

Biogeochemical Exploration in Arid Terrains

An Example from the Rosebud Mine
Pershing County, Nevada

Shea Clark Smith
Minerals Exploration & Environmental Geochemistry



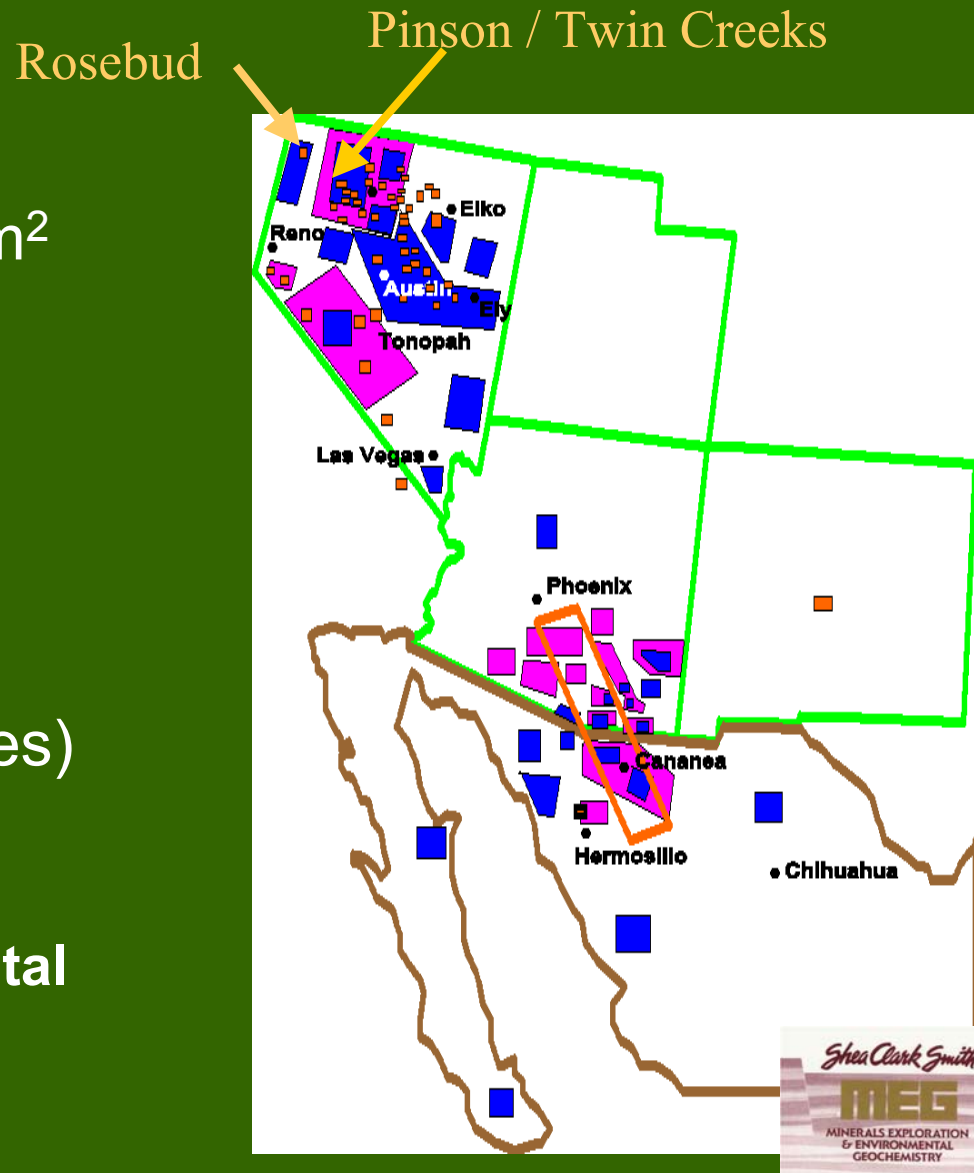
Biogeochemistry in the Search for Mineral Deposits

Dublin, Ireland

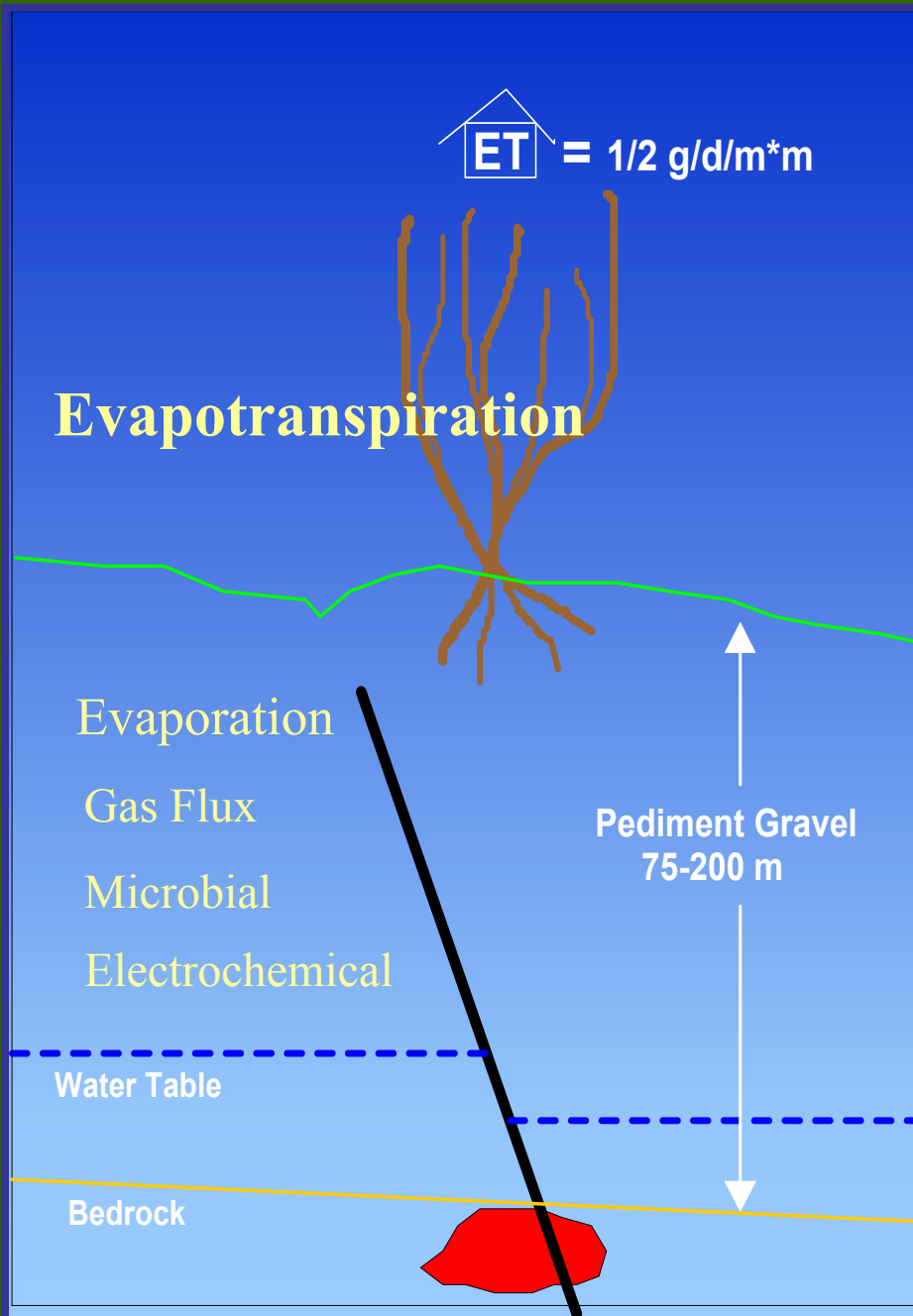
September 2, 2003

20 yrs of Biogeochemistry

- Low density: 1-5 per Km²
- Detail: 30 m centers
- AZ: 16,000
- NV: 56,500
- MX: 7,000
- TOTAL: 300,000
 - (all sources, all states)
- **Baseline for further exploration / environmental**





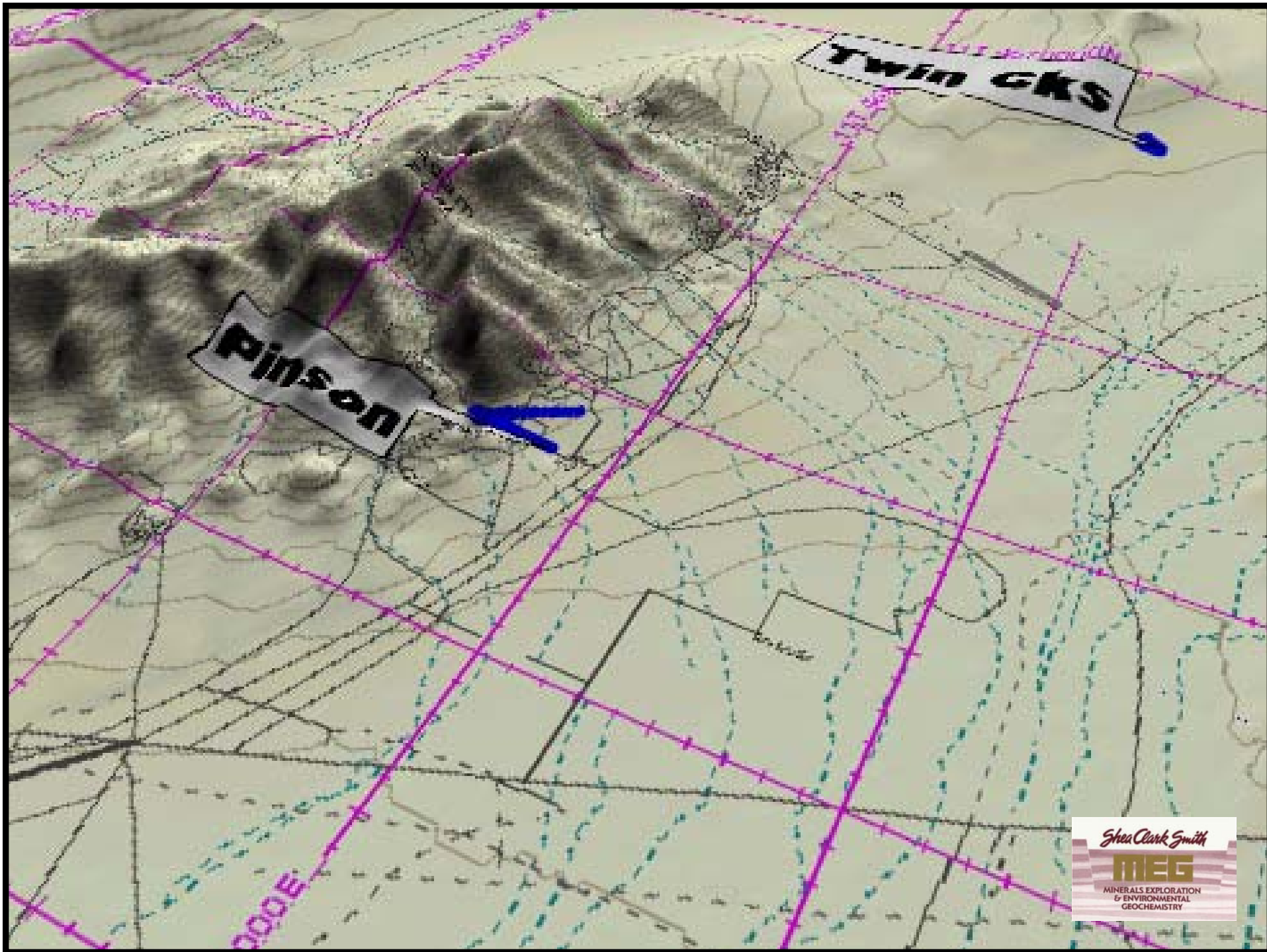


Biogeochemistry

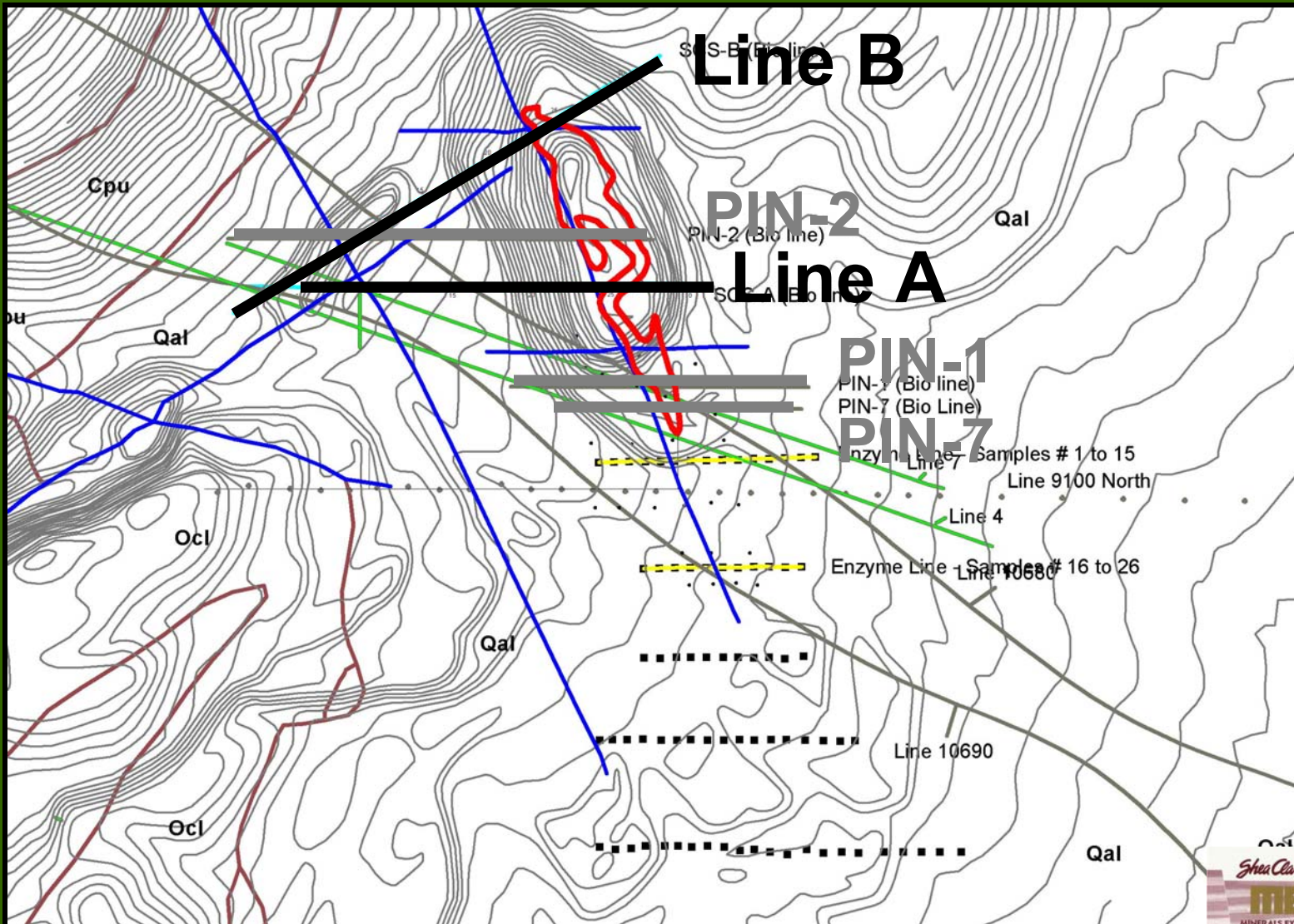
- **Water / Rock interaction**
- **Ion migration**
 - Push / Pull
 - Structure pathways
- **Evapotranspiration**
- **Passive trace metal uptake**
 - Active nutrient uptake
- **Dynamic metal flushing**
- **Accumulation in tissue**
- **Soil / Plant metal cycling**



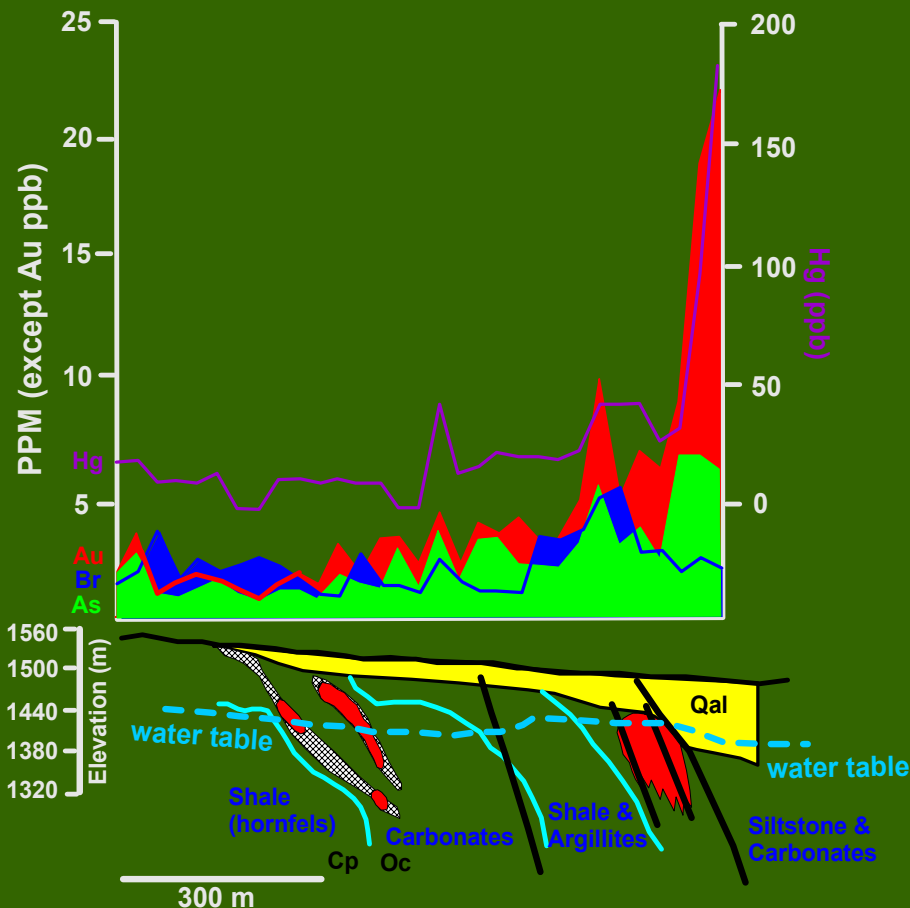
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Pinson Mine: Mag Deposit



Pinson Mine, Mag Deposit Humboldt County, Nevada

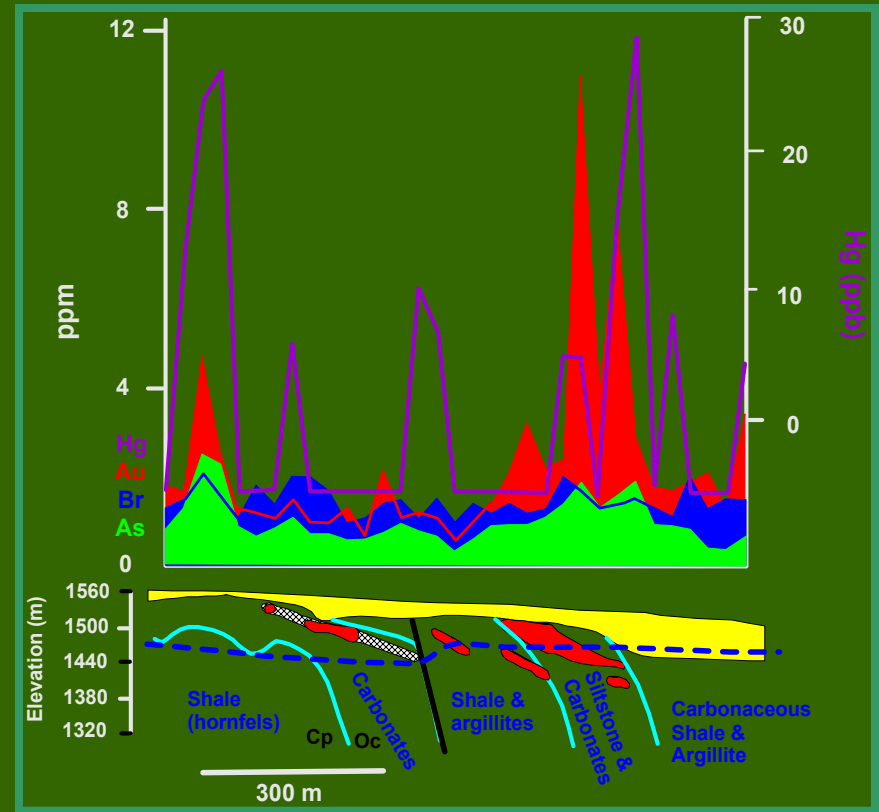
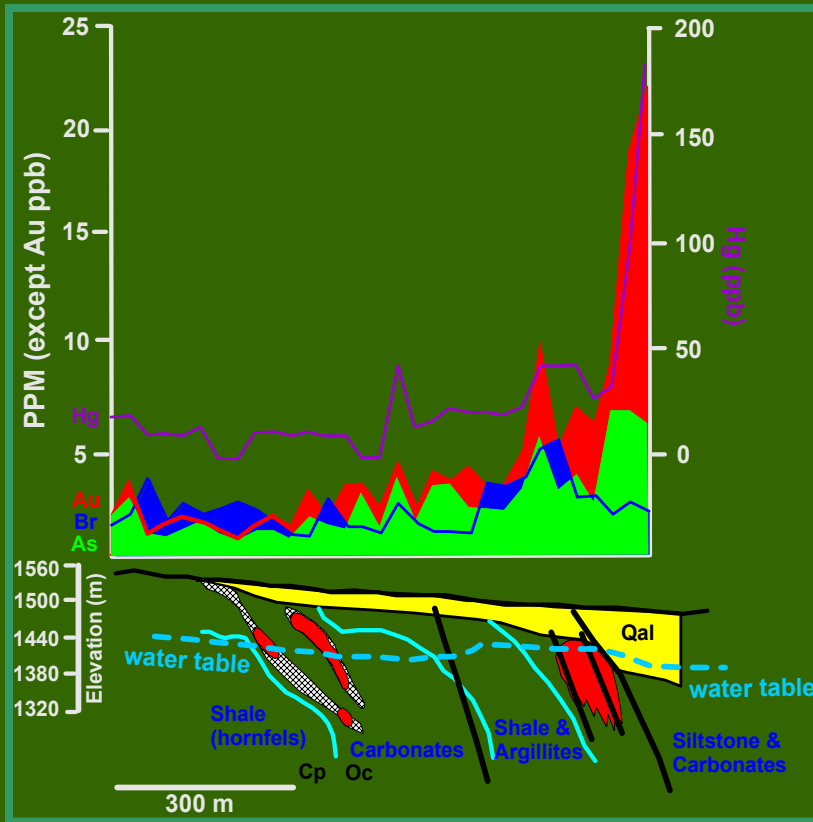


- **Host:** Ord. Comus Fm.
- **CX:** low angle shear
- **Mag:** high angle replacement
- **Overburden:** barren Qal
 – 12 to 60 meters
- **G Water:** 65-105 m
- **Sagebrush:** 1985, 1986
- **JGE:** 1992, **GSN:** 1994

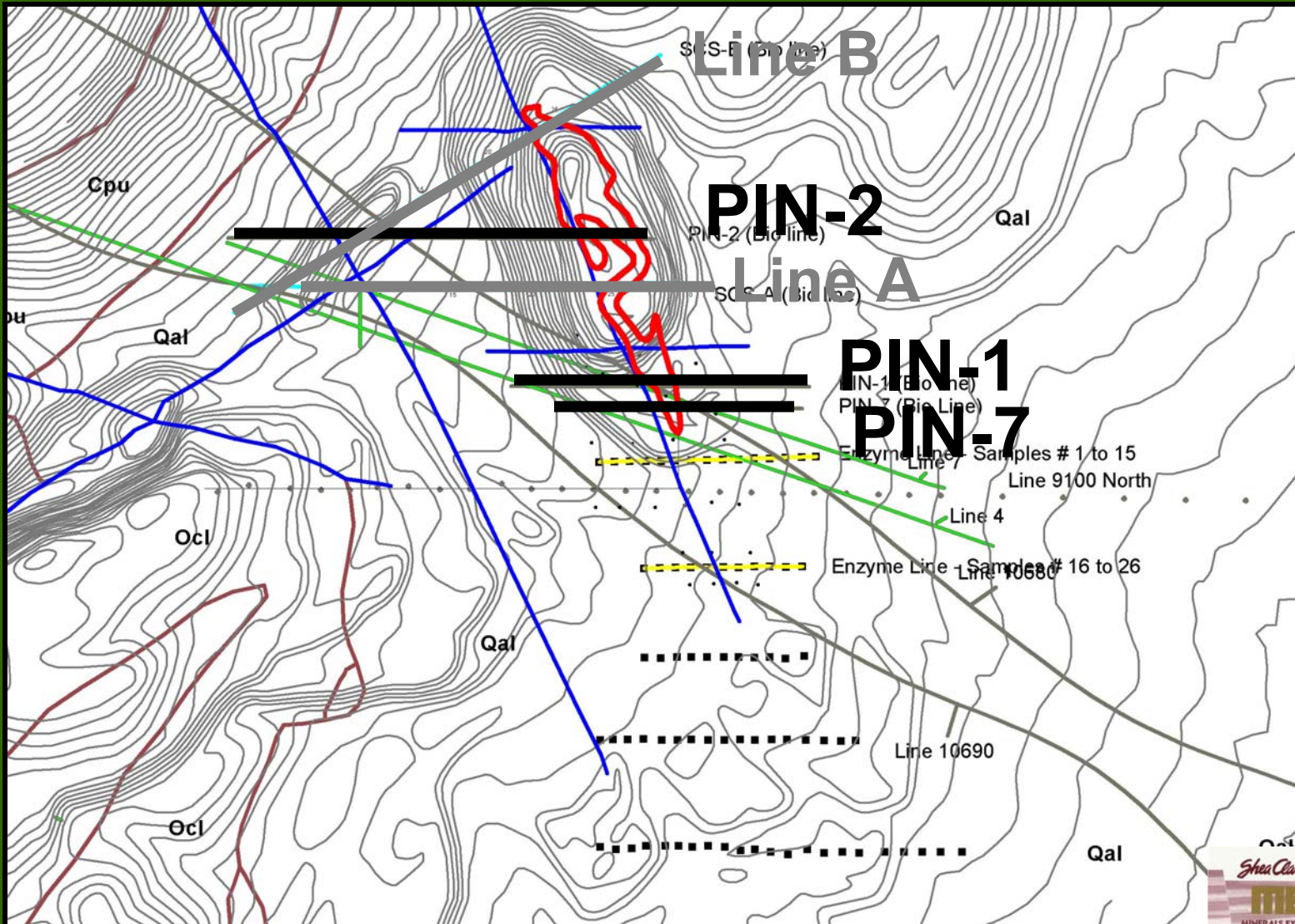
Pinson Mine, Mag Deposit Humboldt County, Nevada

LINE A: EAST-WEST

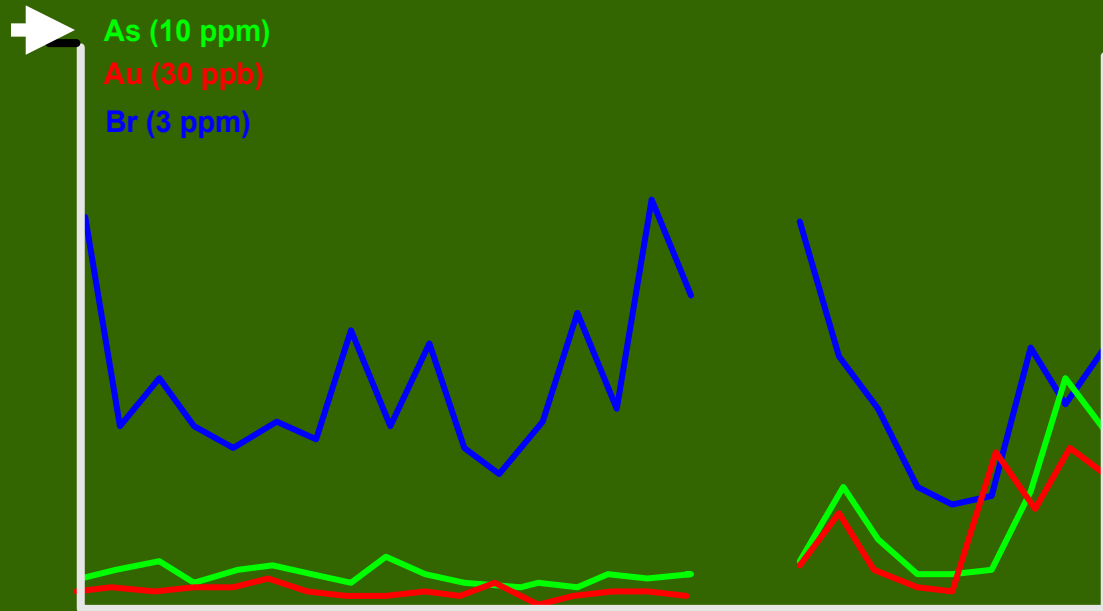
LINE B: NE - SW



Pinson Mine: Mag Deposit



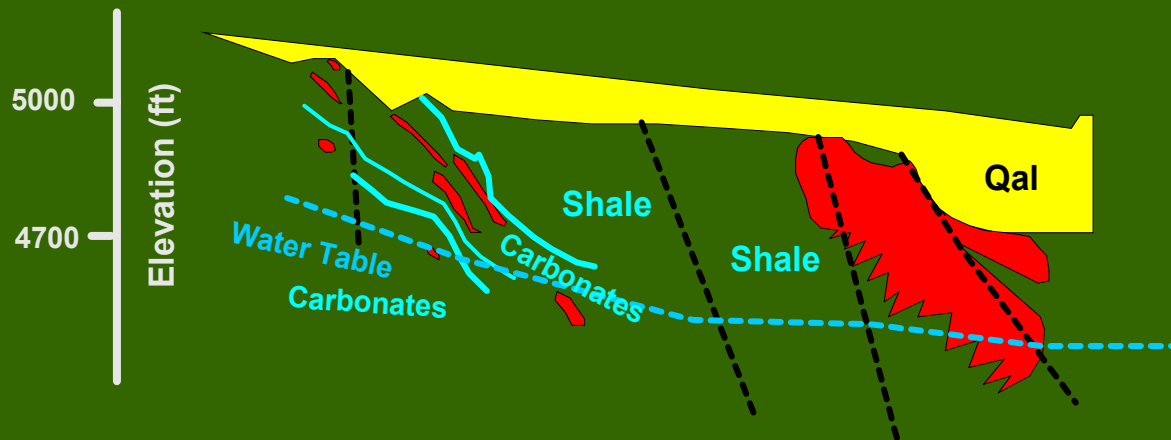
Pinson Mine: Line PIN-2



As = 10 ppm

Au = 30 ppb

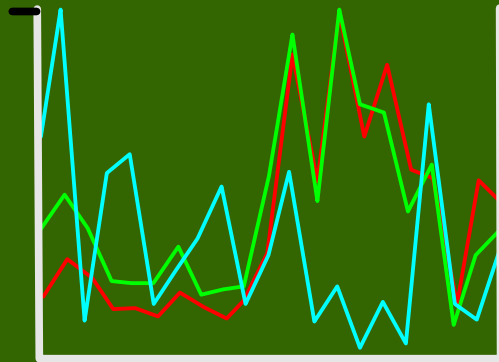
Br = 3 ppm



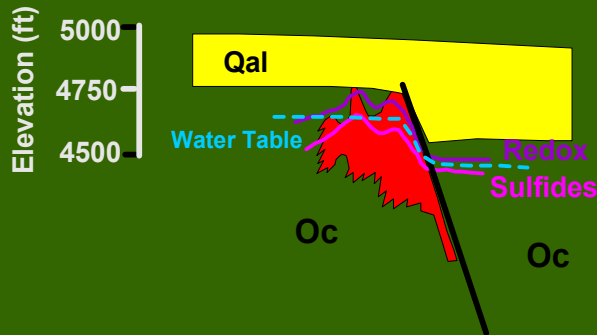
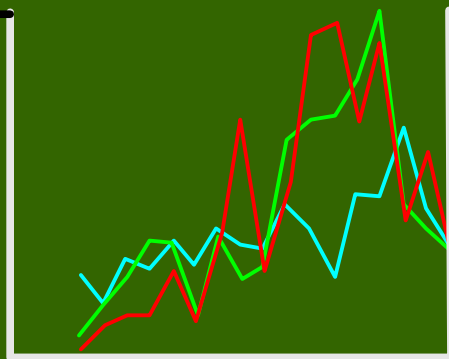
Water table

100 meters

Au (30 ppb)
 As (10 ppm)
 Br (3 ppm)



Au (4ppb)
 As (1.3 ppm)
 Br (3 ppm)



Au = 30 ppb

As = 10 ppm

Br = 3 ppm

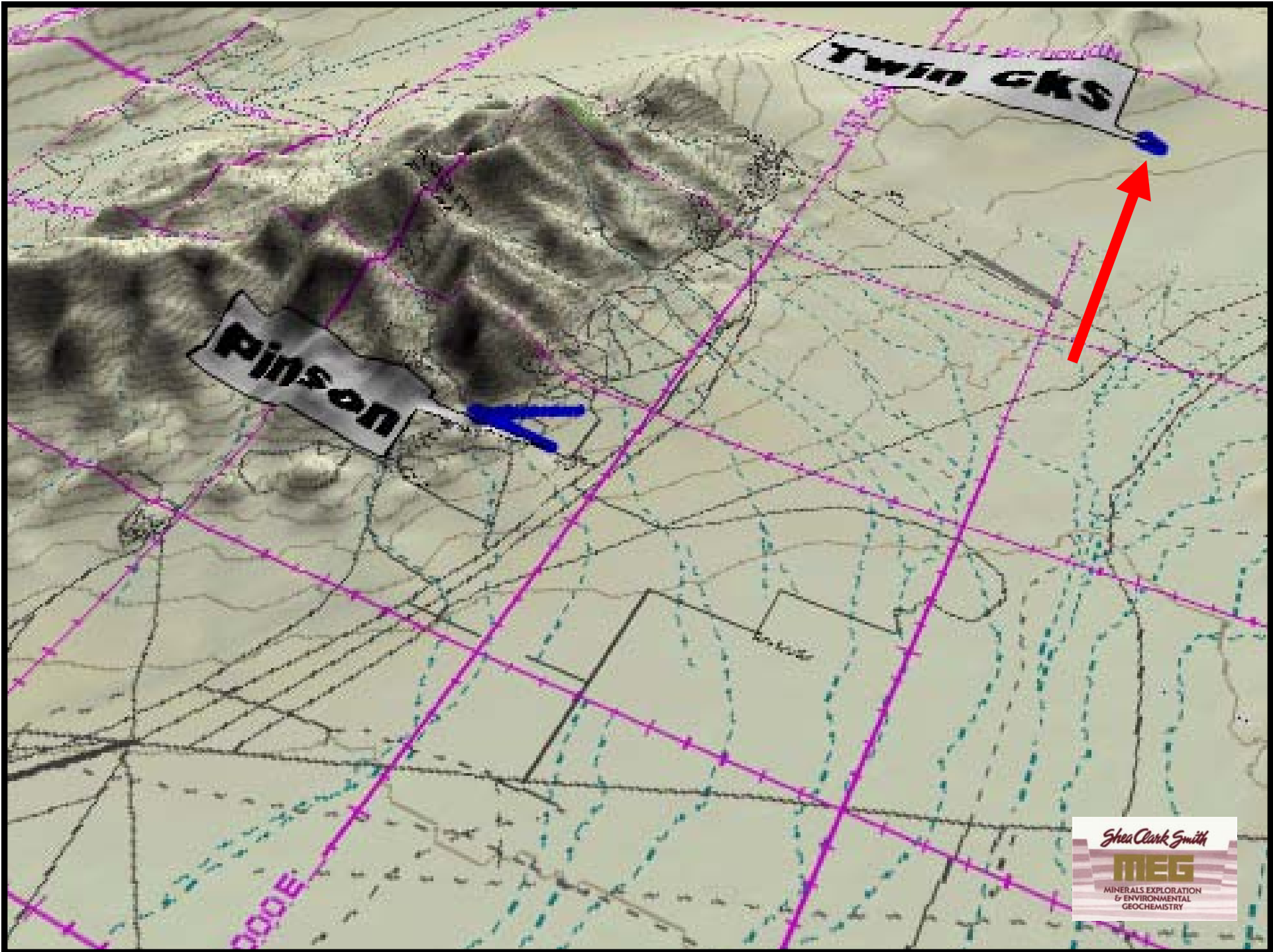
Au = 4 ppb

As = 1.3 ppm

Br = 3 ppm

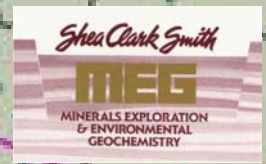
Pinson Mine:

Mag Deposit: Lines PIN-1 & 7



Pinson

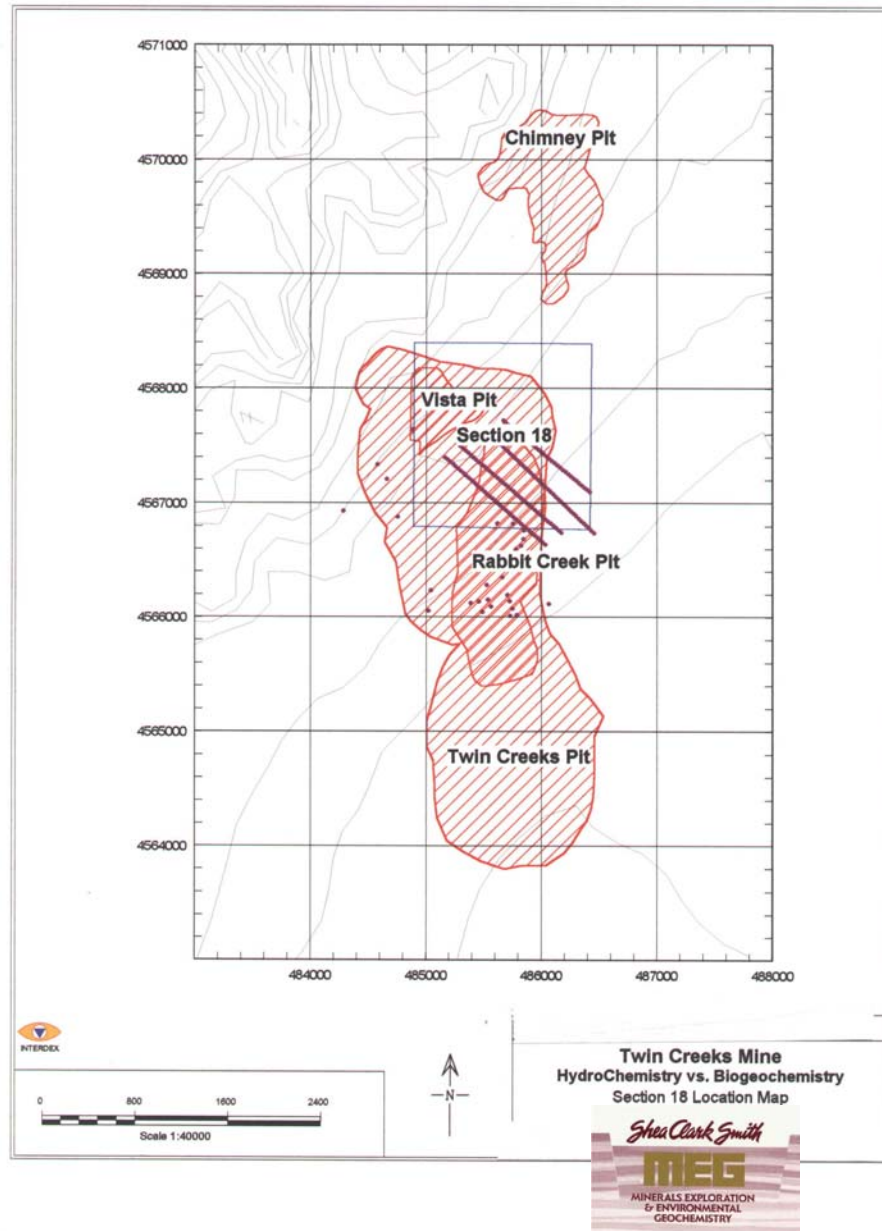
Twin GKS



Twin Creeks Mine

Humboldt County, Nevada

- **Host:** E. Ord. Comus Fm.
Calcareous Shale
- **Overburden:** barren Qal
 - 12 to 200 meters
- **G Water:** +/- 50 meters
- **Bedrock:** +/- 150 meters
- **Redox:** +/- 250 meters
- **Sagebrush:** 1984, 1985



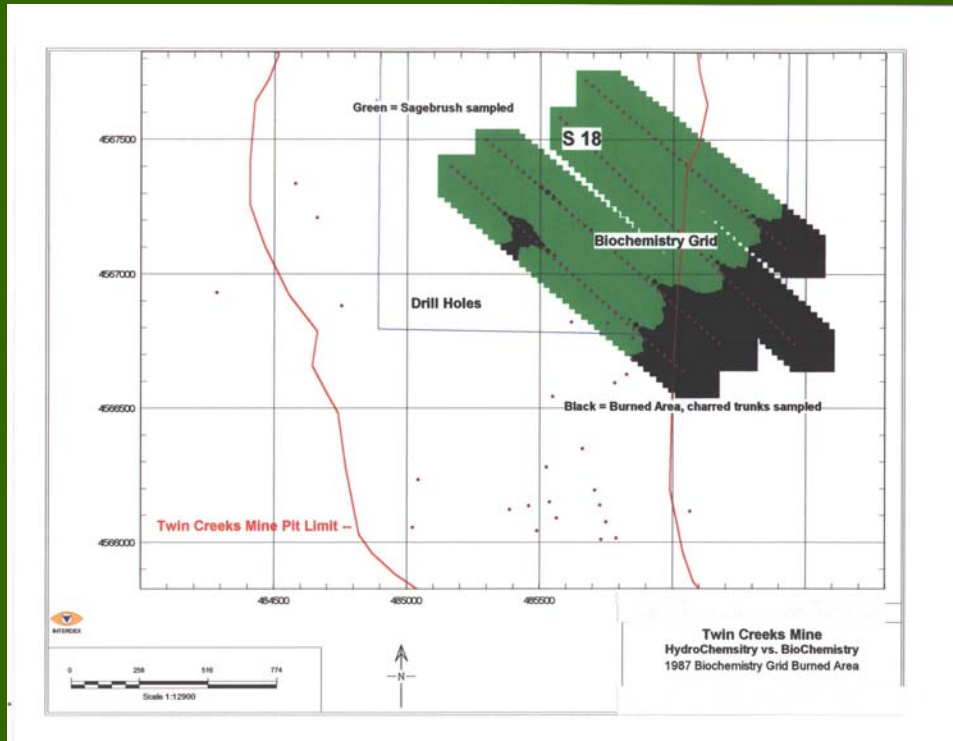
Chimney Ck. Deposit

South Deposit, Section 18

1985 GFMC Survey

- 4 Lines @ 30 m centers
- Live & Charred Sagebrush
- Ashed, reported Dry Weight
- Anomalous: Au, Sb
- Burn affects:

Ag Ga Mo Pb Zn



HISTORY

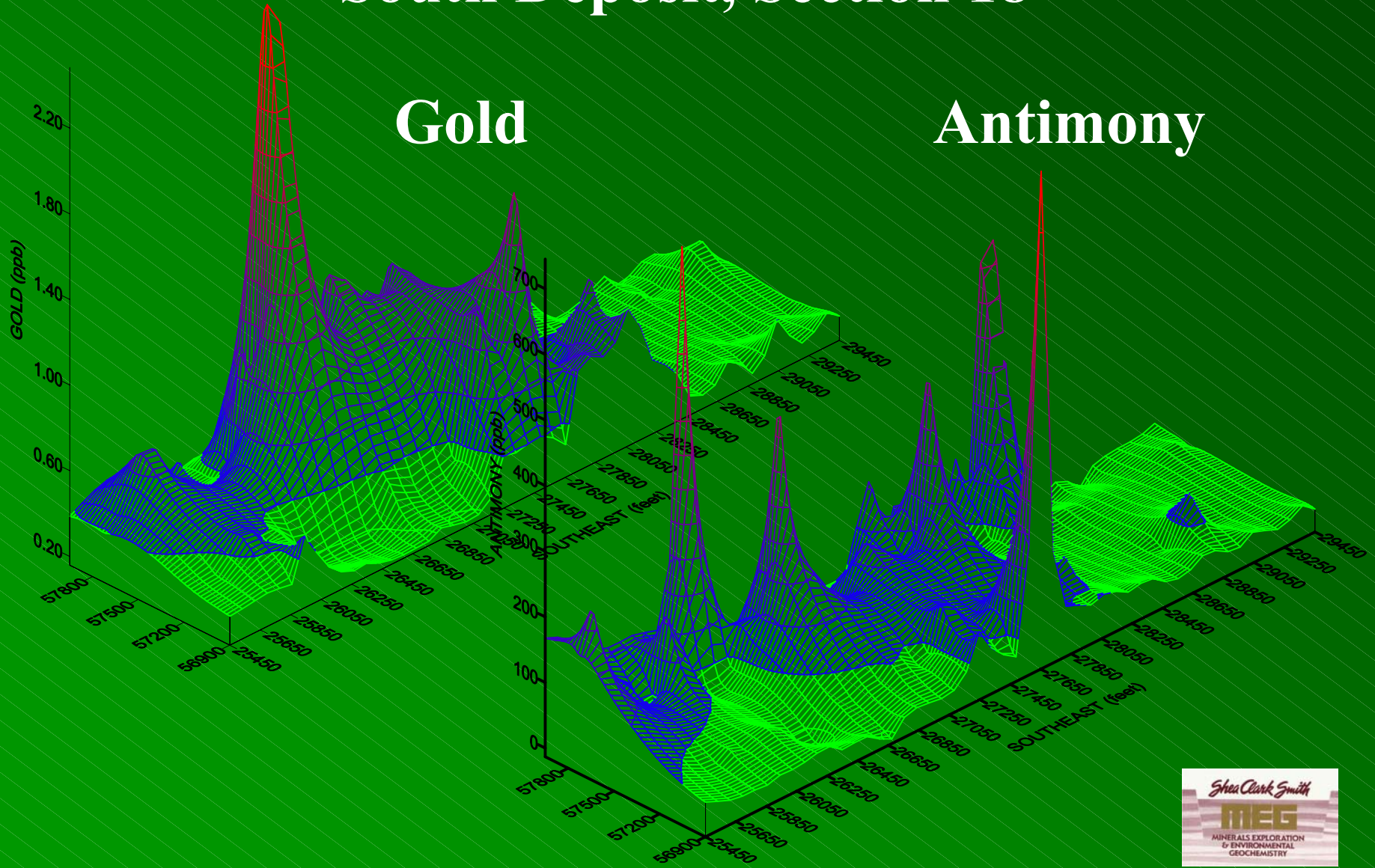
- 1984: A. Gambardella survey
- Late 1984: Range fire
- 1985: GFMC Exploration survey
- July 1986: SFMC drilling



South Deposit, Section 18

Gold

Antimony



South Deposit

Well Water Chemistry

Normalized Gold

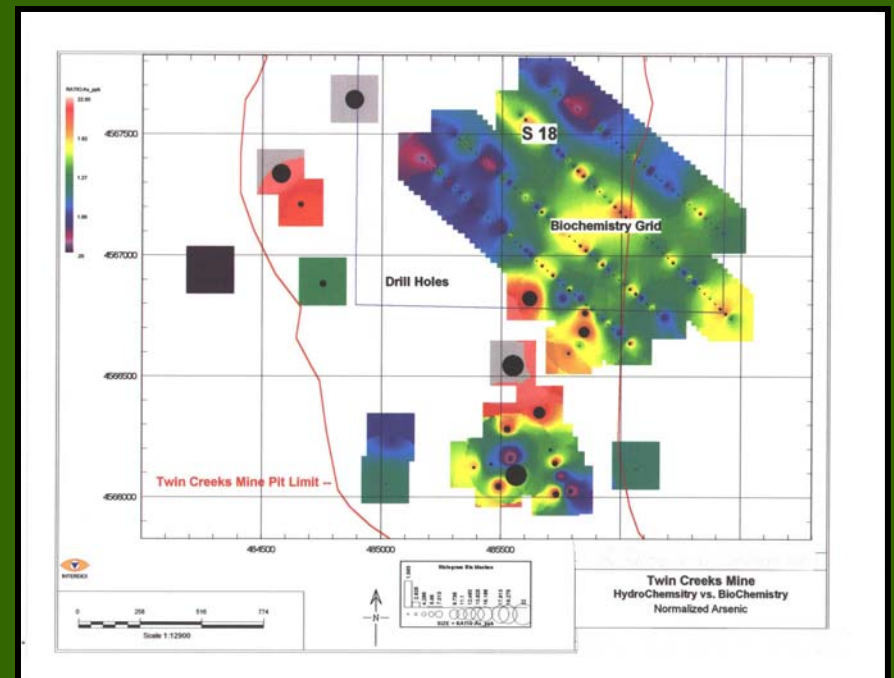
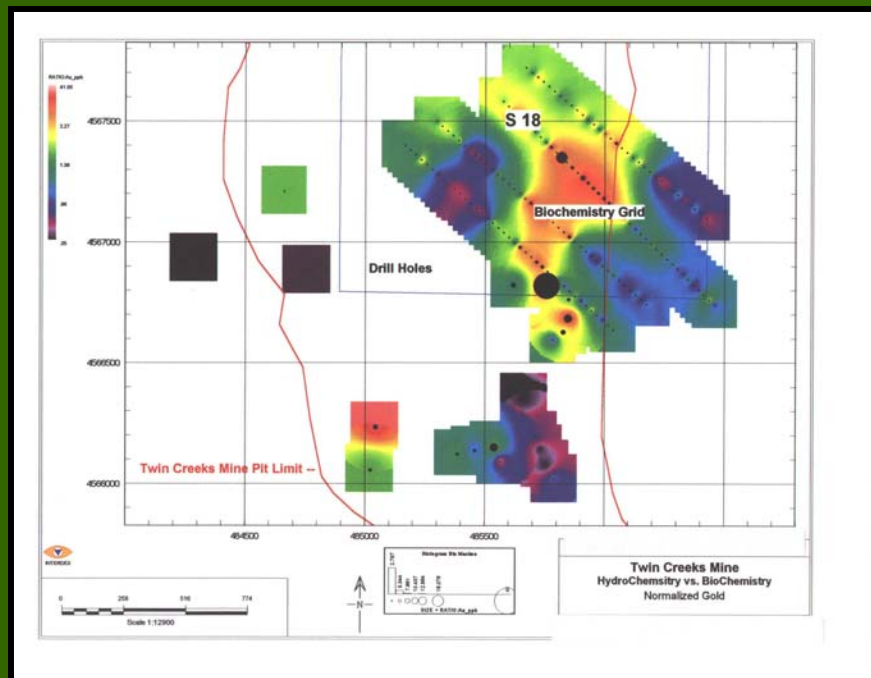
Water: 0.001 – 0.82 ppb

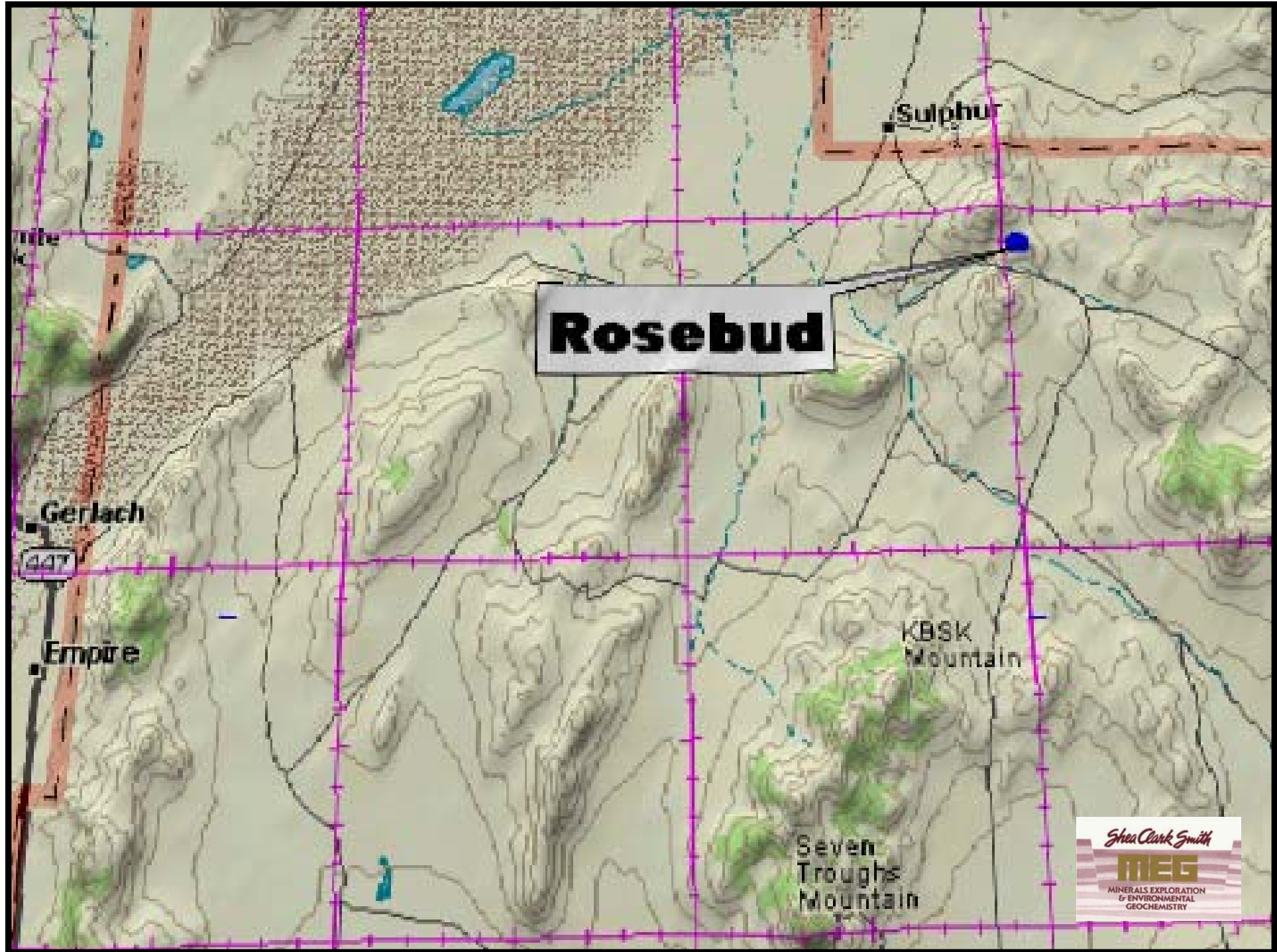
Sagebrush: 0.2 – 3.8 ppb

Normalized Arsenic

Water: 10-1100 ppb

Sagebrush: 350-1530 ppb





Rosebud

Sulphur

Gerlach

447

Empire

KBSK Mountain

Seven Troughs Mountain

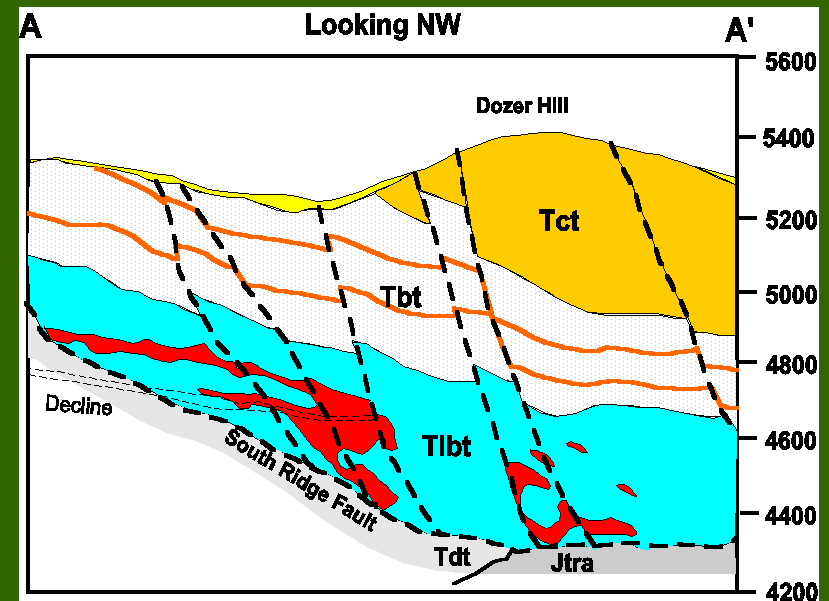
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Rosebud Mine

Sulphur Mining District, Pershing County, Nevada



- Tertiary volcanic package host
- South Ridge Fault control
- Ground water: +/- 300 ft
- Ore 200 to 1200 ft from surface
- Depth increasing to NE
- Sagebrush and Greasewood: 1989
- Mine open mid-1990's
- Mining ceased 2001



Tct: Chocolate Tuff

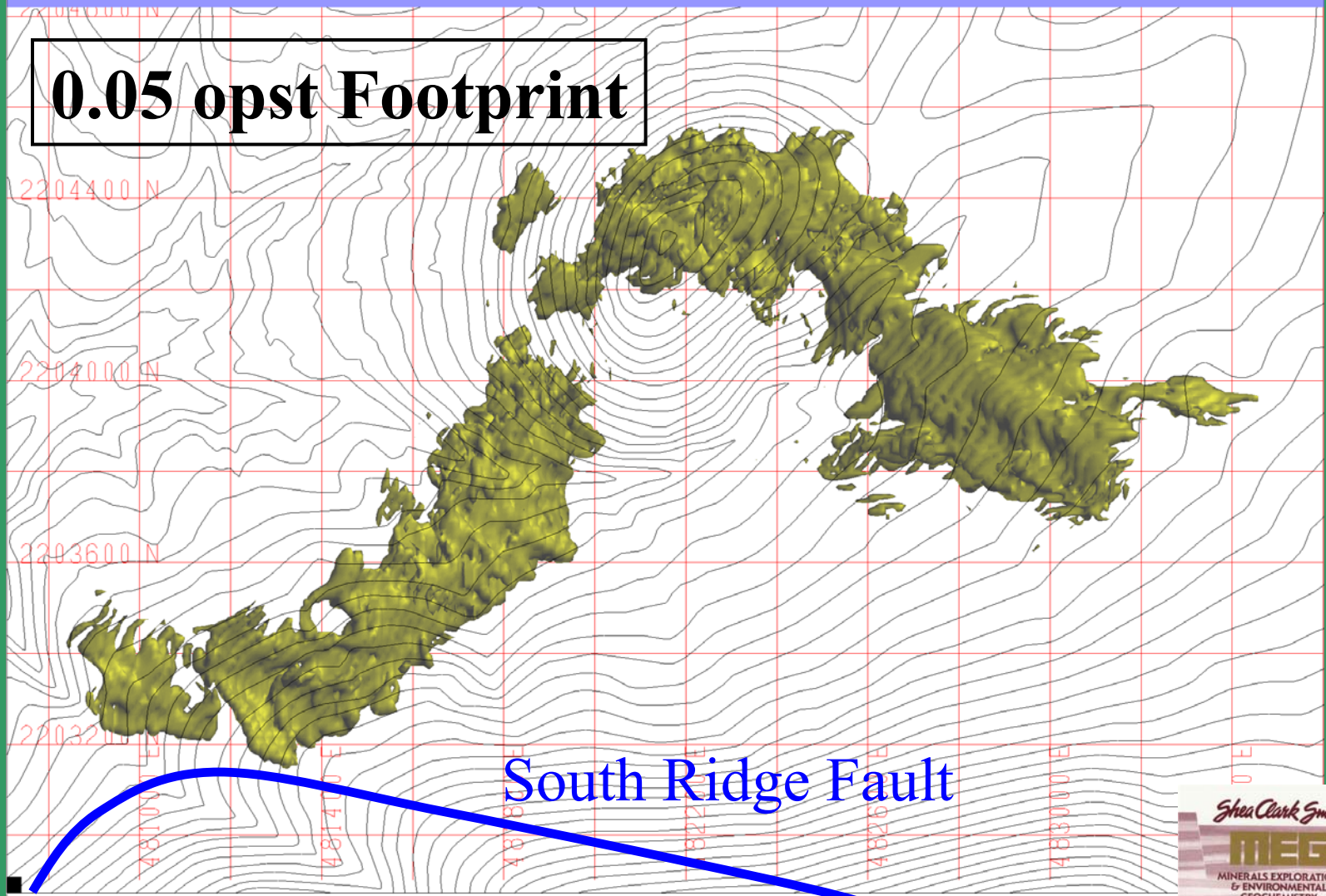
Tbt: Bud Tuff

Tlbt: Lower Bud Tuff

Tdt: Dozer Tuff

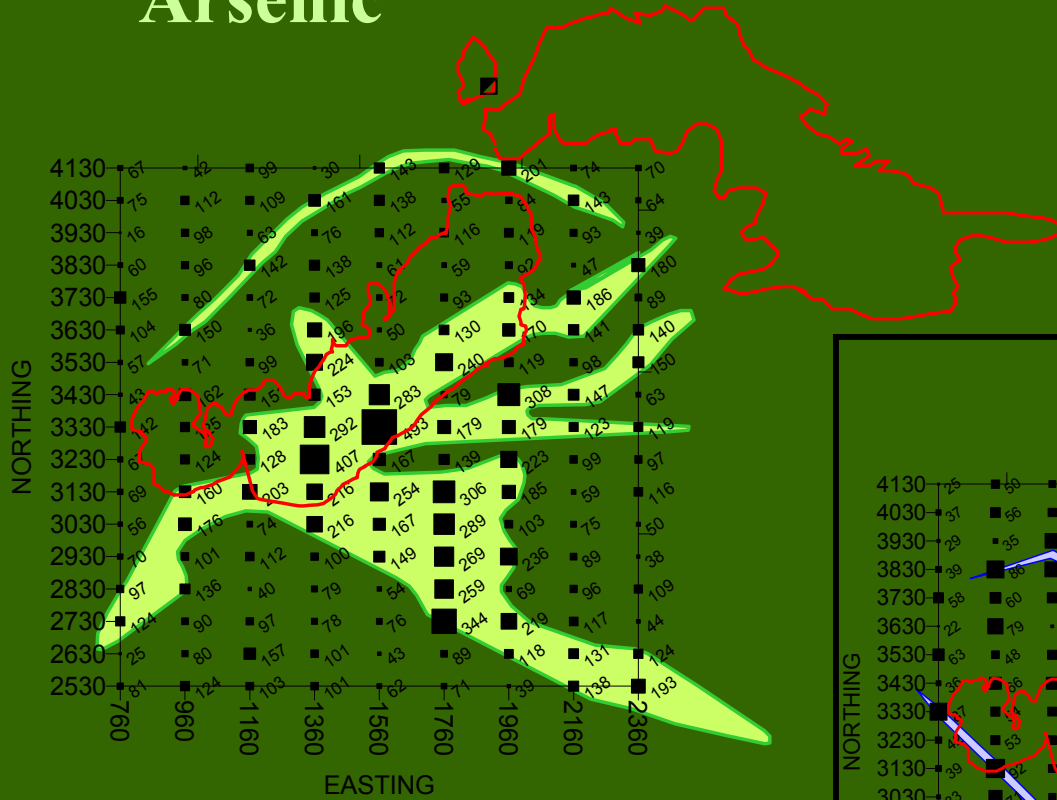
Rosebud Mine

0.05 opst Footprint

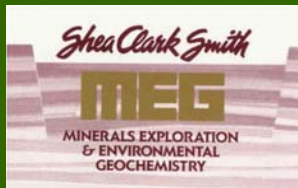
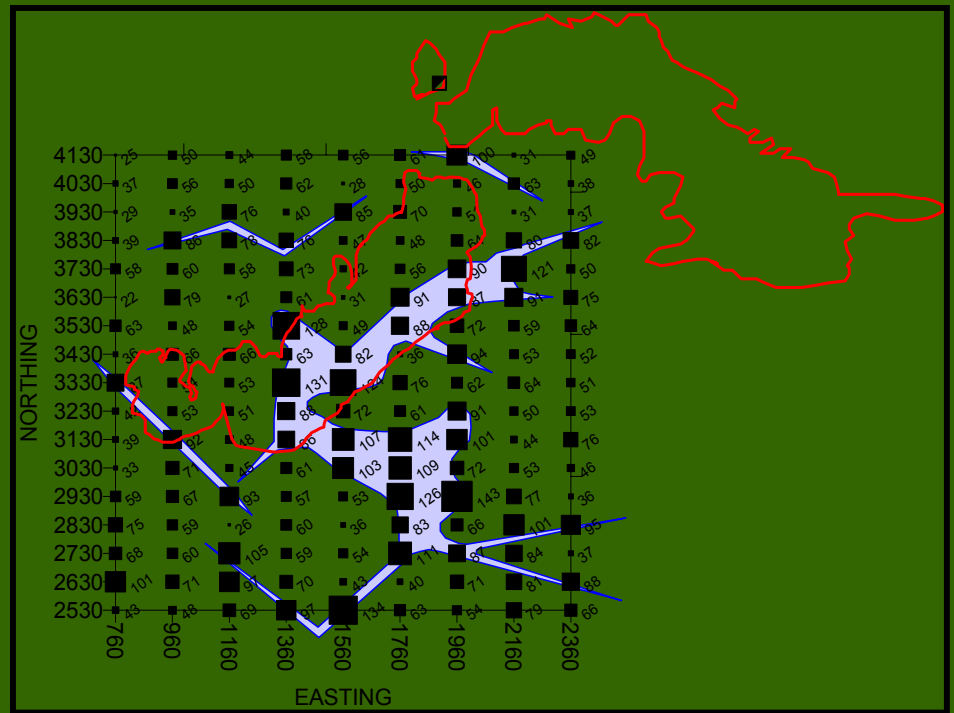


Rosebud Mine

Arsenic

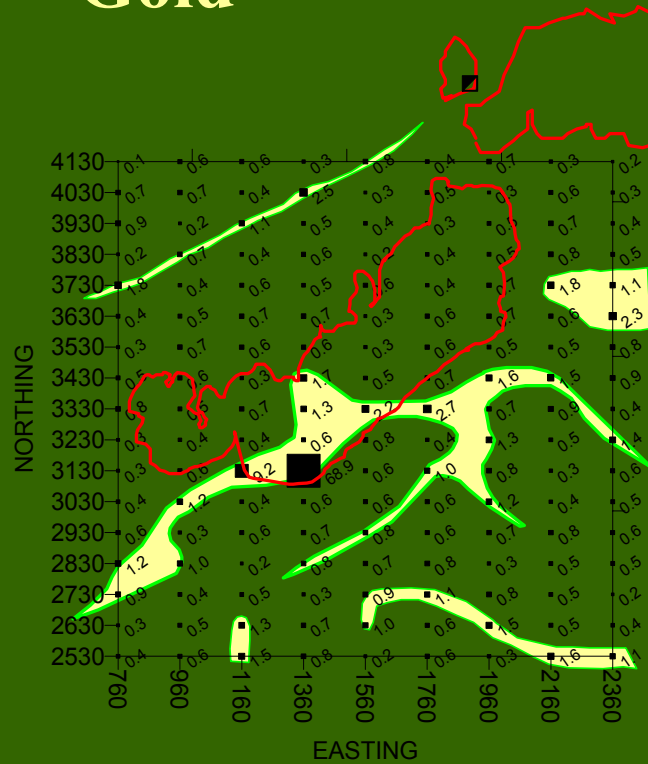


Antimony

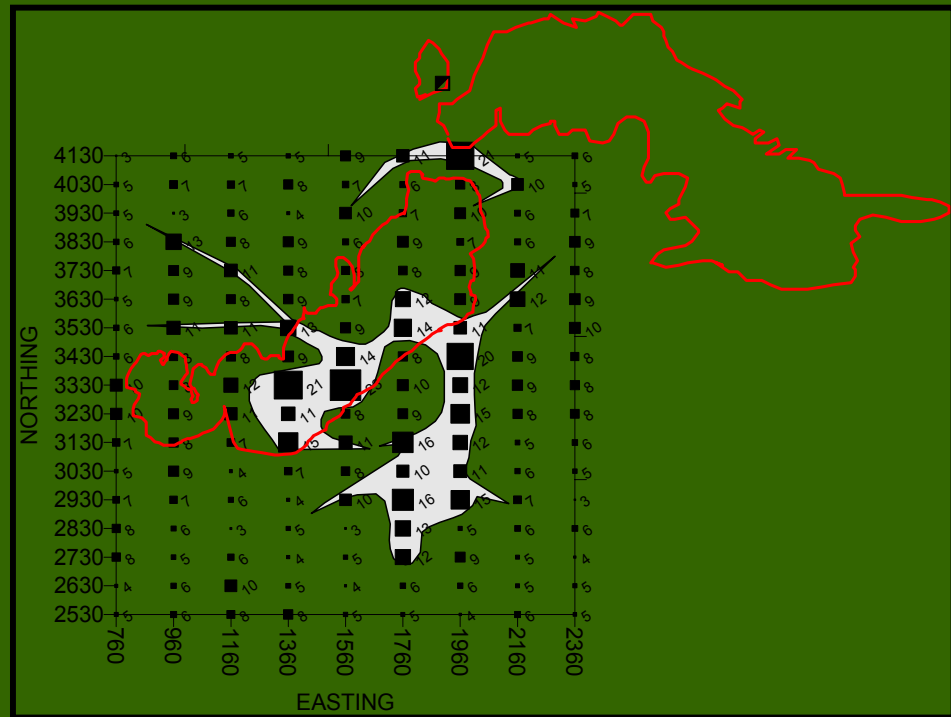


Rosebud Mine

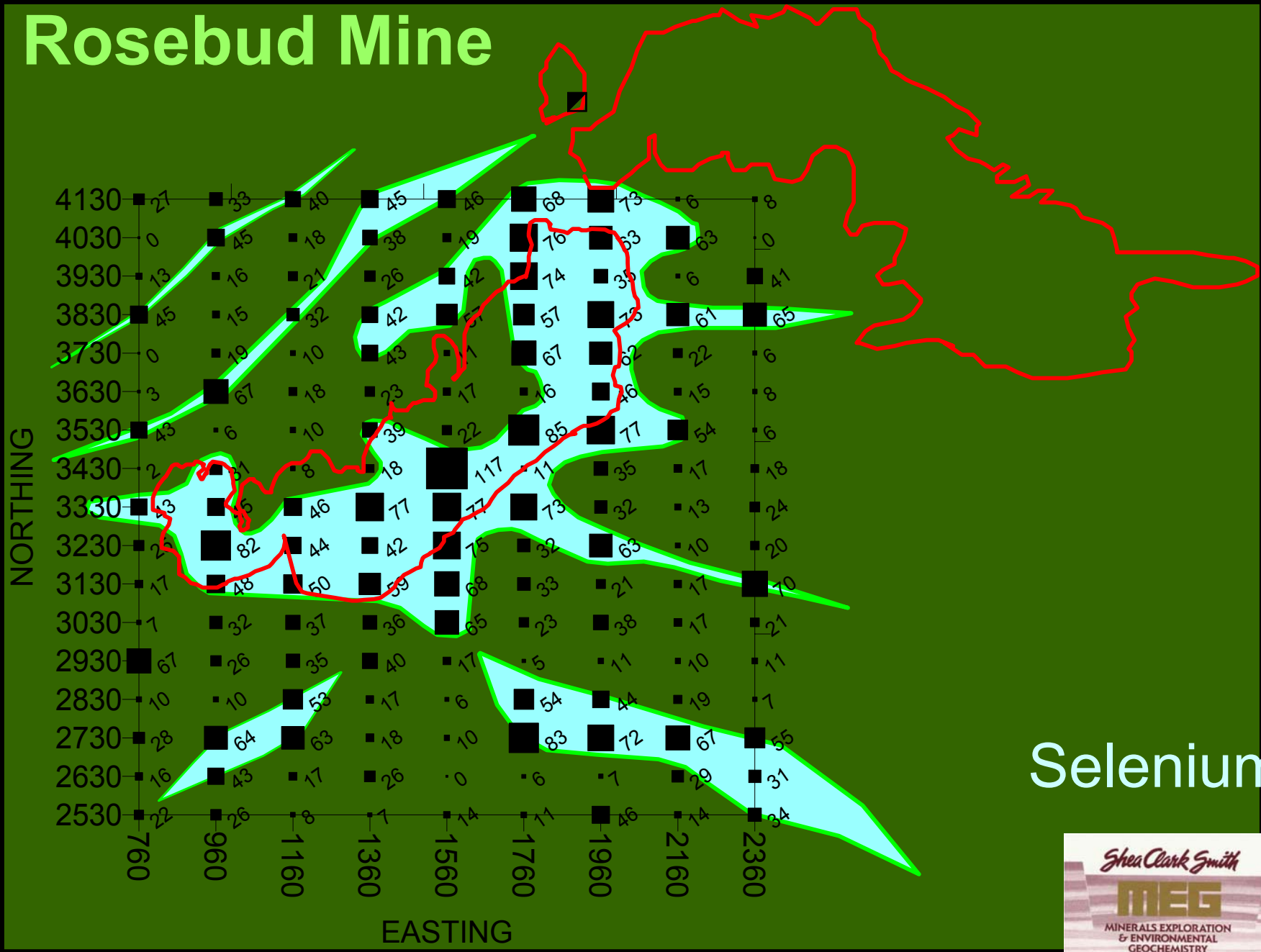
Gold



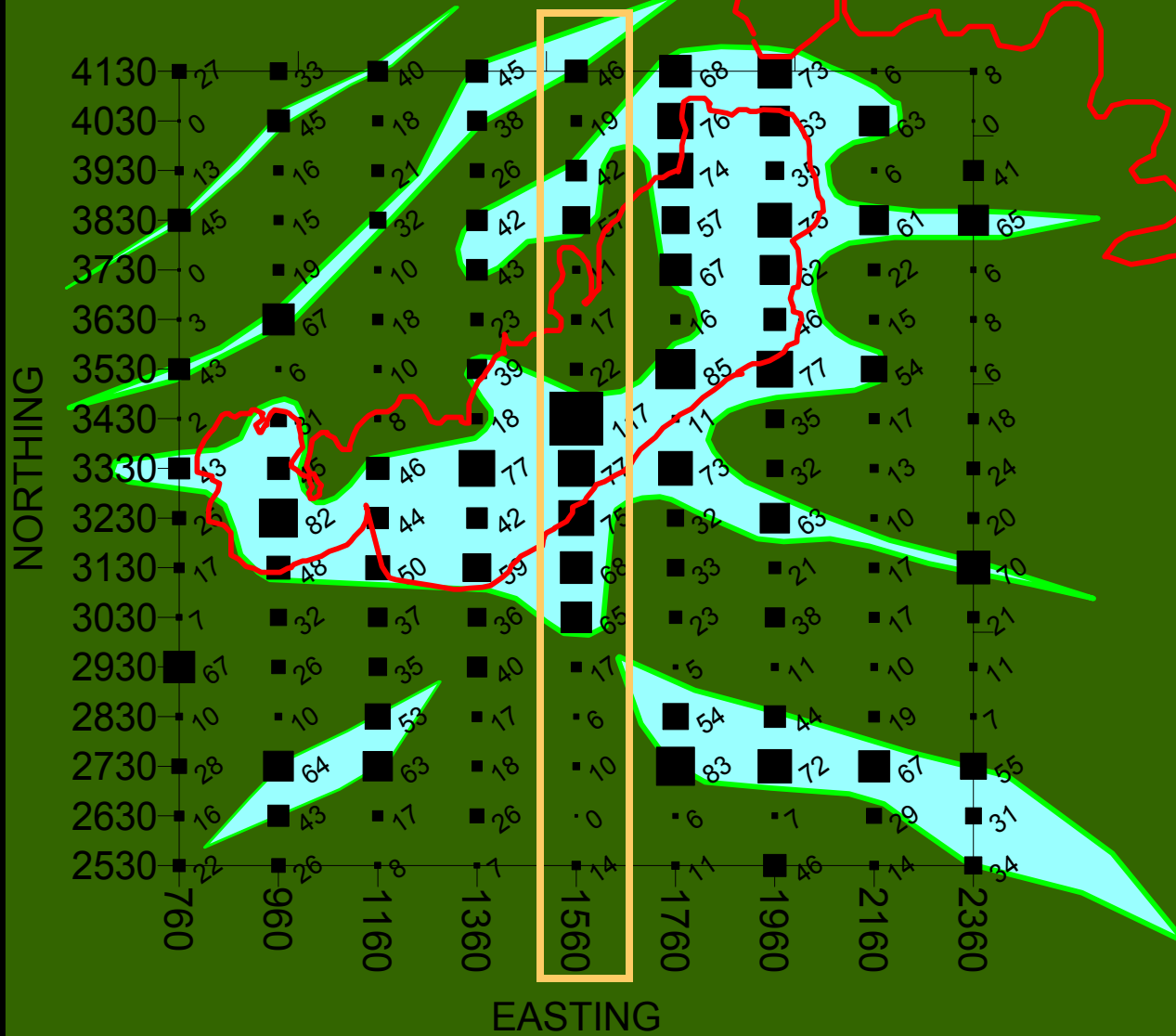
Silver



Rosebud Mine



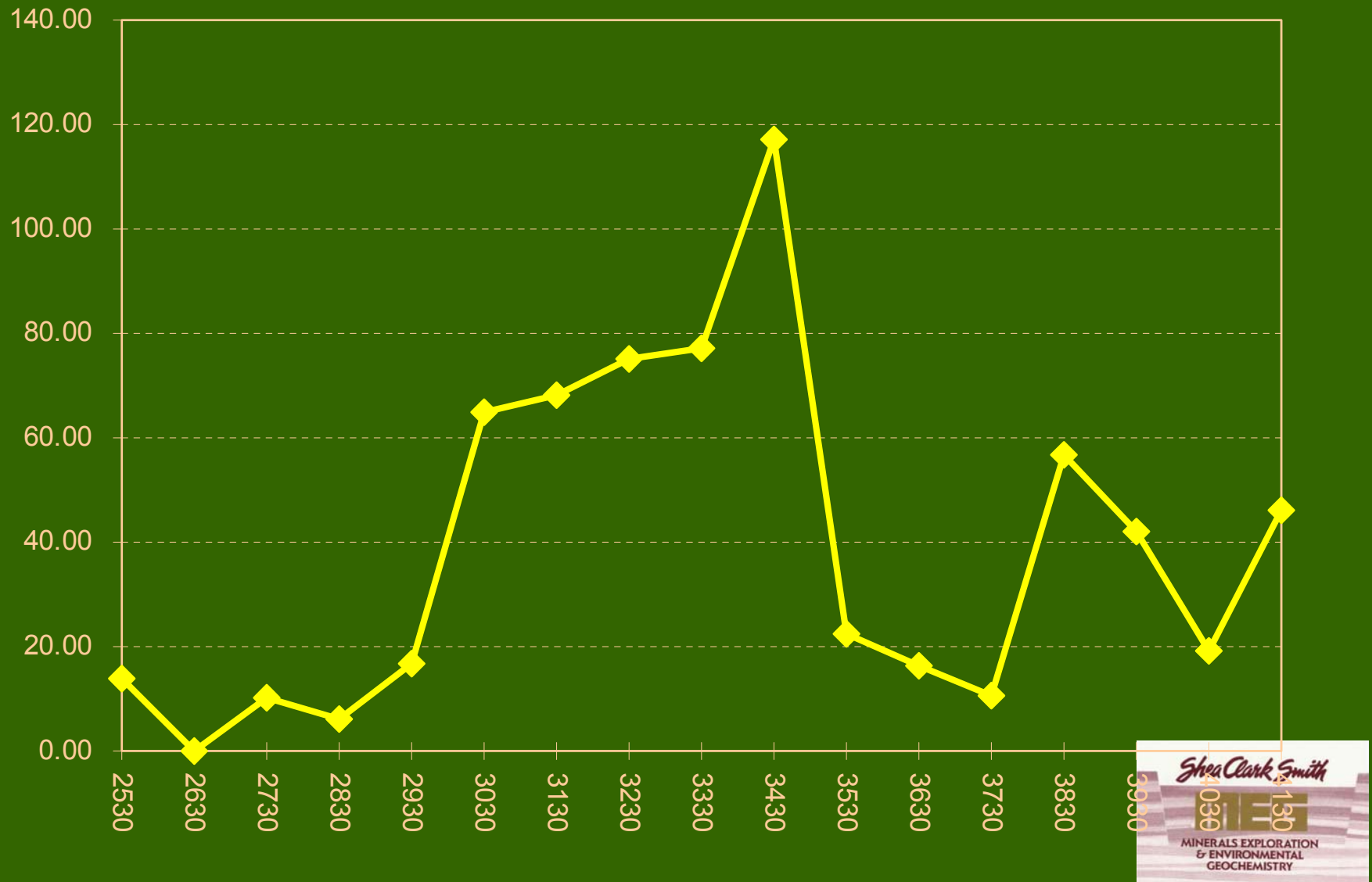
Rosebud Mine



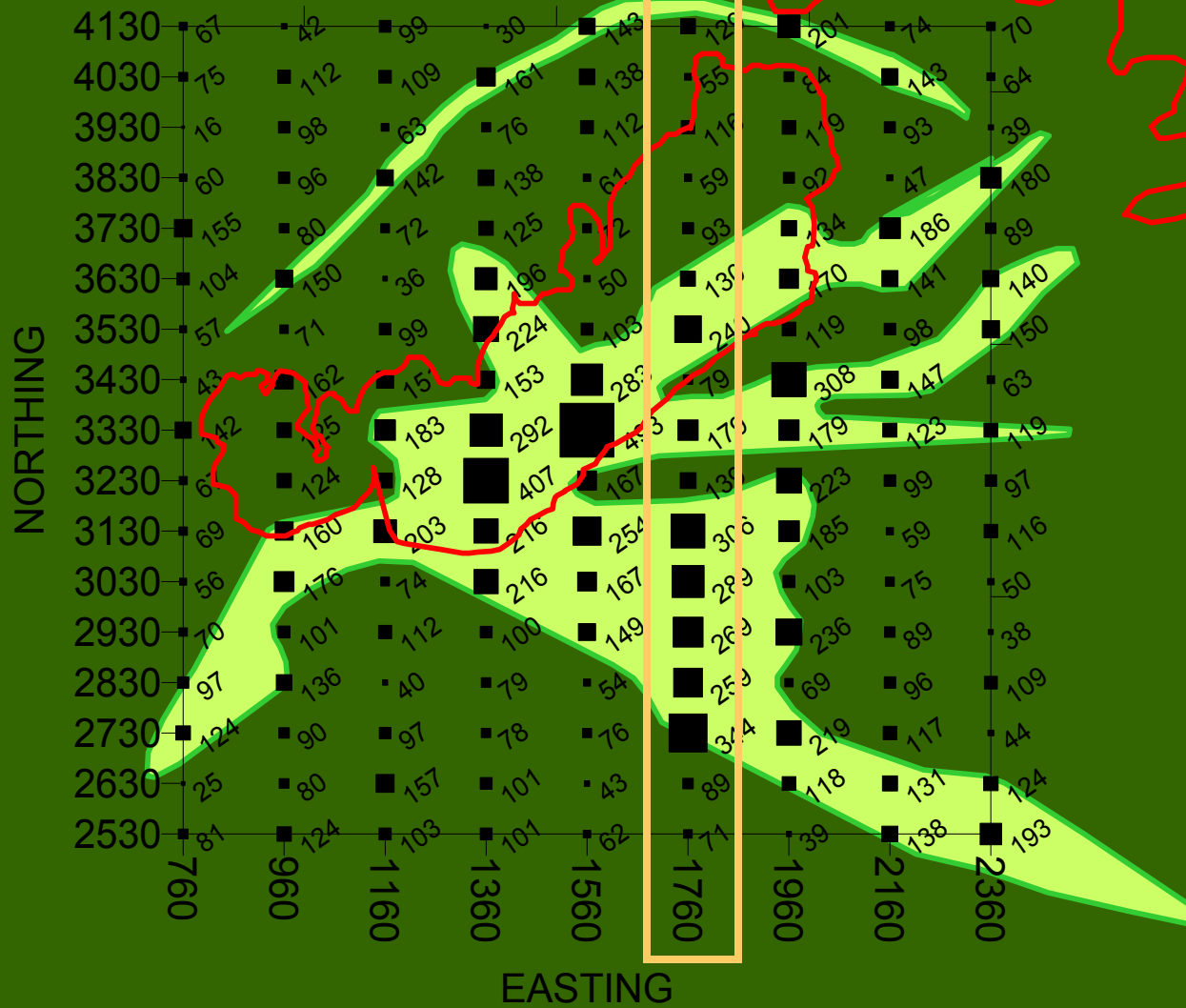
Selenium



Rosebud Mine: Line 1560E: Se (ppb)



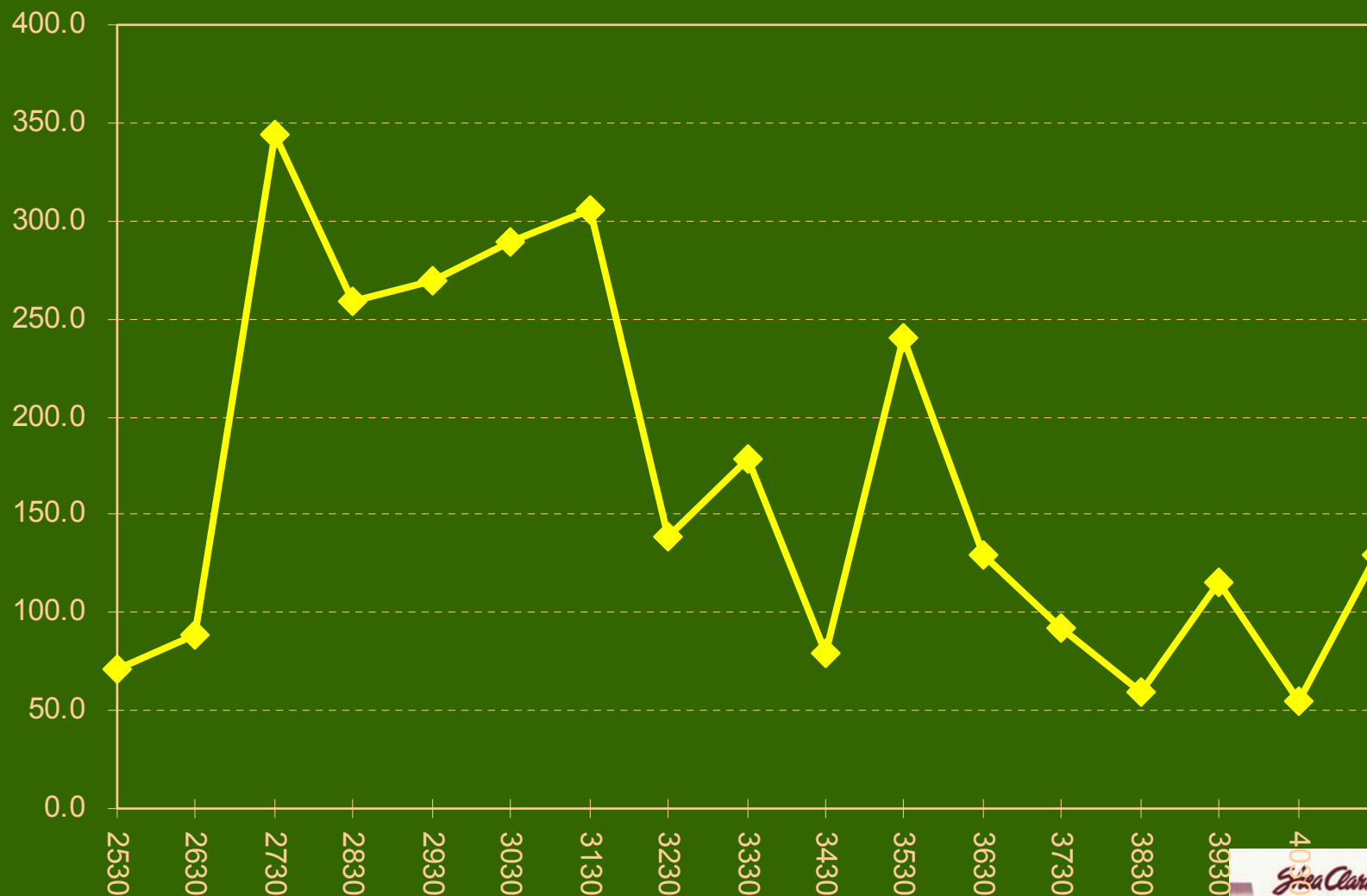
Rosebud Mine



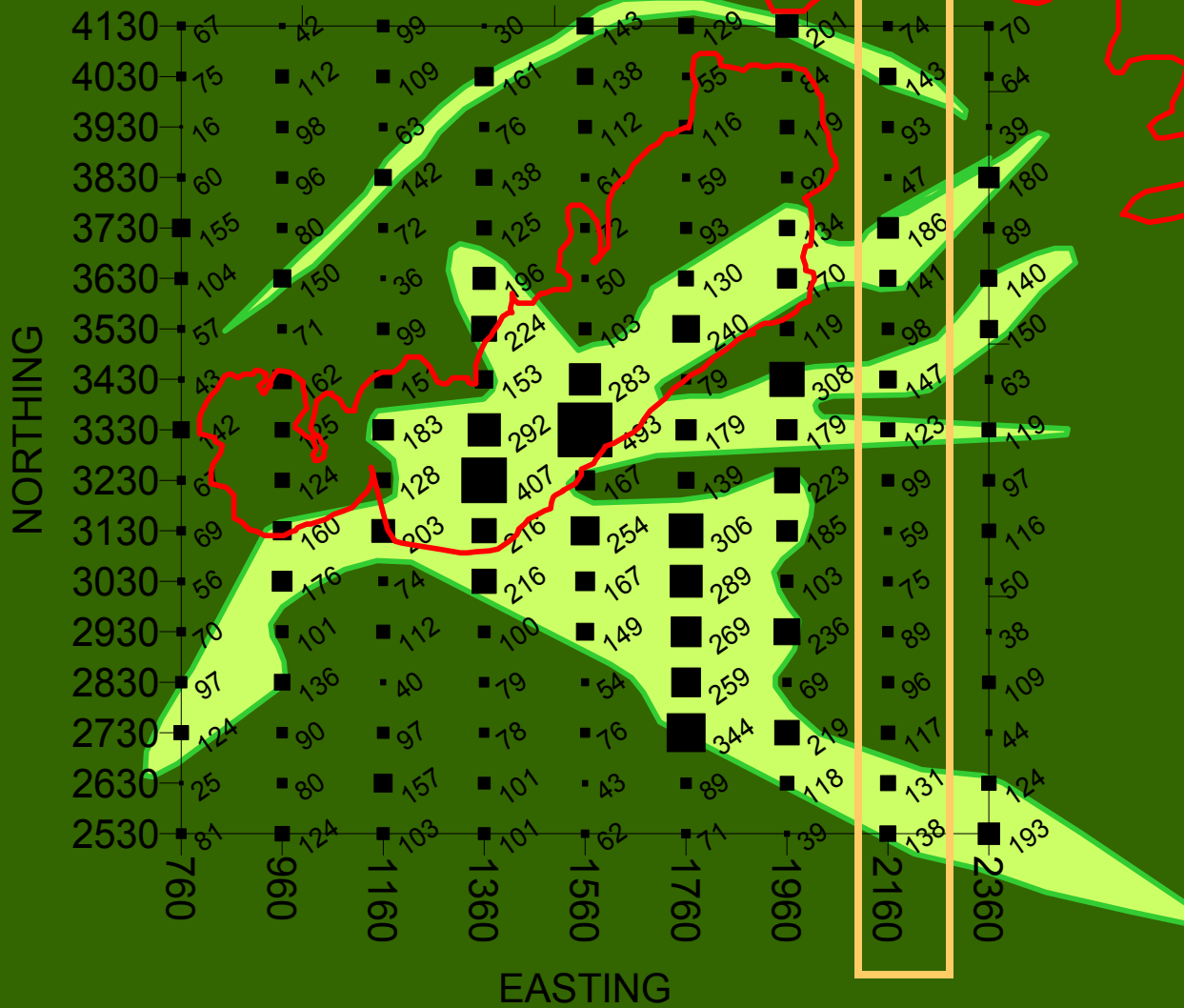
Arsenic



Rosebud Mine: Line 1760E: As (ppb)



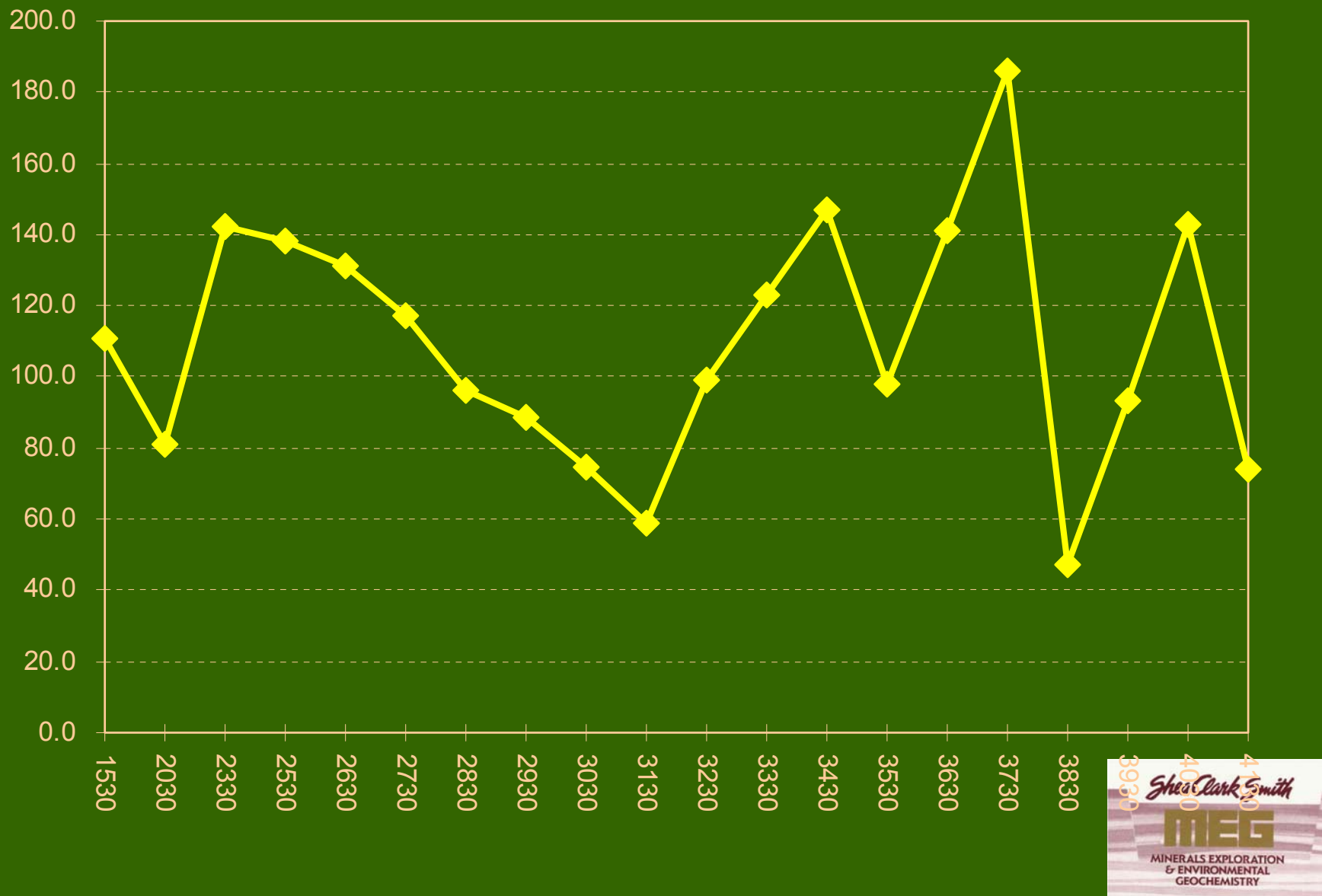
Rosebud Mine



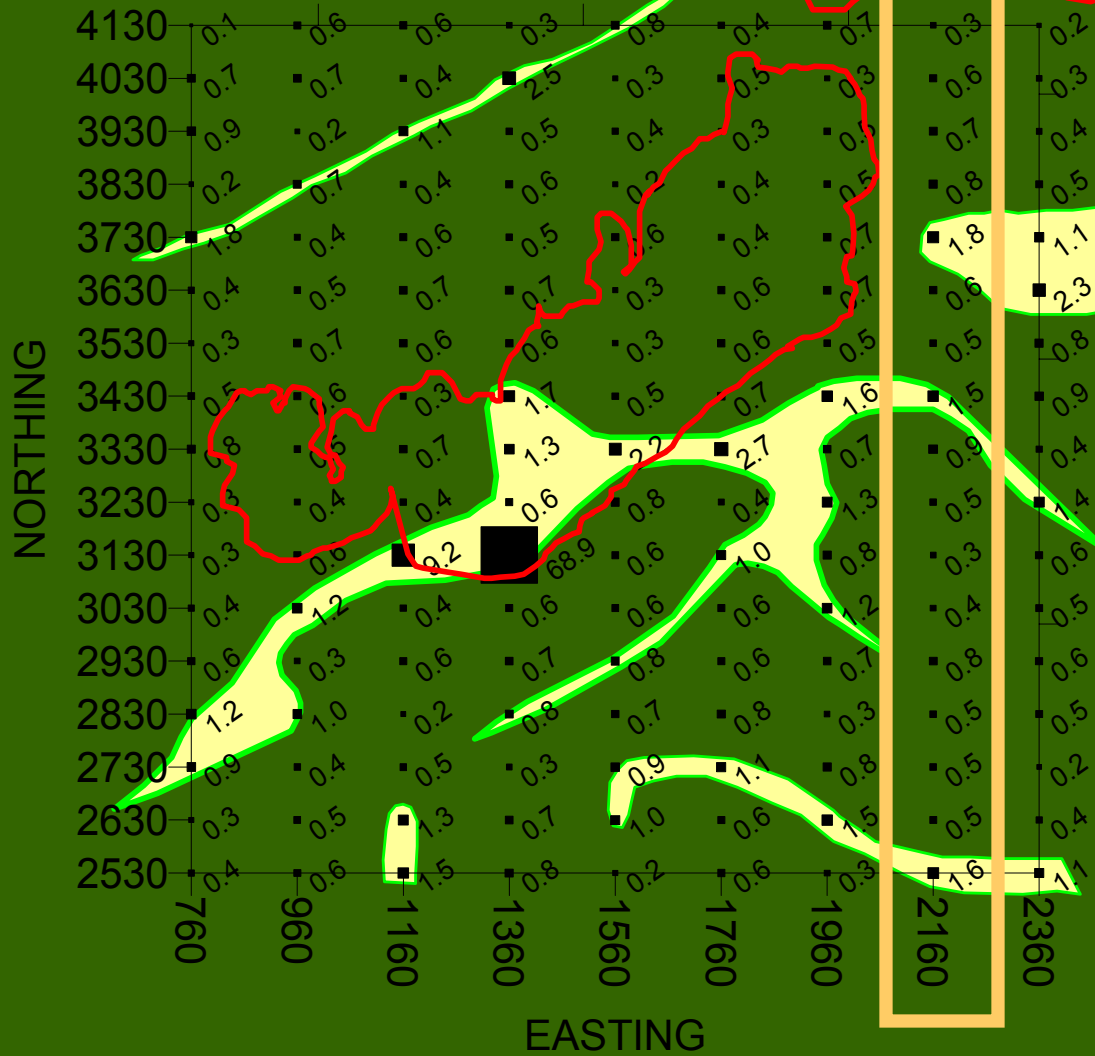
Arsenic



Rosebud Mine: Line 2160E: As (ppb)



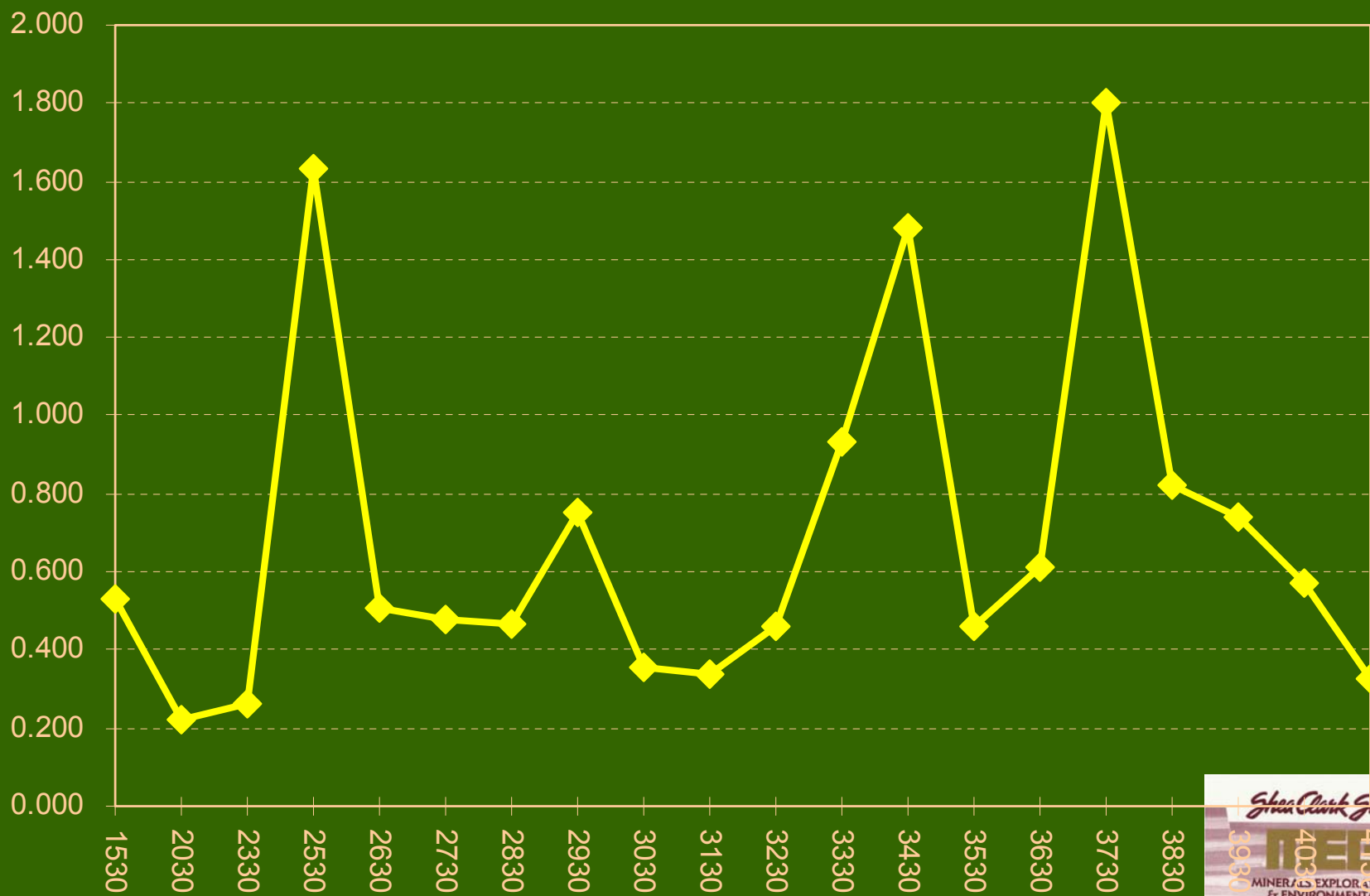
Rosebud Mine



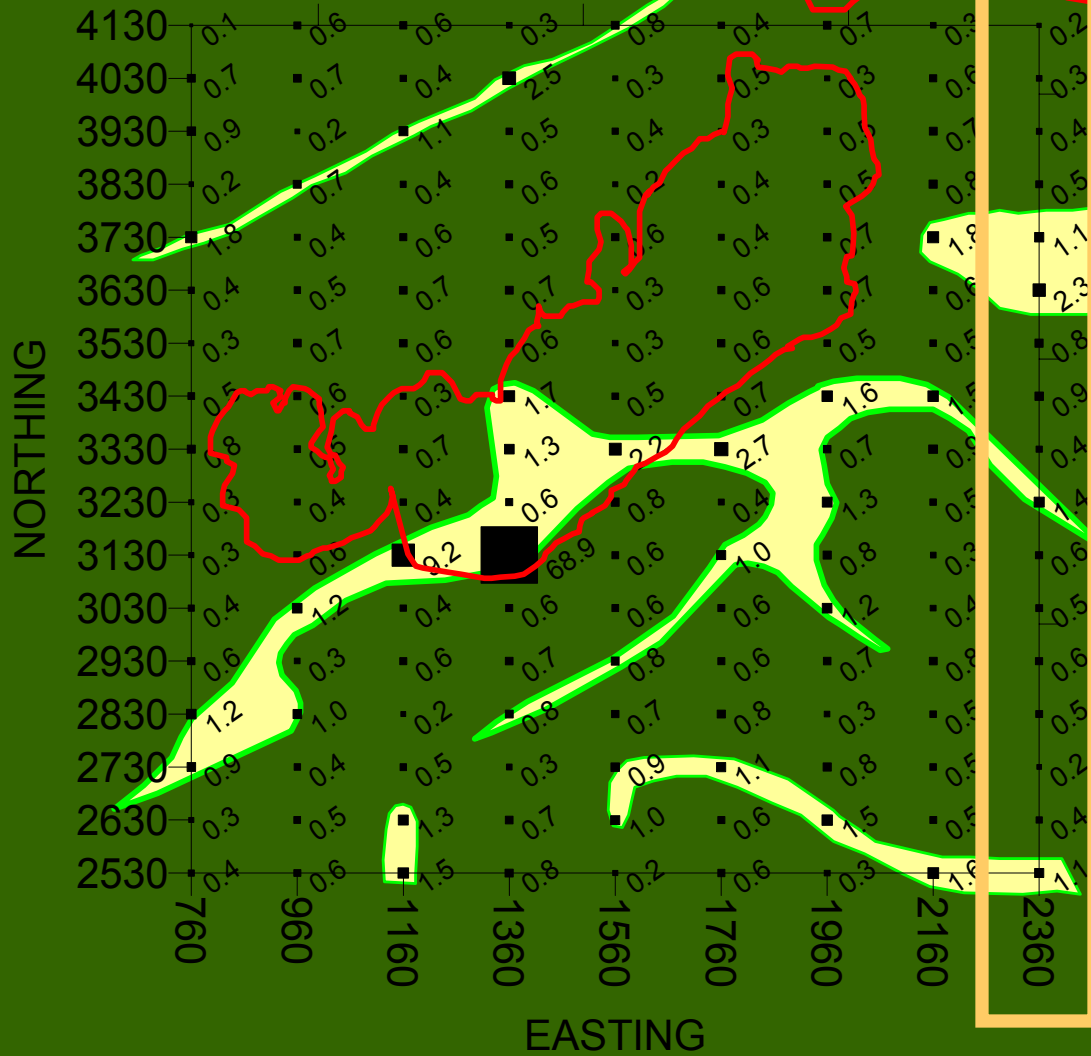
Gold



Rosebud Mine: Line 2160E: Au (ppb)



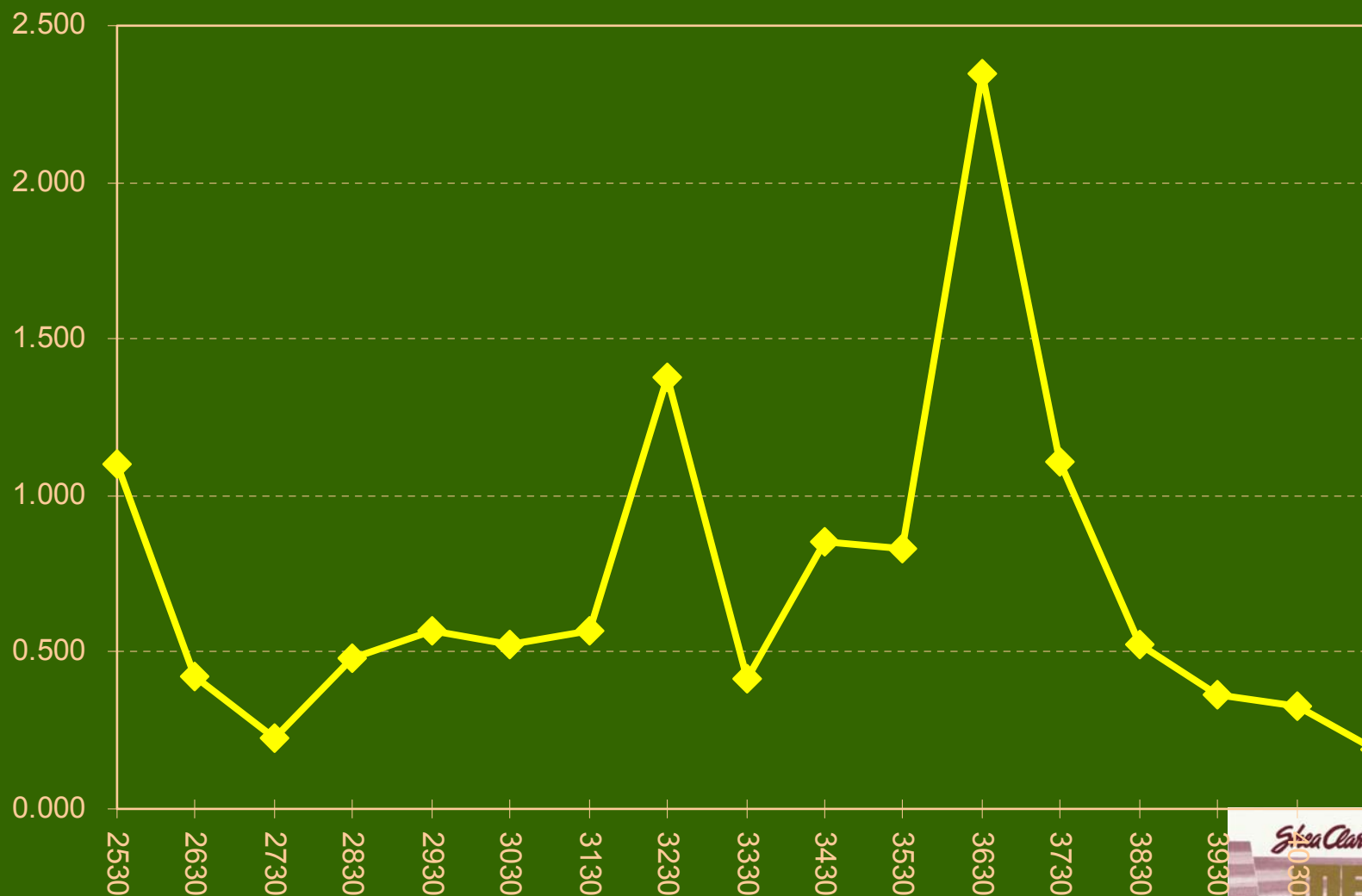
Rosebud Mine



Gold



Rosebud Mine: Line 2360E: Au (ppb)





TRACE METAL DISTRIBUTION IN SAGEBRUSH

PINSON MINE

	Au ppb	As ppm	Sb ppm	Hg ppm	Br ppm	Mo ppm	W ppm	Sr ppm	Co ppm	Zn ppm
FLOWERS	9	0.6	0.0	-0.05	1.2	0.3	0.1	38	-0.1	17
LEAVES	21	1.1	0.1	-0.05	1.5	0.5	0.2	40	0.2	16
TWIGS	35	3.7	0.2	0.07	1.0	0.5	0.5	45	0.3	10
BRANCHES	13	2.4	0.2	0.07	0.7	0.4	0.4	23	0.3	7
U. TRUNK	6	1.4	0.1	-0.05	0.6	0.3	0.3	21	0.2	8
L. TRUNK	3	0.7	0.0	-0.05	0.6	0.3	0.1	27	-0.1	7
	Ba ppm	Fe %	Ca %	Na ppm	K %	Cr ppm	Rb ppm	Sc ppm	Se ppm	Cs ppm
FLOWERS	22	0.01	0.5	184	1.2	0.3	1	0.03	0.5	-0.05
LEAVES	27	0.02	0.5	110	1.2	0.3	1	0.05	1.2	-0.05
TWIGS	51	0.05	0.3	175	0.8	1.3	2	0.16	-0.1	0.12
BRANCHES	40	0.04	0.2	138	0.5	0.9	2	0.14	-0.1	0.09
U. TRUNK	25	0.03	0.3	125	0.4	0.6	1	0.09	-0.1	0.05
L. TRUNK	21	0.01	0.3	130	0.4	0.3	-1	0.04	-0.1	-0.05
	La ppm	Sm ppm	Ce ppm	Nd ppm	Yb ppm	Lu ppm	Hf ppm	U ppm	Th ppm	Ir ppm
FLOWERS	0.14	0.02	0.2	-0.3	0.01	-0.001	-0.05	-0.01	-0.1	-0.1
LEAVES	0.24	0.03	0.4	-0.3	0.02	-0.001	-0.05	0.03	-0.1	-0.1
TWIGS	0.71	0.10	0.9	0.4	0.04	0.003	-0.05	0.10	0.2	-0.1
BRANCHES	0.57	0.09	0.8	0.4	0.03	0.006	0.08	0.05	0.1	-0.1
U. TRUNK	0.35	0.05	0.5	0.3	0.02	0.004	-0.05	0.03	-0.1	-0.1
L. TRUNK	0.15	0.02	0.2	-0.3	0.01	0.001	-0.05	0.01	-0.1	-0.1

CONCLUSIONS

- Plant trace metal chemistry linked to ground water chemistry
- Desert shrubs & trees see to deep ground water / mineral zone
- Plant / soil link similar to weak & selective soil extraction methods
- Most metal absorption & translocations derive from roots
- Sample uniformity & consistency extremely important
- Species effects of subsidiary importance
- Pattern recognition & data structure methods point to ore
- Numerical statistics less useful for finding ore
- Large database: knowledge & data baseline for future work

Biogeochemistry finds ore

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