.320000	.565685	.400000	--	--	--	--

Z33 0.355 0.439
1.02 1.89
5.03

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_13:34							
Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	1	1.753000	--	--	1.753000	1.753000	1.753000	--
AGAVG	1	2.440000	--	--	2.440000	2.440000	2.440000	--
LENGTH	1	1.000000	--	--	1.000000	1.000000	1.000000	--

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_13:34						
Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	--	--	--	--	--	--	--
AGAVG	--	--	--	--	--	--	--
LENGTH	--	--	--	--	--	--	--

Z 34 1.399 1.547
2.95 4.00
4.79

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_14:41

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	14	.027643	-.004257	.059542	.38700	0.000000	.218000	.218000
AGAVG	14	.205714	.068002	.343427	2.88000	0.000000	.870000	.870000
LENGTH	14	1.642857	1.339259	1.946455	23.00000	.400000	2.500000	2.100000

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_14:41

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	.003052	.055249	.014766	3.632359	.597380	13.42695	1.154050
AGAVG	.056888	.238512	.063745	2.067220	.597380	4.29740	1.154050
LENGTH	.276484	.525817	.140531	-.878563	.597380	1.31034	1.154050

Z 41 0.017 0.028
0.18 0.363
4.62

no samples
for Z 42

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_15:43

Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	1	.492000	--	--	.492000	.492000	.492000	--
AGAVG	1	.810000	--	--	.810000	.810000	.810000	--
LENGTH	1	1.100000	--	--	1.100000	1.100000	1.100000	--

STAT. BASIC STATS — Descriptive Statistics (all9999.sta) by ZONE: G_15:43

Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	--	--	--	--	--	--	--
AGAVG	--	--	--	--	--	--	--
LENGTH	--	--	--	--	--	--	--

Z43 0.314 0.219
1.17 3.19
5.07

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_16:44							
Variable	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
AUAVG2	1	1.517000	--	--	1.517000	1.517000	1.517000	--
AGAVG	1	3.940000	--	--	3.940000	3.940000	3.940000	--
LENGTH	1	2.300000	--	--	2.300000	2.300000	2.300000	--

STAT. BASIC STATS	Descriptive Statistics (all9999.sta) by ZONE: G_16:44						
Variable	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
AUAVG2	--	--	--	--	--	--	--
AGAVG	--	--	--	--	--	--	--
LENGTH	--	--	--	--	--	--	--

Z 44   0.747   0.851
       1.95   2.14
       3.90

facsimile
TRANSMITTAL

to: Charlie Muerhoff
fax #: 702-623-6967
re: Geostat comments
date: September 13, 1996
pages: 3, including this cover sheet.

Charlie,
Here are my comments about the questions raised by Santa Fe.
Thanks

From the desk of...

H. Peter Knudsen
Professor and Head, Mining Department
Montana Tech
1300 West Park St.
Butte, MT 59701 USA

1-406-496-4395
Fax: 1-406-496-4133

School of Mines
Montana Tech
Memorandum

September 13, 1996

To: Charlie Muerhoff, Steve Ristorcelli
From: Pete Knudsen , Dean
Re: Geostat questions

Concerns expressed by Santa Fe

1. Use of assay data violates Santa Fe's standard practices
Comment;

It is important that all samples have the same support, ie., length. It is acceptable to use assay data as long as they have the same lengths. There is always some samples that will have shorter lengths, usually at the end of the hole. These can be ignored if they are very small, or used in the analysis if they are at least one half the length of the other samples. What must be avoided is the use of short samples that were expressly taken to sample a high grade structure. This will lead to a bias.

The resolution to this problem is to composite use down-the-hole composites of 5 feet length.

2. A relative variogram or correlogram may be more appropriate.
Comment;

Correlograms were calculated and converted to variograms.

3. Block Size. Santa Fe seems to worry that the sub - blocking ability of SURPAC2 will change the "variance". Also, Santa Fe seems to feel the composite length must be the same as the block height.
Comment;

Kriging can be done with composites that are a different size than the block. Most software is not written for the case of the composites being longer than the block, but all of the software that I know of will correctly calculate the Kriging weights for samples that are a shorter length. What must be done is to use the correct block descritization. In the case of a 10 ft high block and 5 ft samples, the vertical descritization must be two!

Santa Fe's worries about sub-blocking revolve about a 'change of support'. The purpose of Kriging is to make optimal estimates of the grade of each block. A block that is on the edge of an ore zone should correctly model the geometry of the zone. That is why sub-blocks are used. We are not violating any principle of geostatistics by keeping and using on a portion of a block. Assume the original kriged block is say 25'x25'x10' but only 25'x12'x10' of the block is in the zone. If we use the same composites to estimate the full block, and then use them again to krige only the partial block, the kriged estimates will be very similar. The kriging variance will be almost the same in each case, because the main determinate of the kriging variance is the samples and their locations. In each case the same samples are used, hence the kriging variance will be nearly identical.

Santa Fe also makes the assumption that if the block size should change, a new size composite should be computed. This assumption is not true.