Sphalerite: Not Only Zinc and Stink

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NDSU Geology 422

May 1st, 2012

Outline

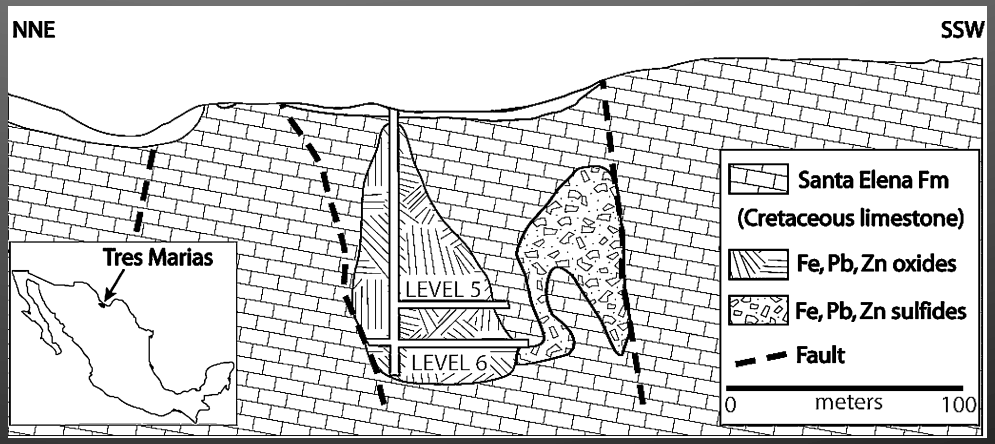
- Background of the mines
  - Tres Marias
  - Red Dog
- SEM results
- Separation of sphalerite and galena
- Trace elements of sphalerite

Tres Marias Mine

Map taken from War Eagle Mining

Tres Marias Background

- Located 100 meters below the surface
- Two major ore types
- 1) Zinc and lead sulfides
- 2) Oxides



B. Saini-Eidukat *et al*, 2009

Formation of Deposits

- Mississippi Valley Type (MVT) deposits
- Hosted mainly by dolostone and limestone
- Ore fluids were hot and salty

USGS, 2010

Red Dog Zinc Mine

The Red Dog mineral deposit is located in the DeLong Mountains, northwestern Alaska, about 90 miles north of the village of Kotzebue

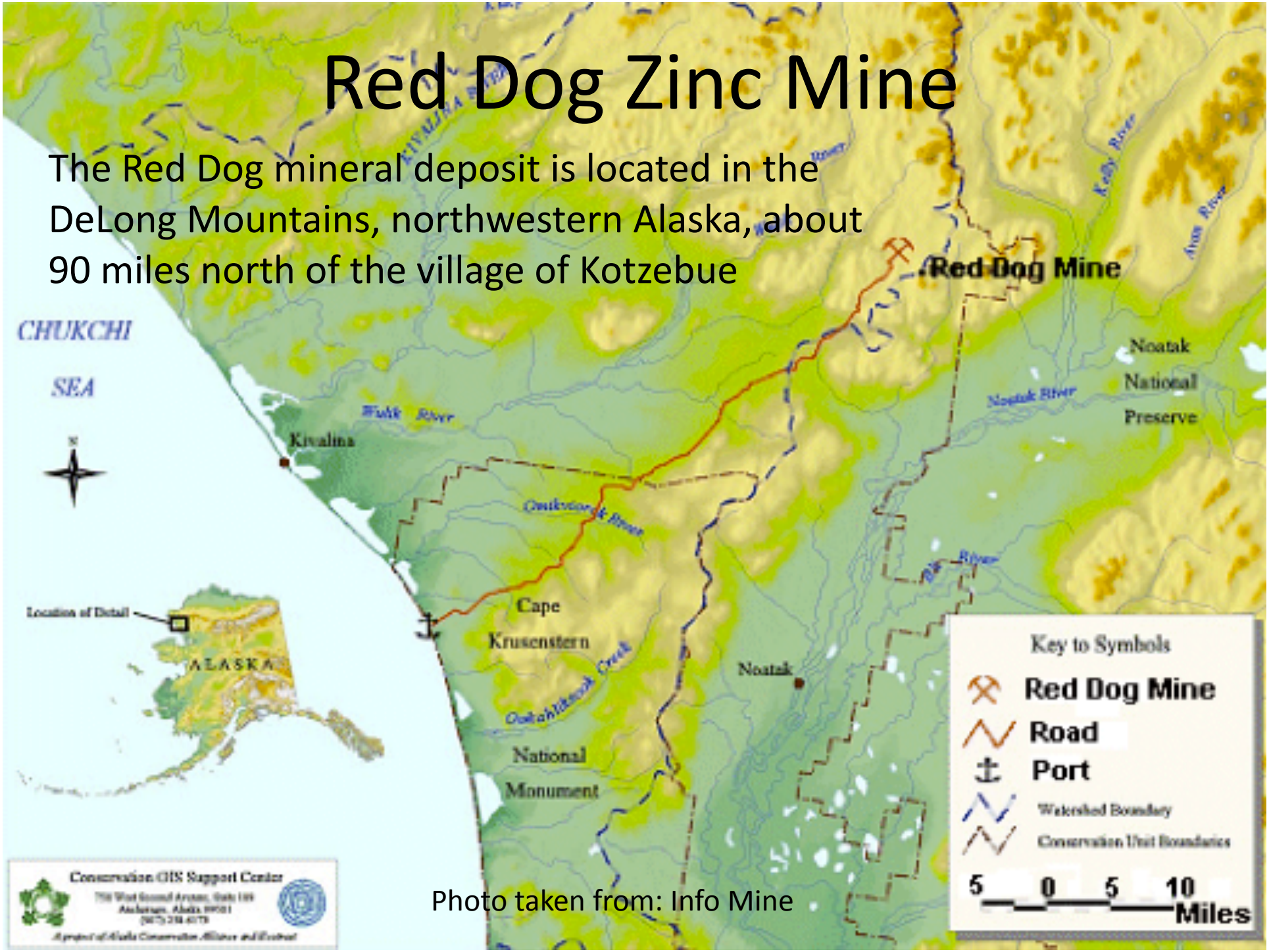


Photo taken from: Info Mine

Background

- 2nd largest zinc mine globally
  - 5% total contribution
- Largest zinc mine in the US
  - 79% total contribution

- Red Dog's ore is found in hard sedimentary rock (black siliceous shale) and occurs in large massive layered veins
  - The zinc occurs in yellow to brown sphalerite
  - Large amounts of lead found in galena
  - Some traces of pyrite found as well
  - Trace amounts of cadmium


Photo taken from: State of Alaska

Mining Methods

- Conventional style of mining using trucks and explosives to extract the ore deposits from the outcrop

- Incorporates new techniques: modular construction, tower mills, column cells and pressure filters to separate the sphalerite and galena from the sedimentary rock

Photo taken from: Info Mine

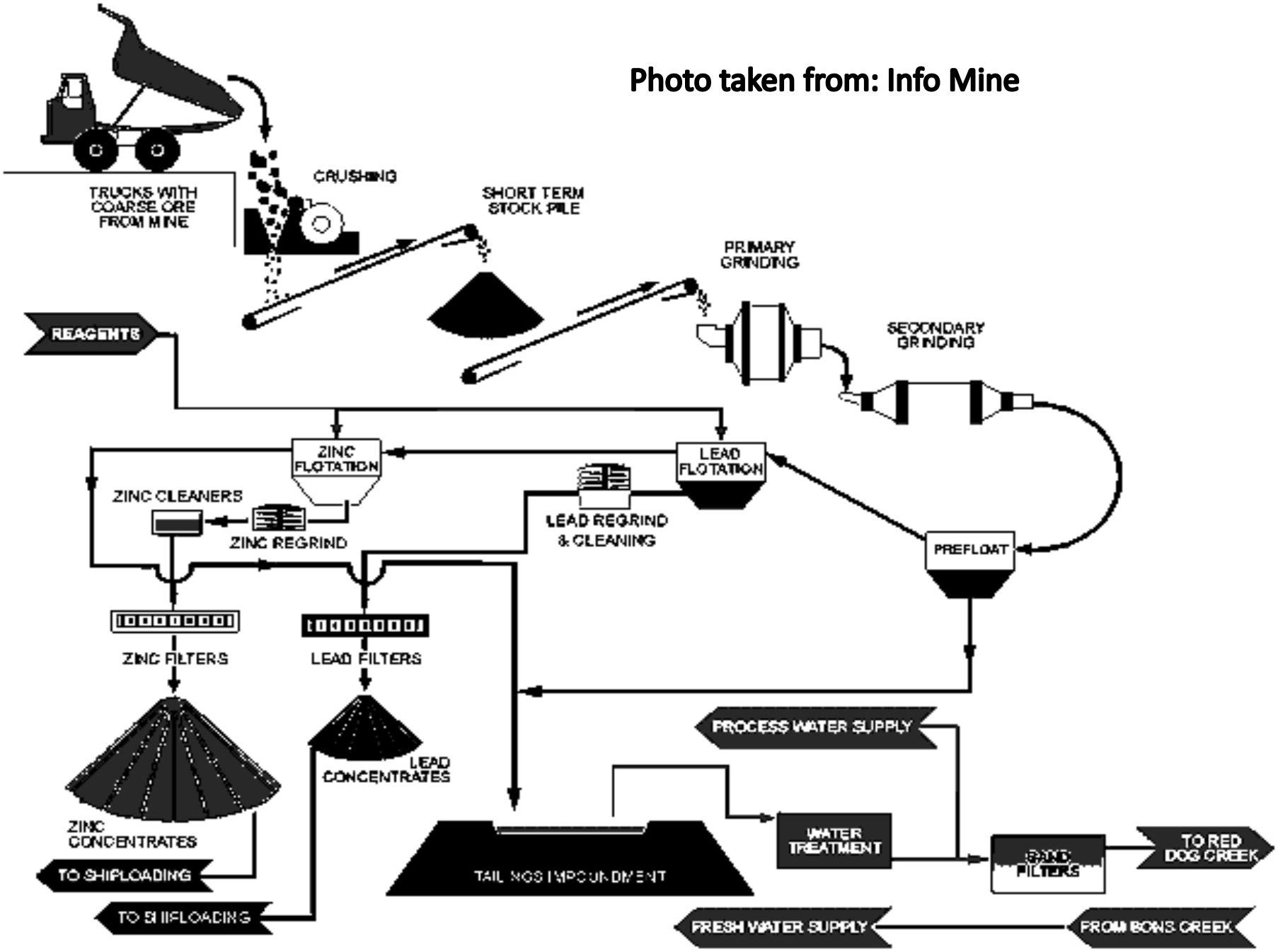



Photo taken from: Mining –Technology.com

How'd it get there?

- Deposits documented in the 1950's and view as precipitates from ocean floor hydrothermal vents
- Precipitates then buried
- Metamorphosed
- Uplifted and erosion exposed the deposits

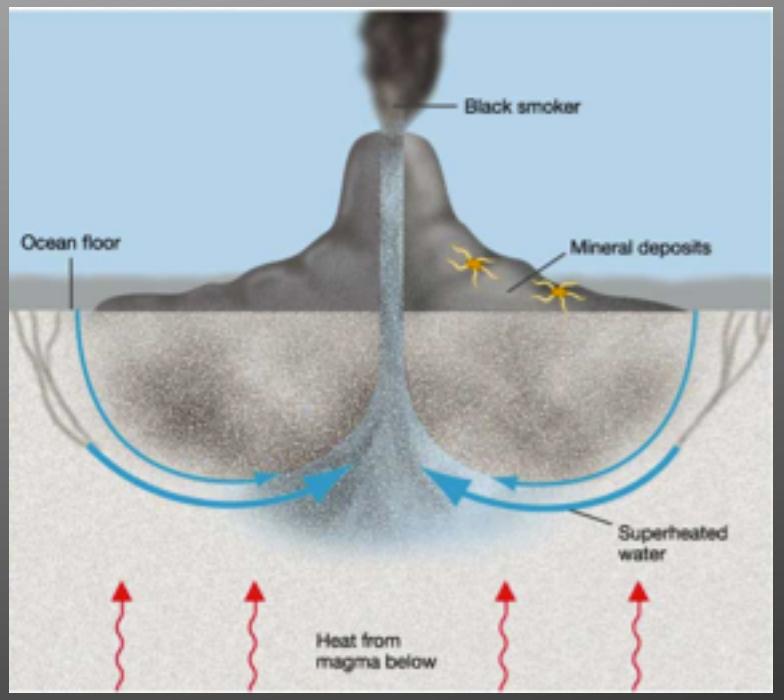


Photo taken from: Center for Geobiology

Pit Presence

- Deposits found in the Mississippian-Pennsylvanian Kuna Formation
  - 4 main deposit zones
  - The Main, Aqqaluk, Paalaaq, and Quaniayaaq

Currently the Main has mostly been mined out and they have moved northward

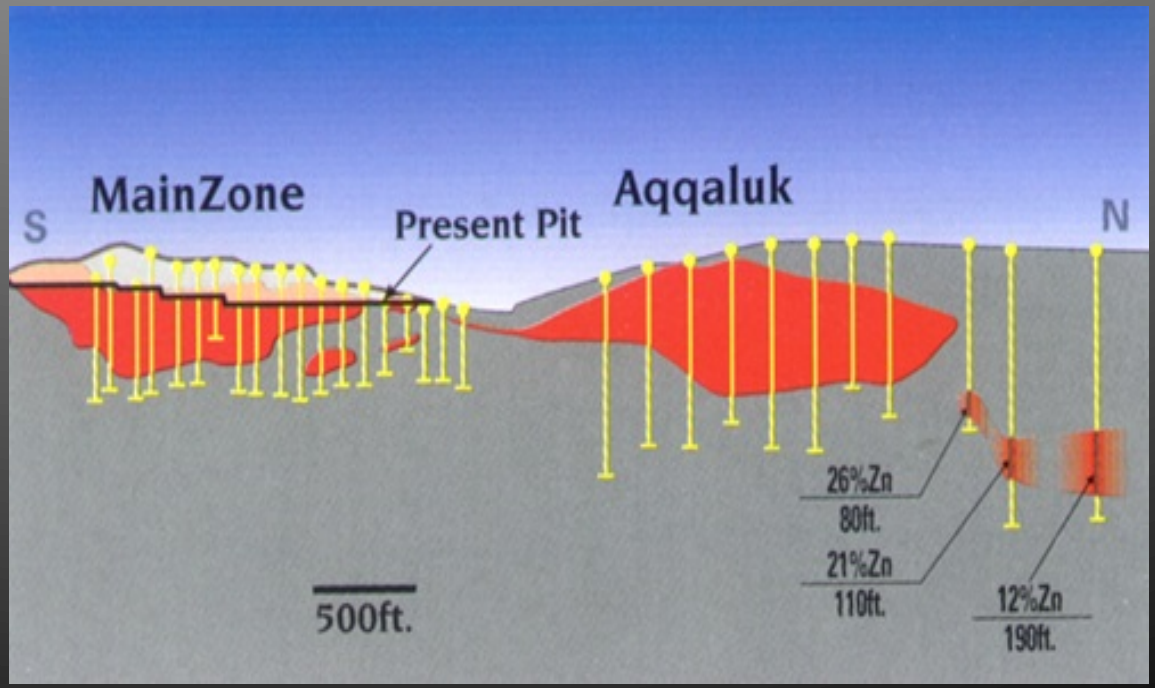
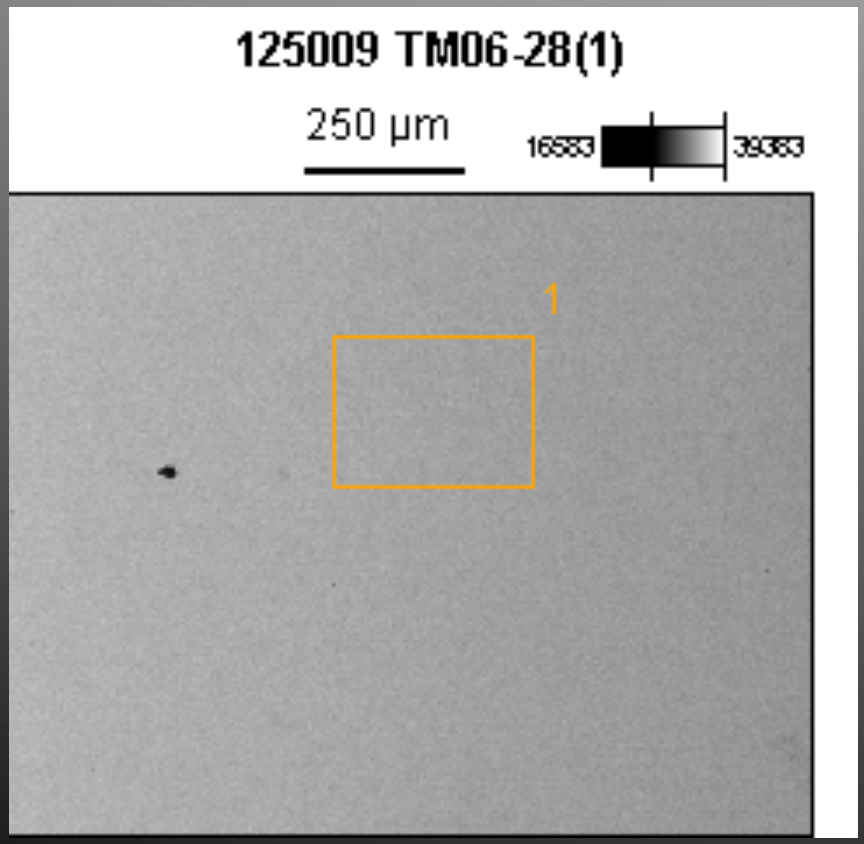


Photo taken from: Info Mine

Weight Percent	From Klein and Dutrow Table 5.4					From SEM Data			
	1	2	3	4	5	6	7	8	9
Fe	0	0.15	7.99	18.25	63.53	10.29	9.76	7.35	6.31
Mn	0	0	0	2.66	0	0	0	0	0
Cd	0	0	1.23	0.28	0	0	0	0	0
Zn	67.1	66.98	57.38	44.67	0	39.31	29.11	0	0.14
S	32.9	32.78	32.99	33.57	36.47	50.4	61.12	92.65	93.55
Total	100	99.91	99.59	99.43	100	100	99.99	100	100
Atomic Proportion									
Fe	0	0.003	0.143	0.327	1.138	0.184	0.175	0.132	0.113
Mn	0	0.000	0.000	0.048	0.000	0	0	0	0
Cd	0	0.000	0.019	0.004	0.000	0	0	0	0
Zn	1.026	1.024	0.878	0.683	0.000	0.601	0.445	0	0.002
S	1.026	1.022	1.029	1.047	1.137	1.572	1.906	2.889	2.918
Zn+Fe+Mn+Cd	1.026	1.027	1.039	1.063	1.138	0.785	0.620	0.132	0.115
(Zn+Fe+Mn+Cd)/S	1.000	0.995	0.990	0.985	1.000	2.001	3.075	22.0	25.3
Zn	1.026	0.997	0.844	0.643	0.000	0.382	0.234	0.000	0.001
Fe	0	0.003	0.138	0.308	1	0.117	0.092	0.046	0.039
Cd	0	0	0.018	0.004	0	0	0	0	0
Mn	0	0	0	0.046	0	0	0	0	0
Atomic Weight									
Fe	55.845								
Mn	54.94								
Cd	65.39								
Zn	65.39								
S	32.065								

Sample 1 Data

SEM Image



Weight Percent	
Fe	10.29
Zn	39.31
S	50.4
Total	100
Atomic Prop.	
Fe	.18
Zn	.60
S	1.572

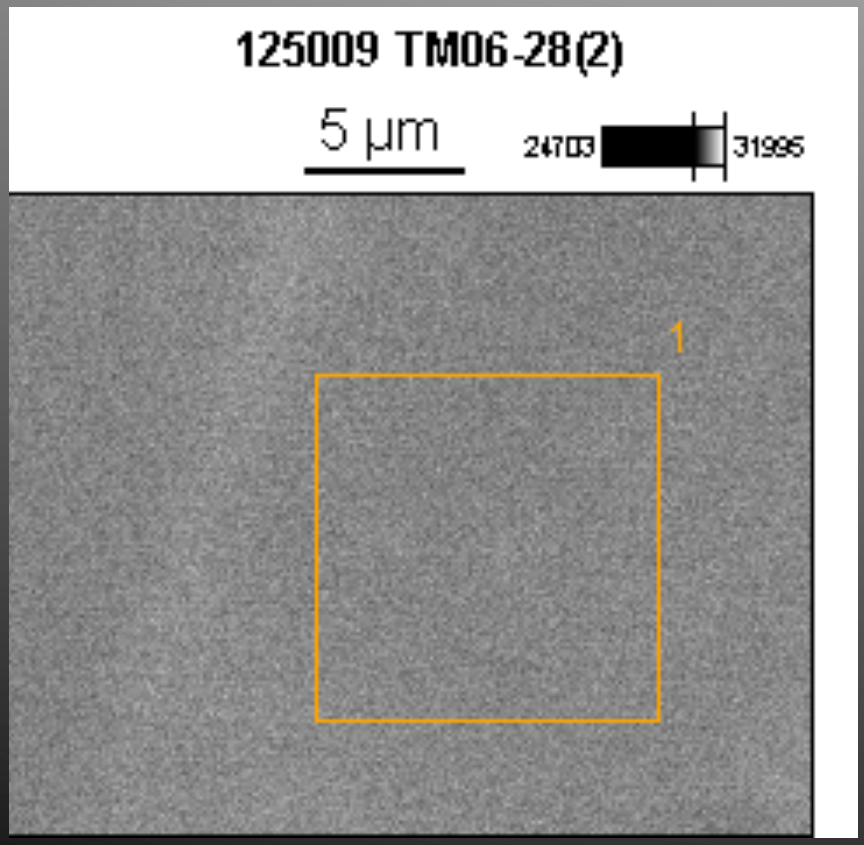
Zn:Fe

3.33:1

$Zn_{.38}Fe_{.11}S$

Sample 2 Data

SEM Image



Weight Percent	
Fe	9.76
Zn	29.11
S	61.12
Total	99.99
Atomic Prop.	
Fe	.17
Zn	.45
S	1.91

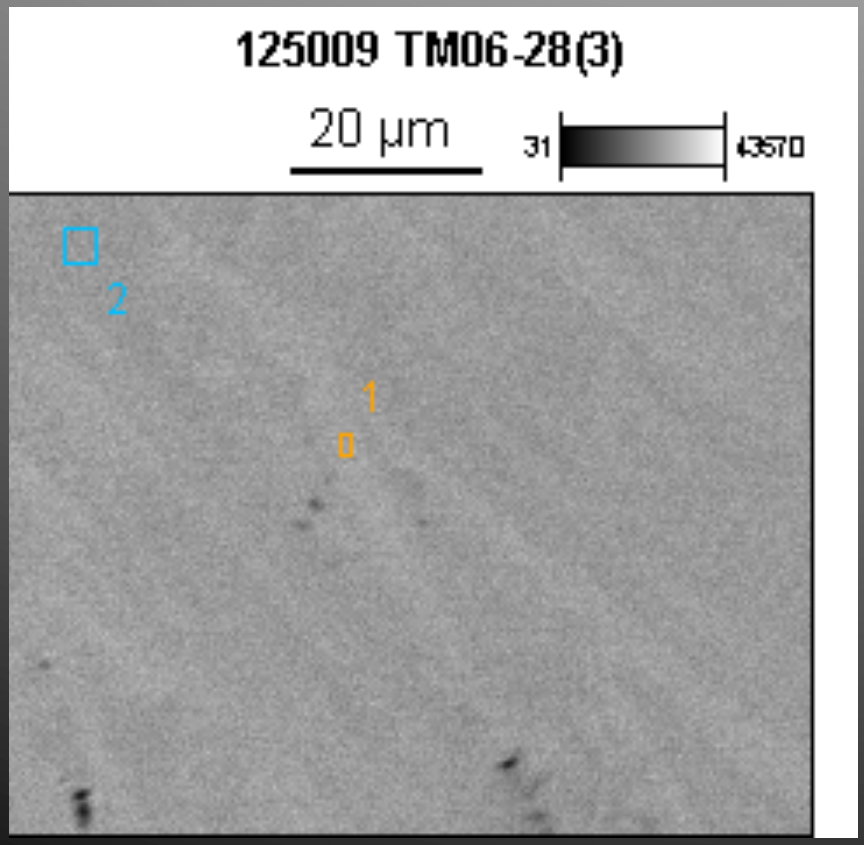
Zn:Fe

2.64:1

$Zn_{.23}Fe_{.09}S$

Sample 3 Data

SEM Image

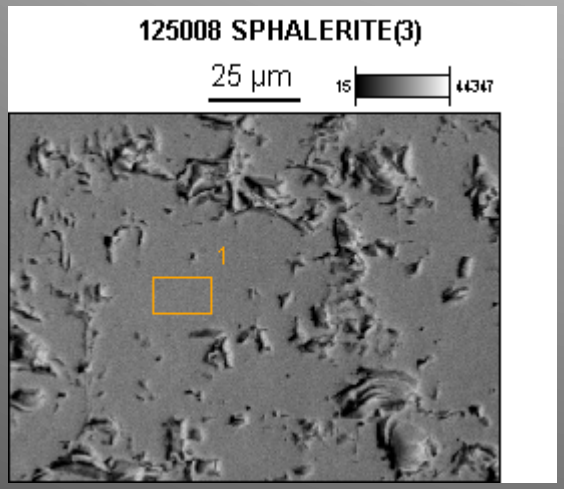


Weight Percent		
Fe	7.35	6.31
Zn	0	.14
S	92.65	93.55
Total	100	100
Atomic Prop.		
Fe	.13	.11
Zn	0	.002
S	2.9	2.92
$Fe_{.04}S$	$Zn_{.0007}Fe_{.04}S$	
	Zn:Fe	Zn:Fe
	0:.13	.018:1

SEM Calculations

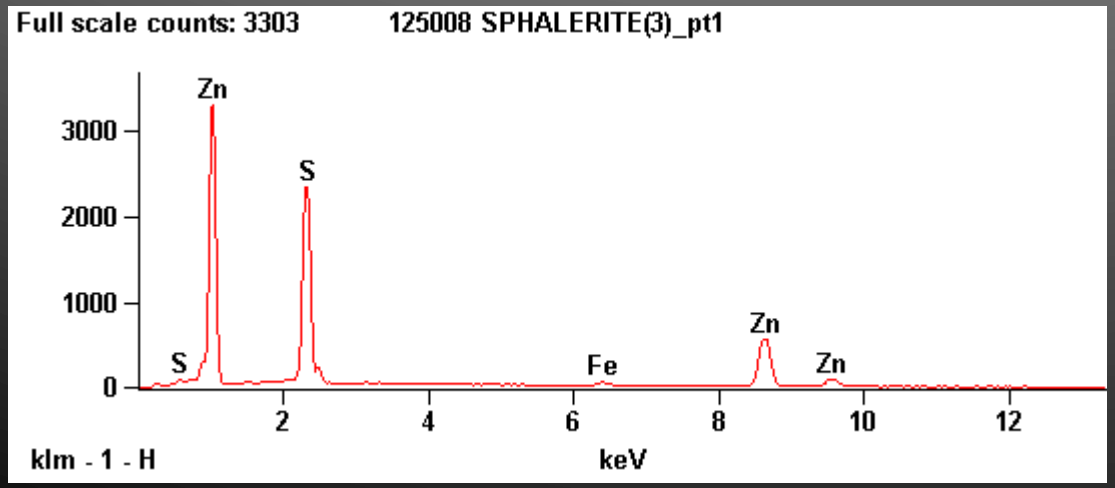
Weight Percent	From Klein and Dutrow Table 5.4					From SEM Data		
	1	2	3	4	5	6	7	8
Fe	0	0.15	7.99	18.25	63.53	3.25	1.53	1.53
Mn	0	0	0	2.66	0	0	0	0
Cd	0	0	1.23	0.28	0	0.86	0	0
Zn	67.1	66.98	57.38	44.67	0	58.67	60.84	60.87
S	32.9	32.78	32.99	33.57	36.47	37.22	37.57	37.6
Total	100	99.91	99.59	99.43	100	100	99.94	100
Atomic Proportion								
Fe	0	0.003	0.143	0.327	1.138	0.058	0.027	0.027
Mn	0	0.000	0.000	0.048	0.000	0	0	0
Cd	0	0.000	0.019	0.004	0.000	0.013	0	0
Zn	1.026	1.024	0.878	0.683	0.000	0.897	0.930	0.930
S	1.026	1.022	1.029	1.047	1.137	1.161	1.172	1.173
Zn+Fe+Mn+Cd	1.026	1.027	1.039	1.063	1.138	0.969	0.958	0.958
(Zn+Fe+Mn+Cd)/S	1.000	0.995	0.990	0.985	1.000	1.198	1.223	1.2
Zn	1.000	0.997	0.844	0.643	0.000	0.926	0.971	0.971
Fe	0	0.003	0.138	0.308	1	0.060	0.029	0.028
Cd	0	0	0.018	0.004	0	0.013	0	0
Mn	0	0	0	0.046	0	0	0	0

SEM Data



Weight Percent	
Fe	1.53
Mn	0
Cd	0
Zn	60.84
S	37.57
Total	99.94

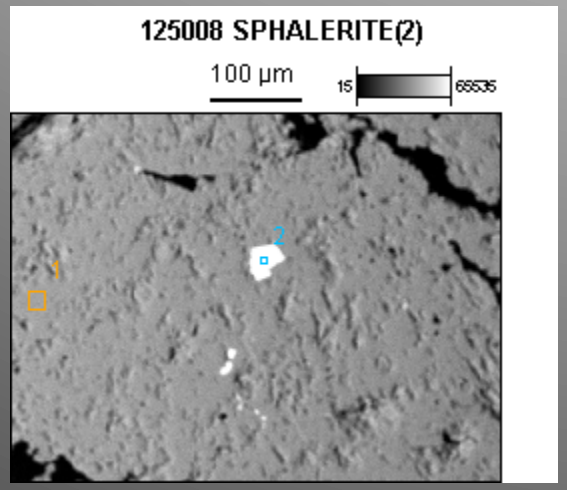
Atomic Proportions	
Fe	0.027
Mn	0
Cd	0
Zn	0.93
S	1.172



$Zn_{.997}Fe_{.003}S$

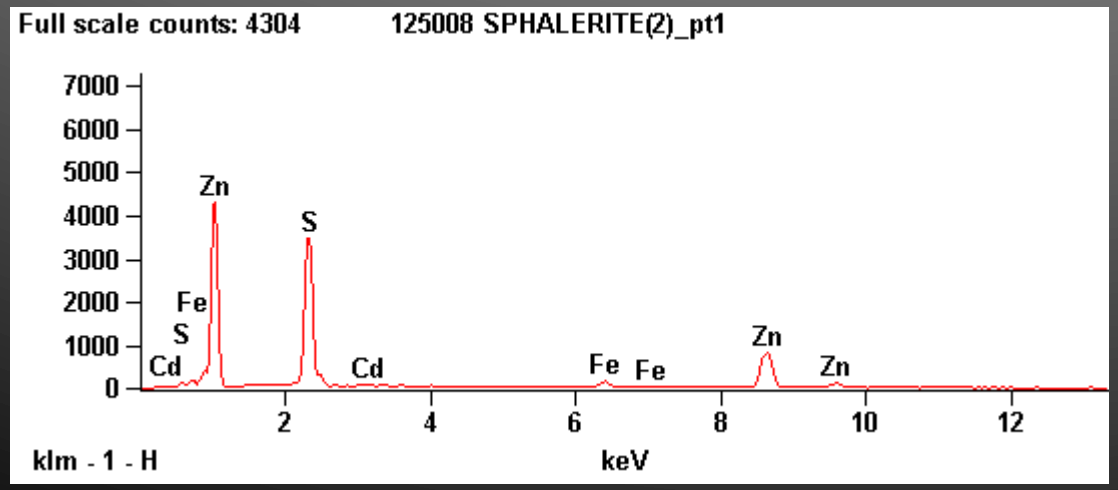
Zn:Fe
34.4:1

SEM Data



Weight Percent	
Fe	3.25
Mn	0
Cd	0.86
Zn	58.67
S	37.22
Total	100

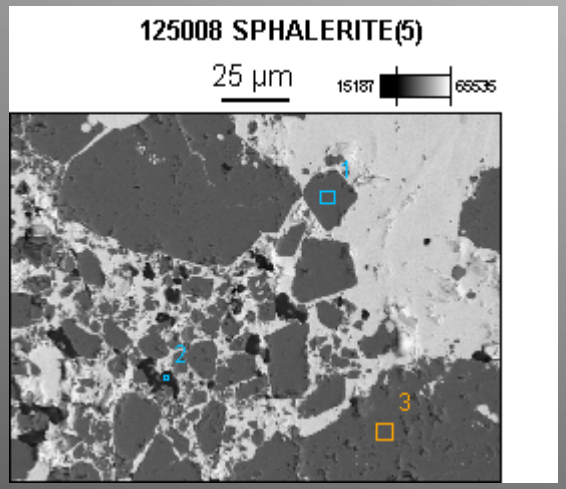
Atomic Proportions	
Fe	0.058
Mn	0
Cd	0.013
Zn	0.897
S	1.161

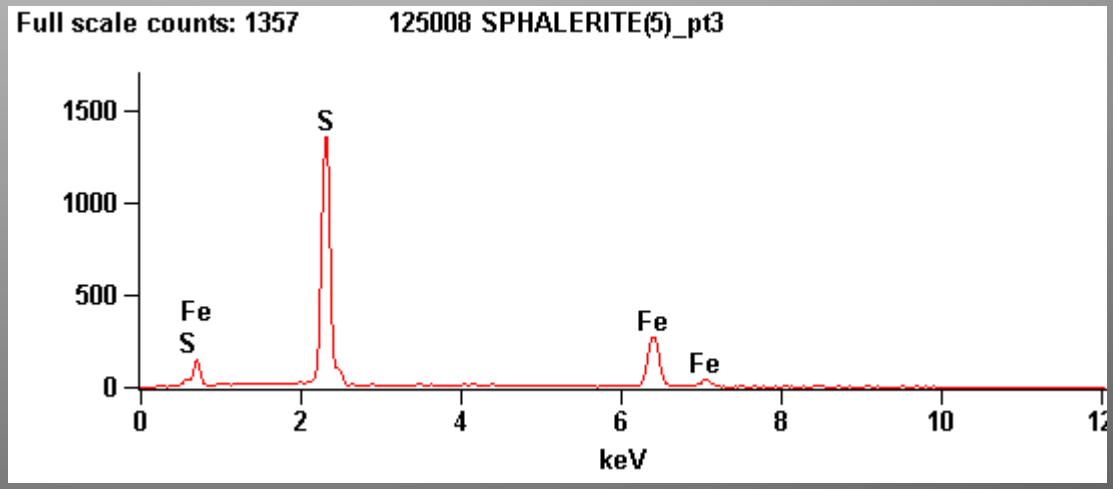


$Zn_{.931}Fe_{.06}Cd_{.007}S$

Zn:Fe
15.5:1

SEM Data


125008 SPHALERITE(5)
25 µm
15187
65535
1
2
3


Full scale counts: 1357
125008 SPHALERITE(5)_pt3
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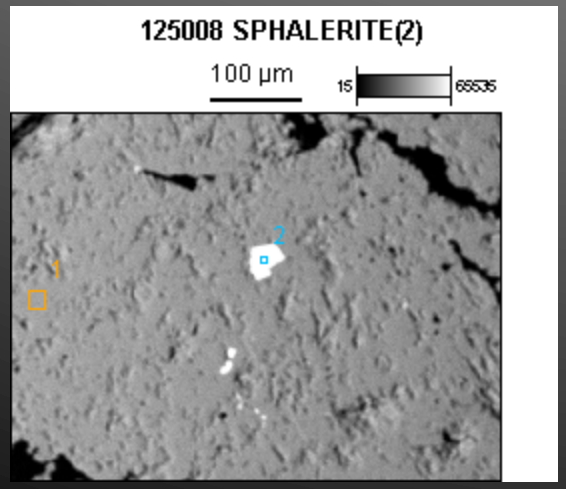
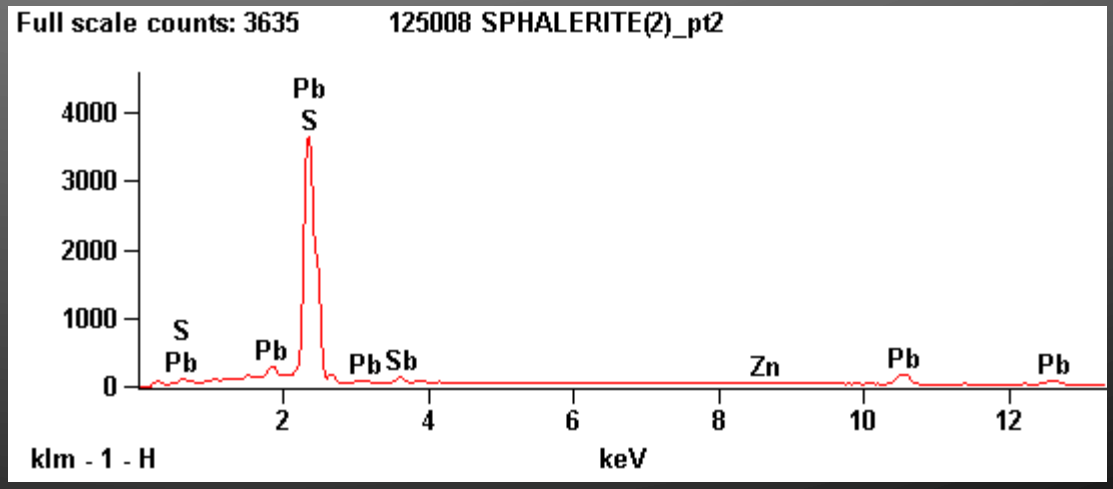
1000
500
0
S
Fe
S
Fe
Fe
0
2
4
6
8
10
12
keV


125008 SPHALERITE(2)
100 µm
15
65535
1
2


Full scale counts: 3635
125008 SPHALERITE(2)_pt2
4000
3000
2000
1000
0
Pb
S
S
Pb
Pb
Pb
Sb
Zn
Pb
Pb
2
4
6
8
10
12
klm - 1 - H
keV

Environmental issues

- Cadmium is toxic
- High winds blow dust ore products
  - Trucks hauling ore deposits blows out and scatters along the road sides
- Wastewater pollution
  - Waste material gets into the water streams and contaminates towns water

Crystal Structure

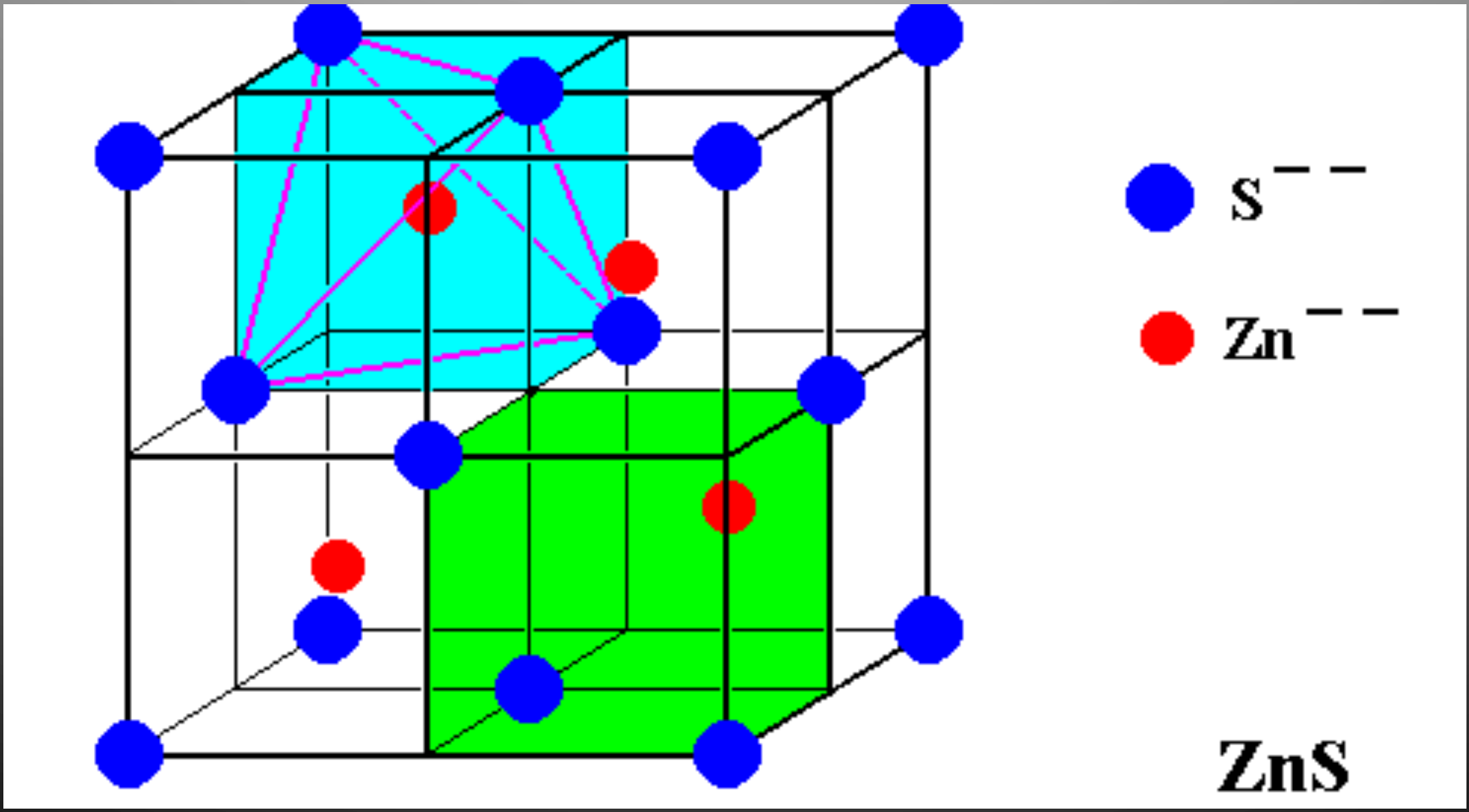


Photo taken from: http://www.metafysica.nl/turing/preparation_3dim_3.html

Common Trace Minerals

- Fe^{2+}, Cd^{2+}, Mn^{2+}, Co^{2+}
- Sn, Ag, Ga, Ge

Ye *et al* (2011)

Common Trace Minerals

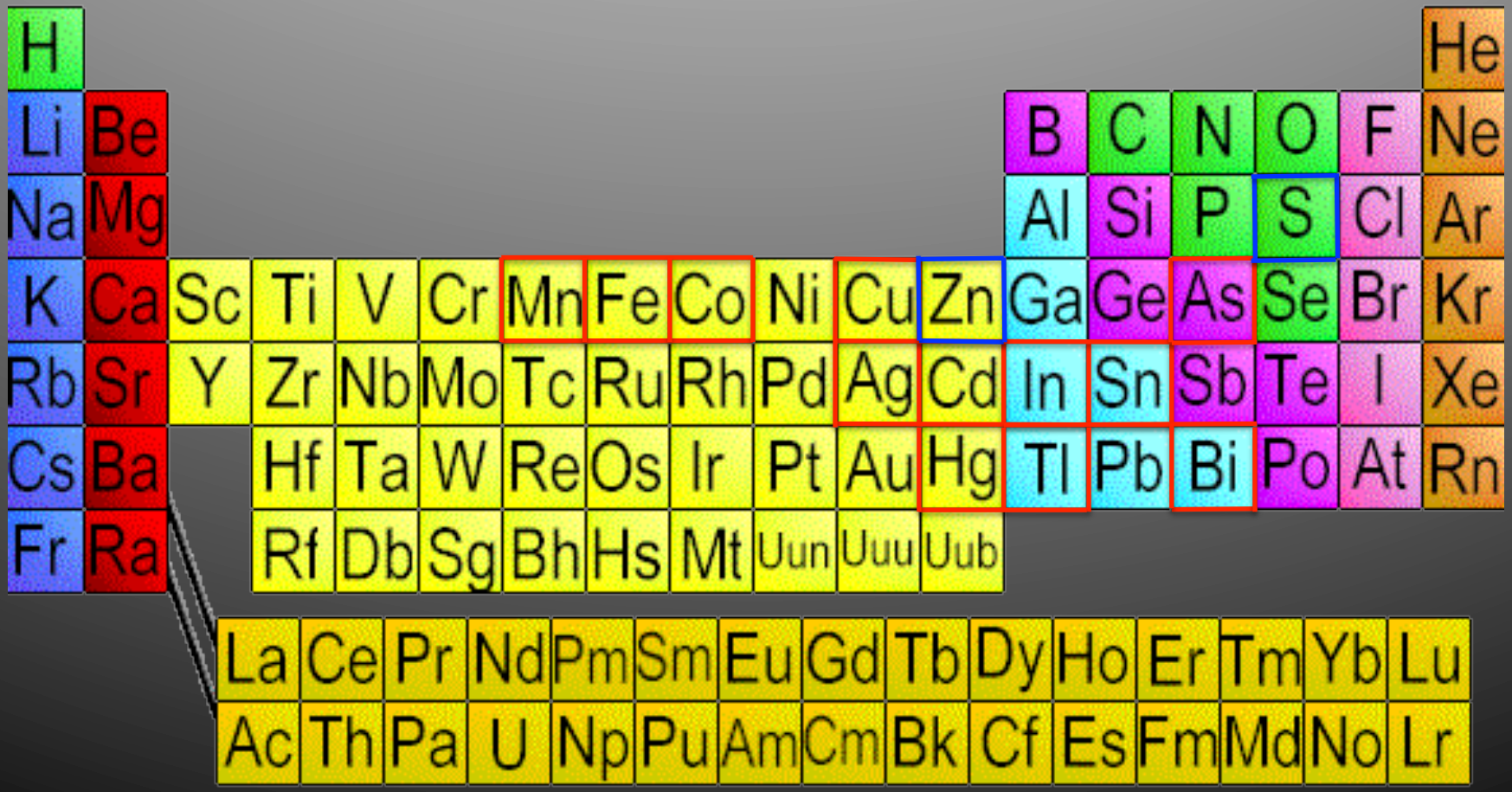


Photo taken from:http://www.chemicalelements.com/

Color	Hg (ppm)	Cd (ppm)	Ga (ppm)	Ge (ppm)	Cu (ppm)	Fe (ppm)	Zn (wt %)	S (wt %)
Green	800	860	<13	9	10	1,400	67.29	32.84
Green	800	779	<13	5	<3	2,100	67.50	33.11
Yellow	825	885	<13	6	55	1,200	67.51	33.02
Yellow	1,110	951	<13	<4	82	2,400	67.12	32.24
Yellow	700	808	<13	10	35	1,100	67.58	33.11
Yellow	600	902	<13	8	30	2,400	67.61	33.23
Yellow	850	947	<13	10	79	1,200	67.11	32.72
Yellow	1,000	743	<13	9	20	1,200	67.28	32.81
Yellow	1,500	822	<13	<4	58	800	67.50	32.62
Orange	1,650	904	<13	12	80	1,600	67.18	33.60
Orange	1,250	839	<13	<4	75	1,000	67.78	33.13
Orange	1,871	999	<13	22	268	600	67.20	32.75
Orange	1,800	946	<13	9	154	800	67.44	32.97
Orange	750	1,025	<13	6	111	1,300	67.60	33.14
Orange	808	975	<13	23	191	1,600	67.42	32.64
Red	2,000	936	<13	<4	61	500	67.40	33.47
Red	1,900	908	<13	<4	84	800	67.45	32.98
Red	2,119	1,026	<13	9	136	1,600	67.12	33.88

Taken from: Gem Sphalerite

Photos taken from: John Betts Fine Minerals

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- An Online, Interactive Periodic Table of Elements: http://www.chemicalelements.com/ (accessed April 2012).
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