The University of British Columbia
Department of Mining Engineering

Geochemistry of Selenium Mobilization from the Elk River Valley Coal Mines

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outline

Selenium in the Elk River

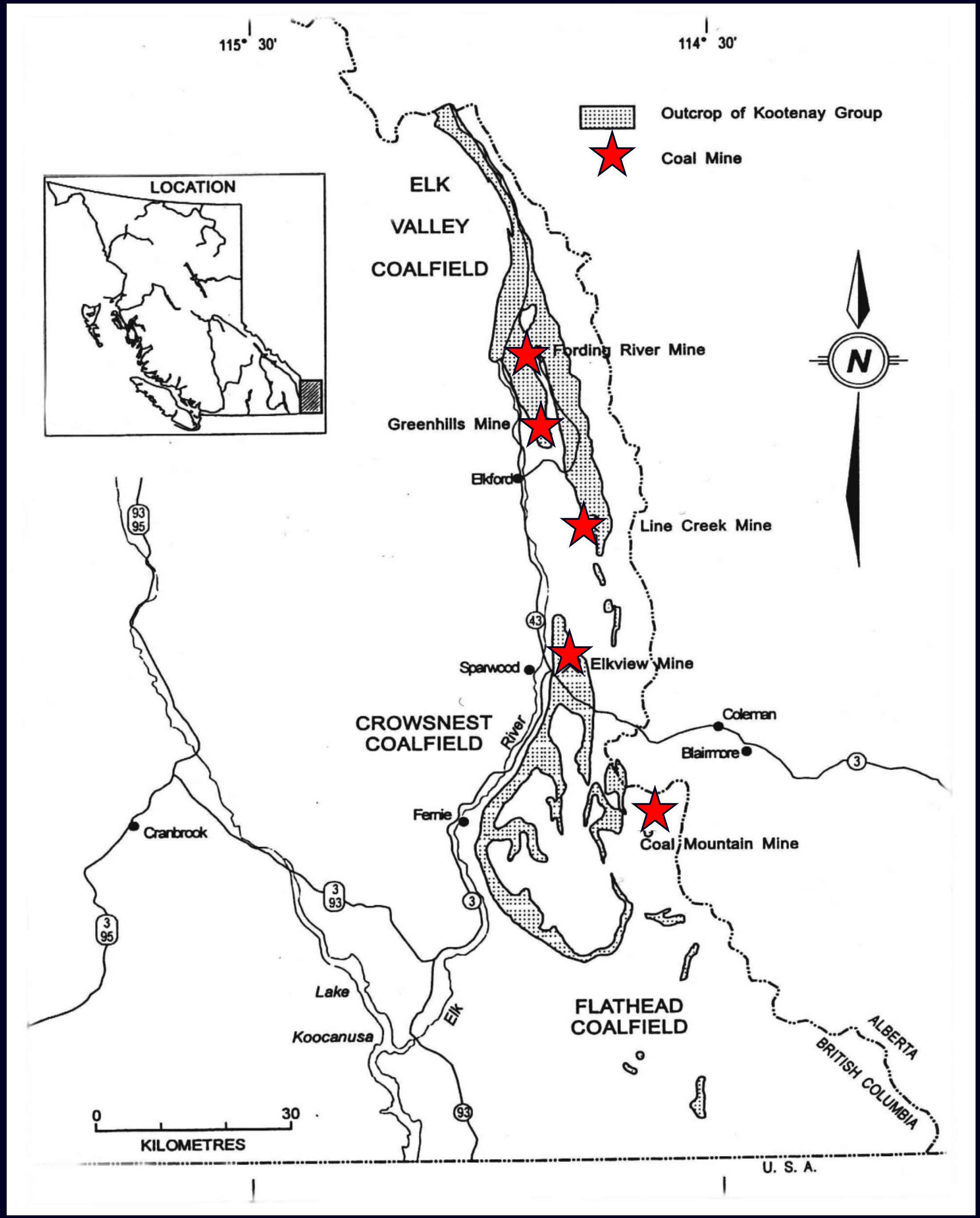
Selenium Biogeochemistry

Selenium in the Mist Mountain Formation

Geochemical Associations of Selenium

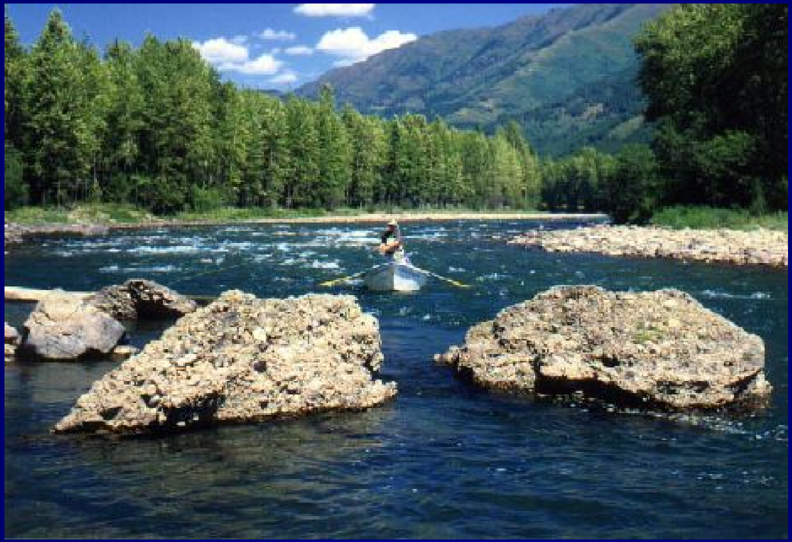
Selenium Mobilization

Conclusions


115° 30'
114° 30'
Outcrop of Kootenay Group
Coal Mine
LOCATION
ELK
VALLEY
COALFIELD
Fording River Mine
Greenhills Mine
Elkford
Line Creek Mine
N
93
95
43
Sparwood
Elkview Mine
Coleman
Blairmore
3
CROWSNEST
COALFIELD
River
Fernie
Coal Mountain Mine
Cranbrook
3
93
3
3
95
Lake
Koocanusa
Elk
FLATHEAD
COALFIELD
ALBERTA
BRITISH COLUMBIA
93
0
30
KILOMETRES
U. S. A.

Mining in the Elk River Valley

- Five open-pit coal mines
- Generate approximately 24 million tonnes of coal annually
- Main product: medium- to low-volatile bituminous coking coals
- Have generated an estimated 2.5 billion tonnes of waste rock since the 1970’s



Selenium in the Elk River

- The provincial freshwater guideline for Se is 1 µg/L
- In the main tributaries of the Elk River Se concentrations of up to 20 µg/L were detected
- Se concentrations as high as 542 µg/L were measured in waste dump seepage

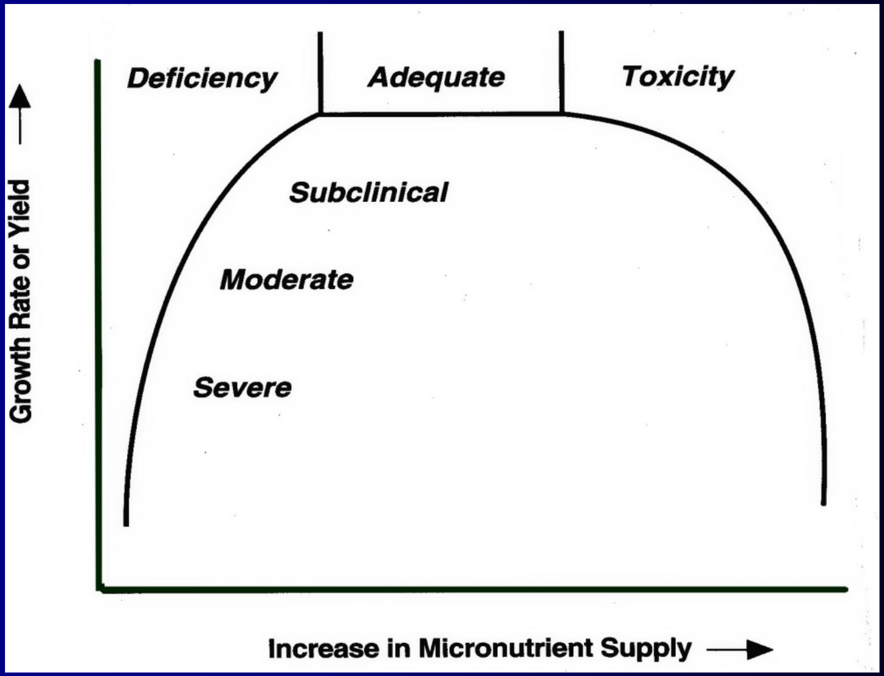
Selenium in the Elk River

- Se concentrations in algae and invertebrates downstream from the mines were 2 to 5 times greater than at references sites
- Se levels in fish were 2 times greater than the published toxic effects thresholds

However, no negative effects were observed in biota

Essentialiaty and Toxicity of Selenium

- Essential micro-nutrient involved in the destruction of free-radicals
- Narrow range of tolerance
- Can disrupt reproduction of fish and aquatic birds
- Can cause embryo defects in fish at concentrations as low as 2µg/L in water



Thornton, 1995

Selenium Speciation

Selenium is a sulphur analog

OXIDATION STATES

Poorly soluble	Selenide (-2)		
	Elemental Se (0)		
Highly soluble	Selenite (+4)	←	Adsorbs to sediment
	Selenate (+6)	←	Most bioavailable

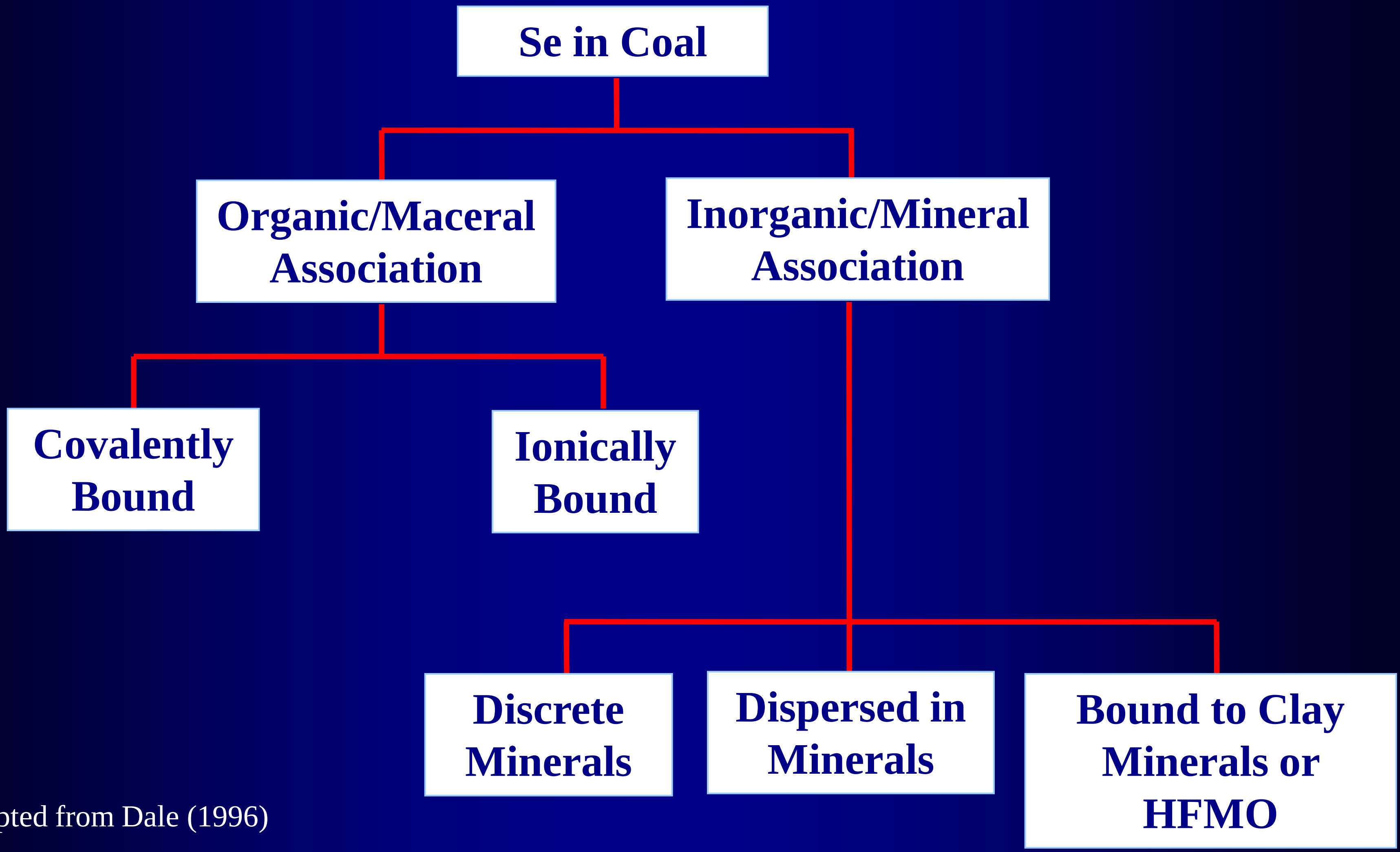
Selenium in the Mist Mountain Formation

	Se Concentration (mg/kg)
Coal	1.9
Hanging wall	4.2
Foot wall	4.2
Partings	3.2
Coarse refuse	2.8
Interburden	1.1

Ryan and Dittrick, 2000

Coal world average	2.2
Crustal average	0.05-0.1

Possible Associations of Selenium in Coal and Associated Lithologies

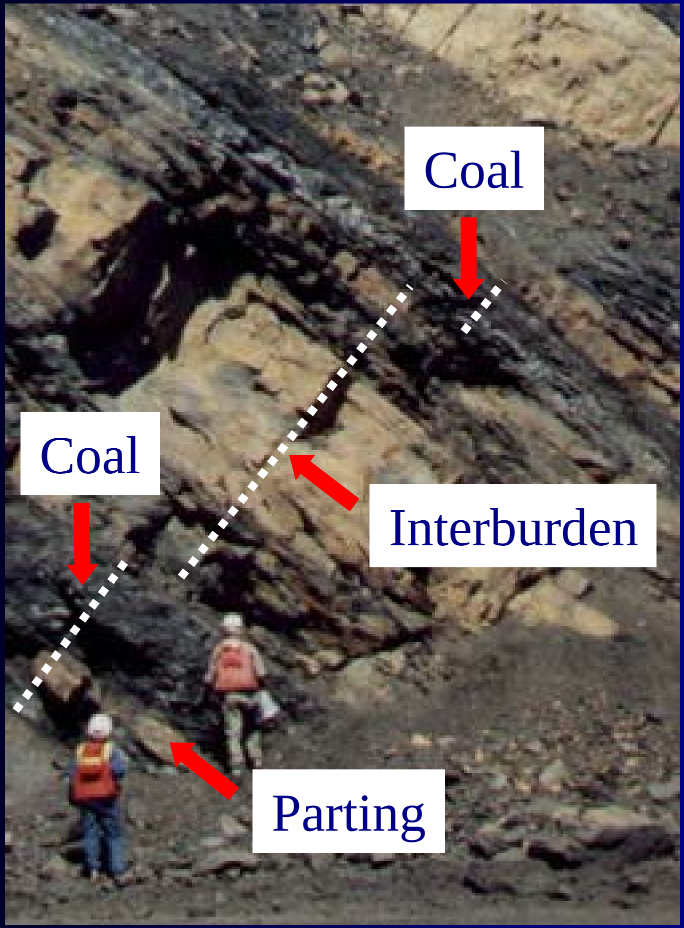


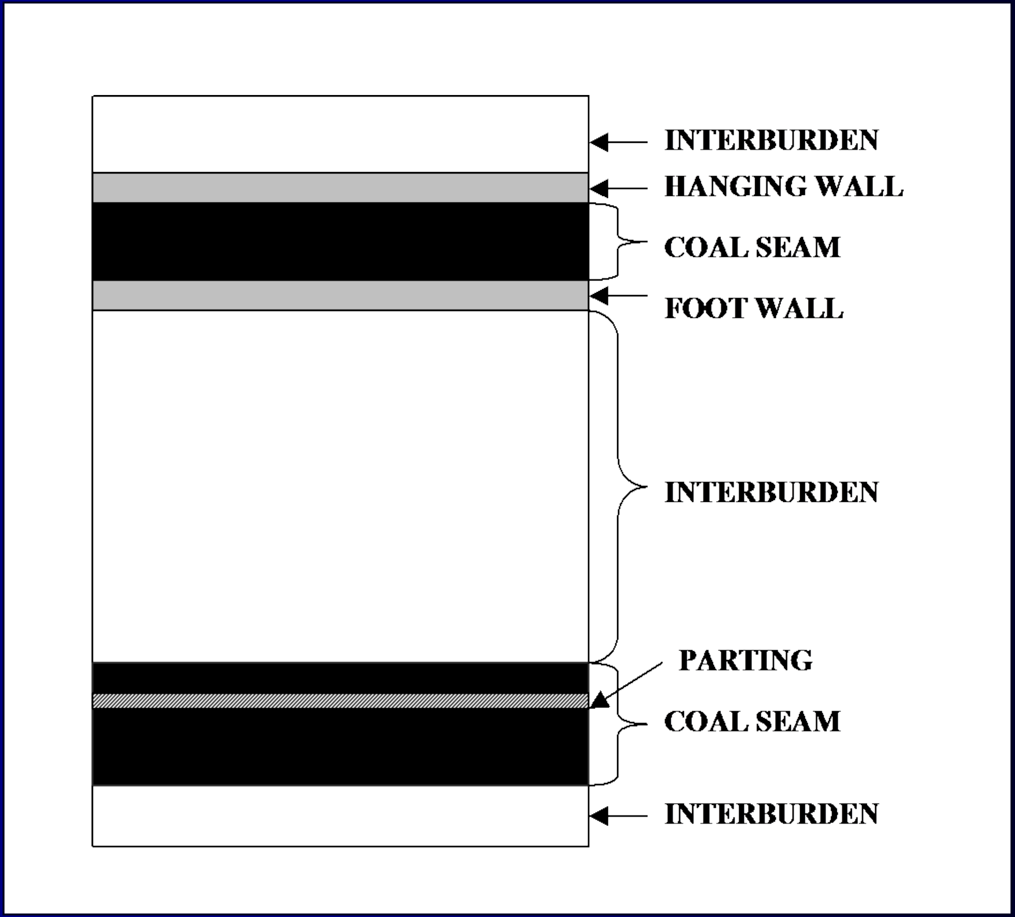
Adapted from Dale (1996)

Objectives

- Identify Se-bearing mineralogical components in the Mist Mountain Formation
- Evaluate the rate of Se release from different lithologies
- Suggest possible geochemical mechanisms of Se mobilization
- Provide mine operators with information needed to assess the risk of Se release from waste rock and plant refuse

Sampling

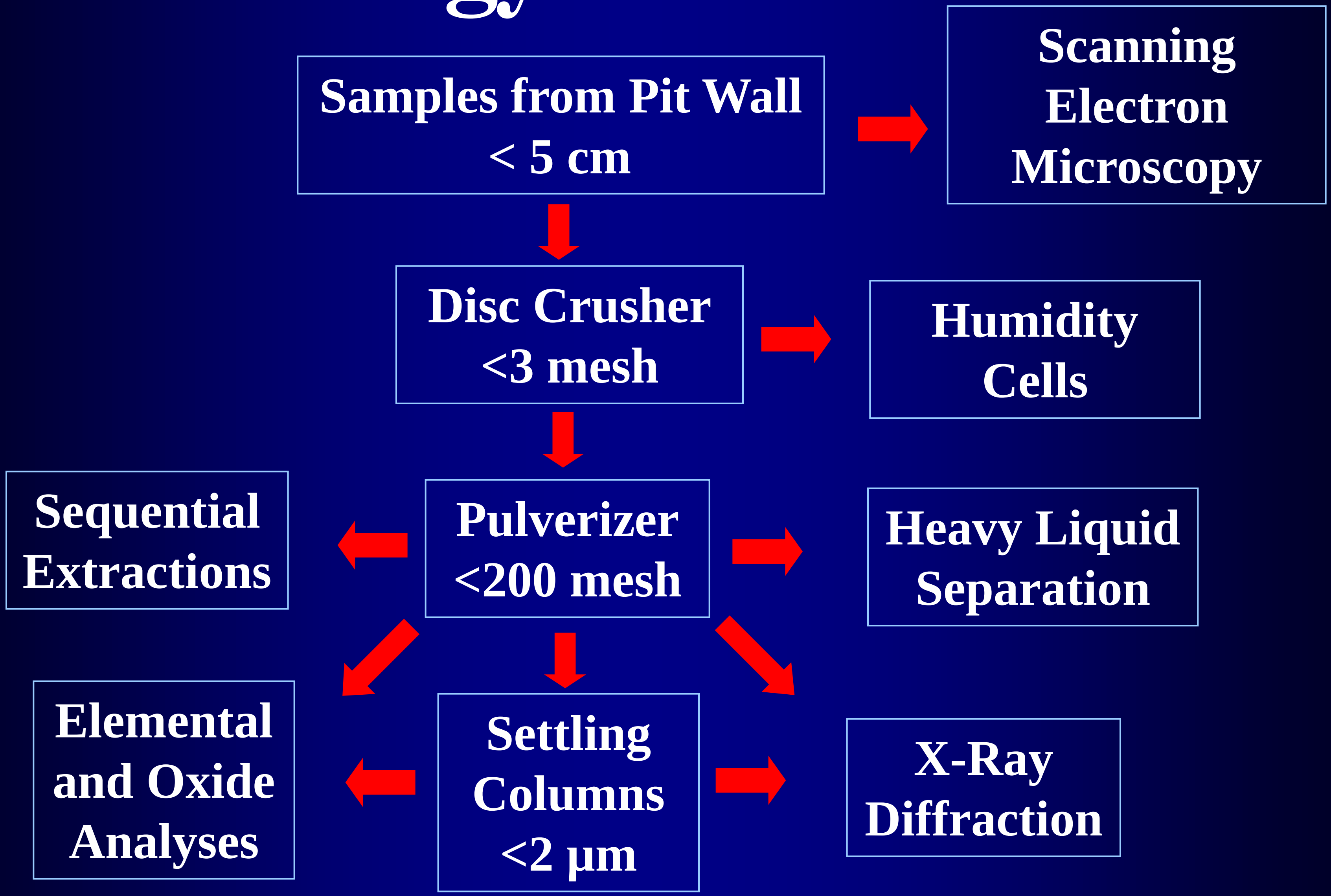

Coal
Coal
Interburden
Parting


INTERBURDEN
HANGING WALL
COAL SEAM
FOOT WALL
INTERBURDEN
PARTING
COAL SEAM
INTERBURDEN

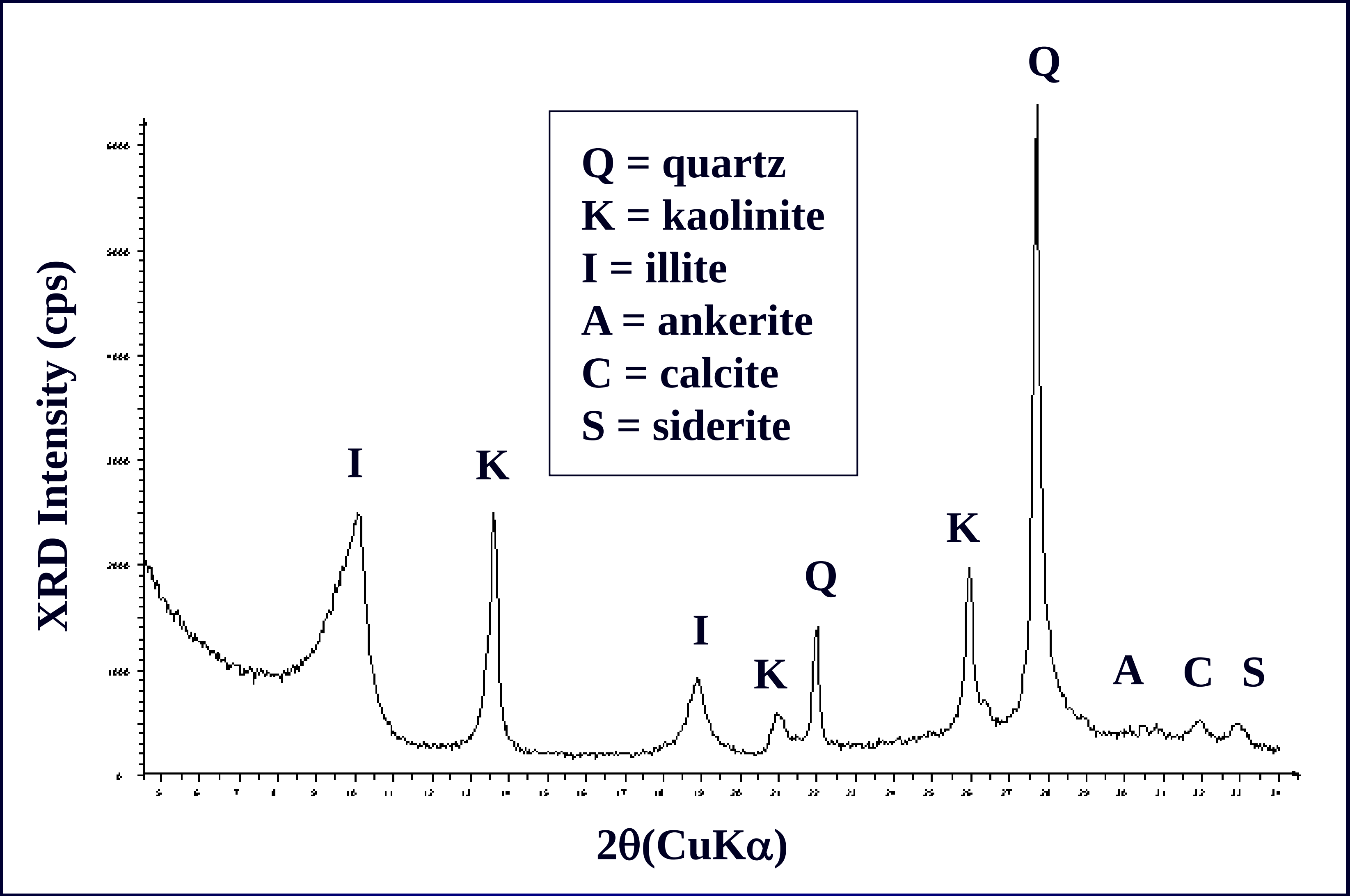
Sample Selection

- 375 samples were collected and analyzed for Se by INAA
- 16 samples, representing the 5 main lithologies, were selected to study the mineralogical associations of Se
- 5 of these samples were used to study the rate of Se release

Methodology



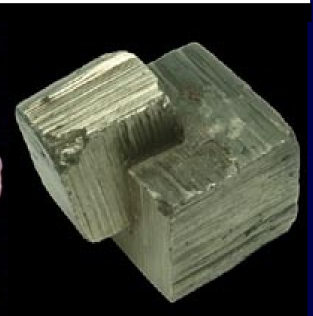
X-Ray Diffraction



Mineralogy

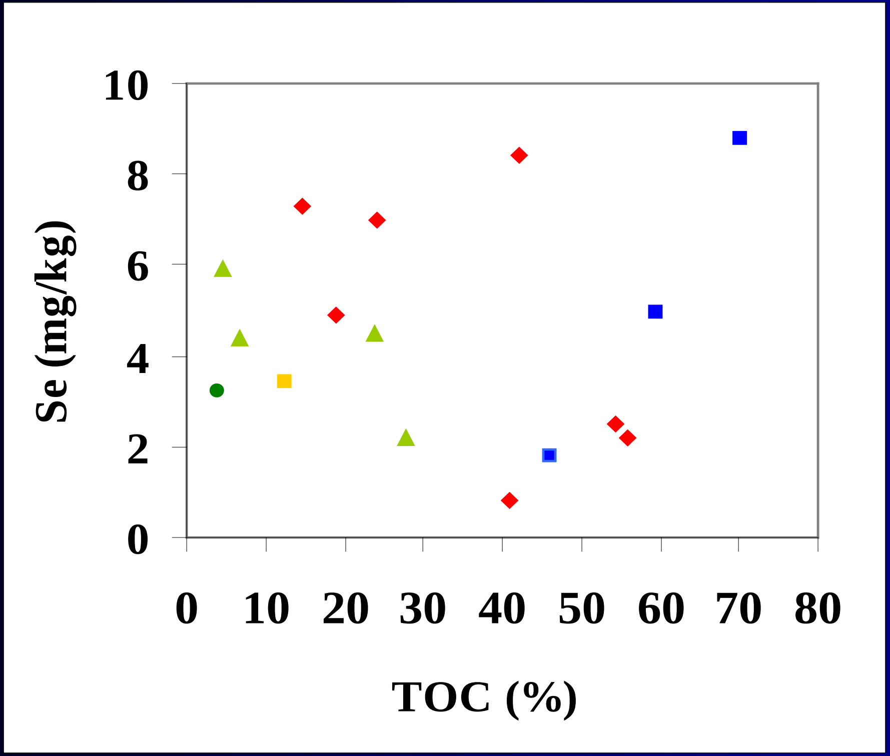
Mineral	Sample Weight
Illite	3.90 - 22.5
Kaolinite	1.80 – 20.8
Quartz	1.30 – 22.3
Carbonate	0.20 – 5.85
Sulphides	0.03 – 0.84

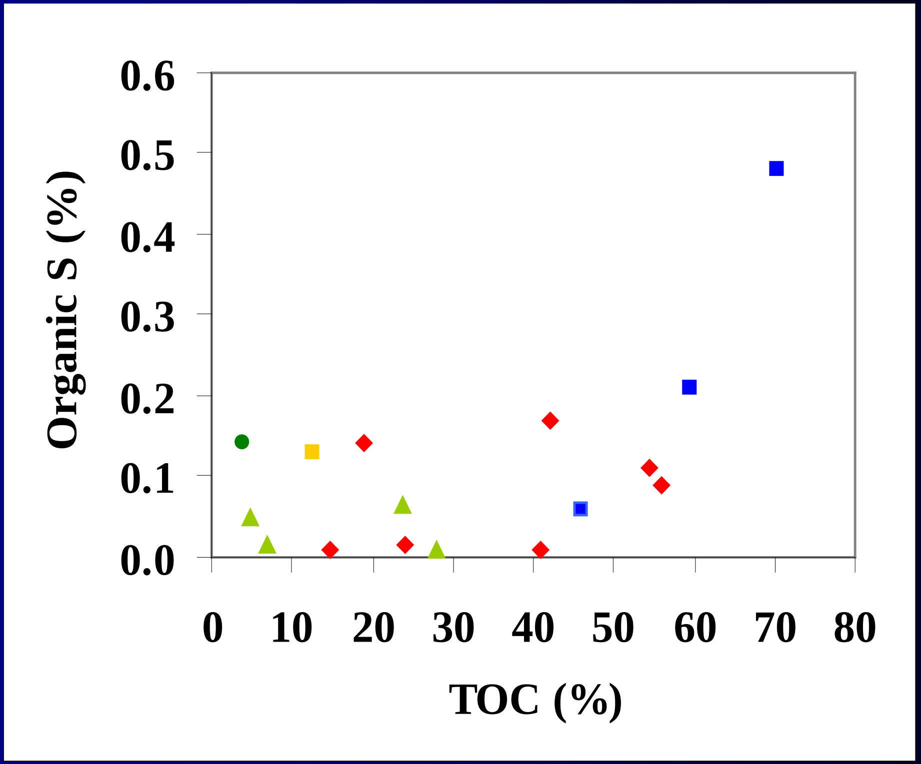


Se versus TOC

Organic S versus TOC



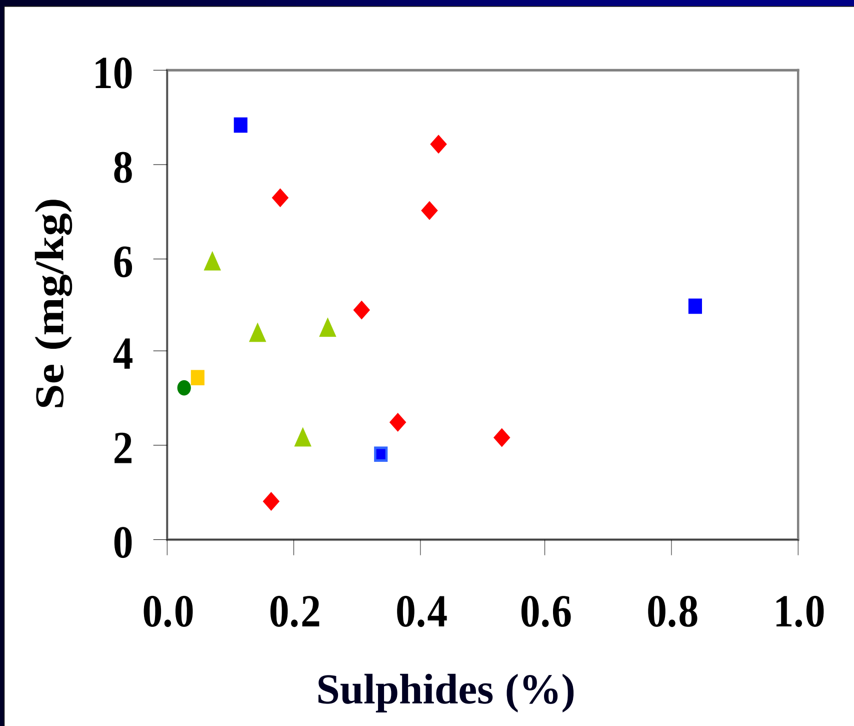


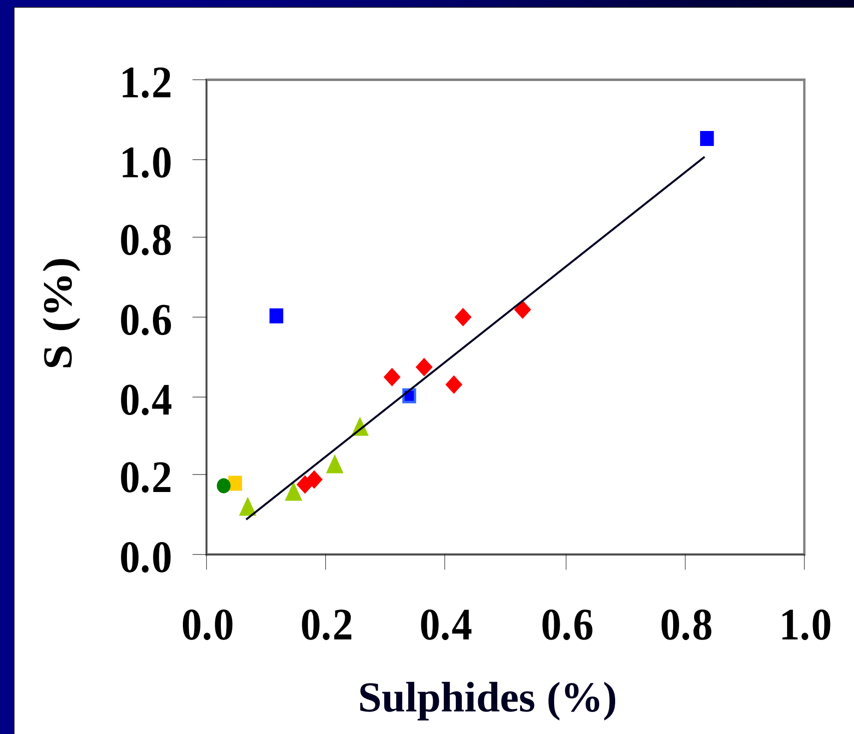
■ refuse ■ coal ▲ parting

● interburden ◆ hanging wall/foot wall

Se versus Sulphides   S versus Sulphides

sulphides ≈ 71 % of total S





■ refuse ■ coal ▲ parting

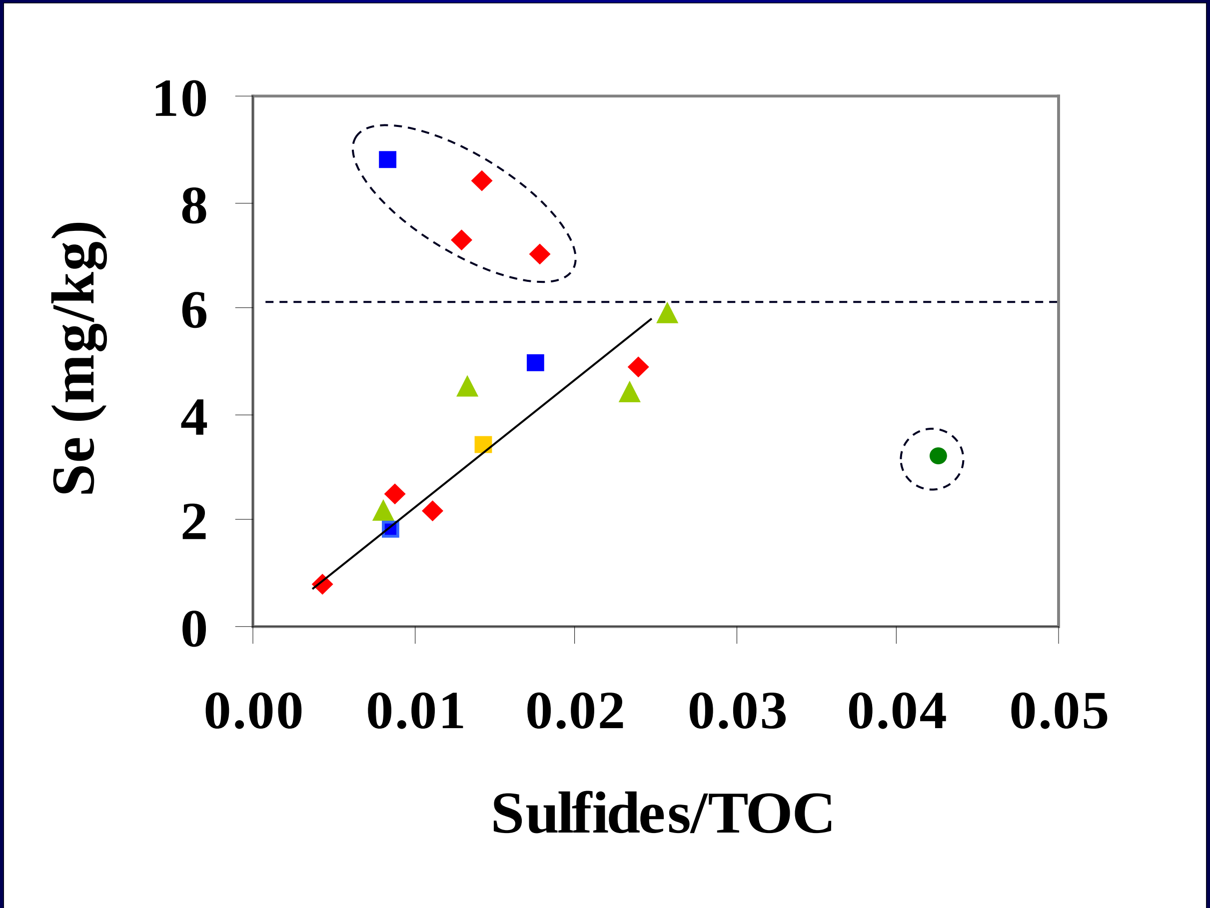
● interburden ◆ hanging wall/foot wall

1. The amount of Se substituting for S in sulphides is highly variable

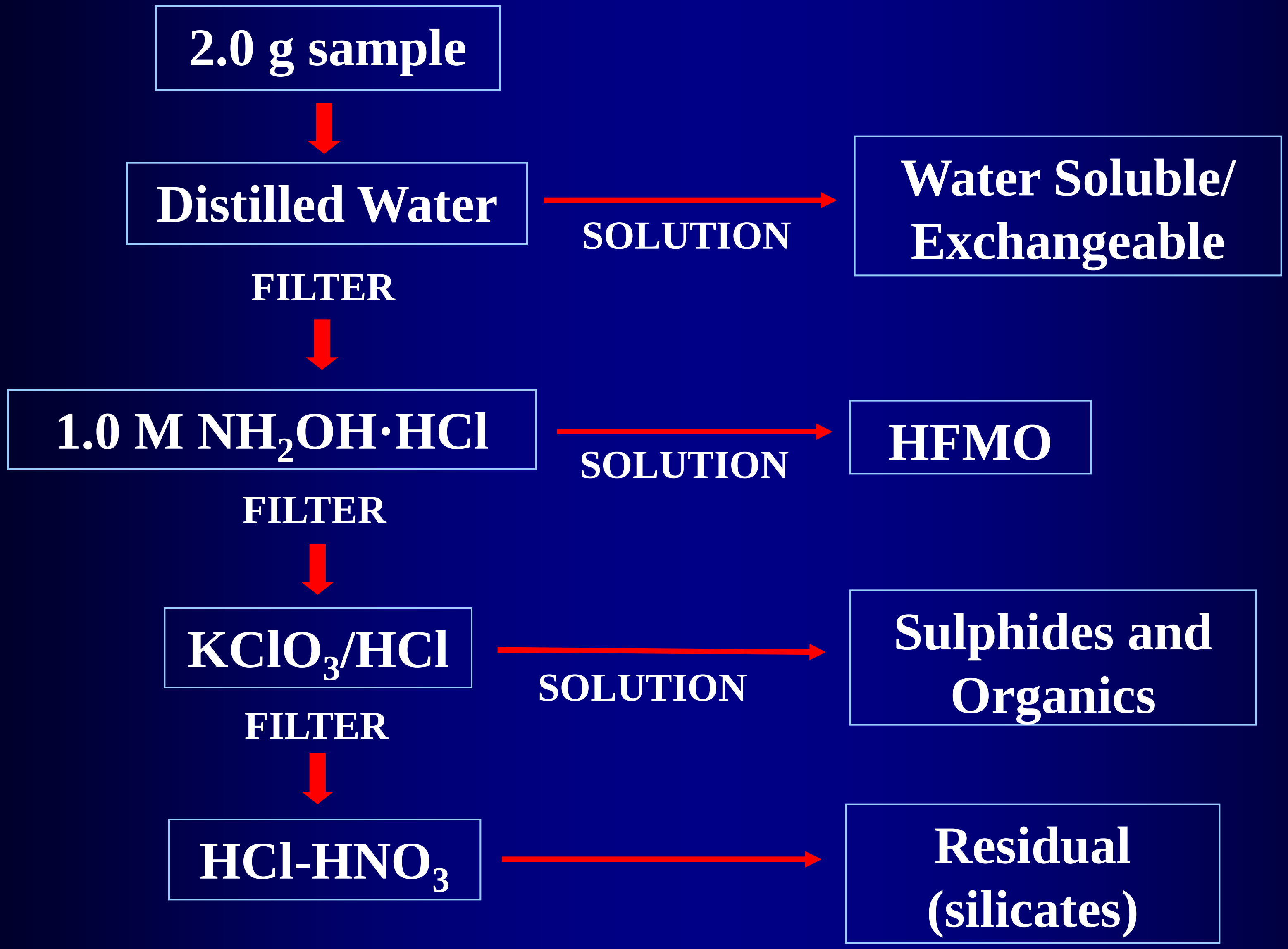
or

2. Other mineralogical associations are of greater importance in determining total Se concentrations

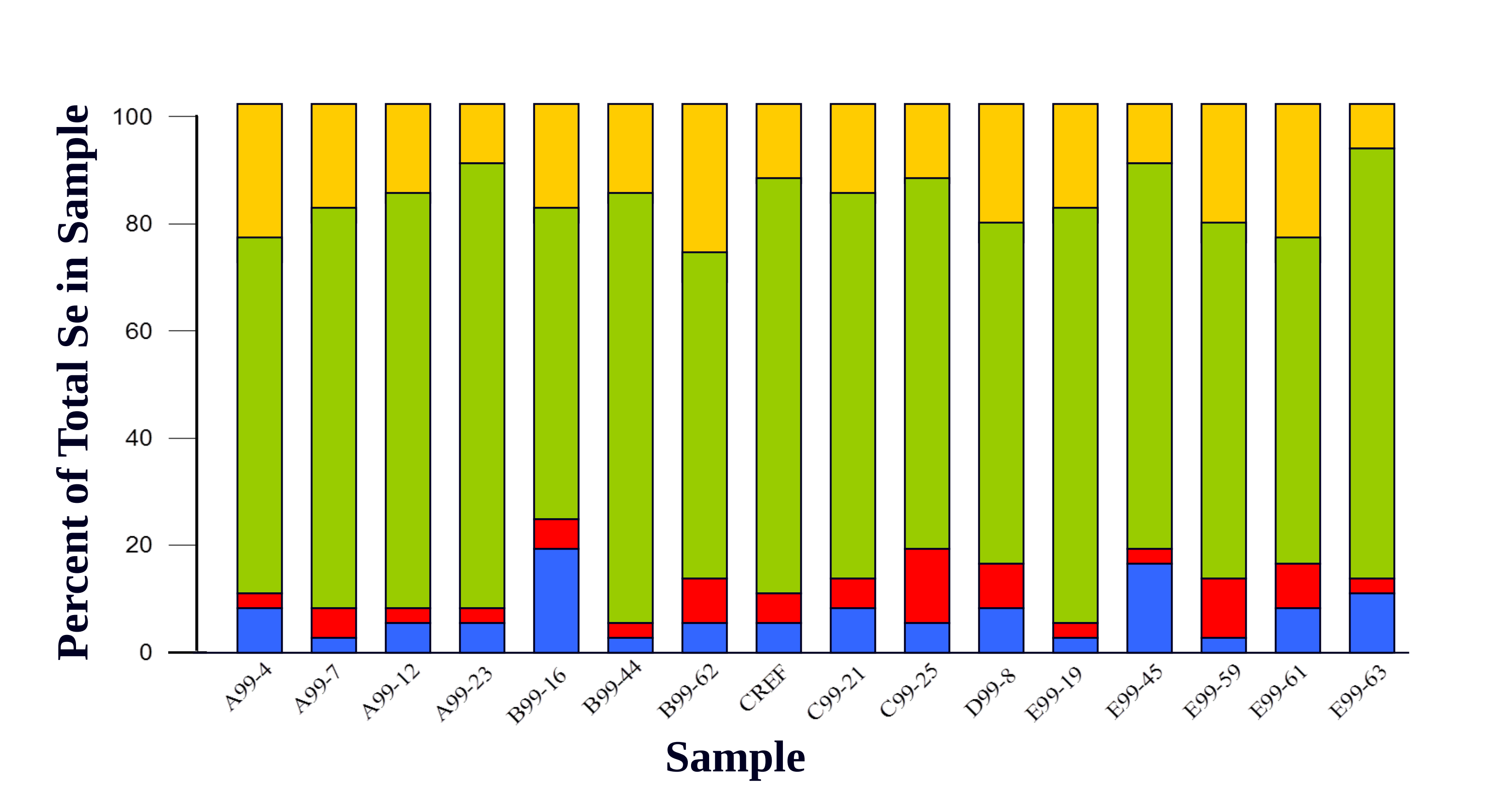
Se versus Sulphides Normalized for TOC



Sequential Extractions



Geochemical Associations of Selenium



Average contribution to total Se (%)	
15	Residual
73	Organic matter and sulphides
4	HFMO
8	Water soluble

Heavy Liquid Separation

20 g sample

Perchlorethylene
d = 1.6 g/cm^3

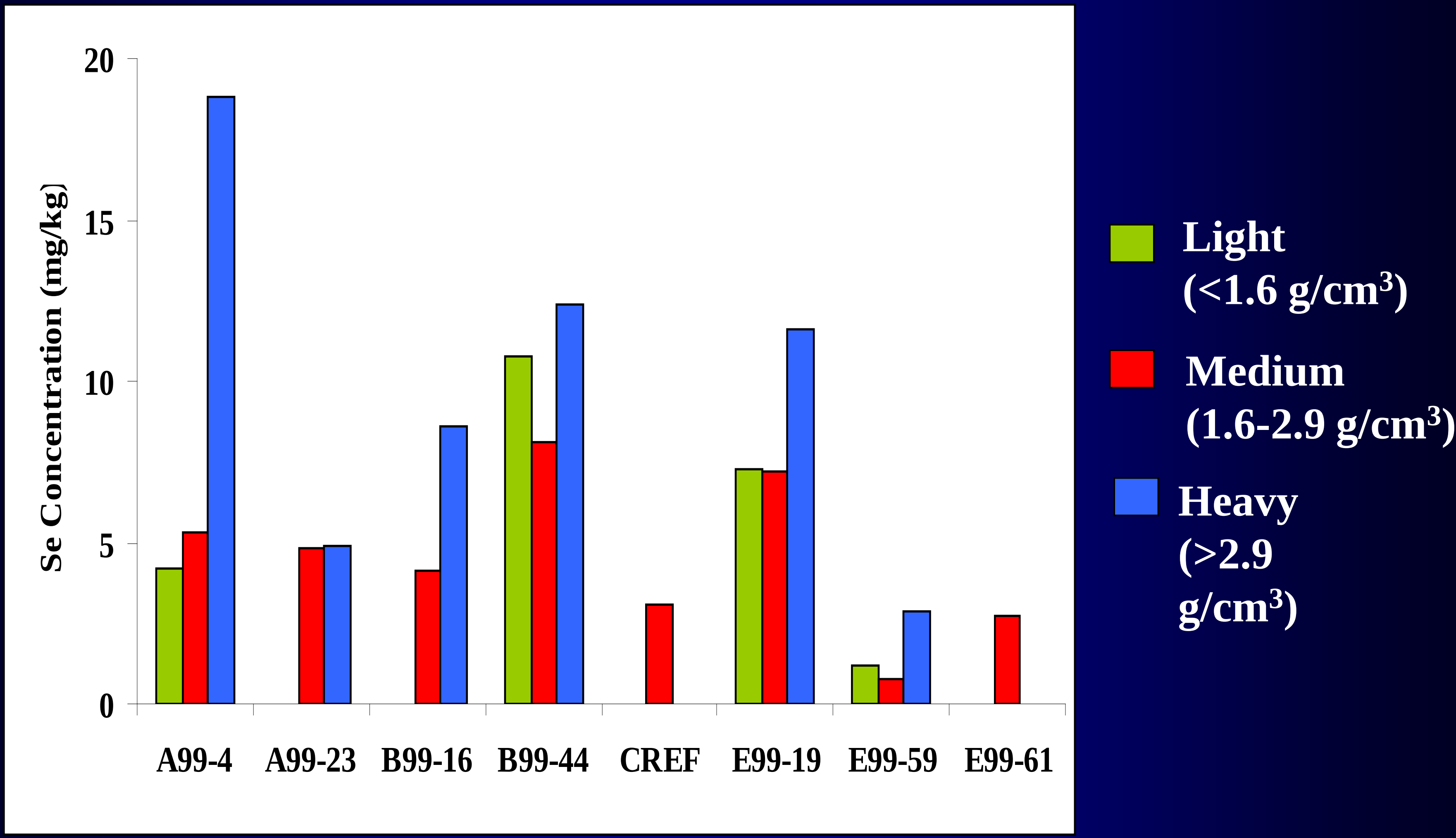
LIGHT

Methylene iodide
d = 3.3 g/cm^3

MEDIUM

HEAVY

Heavy Liquid Separation



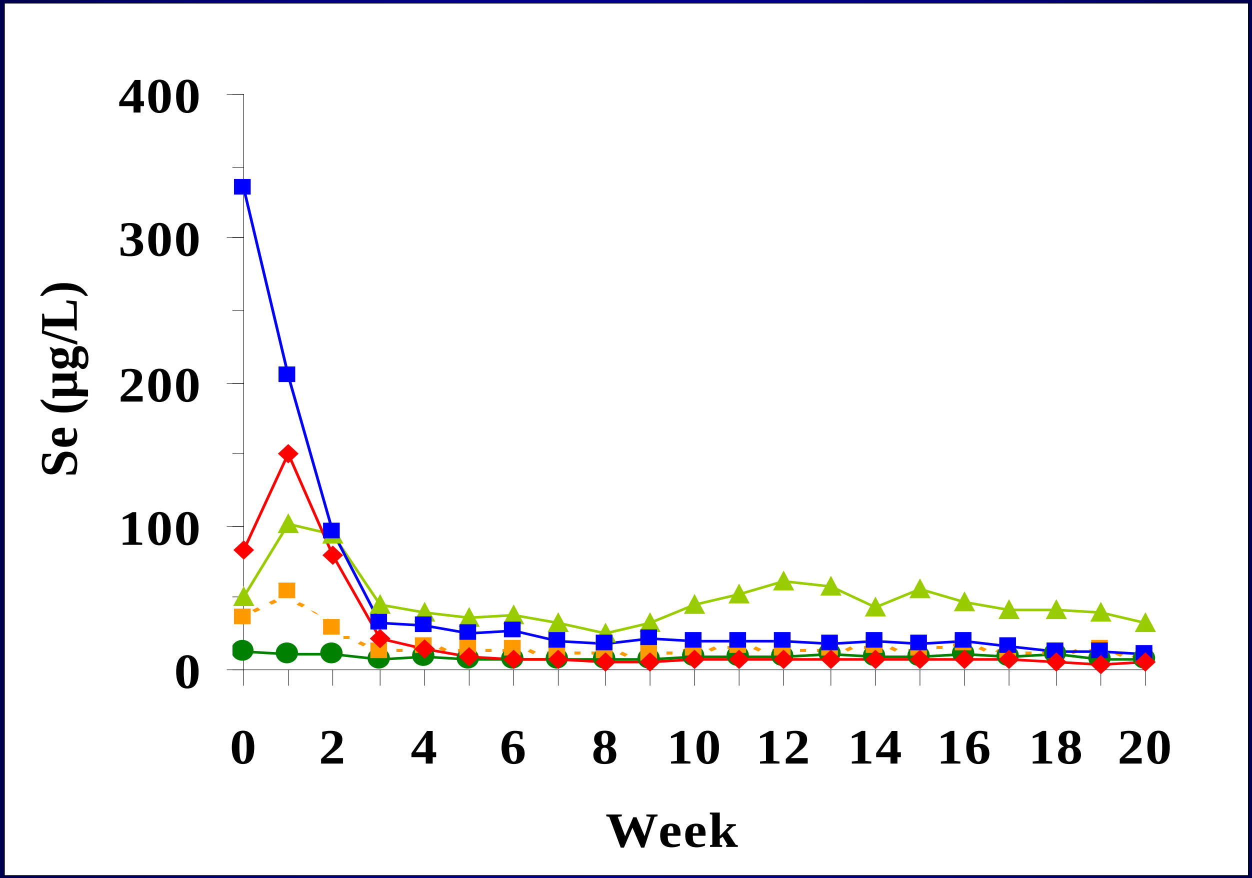
Humidity Cells

- 5 different materials selected
- 1 kg of material placed in each cell
- 7 day moist-air/dry-air/leach cycle
- Leached once a week with 500 ml of distilled water
- Run for 20 weeks

Humidity Cells Samples

Designation in Tables	Se Content (mg/kg)	Sulphides (%)	TOC (%)
Interburden	3.2	0.05	4.7
Refuse	3.4	0.13	12.5
Parting	5.9	0.07	5.8
Foot wall	8.4	0.43	4.0
Coal	8.8	0.12	70.3

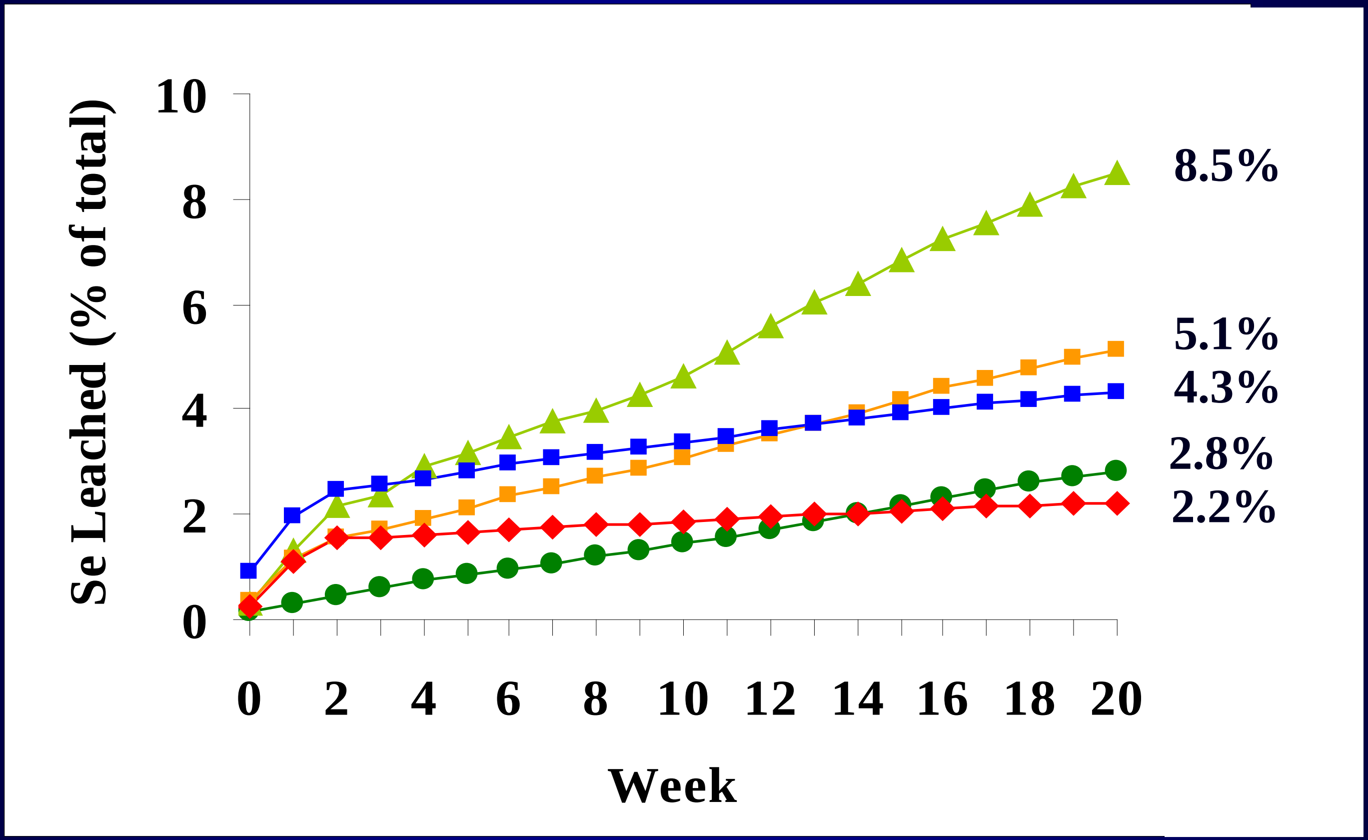
Se Concentration in Humidity Cell Leachate



refuse coal parting

interburden hanging wall/foot wall

Percent of Total Se Extracted from the Humidity Cells in 20-Weeks

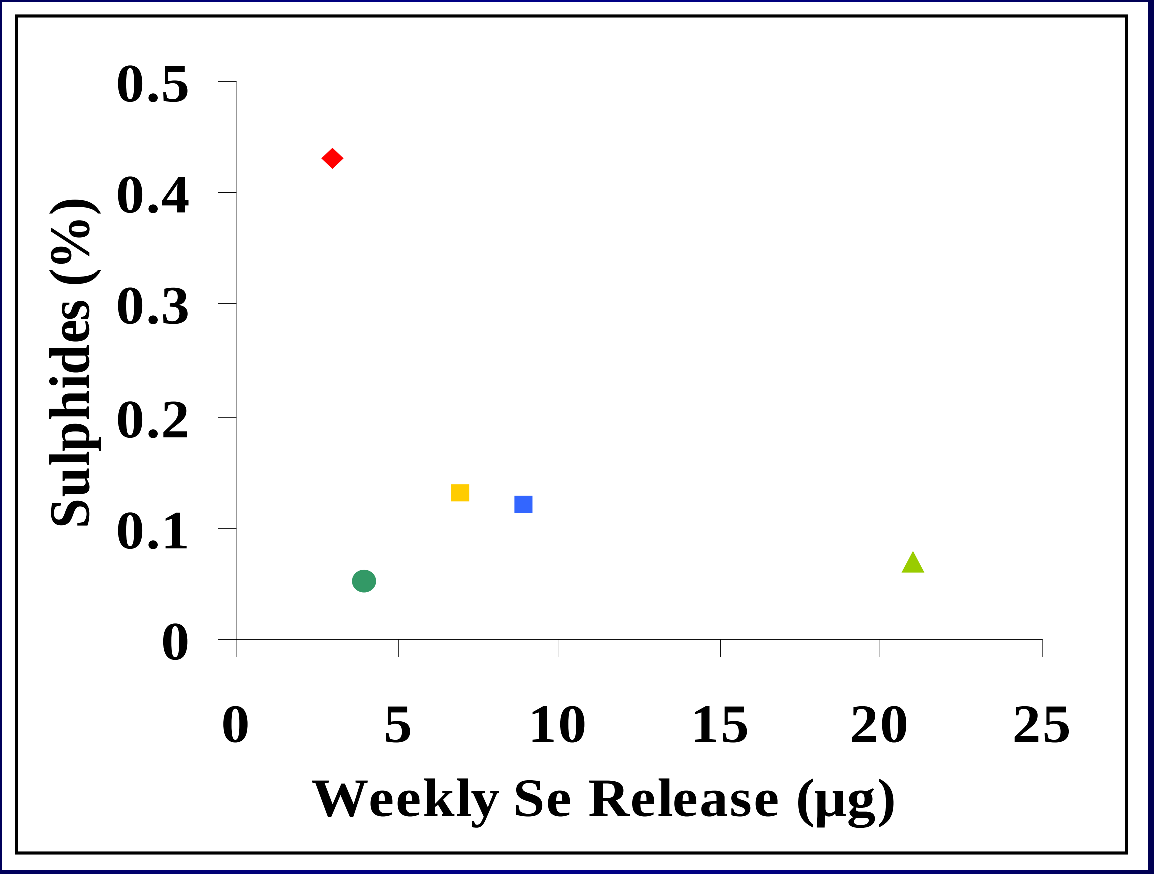


refuse coal parting

interburden hanging wall/foot wall

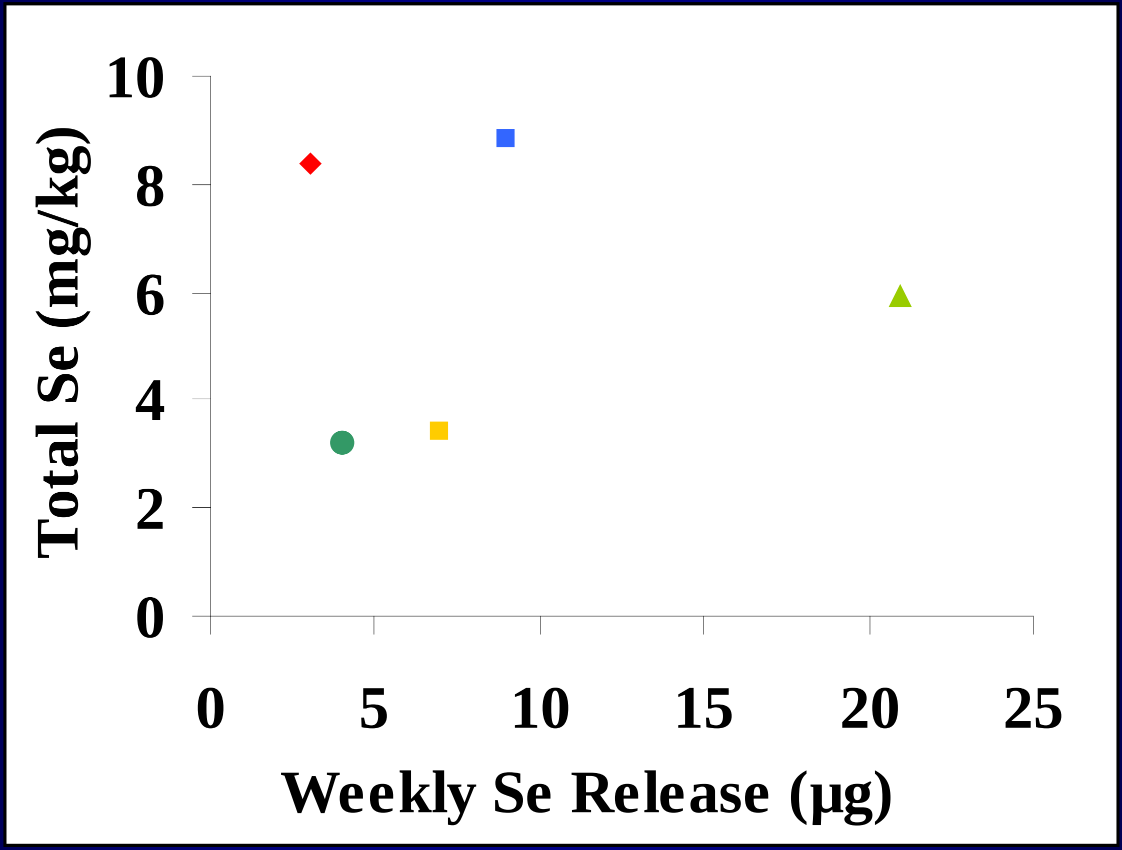
Weekly Se Release

Not correlated with: Sulphides



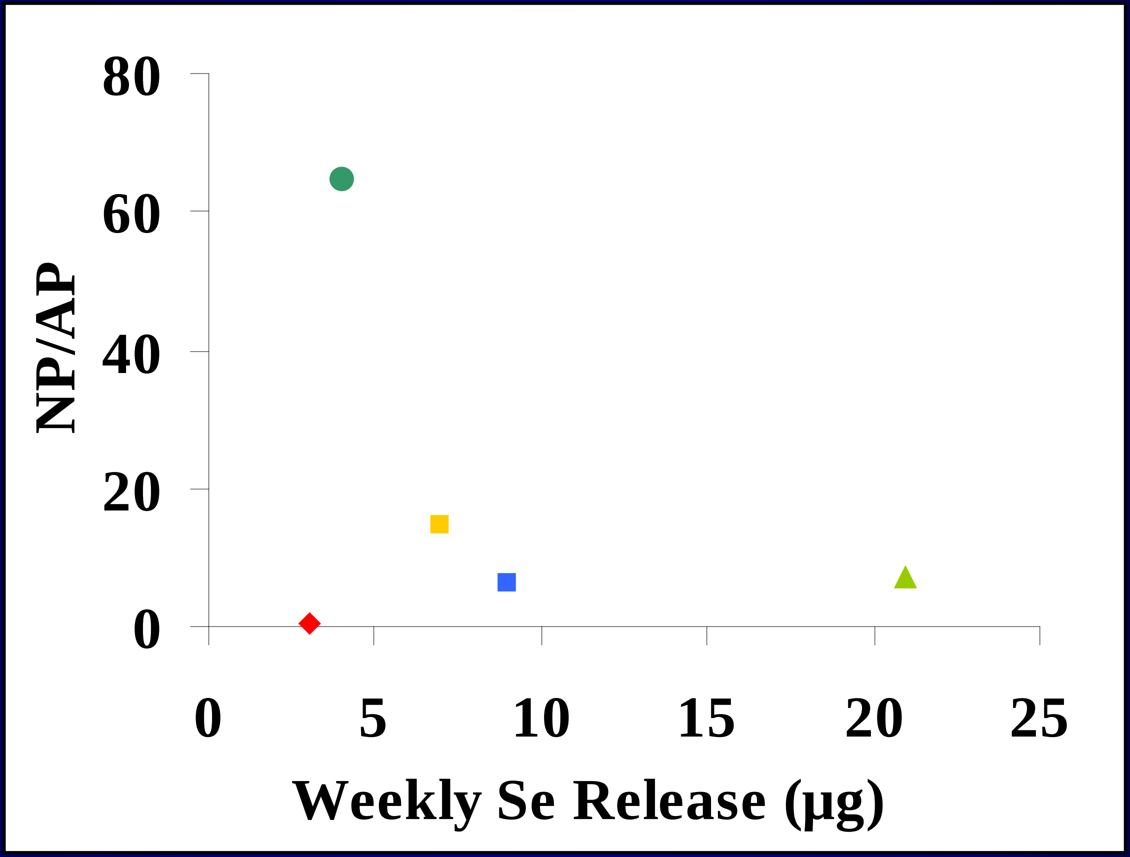
Weekly Se Release

Not correlated with: Total Se

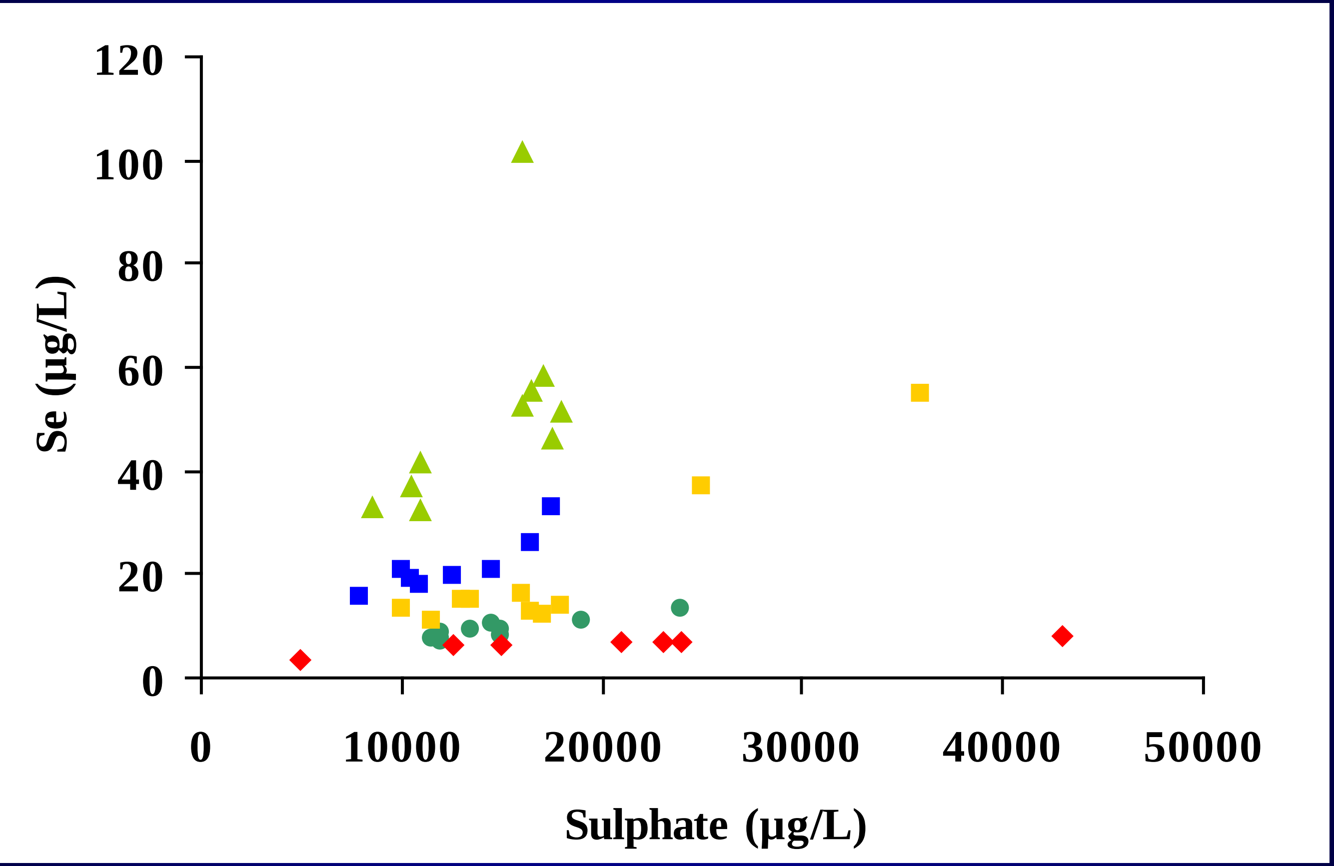


Weekly Se Release

Not correlated with: NP/AP ratio



Se and Sulphate in Humidity Cell Leachate

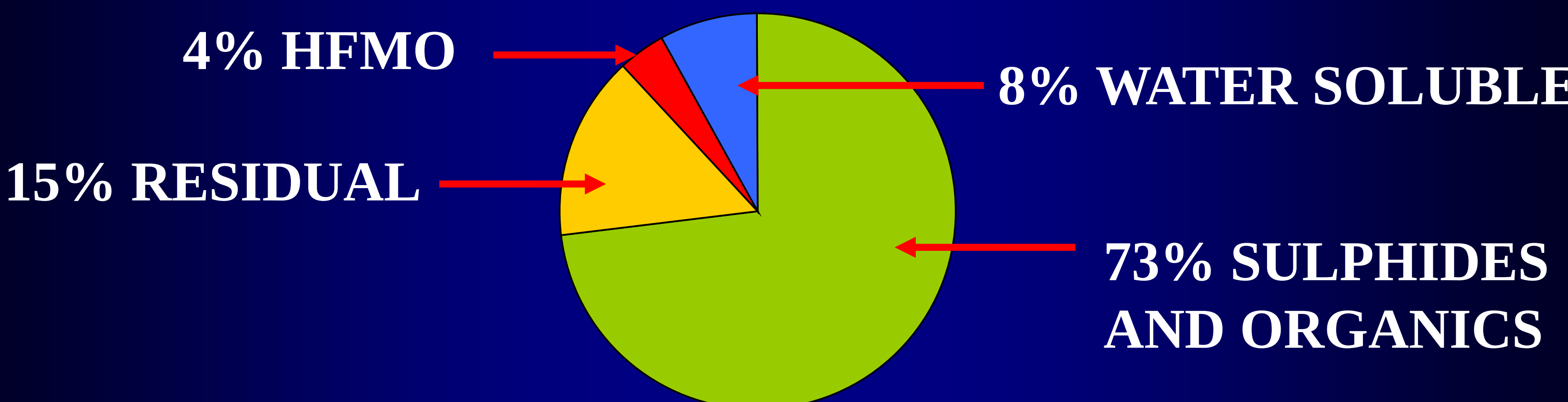


refuse coal parting

interburden hanging wall/foot wall

Conclusions

In which mineralogical associations is Se found?



Conclusions

From which lithologies is Se being mobilized?

➡ **Se is released from all lithologies**

parting > coal > refuse > foot wall > interburden

Conclusions

What controls the rate of Se release?

- Sample mineralogy plays an important role in controlling the rate of release
- The rate of Se release is not correlated with total Se or sulphide content or with AP/NP

Conclusions

From what minerals is Se being released?

➡ Humidity cell test results suggest that sulphide oxidation is the main source of Se

Recommendations

- Conduct longer term humidity cell or field plot tests
- Study the effect of sulphide form and mineralogy on Se release rates
- Perform a mass balance to determine the effect of waste dump hydrology on Se release
- Study abatement methods and their applicability

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