Exploration07

Plants: The Ultimate Selective Leach

Colin E. Dunn

Consulting Geochemist

Sidney, BC

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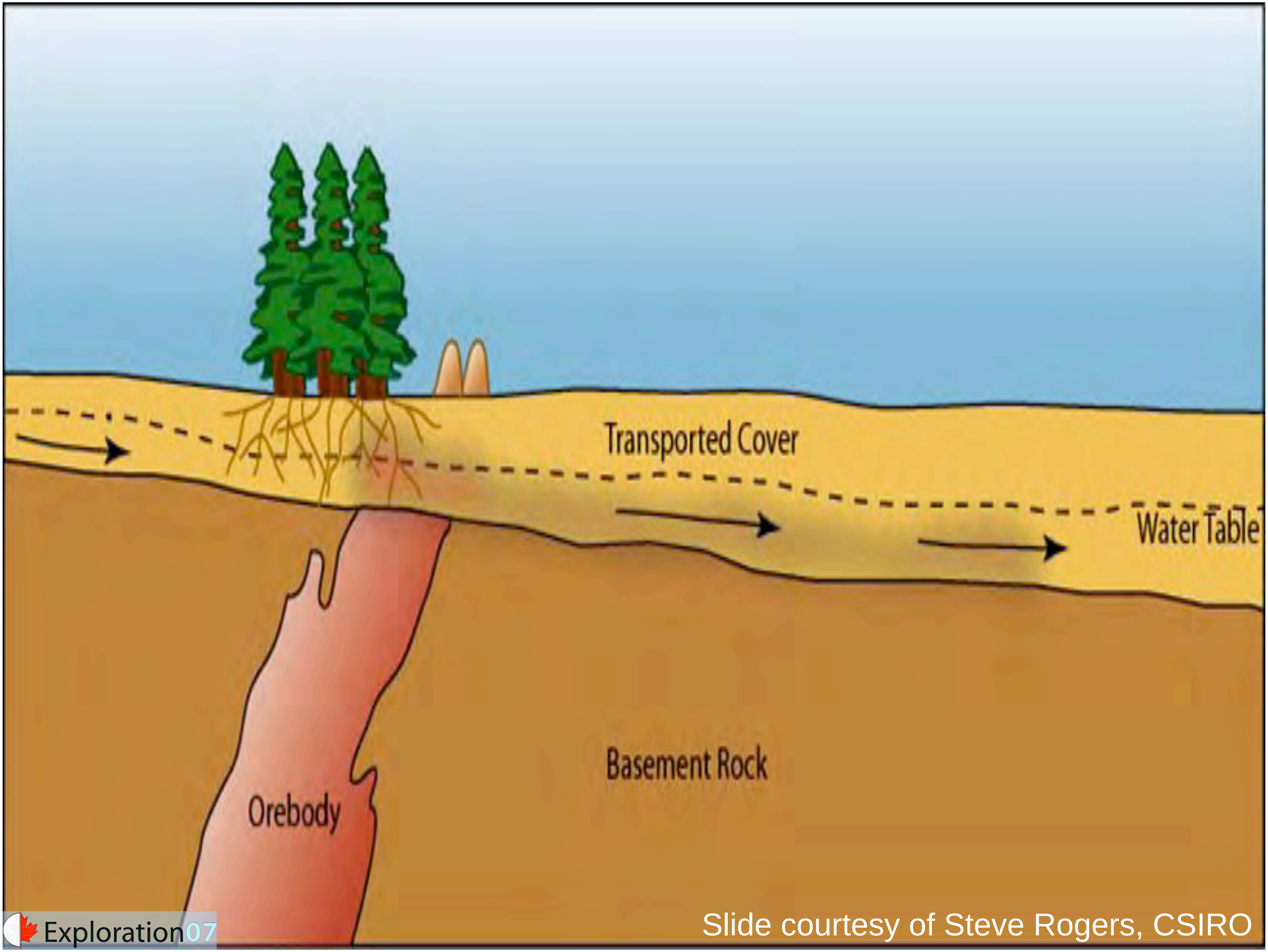
Sample the Trees or Shrubs

"Biogeochemistry"

(Phytogeochemistry)


Transported Cover
Water Table
Basement Rock
Orebody
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Slide courtesy of Steve Rogers, CSIRO

Biogeochemistry and Geobotany

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GEOBOTANY

Plants associated with minerals

Visual approach

BIOGEOCHEMISTRY

The chemical composition of plants

Chemical Approach

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Poison Milkvetch

(*Astragalus pattersonii*)
Colorado

Selenium indicator plant

Used in U roll-front Exploration (Cannon, 1960)

Photos: Mary Ellen (Mel) Harte

Fireweed (*Epilobium*)


MINOLTA
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BIOGEOCHEMISTRY

Technology to Discover Mineralization and Define Underlying Geology

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To better target

CRCLEME

BIOGEOCHEMISTRY

The chemical composition of plants

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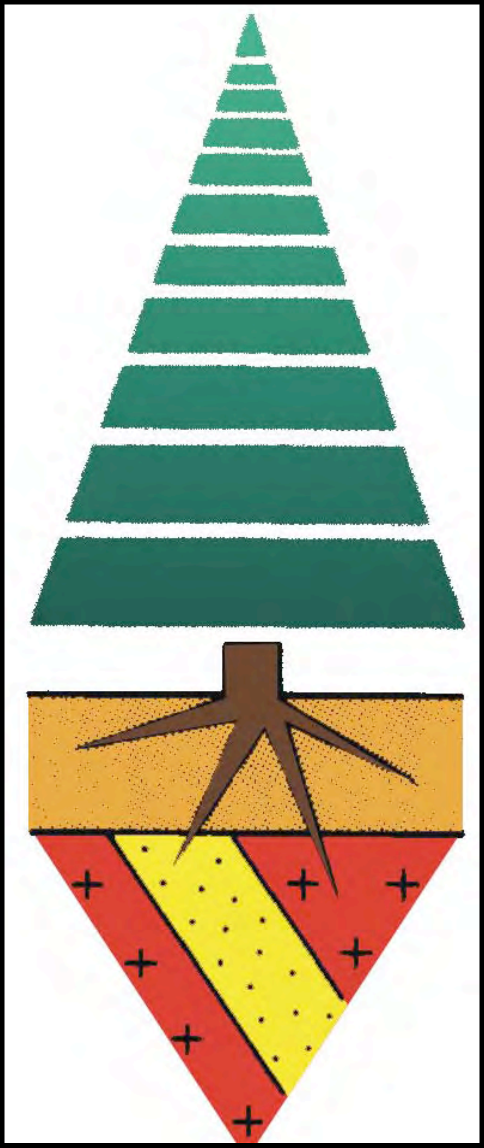

OUTLINE

- Why
- How
- Results

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Use Plant Chemistry for:

- Delineating stratigraphy
- Delineating structure/faulting
- Outlining mineralization

RATIONALE
Why use plants?

Power of Plants

- Complex – 425 million years
- Sophisticated abilities to select elements that they need
- Tolerate metals they don't need
- Store those they don't need (often in extremities such as bark and twig ends and tree tops)

Earliest form of vascular plant – *Cooksonia* Lower Silurian (~425 my)

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Precambrian Life

- Bacteria
- Fungi
- Algae

Metals in Primitive Life Forms (*Lepp, 1992*)

Concentrations (%)		
	Bacteria	Fungi
Cd	40	3
Co	25	
Cu	40	1.6
Pb	49	10.4
Ni	13	
Ag	35	5.4

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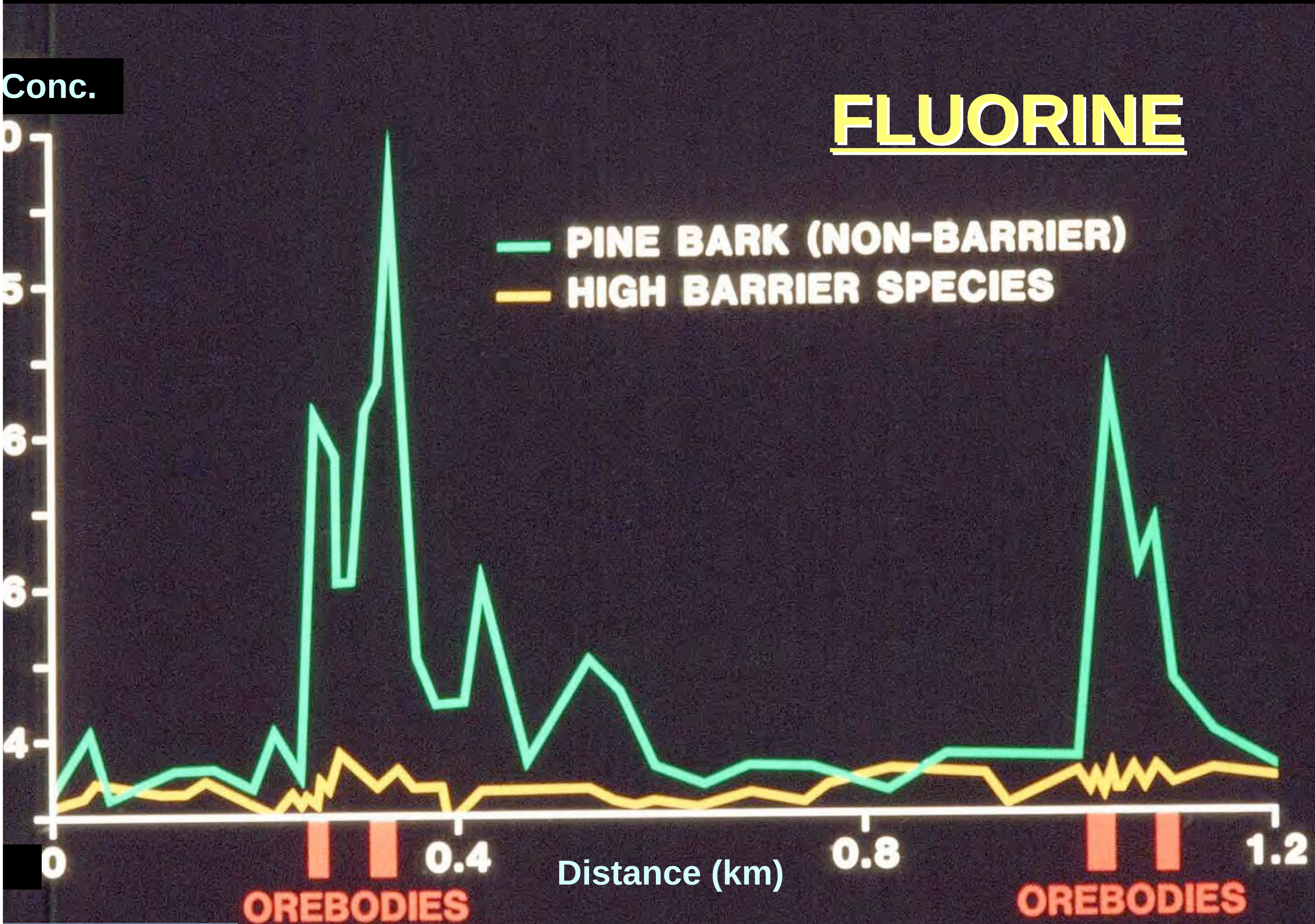
‘Barrier’ Mechanisms

(i.e. a type of selective extraction [leach] of elements)



Conc.
FLUORINE
PINE BARK (NON-BARRIER)
HIGH BARRIER SPECIES
0
0.4
0.8
1.2
Distance (km)
OREBODIES
OREBODIES
After Kovalevsky, 1987

Correlations: Bark v. Soil Horizons

Soil Horizon	Douglas-fir Bark n = 12		Engelmann Spruce Bark n = 13	
	Au	*As*	*Au*	*As*
Forest Litter	.13	.10	.48	.58
A - Horizon	.63	.63	.65	.65
B - Horizon	.60	.55	.79	.80
C - Horizon	.76	.64	.90	.88

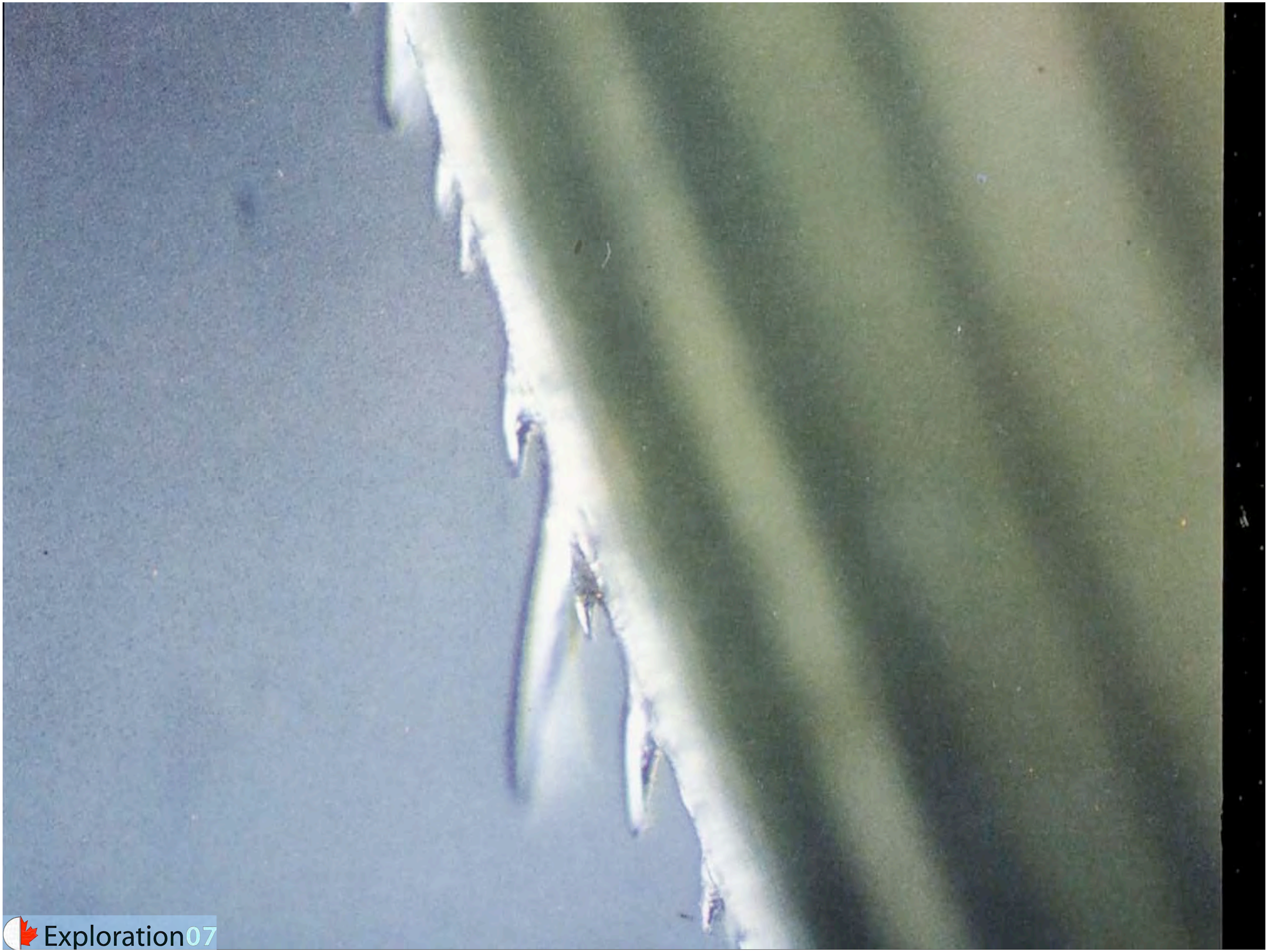
Relationships between the Organic world of Plants and the Inorganic world of Rocks

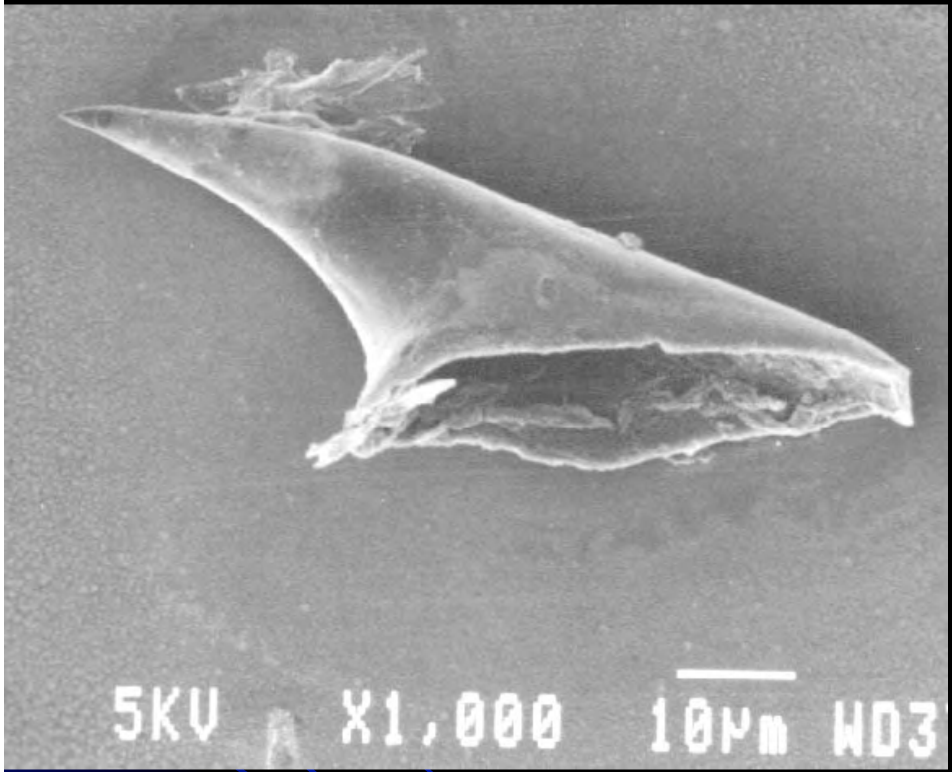
Trees

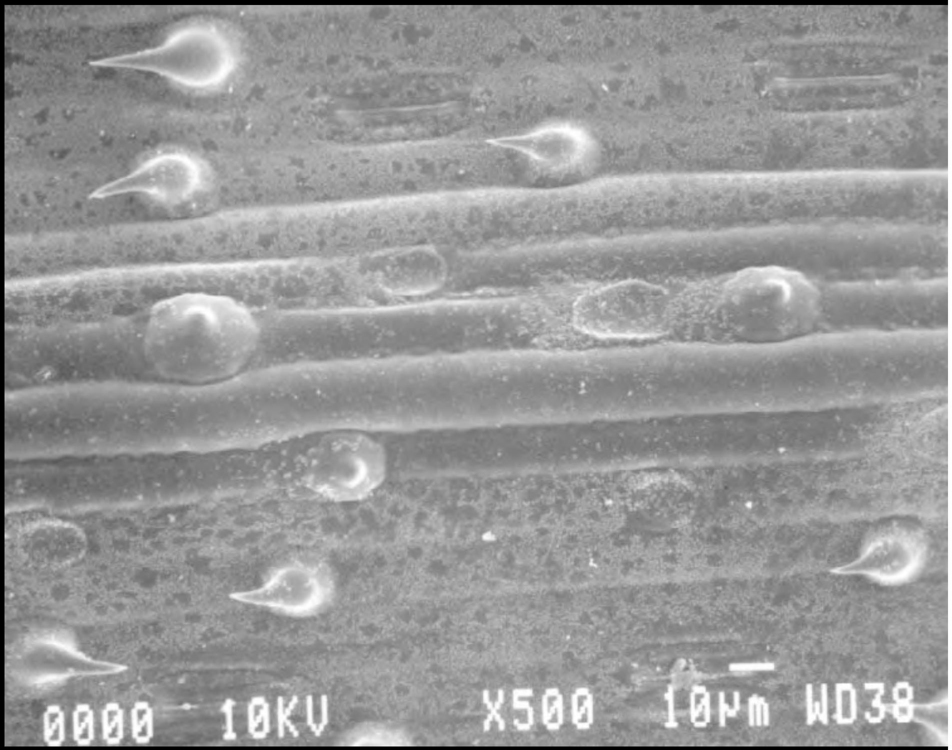
- Extensive root systems – roots, rootlets and mycorrhizal fungi can be 100s kilometres *in a single plant!*

- On a hot summer's day a large tree can transpire 100 to 150 litres of water (with dissolved metals that precipitate in the plant tissues)

Mineral Phases in Plants
SEMs







Silica phytoliths on grass


20KV WD:23MM S:00000 P:00014
500UM
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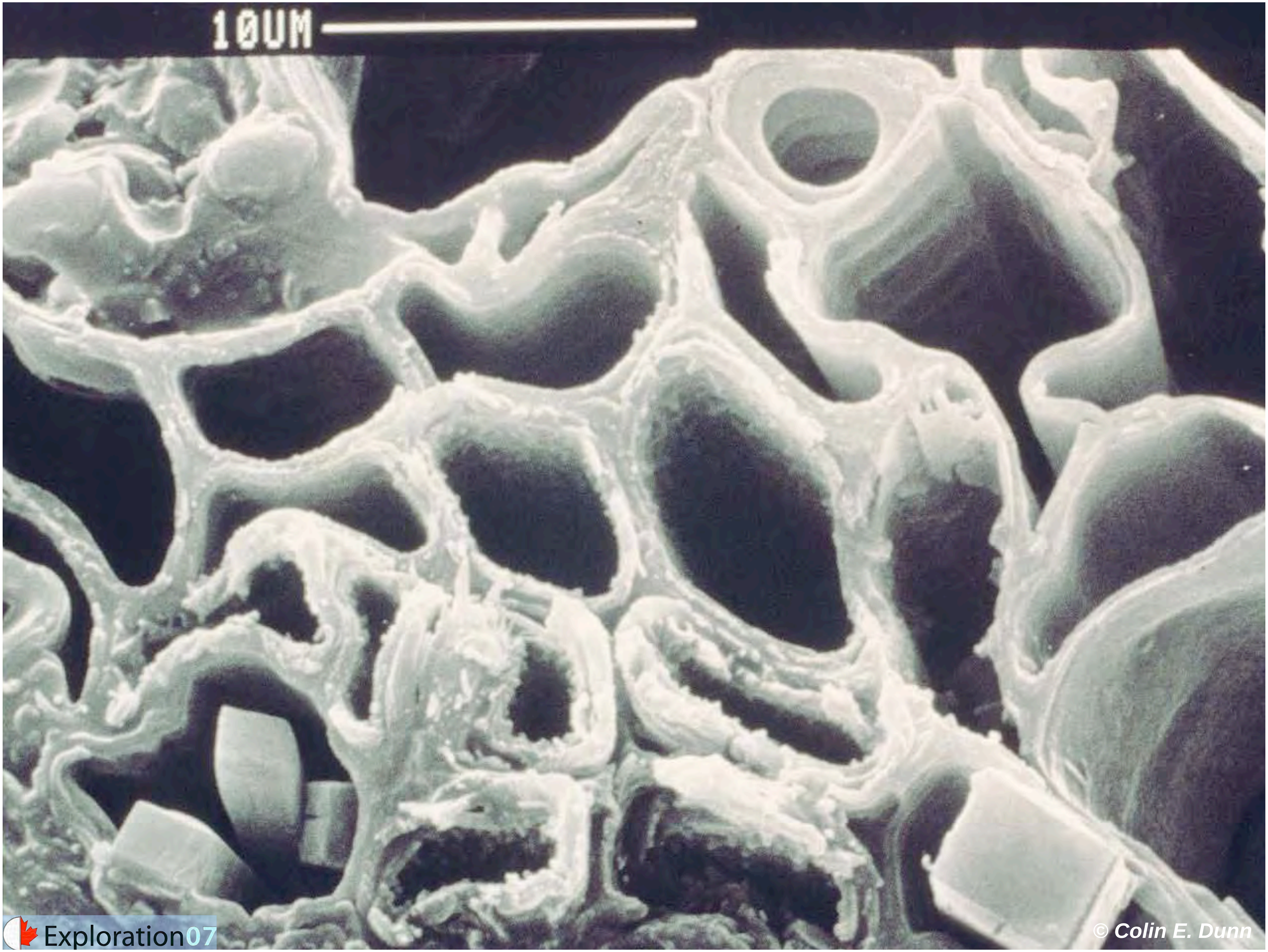
10UM
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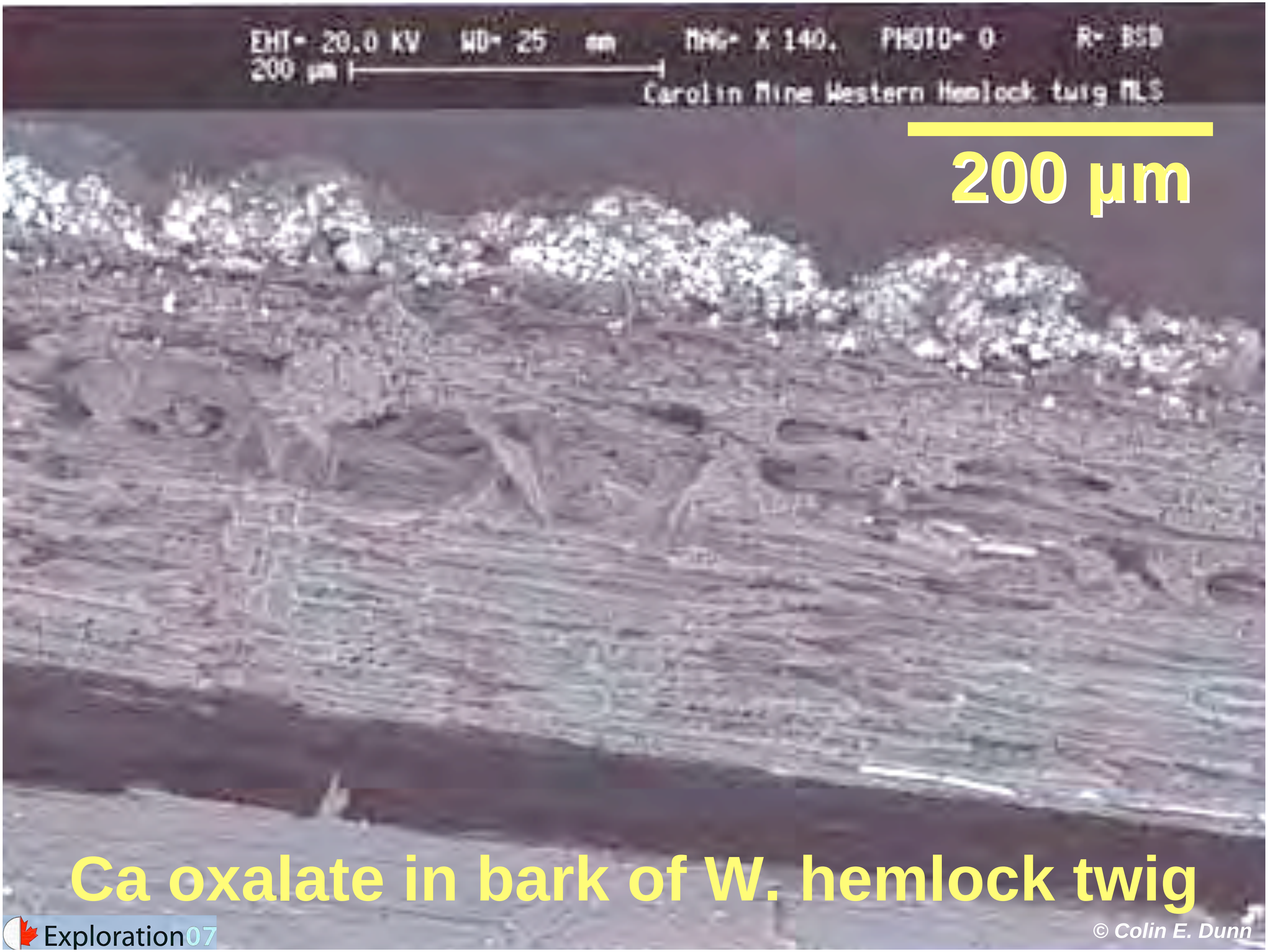
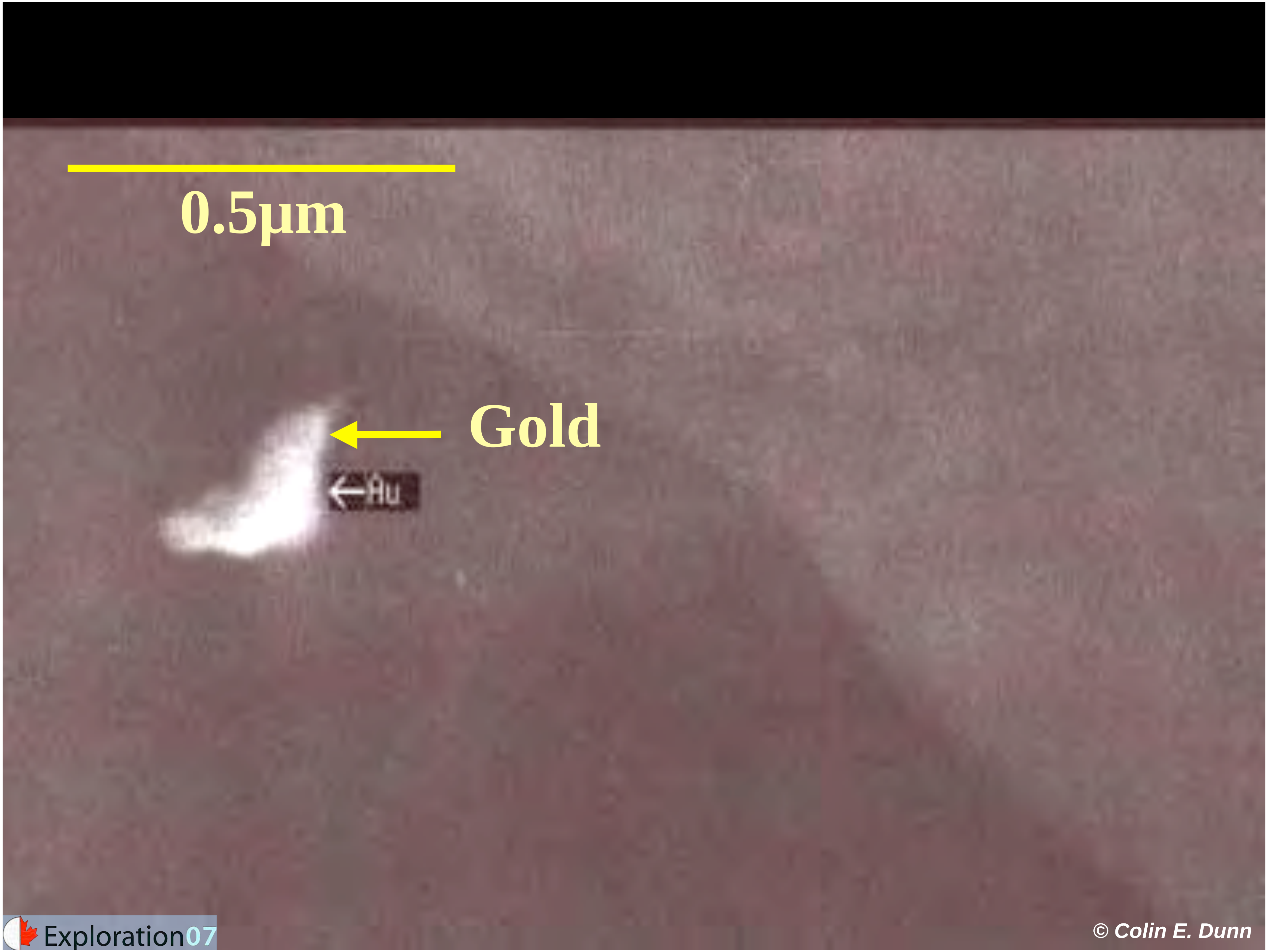
© Colin E. Dunn



Ca oxalate in bark of W. hemlock twig

Fe, Zn, S phase within western hemlock twig


0.5µm
Gold
Au
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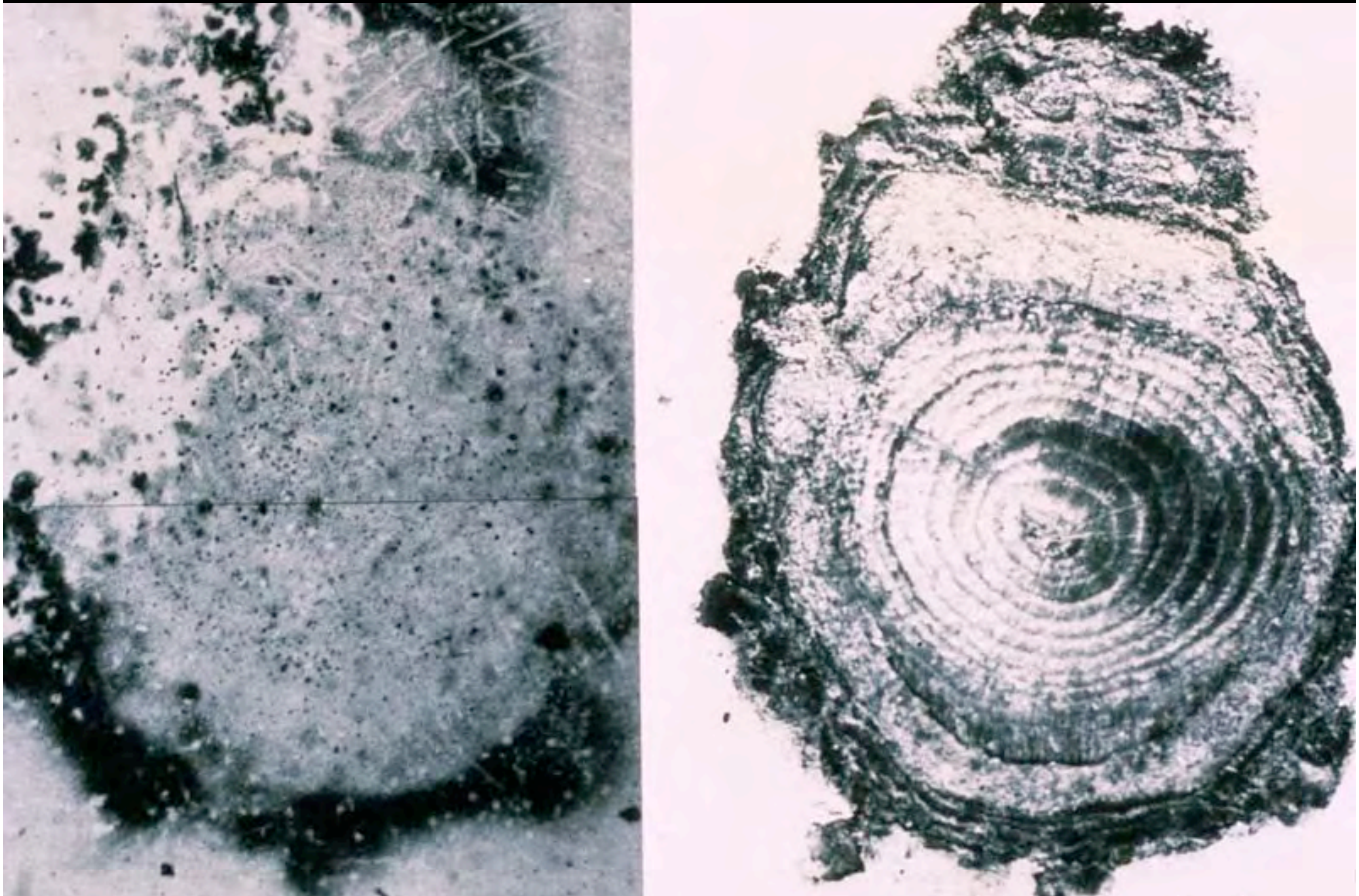
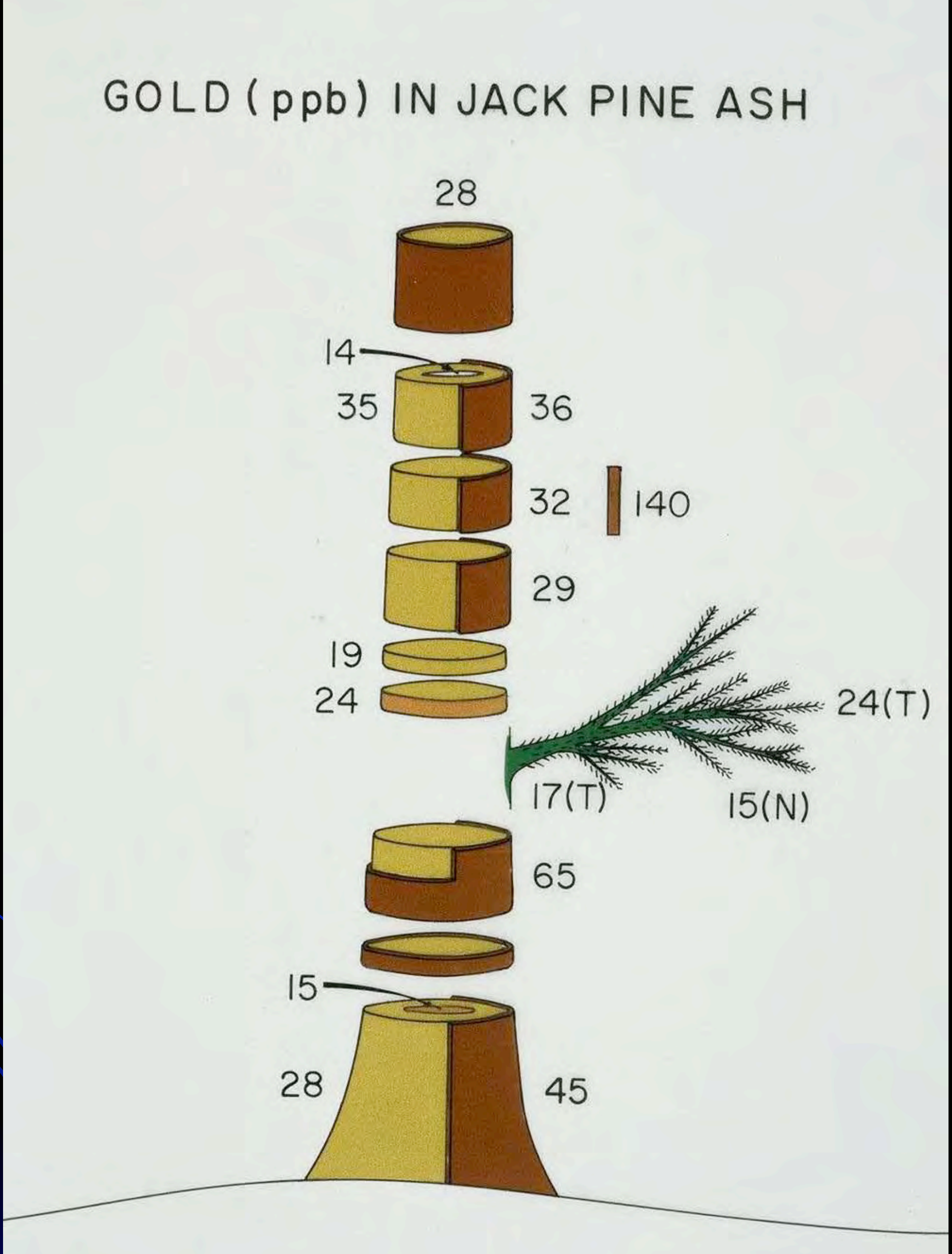


Heterogeneity of Plants

VARIATIONS AMONG SPECIES AND TISSUES

Tree	Tissue	Au ppb	As ppm	Mo ppm	Sb ppm
Douglas fir	*Twig*	35	1600	<1	1
Douglas fir	*Needle*	23	130	<1	2
Douglas fir	*Bark*	53	250	<1	8
Western Hemlock	*Twig*	200	710	<1	8
Western Redcedar	*Twig*	7	11	4	1
Western Redcedar	*Needle*	5	6	<1	1
Western Redcedar	*Bark (all)*	8	12	<1	1
Western Redcedar	*Bark (outer)*	31	46	<1	11
Red Alder	*Twig*	14	4	57	0.5
Red Alder	*Bark*	<5	4	4	0.3
Douglas Maple	*Twig*	12	6	4	1



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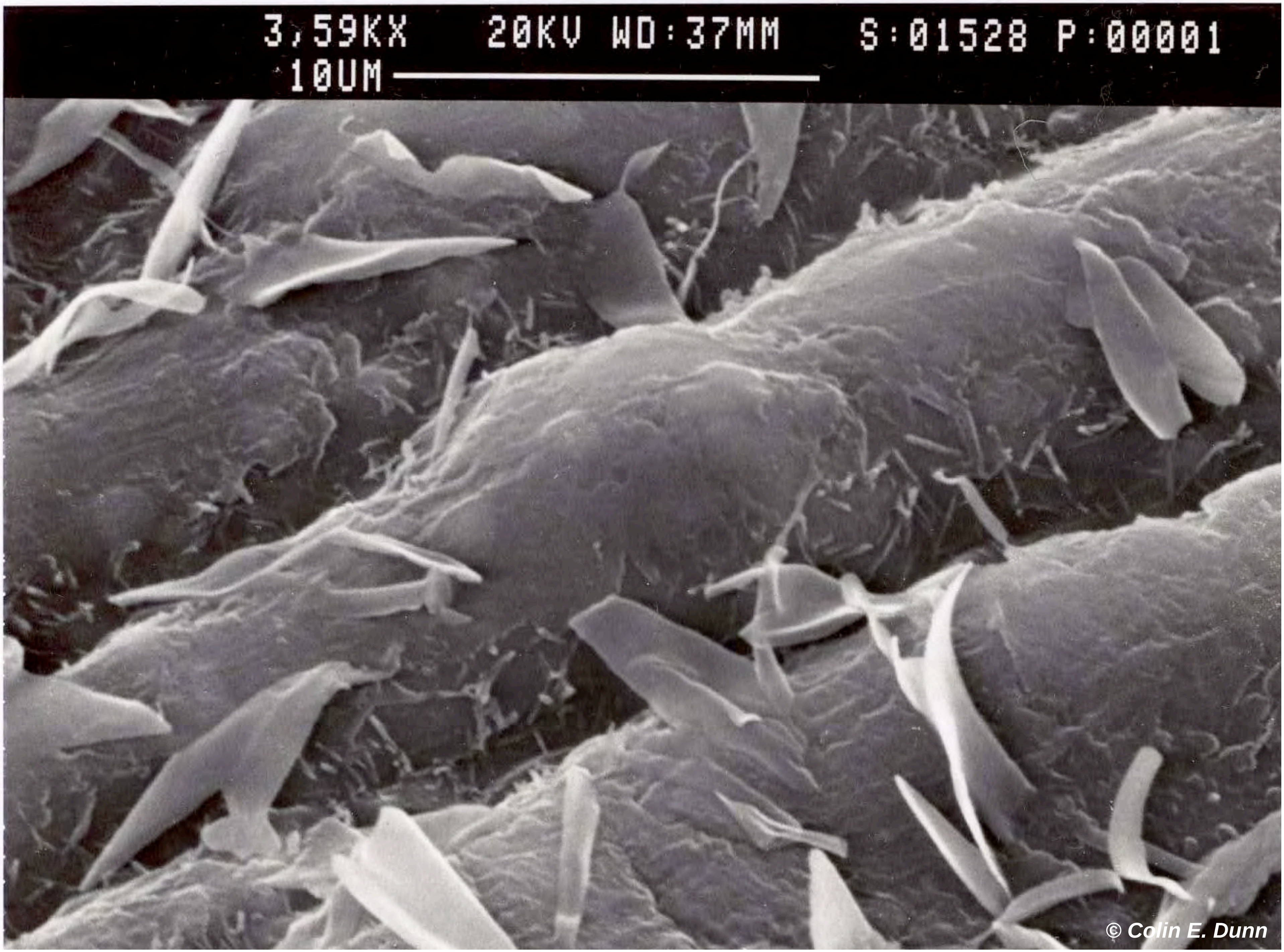
SULLIVAN – Lodgepole Pine (Ash)

		Top Stem	Lower Twigs	Outer Bark	Roots
Ag	ppm	1	3	13	77
As	ppm	9	9	52	190
Au	ppb	<5	<5	20	19
B	ppm	1150	400	260	580
Cd	ppm	52	95	143	135
Cs	ppm	110	9	5	38
Cu	ppm	400	180	158	190
Ni	ppm	180	22	14	24
Pb	ppm	150	2950	4900	16400
Zn	ppm	6100	7350	5700	12800

Seasonal Variations – Alder
Gold (ppb) in twig ash (n = 17)

June	August	September	April
29	18	17	71


3,59KX 20KV WD:37MM S:01528 P:00001
10UM
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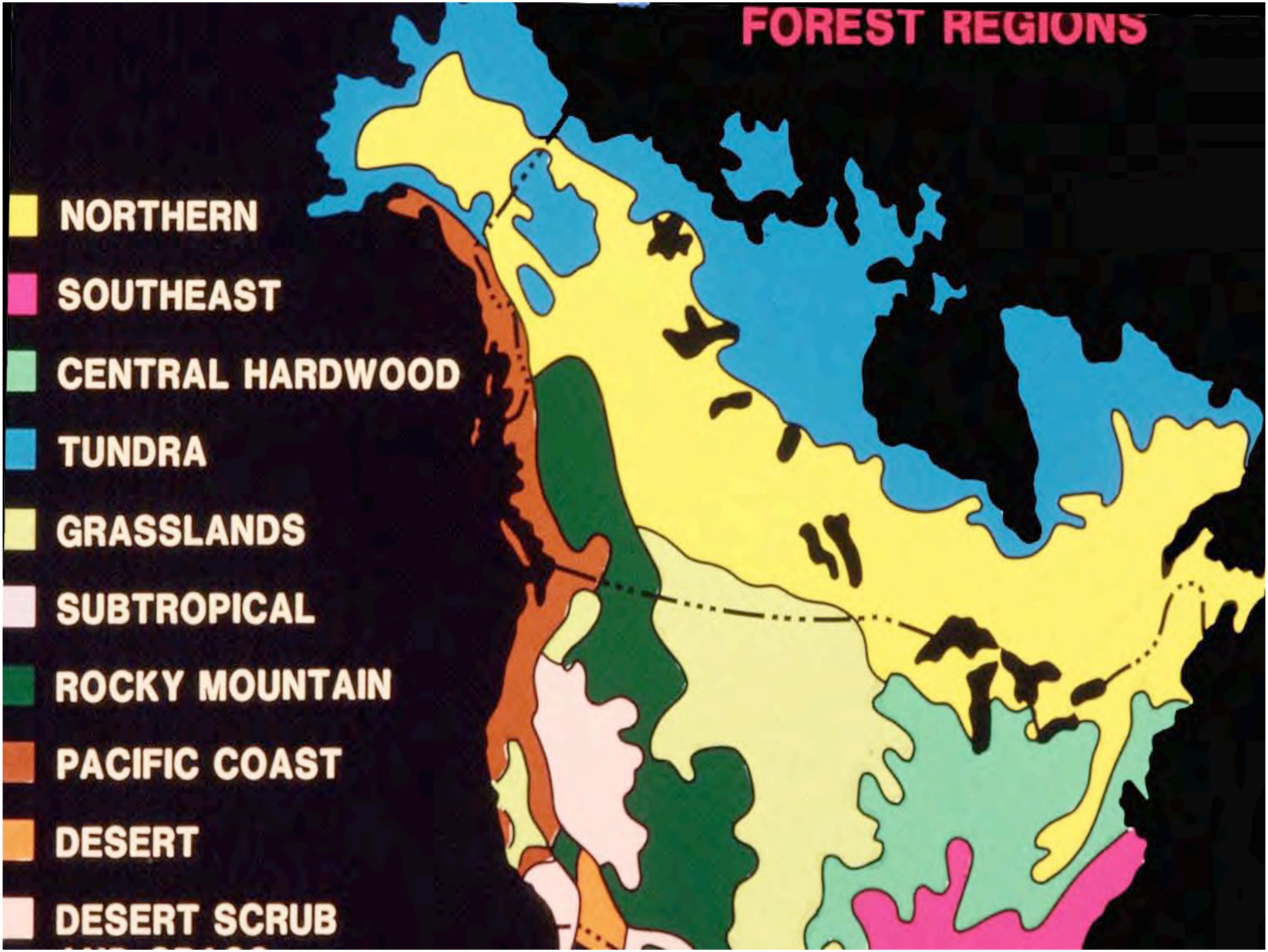
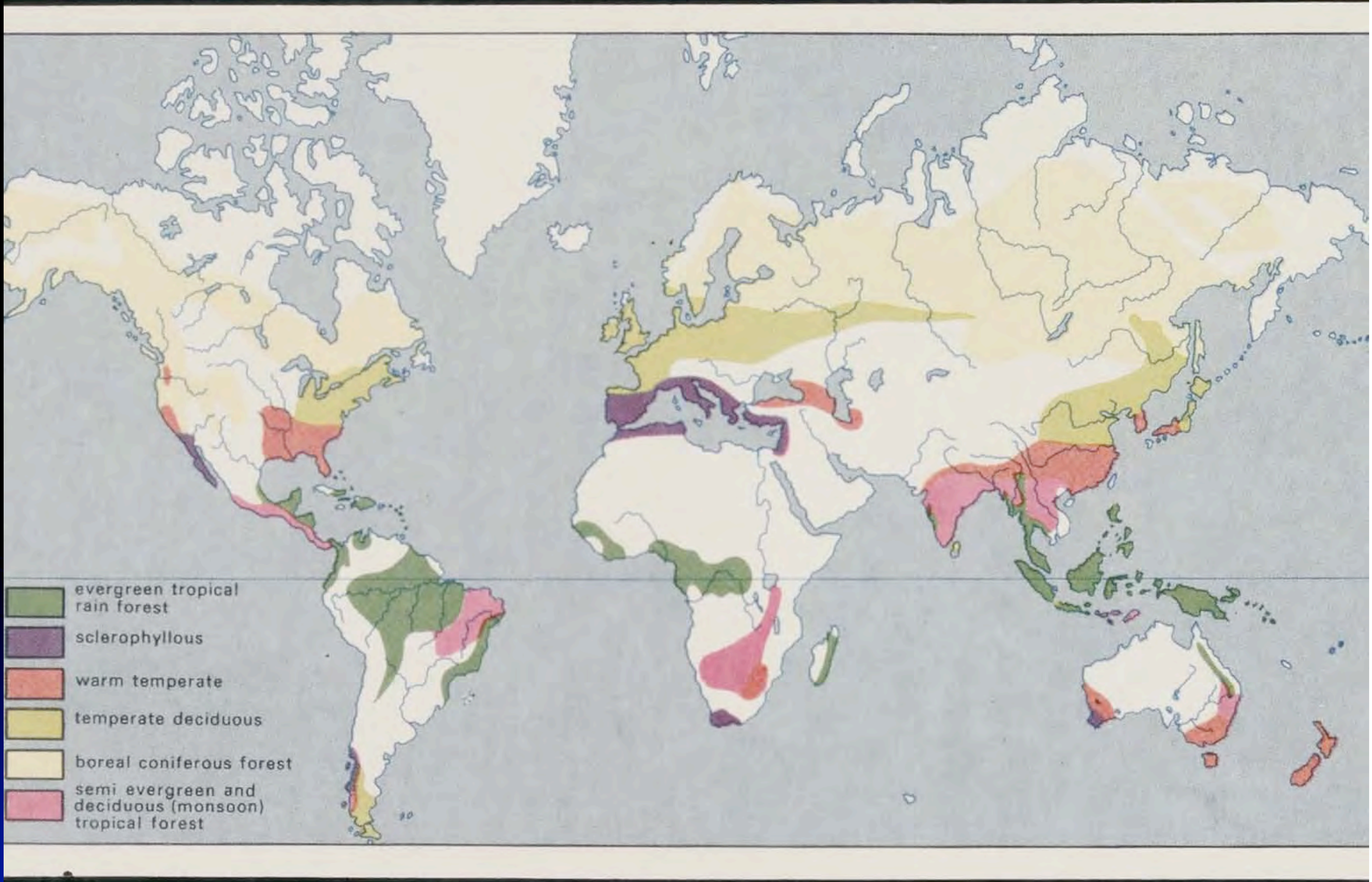
PLANT SAMPLING AND PREPARATION


FOREST REGIONS
NORTHERN
SOUTHEAST
CENTRAL HARDWOOD
TUNDRA
GRASSLANDS
SUBTROPICAL
ROCKY MOUNTAIN
PACIFIC COAST
DESERT
DESERT SCRUB


evergreen tropical rain forest
sclerophyllous
warm temperate
temperate deciduous
boreal coniferous forest
semi evergreen and deciduous (monsoon) tropical forest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88-z-BOOIC


TIMBERS OF TAHUNE
CELERY TOP PINE
EUCALYPTUS
KING BILLY PINE
HUON PINE
MYRTLE


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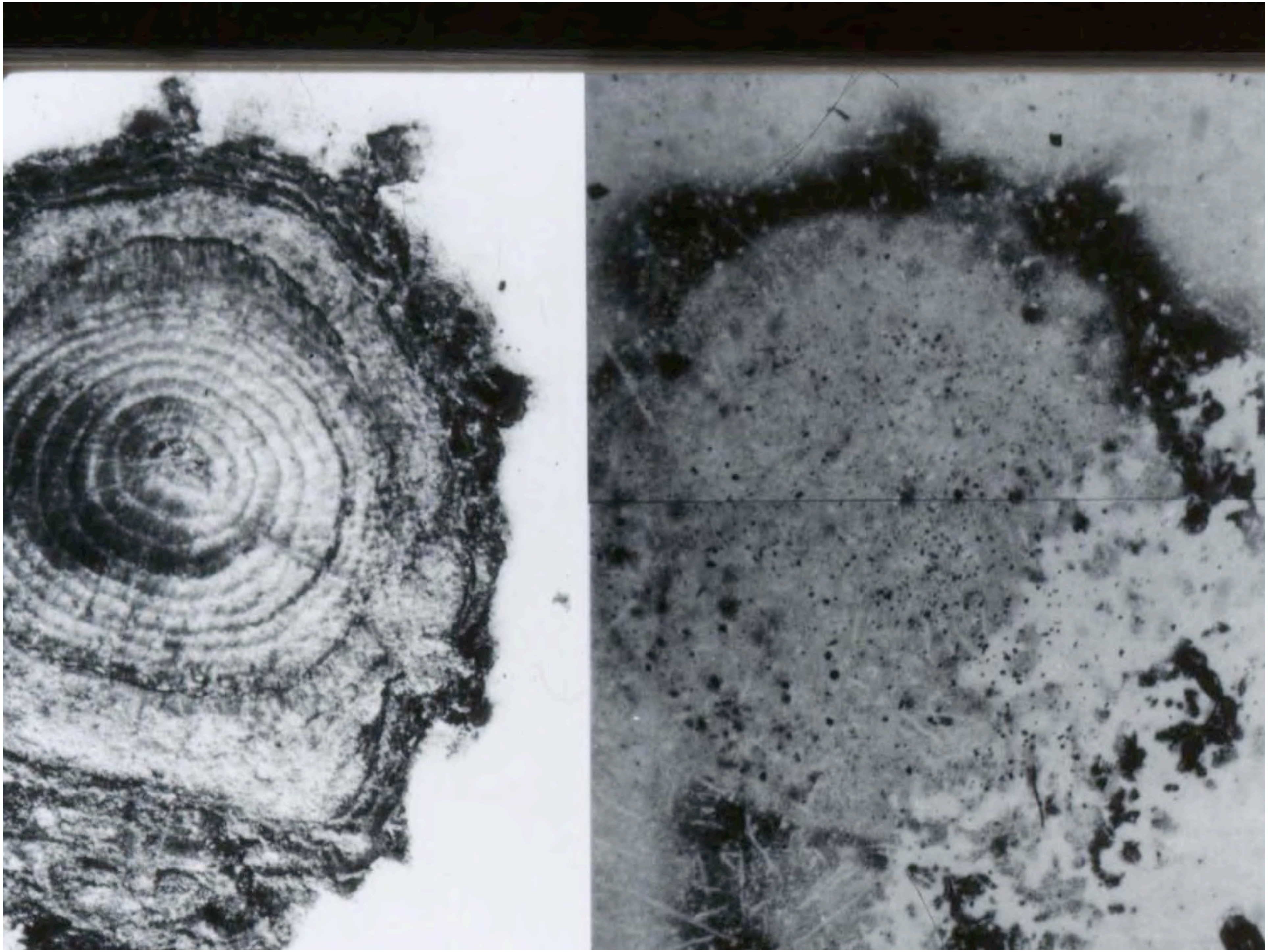


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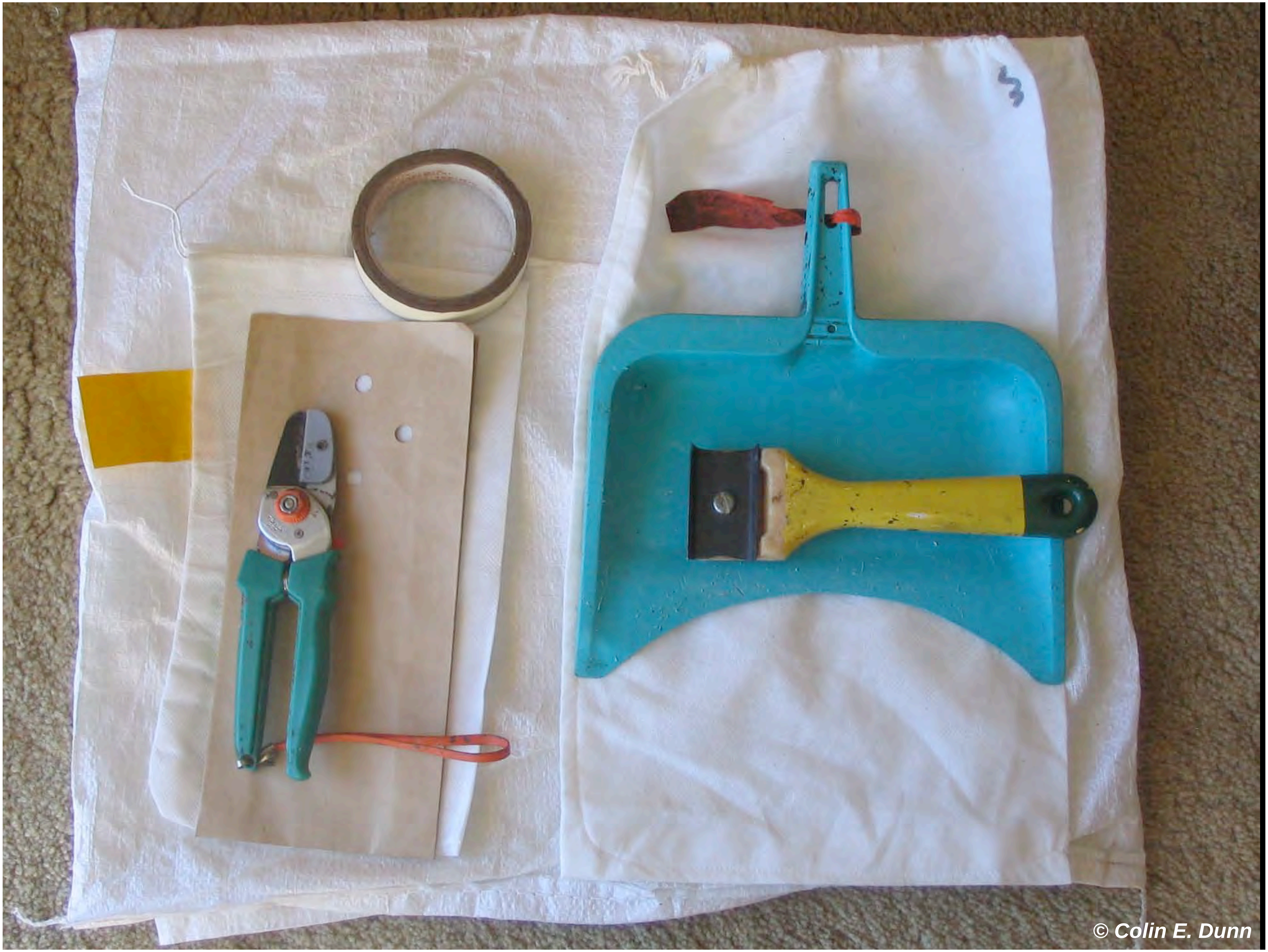
C-FJRG


AVH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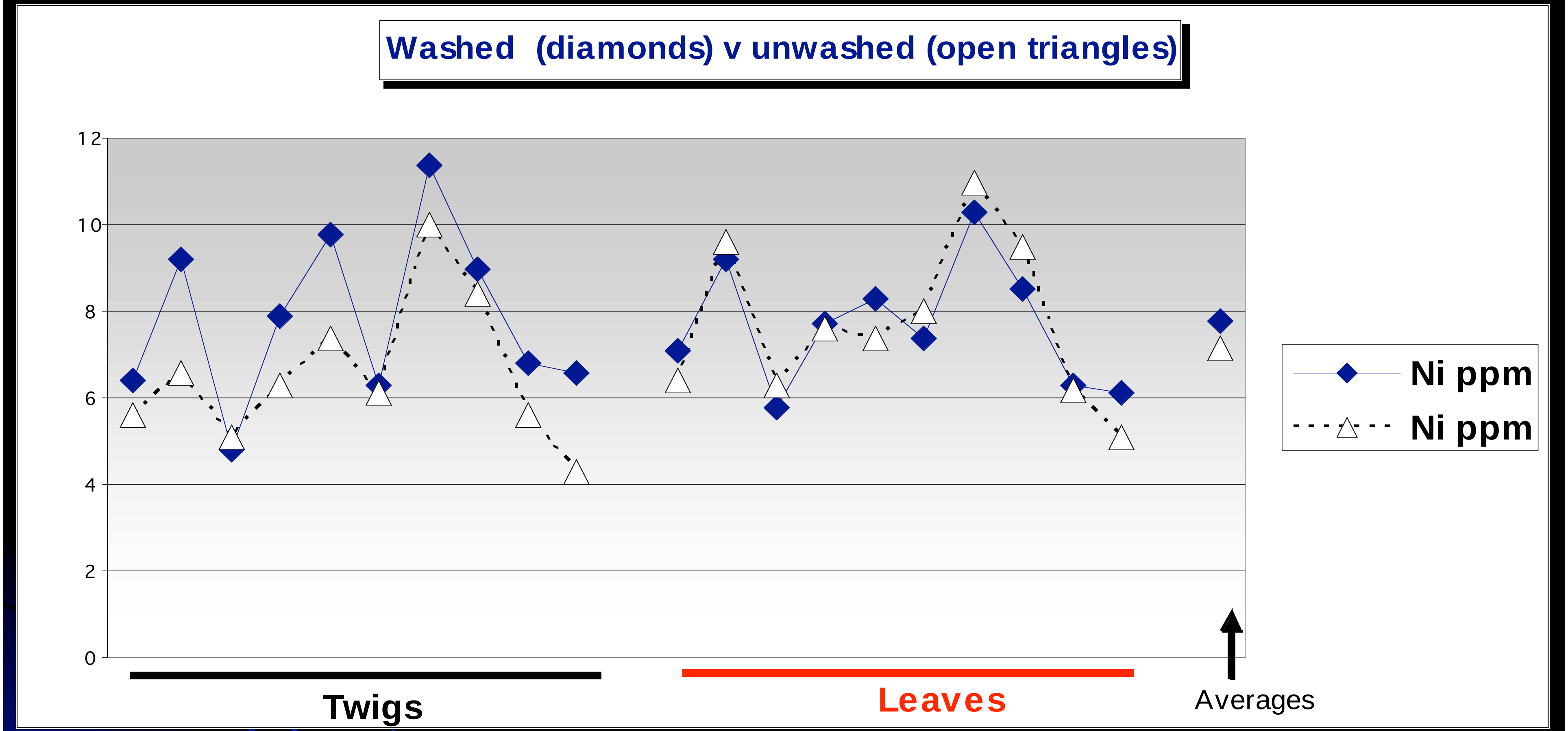
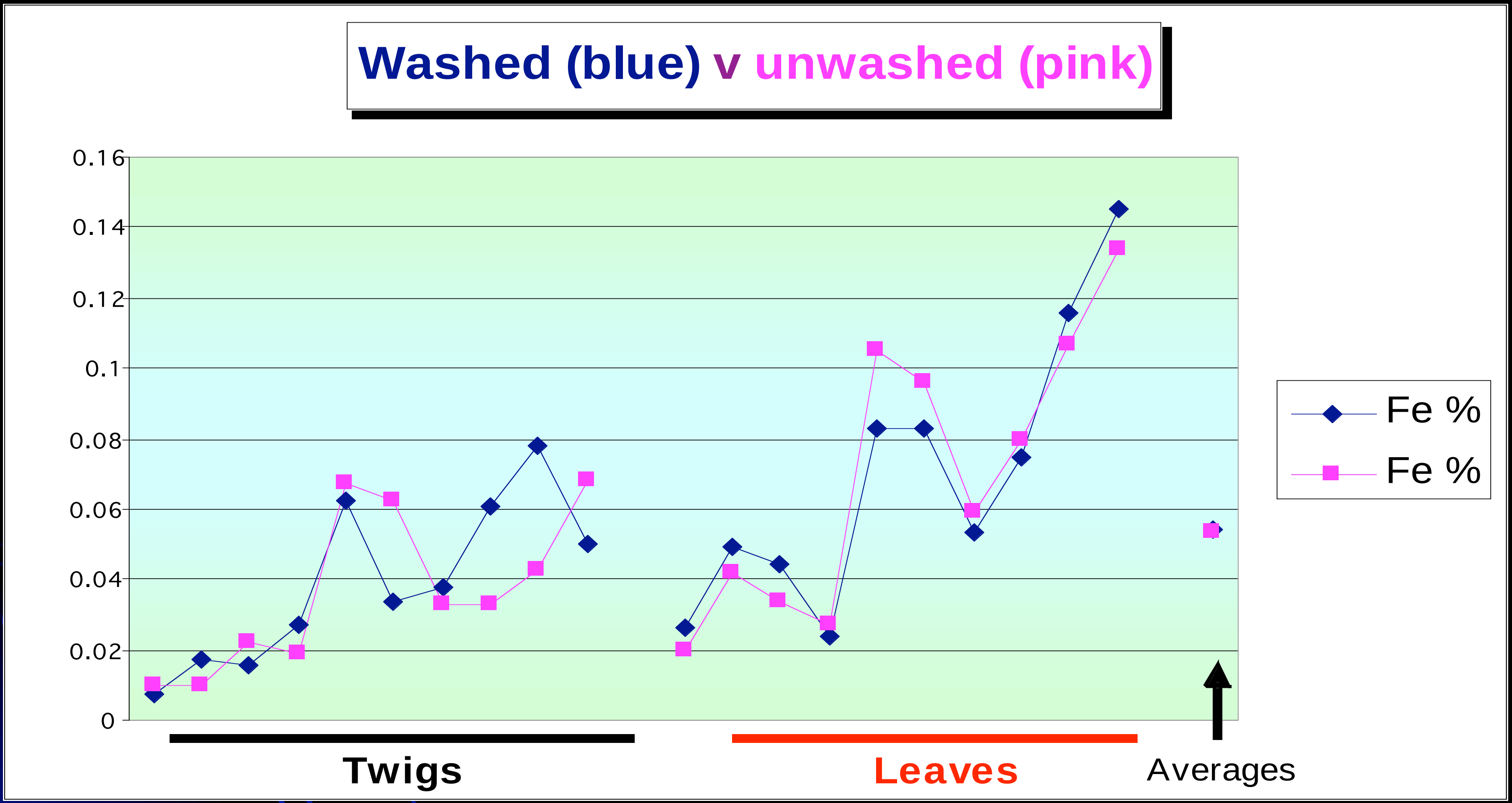
Whether or not to Wash Samples

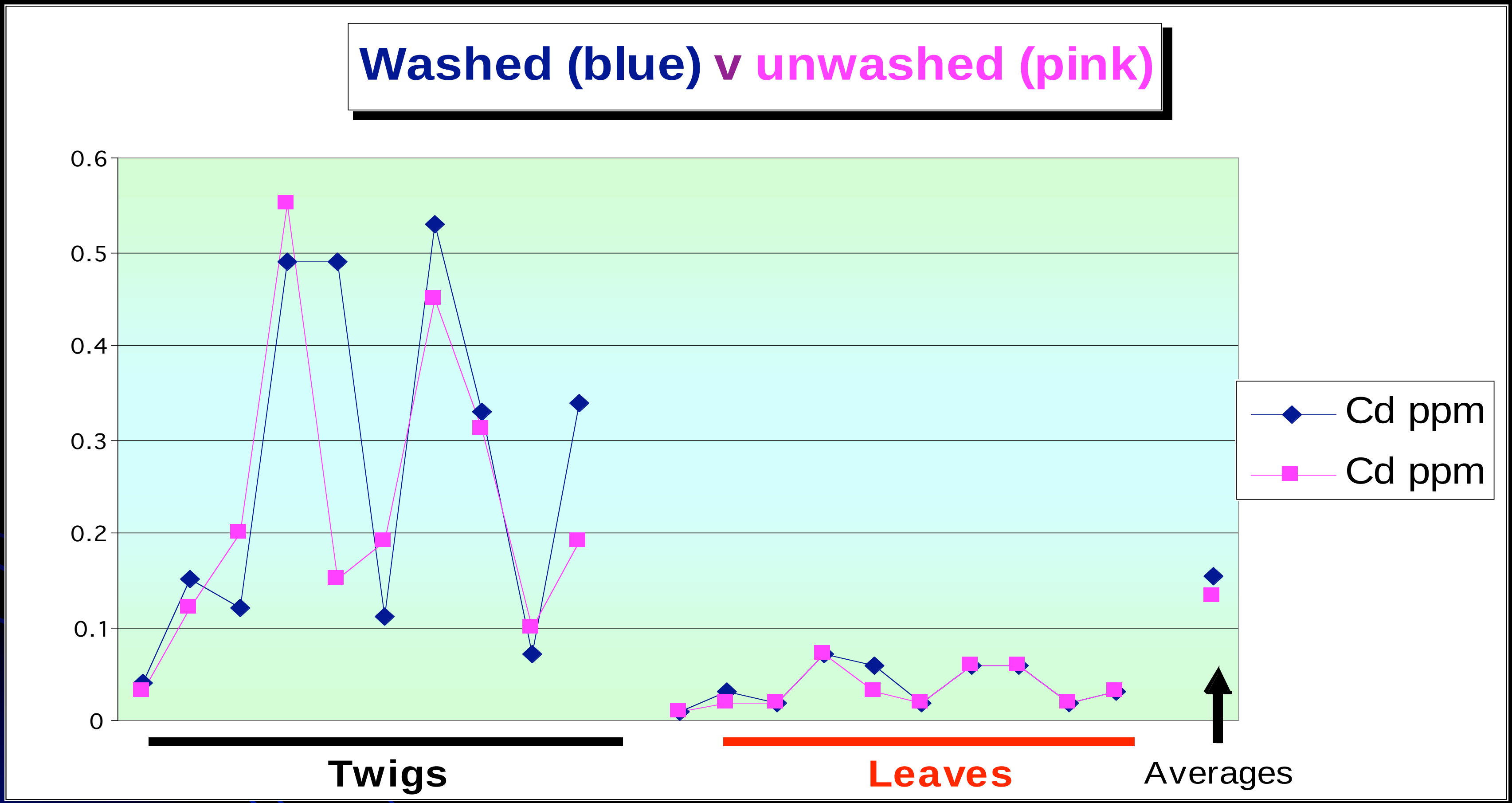


Washed (diamonds) v unwashed (open triangles)
12
10
8
6
4
2
0
Ni ppm
Ni ppm
Twigs
Leaves
Averages

Iron - No Difference



Cadmium - No Difference




BULK

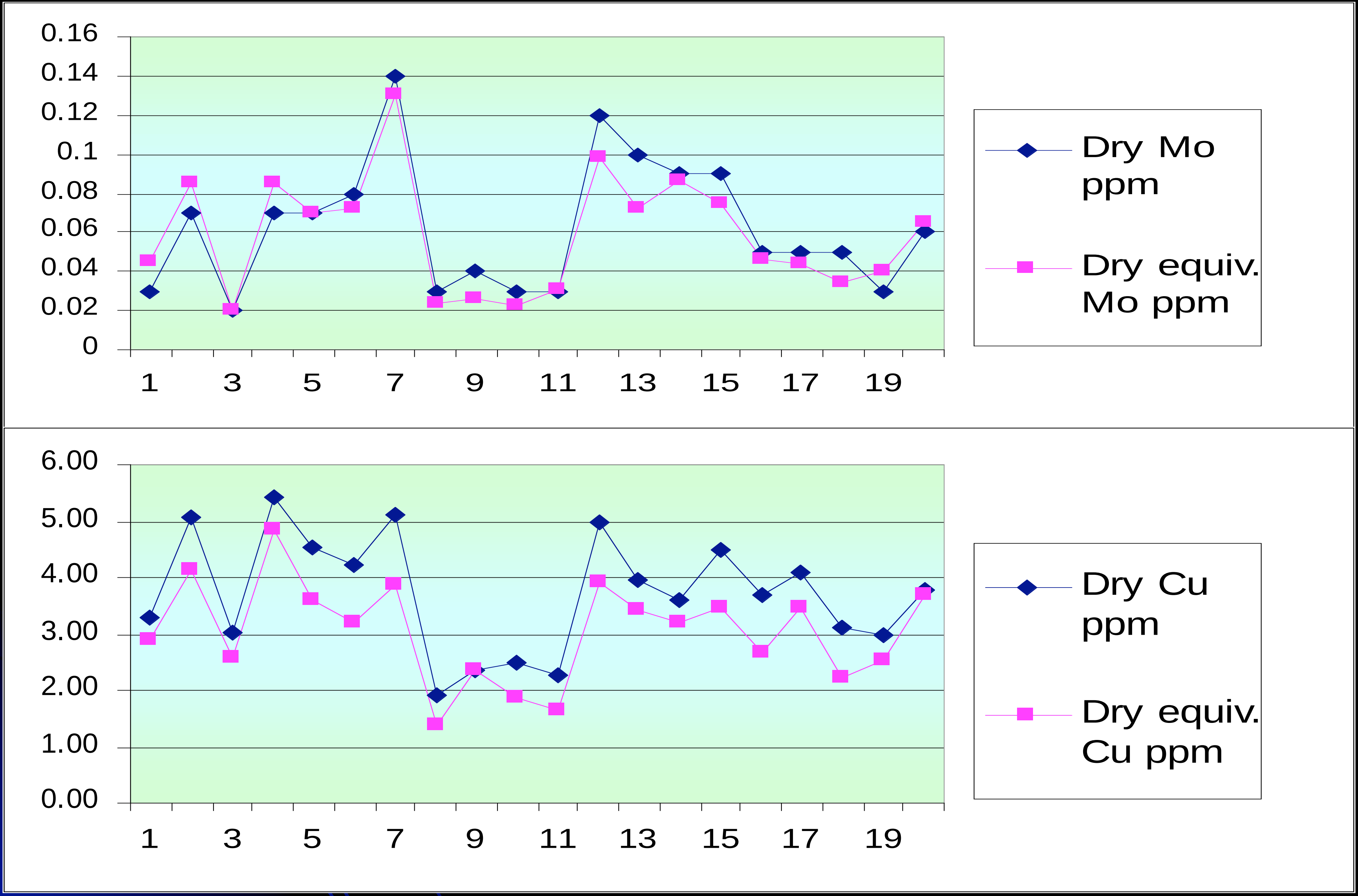

WESTCOTT® Flexible Stainless Steel Ruler
© Colin E. Dunn

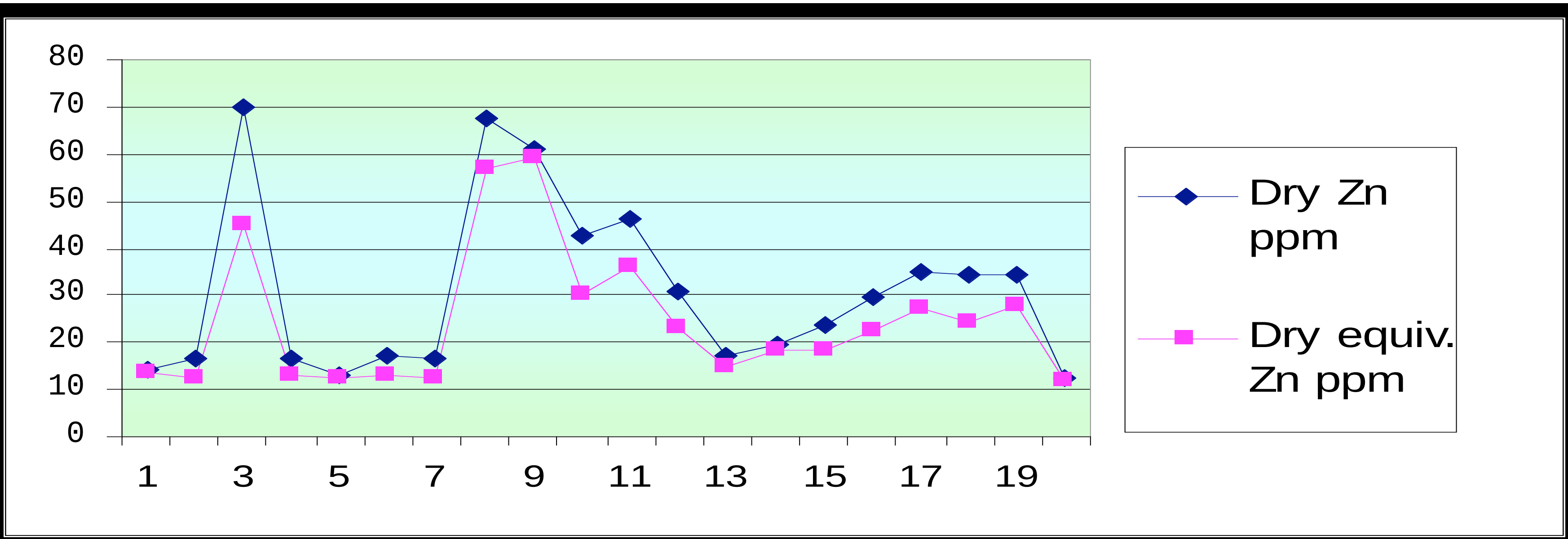
Whether or Not to *Ash* Samples

- **Pro:** Reduction to ash permits concentration of elements from large samples
- **Con:** During ashing, some elements (As, Sb) partially, or completely (Hg) volatilize from some species
- ***However,*** *Controlled* ignition results in constant losses, therefore distribution patterns are relevant

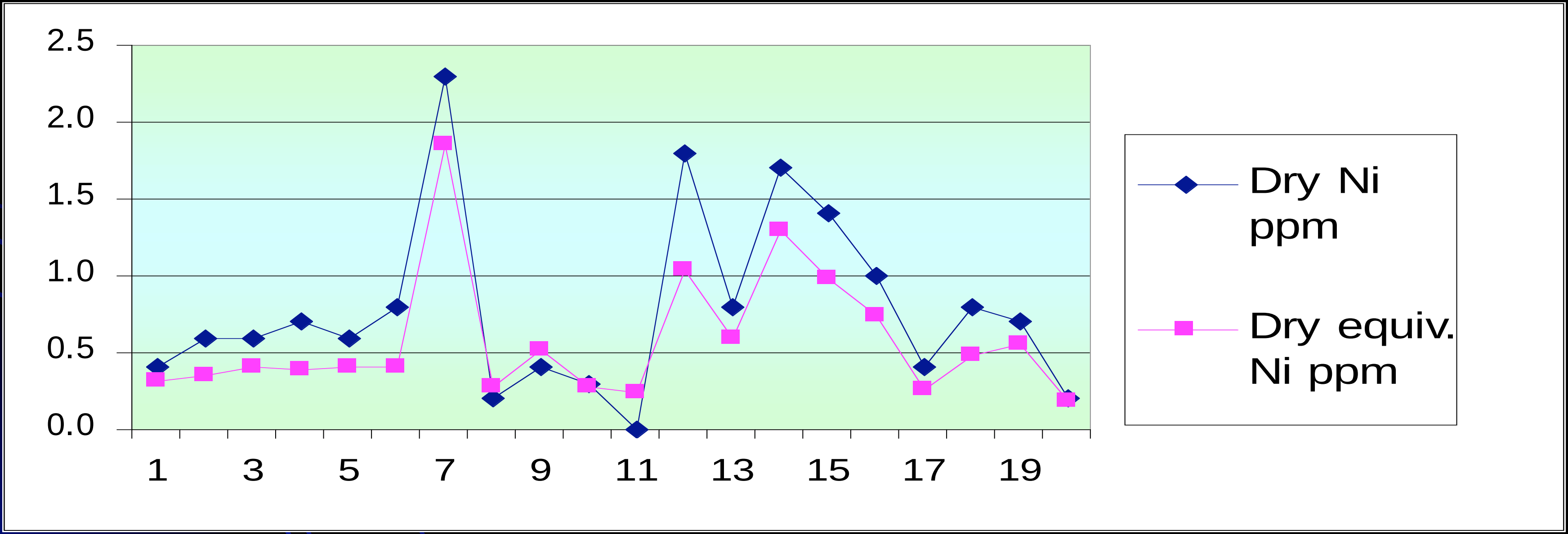
Element Losses

Analysis of ash [at 475ºC] compared to analysis of dry tissue

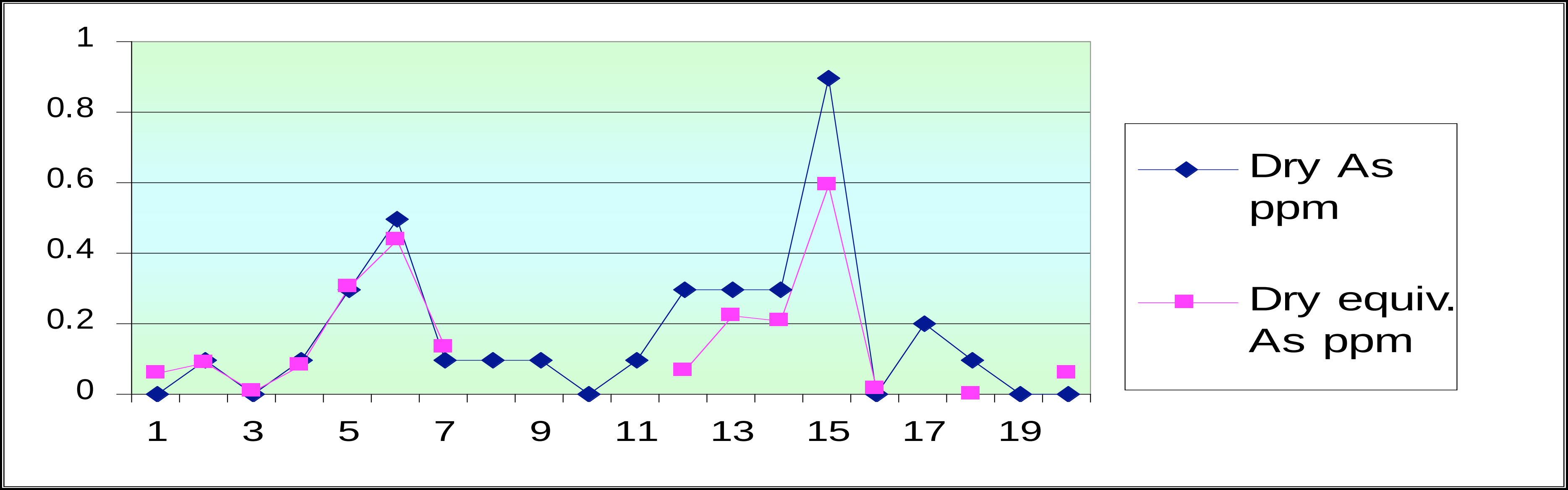

0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1
3
5
7
9
11
13
15
17
19
Dry Mo ppm
Dry equiv. Mo ppm
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1
3
5
7
9
11
13
15
17
19
Dry Cu ppm
Dry equiv. Cu ppm

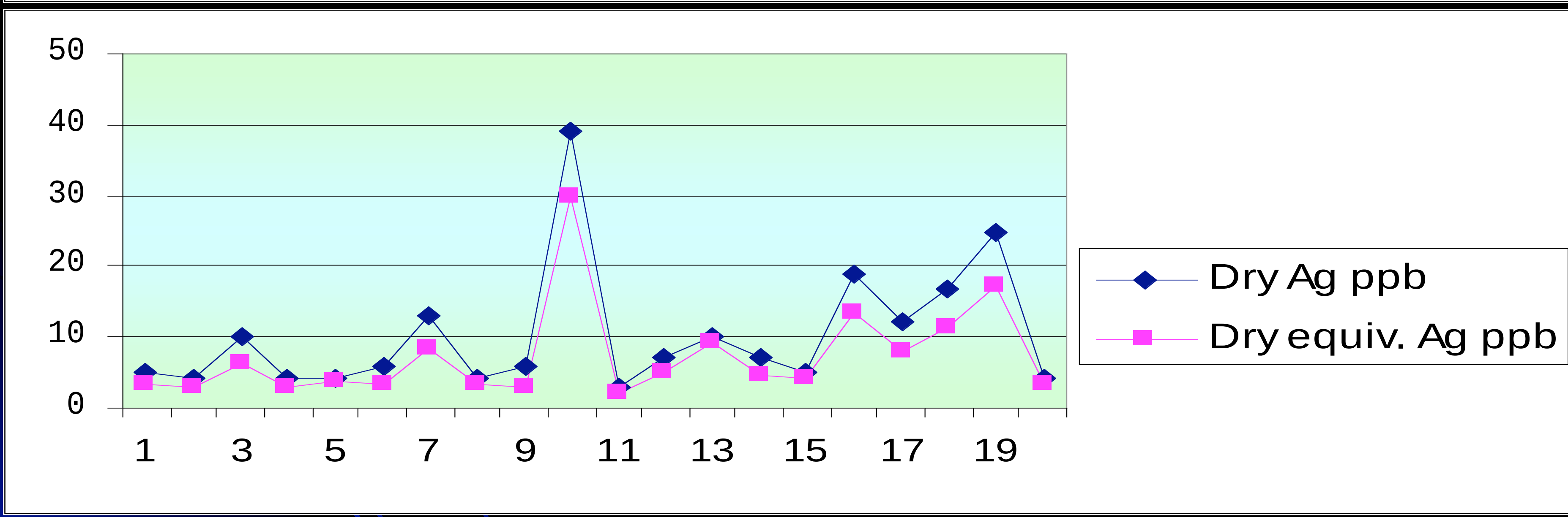


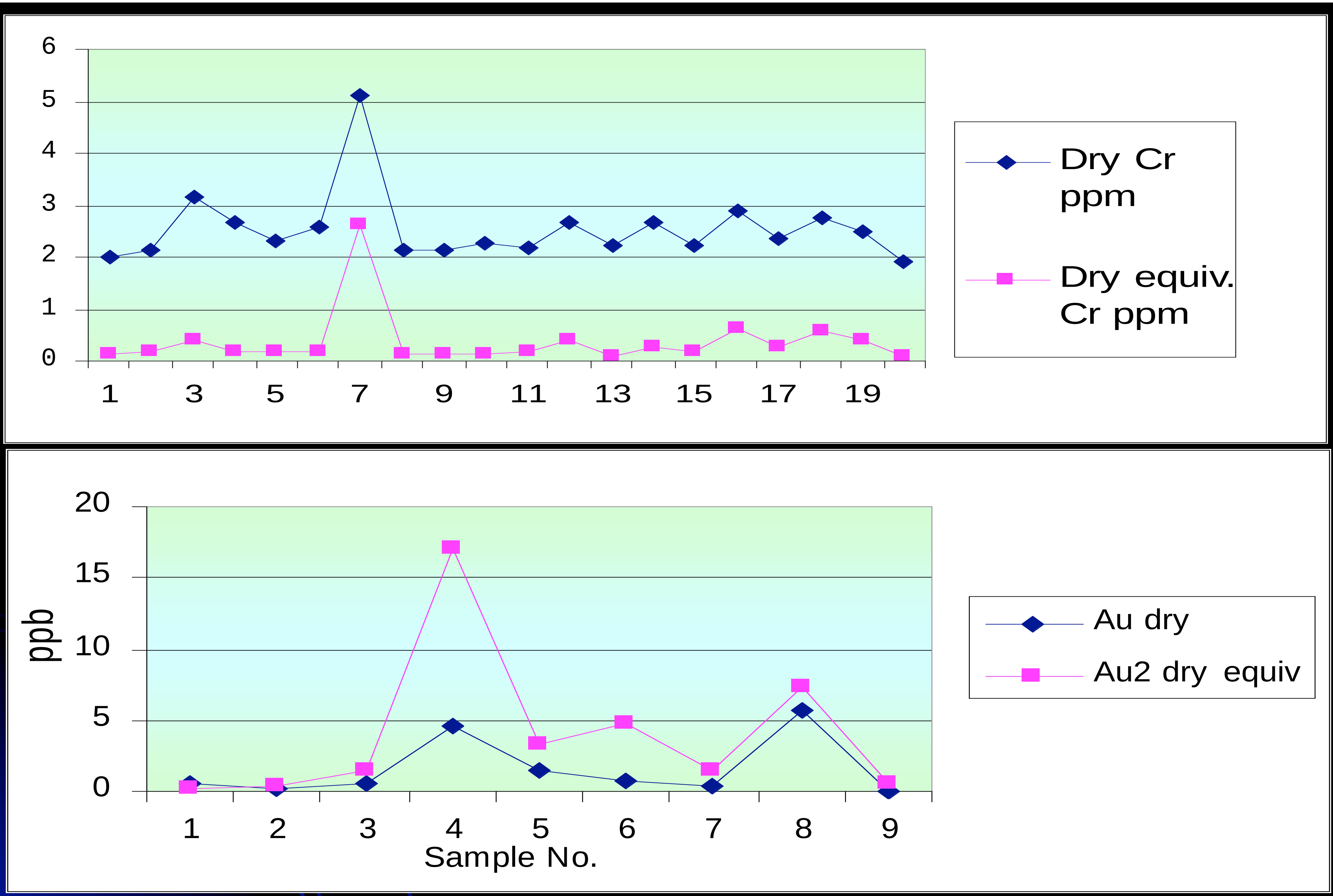
80
70
60
50
40
30
20
10
0
1
3
5
7
9
11
13
15
17
19
Dry Zn ppm
Dry equiv. Zn ppm



2.5
2.0
1.5
1.0
0.5
0.0
1
3
5
7
9
11
13
15
17
19
Dry Ni ppm
Dry equiv. Ni ppm


1
0.8
0.6
0.4
0.2
0
1 3 5 7 9 11 13 15 17 19
Dry As ppm
Dry equiv. As ppm


50
40
30
20
10
0
1 3 5 7 9 11 13 15 17 19
Dry Ag ppb
Dry equiv. Ag ppb


6
5
4
3
2
1
0
1
3
5
7
9
11
13
15
17
19
Dry Cr ppm
Dry equiv. Cr ppm
20
15
10
5
0
ppb
1
2
3
4
5
6
7
8
9
Sample No.
Au dry
Au2 dry equiv

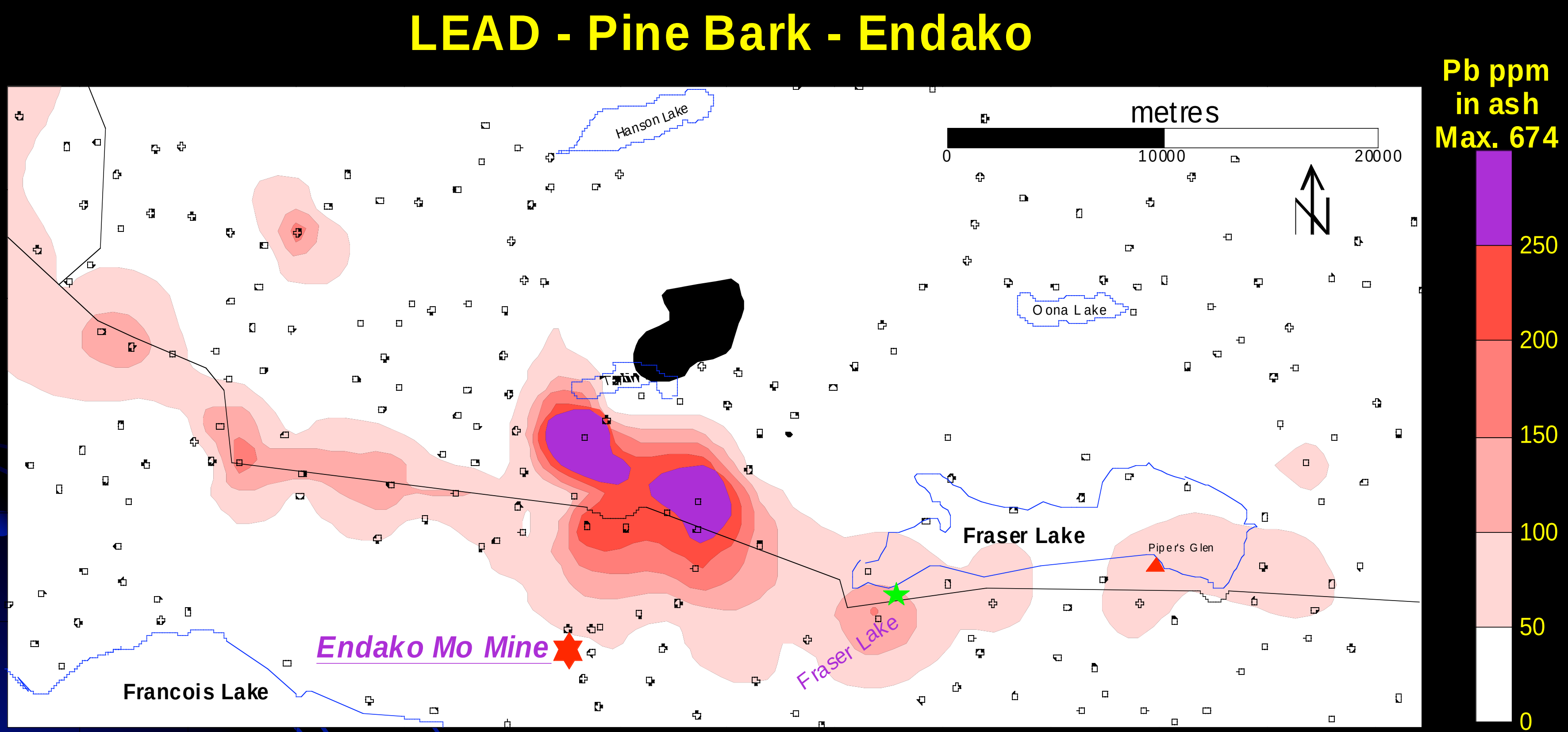
Elements that are Commonly Only Detected in Ash (ICP-MS) i.e. below detection in dry tissue:

Pt, Pd, Bi, Sb, Te, Tl,
In, Re, Th, V, most REE

CONTAMINATION

Precautions

Pb contamination along road



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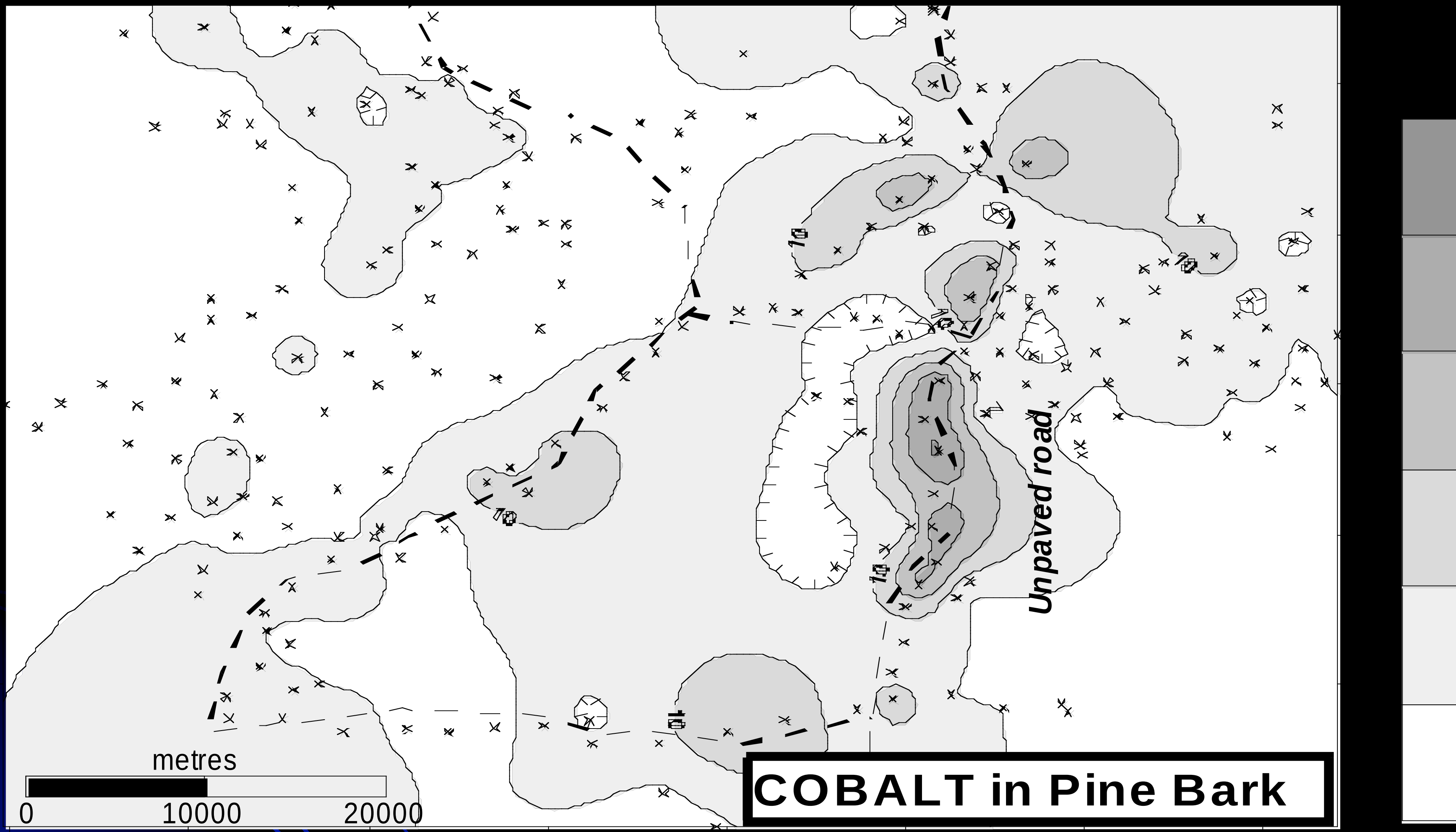

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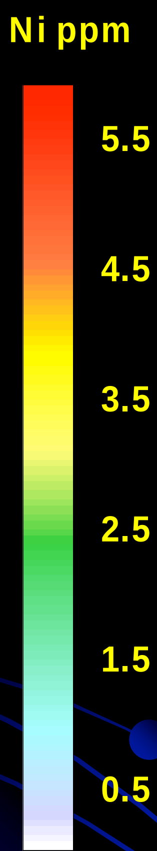
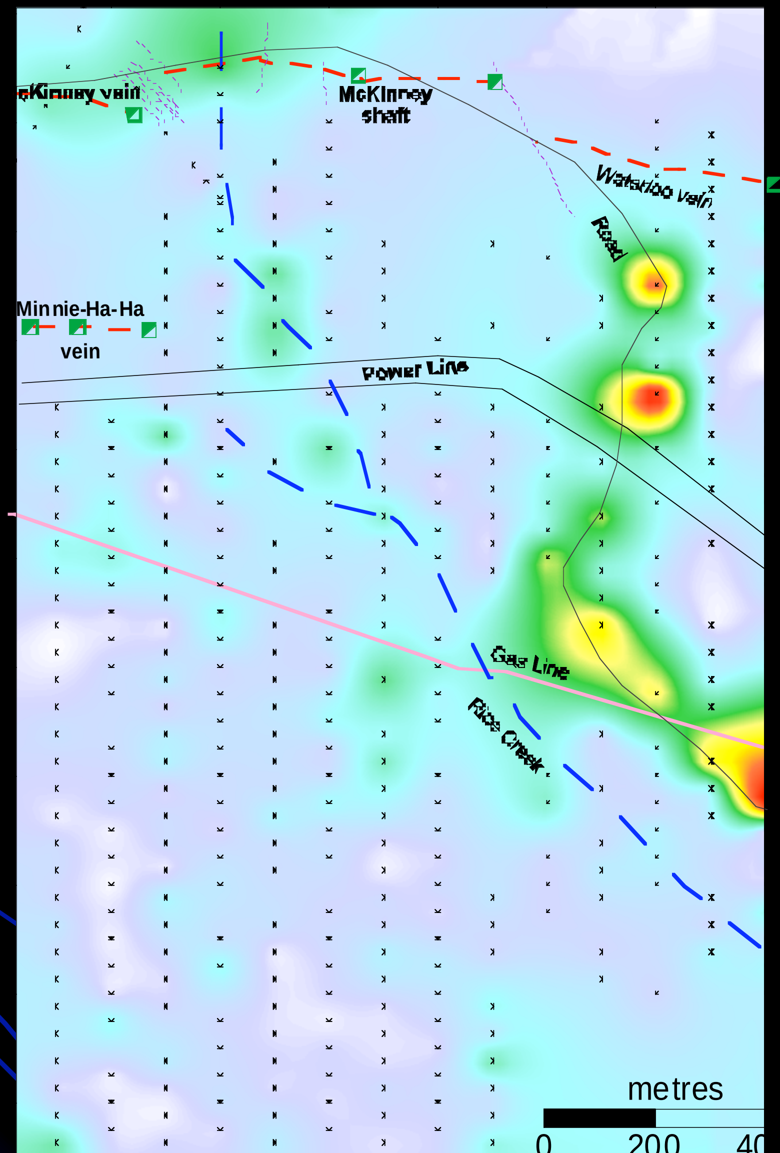
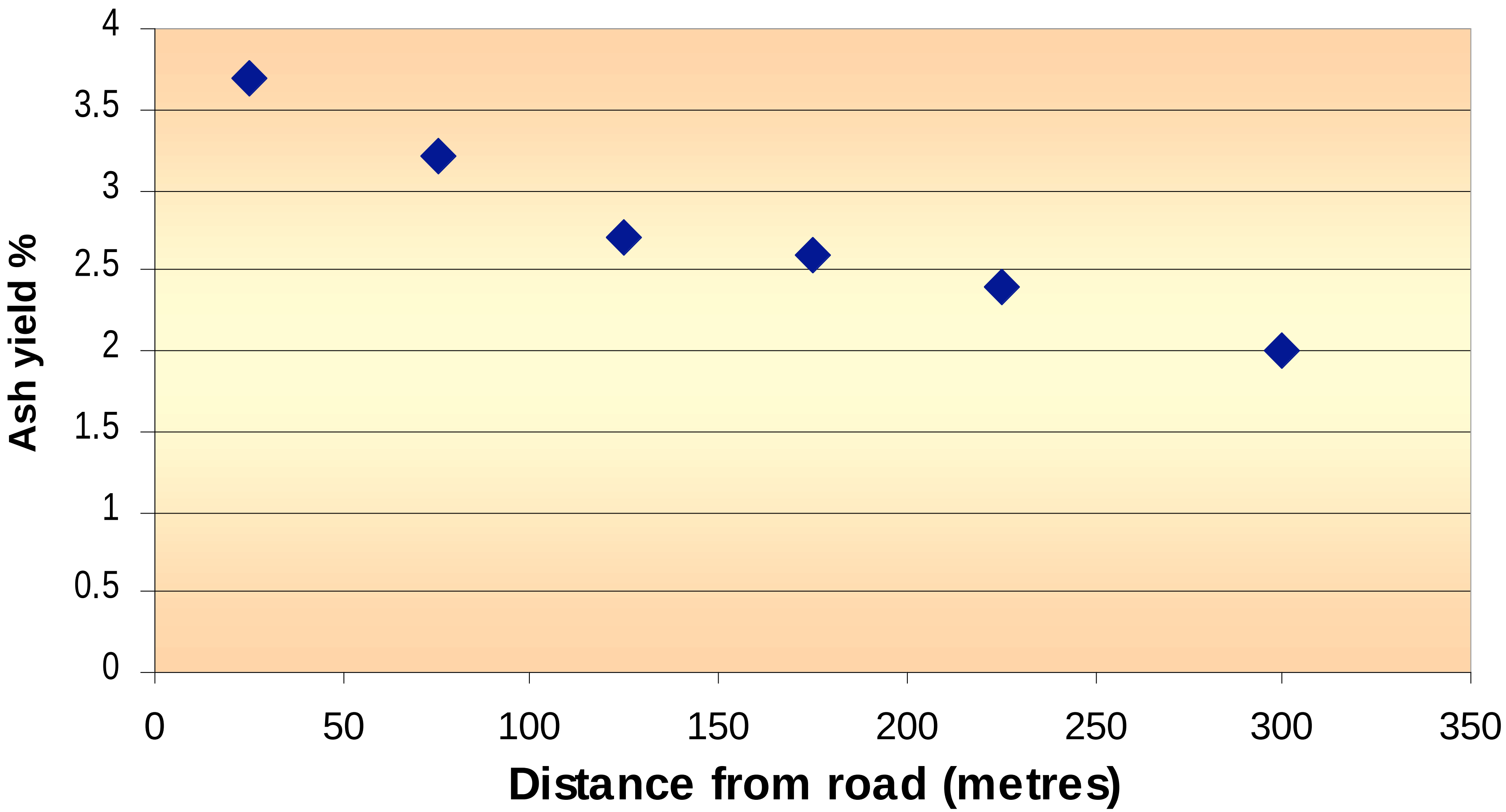
CARAMELIA - BC
NICKEL (ppm)
in Dry Larch Bark

Courtesy of
Merit Mining







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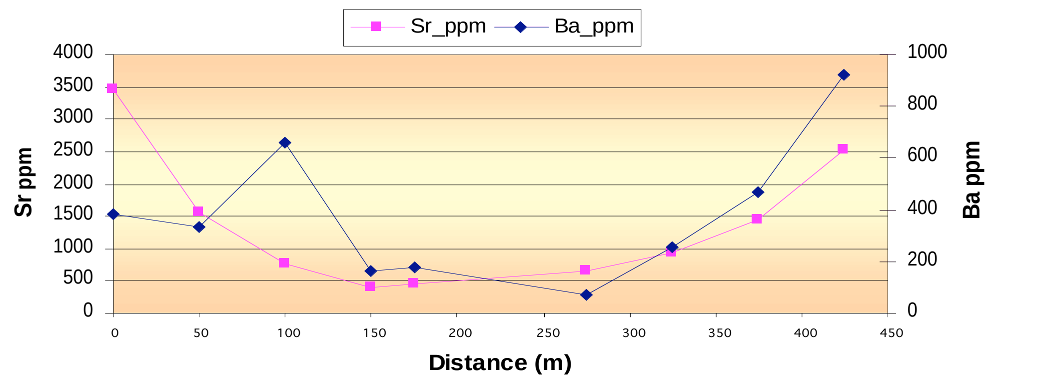
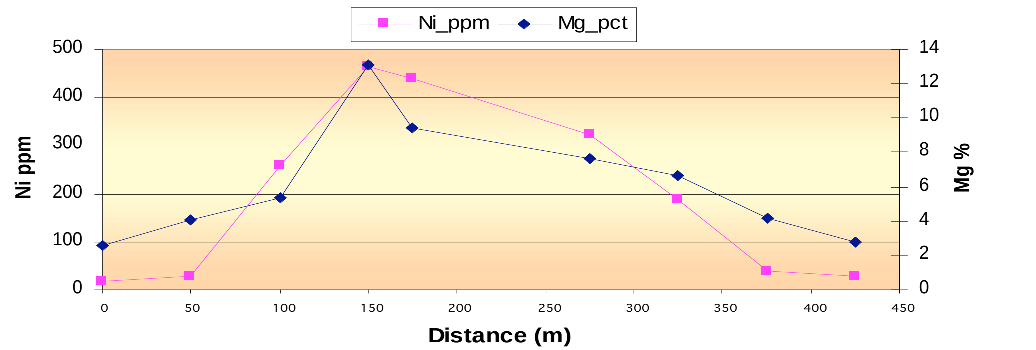
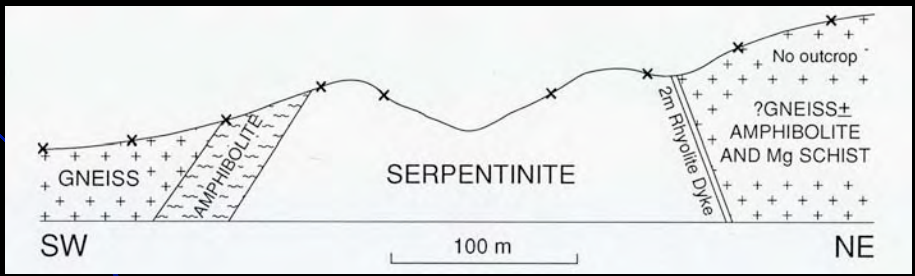
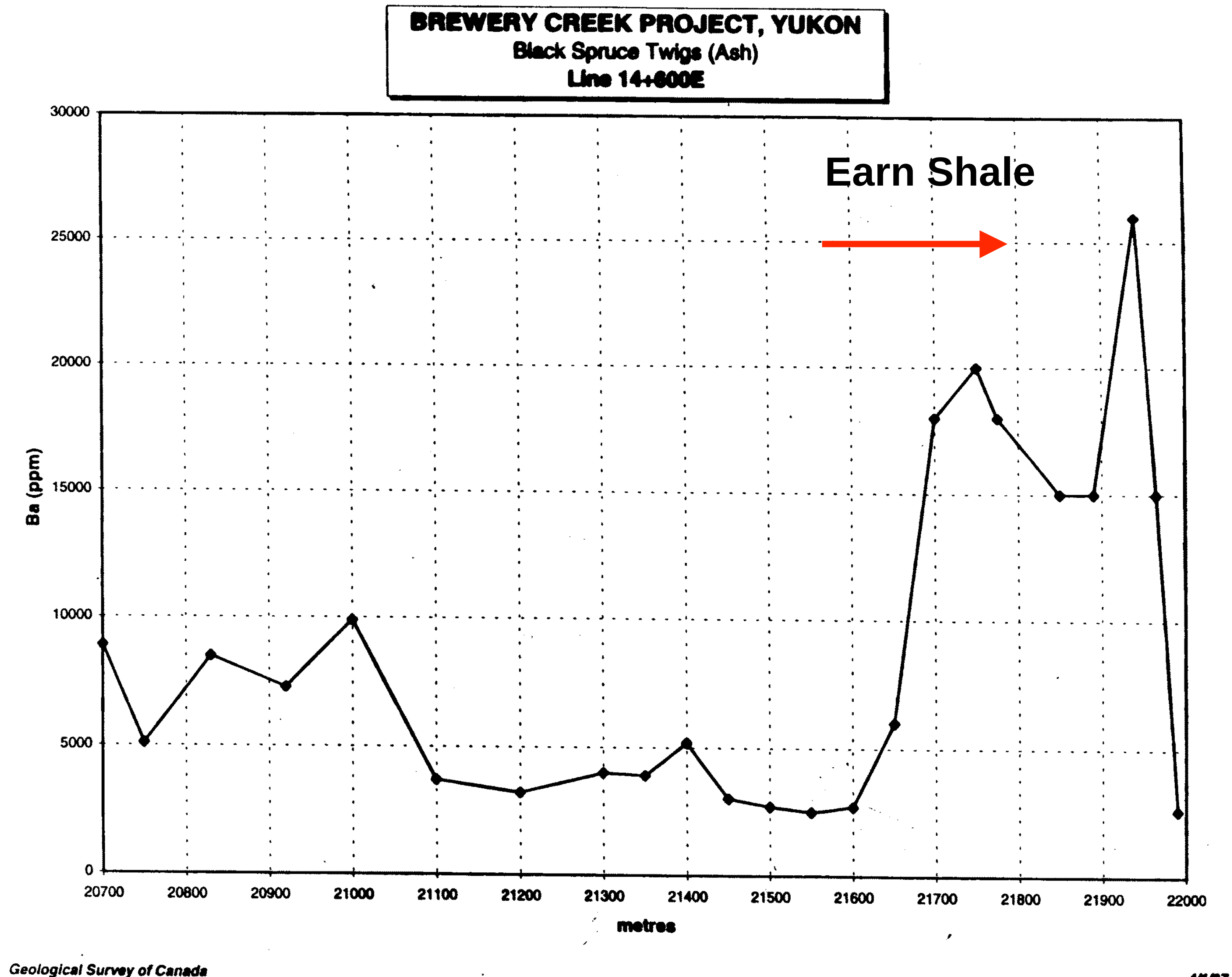
STRATIGRAPHY and LITHOLOGY


Sr_ppm
Ba_ppm
Sr ppm
Ba ppm
Distance (m)


Ni_ppm
Mg_pct
Ni ppm
Mg %
Distance (m)


No outcrop
?GNEISS±
AMPHIBOLITE
AND Mg SCHIST
GNEISS
AMPHIBOLITE
SERPENTINITE
2m Rhyolite Dyke
SW
100 m
NE


BREWERY CREEK PROJECT, YUKON
Black Spruce Twigs (Ash)
Line 14+600E
Earn Shale
Ba (ppm)
30000
25000
20000
15000
10000
5000
0
20700
20800
20900
21000
21100
21200
21300
21400
21500
21600
21700
21800
21900
22000
metres
Geological Survey of Canada
4/1/97

Structural Trends

MERCURY and GOLD

Dry Larch and Pine Bark

Merit Mining Corp.

Caramelia Property, Southern BC

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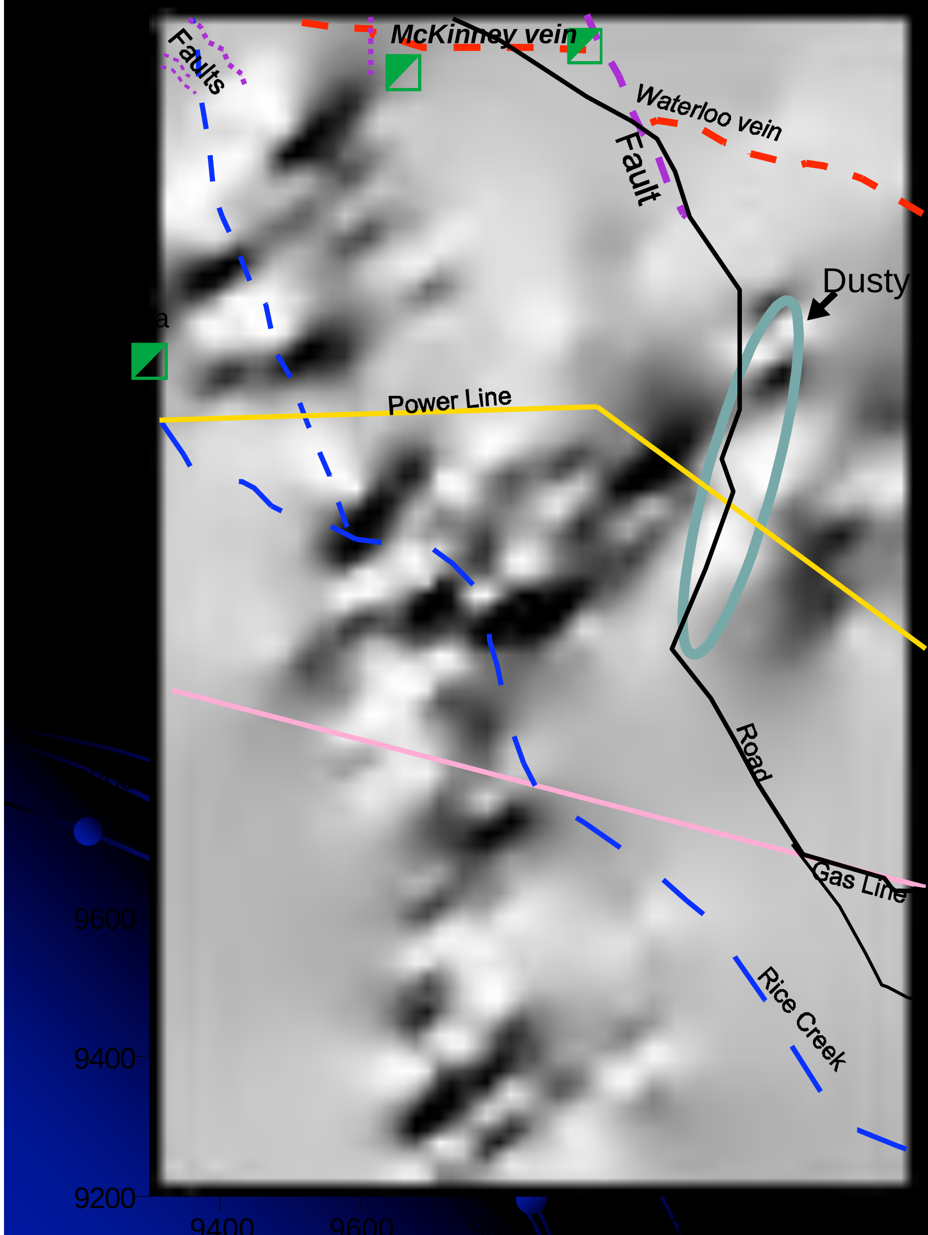
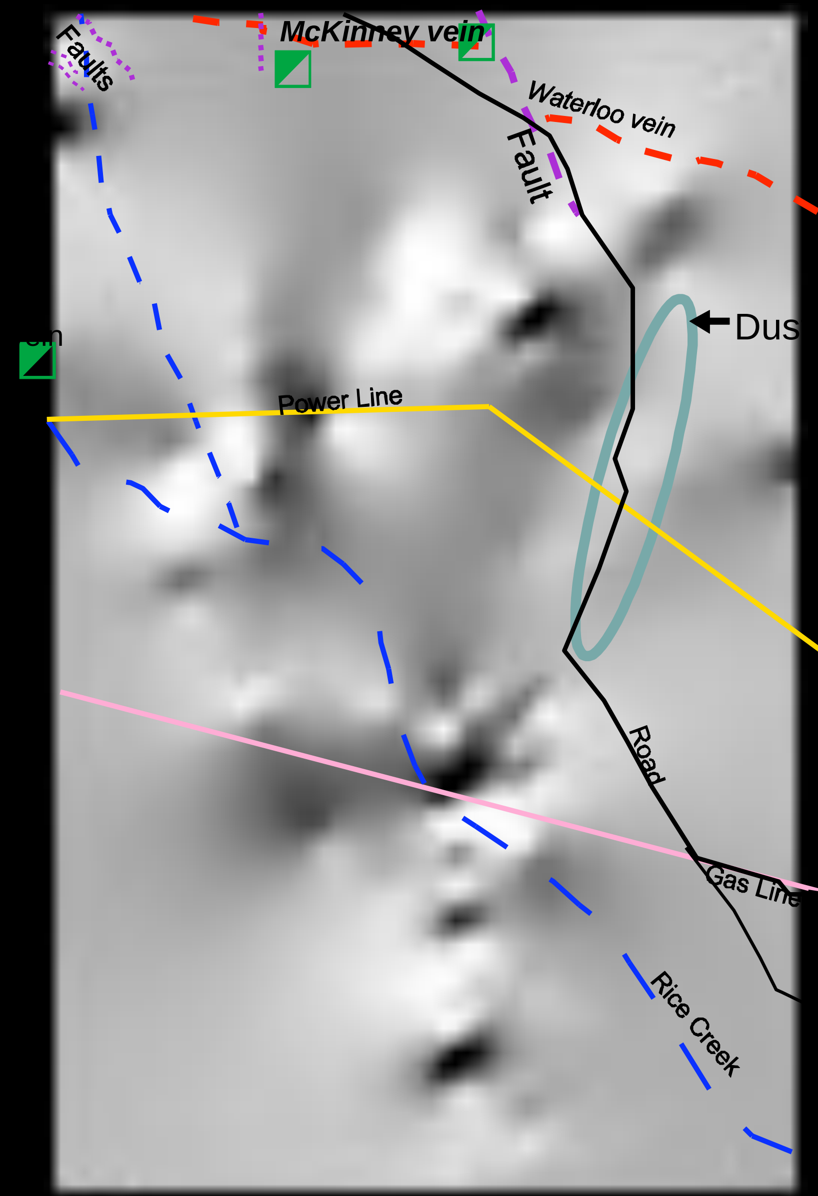
Mercury in Larch Bark



Mercury in Pine Bark



200 m

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Keep in Mind:

- What are we trying to achieve?
- Why are we using plants?
- How do we use plants?
- Where should we be using plants (rather than soils, rocks, water etc.)?
- What precautions do we need to take?

Be consistent, and, when interpreting the analytical results ask the questions:

- Is there a possible analytical explanation?
- Is there a possible contamination explanation?
- Is there a possible ecological or physiological explanation?
- **Is there a possible geological explanation?**

Finally, ask the question

Are your interpretations correct, reasonable and justifiable?

CASE HISTORIES and More Details

Plenary Session

Tuesday, 10:40

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