Biogeochemical Exploration

Bryophyte Alternative to Stream Sediment Geochemistry

Alaska Miners Association Annual Meeting

Advanced Geochemical Techniques for Alaska

November 6-7, 2006

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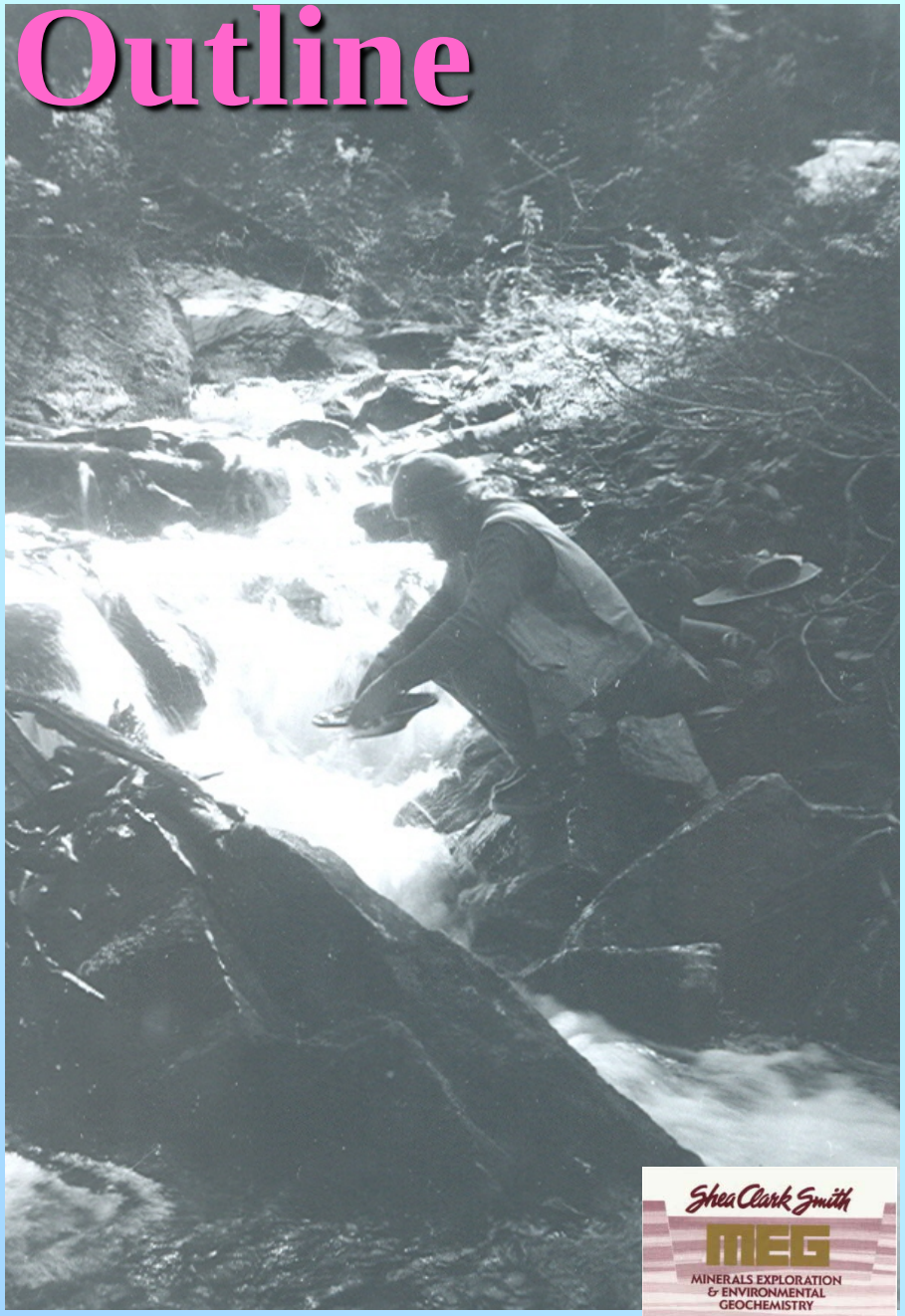
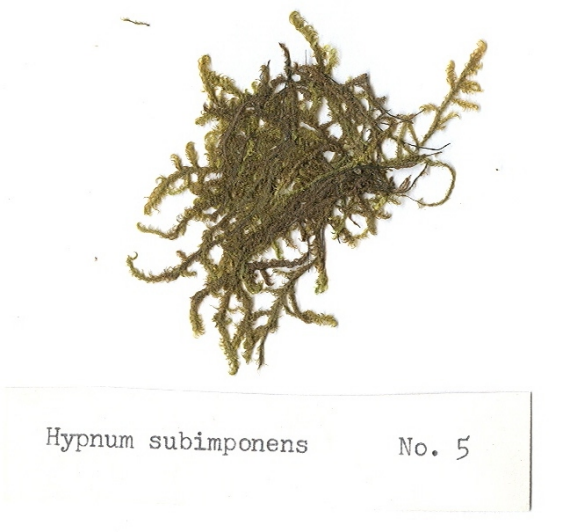
MEG
MINERALS EXPLORATION & ENVIRONMENTAL GEOCHEMISTRY

Discussion Outline

- Chandalar AMRAP 1975
- Geroe Creek Cu-Mo Belt
- Sed & Pan Cons v. Aquatic Moss
- High Energy Erosion Terrain
- Moss = Detrital & Chemical Filters
- Hydrochemical Enhancements
- Biogeochemical Enhancements
- Hydrochemical pH v. Species
- Pathfinder Distribution
- Compare Riparian Mesquite



Bryophyte Species



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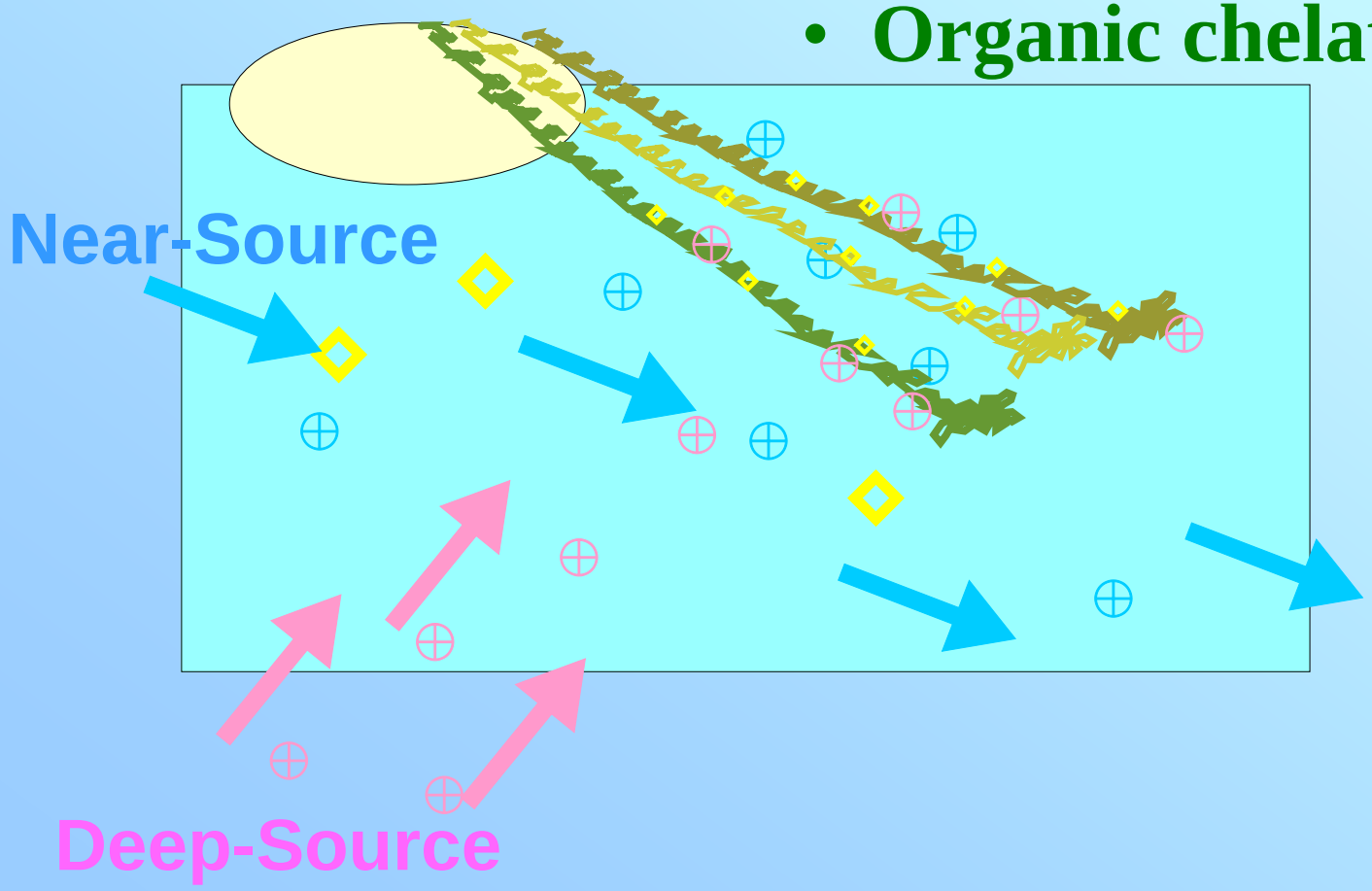
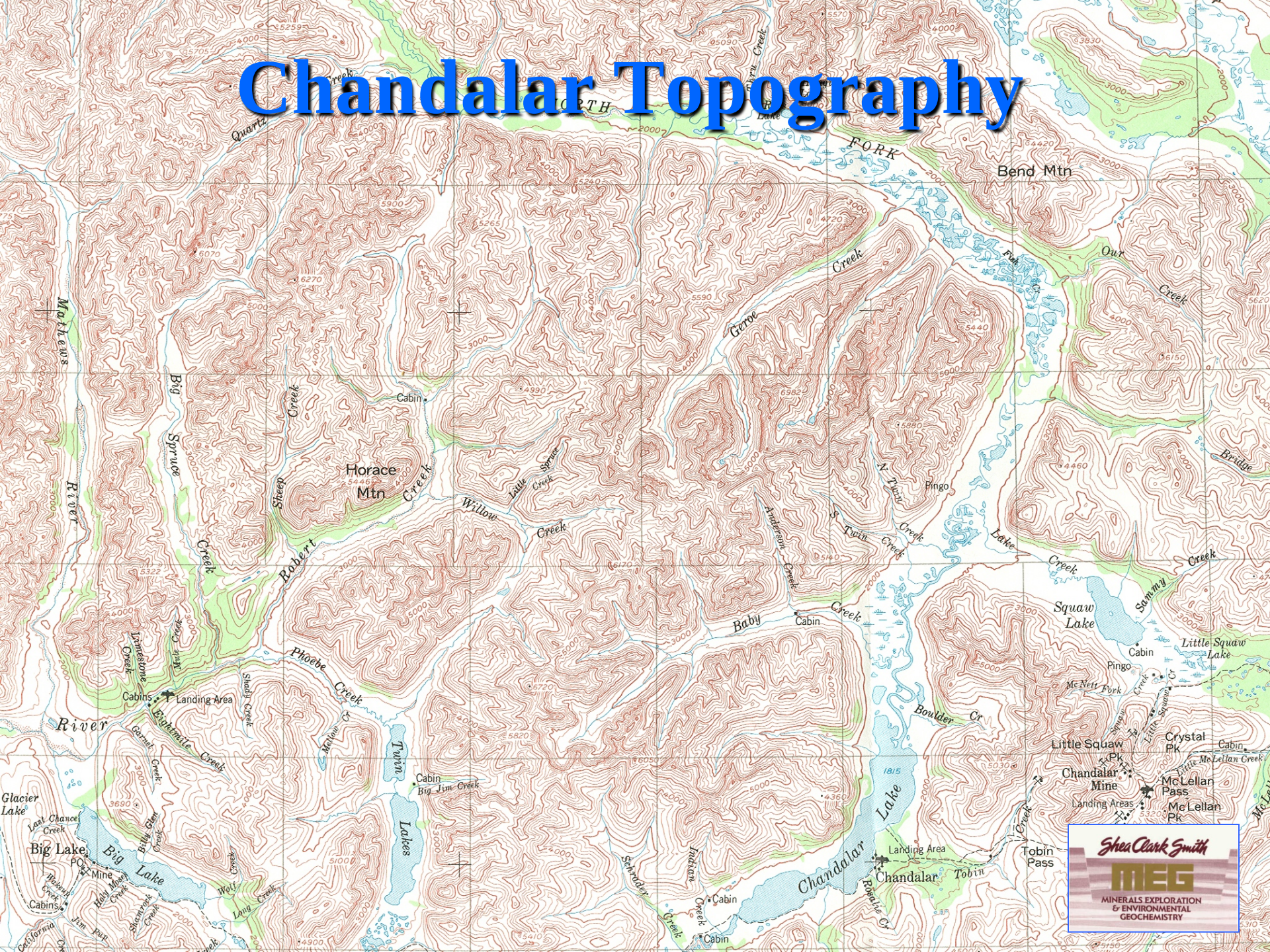
Bryo-Filters

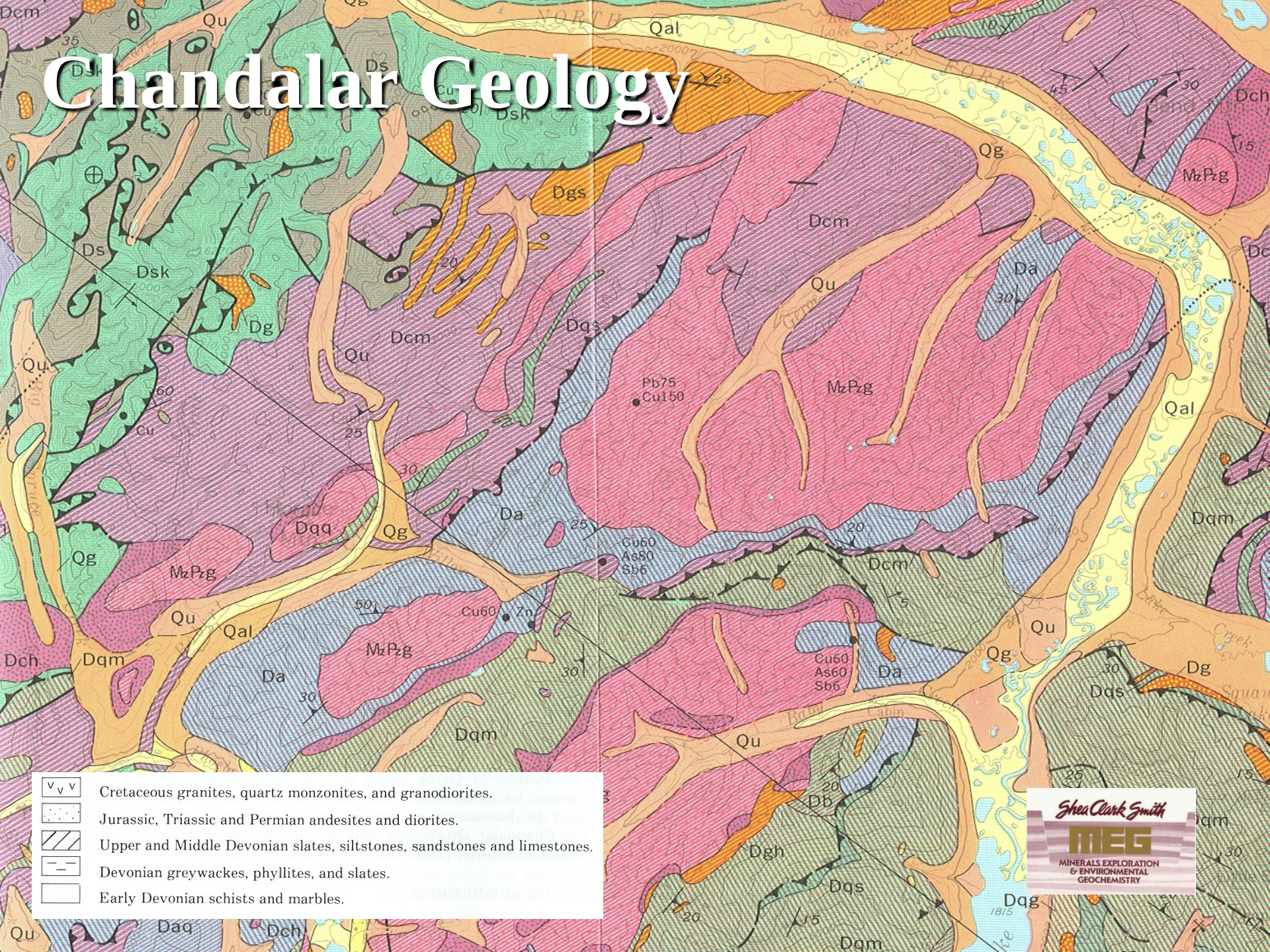
- Fine Particle Trap
- Ion-Exchange
- Organic chelators



Chandalar Topography



Chandalar Geology



Chandalar Bryophytes

TABLE 1

The mean percent organic content (%ORG), the mean concentrations (μg/g, dry weight basis) of copper, lead, zinc, mercury, iron and manganese in bryophytes by species, and the number of samples in each statistical population. These are compared to means for all species together. Mean trace element concentrations are based on log transformed data. %ORG is the percent organic content which is related to percent ash content by: %ORG = 100—%ASH.

Id	Species*	%ORG	Cu	Pb	Zn	Hg	%Fe	%Mn	*n*
Cg	*Calliergon giganteum* (Schimp.) Kindb.	75	17	9	67	170	2.3	0.11	23
Ga	*Grimmia alpicola* Hedw.	73	29	12	144	260	2.6	0.29	9
Lt	*Leptodictyum trichopodium* (Schultz) Warnst.	67	28	12	67	370	2.5	0.11	2
Hs	*Hypnum subimponens* Lesq.	63	29	13	70	150	2.3	0.06	42
Sc	*Sphagnum cuspidatum* Ehrh. *ex* Hoff.	63	49	12	63	110	2.4	0.04	4
Cc	*Calliergon cordifolium* (Hedw.) Kindb.	73	20	9	58	150	2.0	0.08	271
Si	*Scapania irrigua* (Nees) Dum.	65	47	11	73	230	2.9	0.14	4
Bt	*Brachythecium turgidum* (C.J. Hartm.) Kindb.	52	35	16	76	60	2.9	0.06	2
Hc	*Hypnum cupressiforme* Hedw.	62	18	13	71	110	2.3	0.09	4
Hb	*Hygrohypnum bestii* (Ren & Bryhn *ex* Ren.) Holz. *ex* Broth.	59	17	10	76	130	2.5	0.17	10
Da	*Drepanocladus aduncus* (Hedw.) Warnst.	65	28	11	69	180	2.2	0.05	10
Lr	*Leptodictyum riparium* (Hedw.) Warsnt.	66	33	12	116	260	3.4	0.21	9
Du	*Dichelyma uncinatum* Mitt.	73	26	6	64	240	1.7	0.05	1
Dr	*Drepandocladus revolvens* (Sw.) Warnst.	96	1	5	21	50	6.2	0.19	1
Ps	*Paludella squarrosa* (Hedw.) Brid.	93	21	6	55	220	0.4	0.01	1
	All species	72	22	10	62	140	2.1	0.07	418

*Crum et al. (1965).

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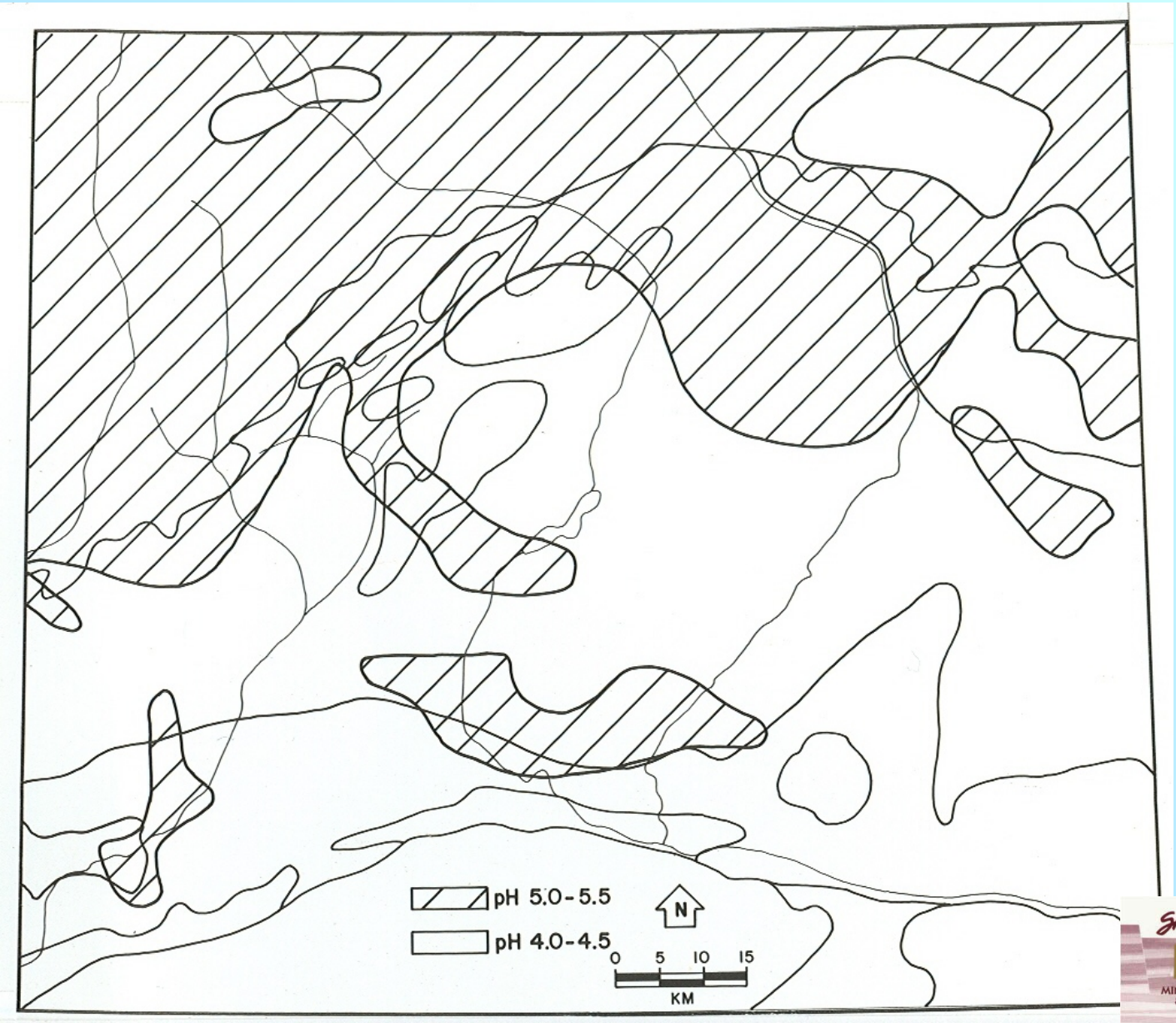
Surface Water Acidity



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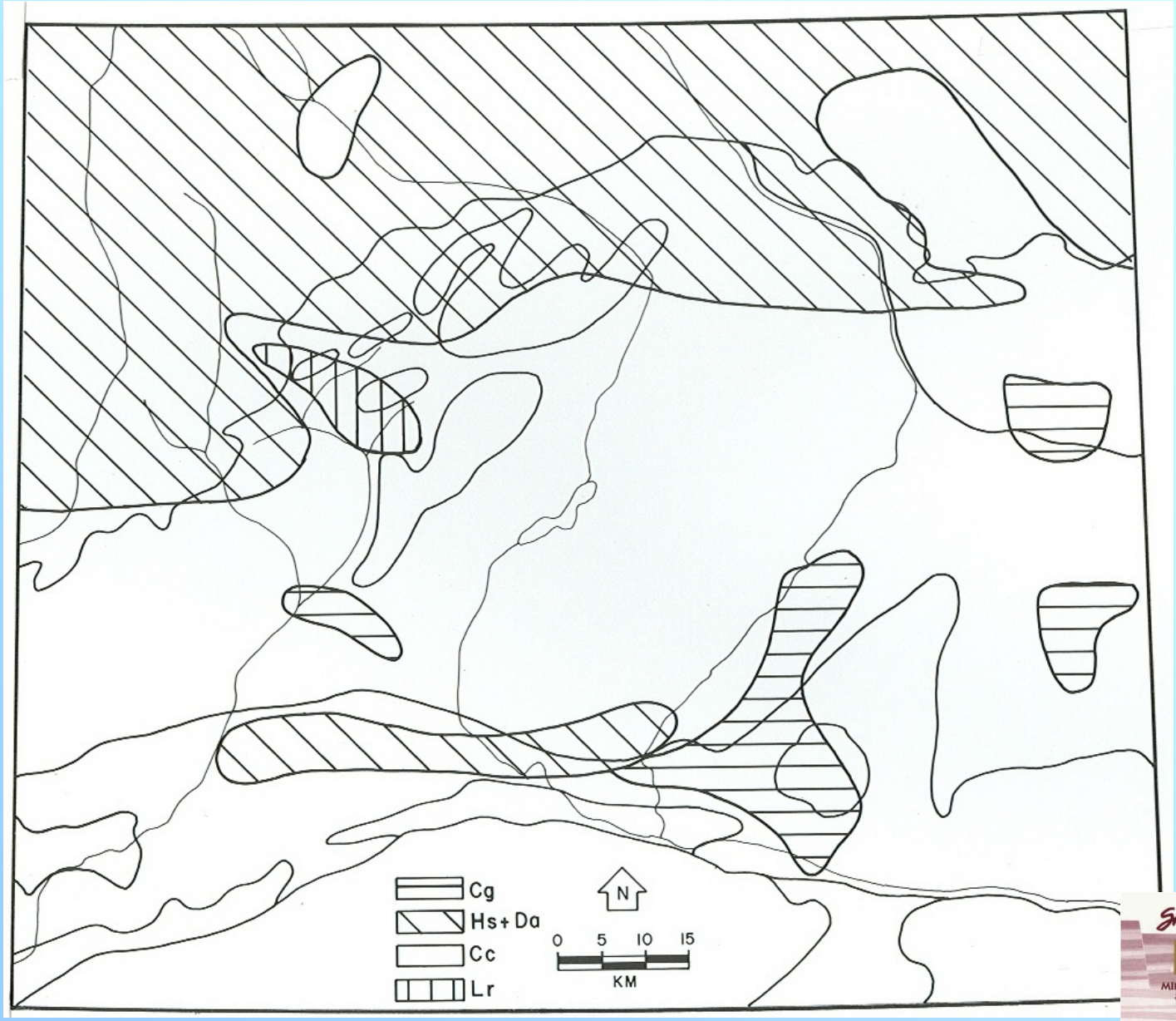
Bryophyte Distribution



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Species Effects

- %ORG compares Detrital Loading
- Ion Exchange Capacity
- Fe/Mn coprecipitation

TABLE 7

Selected data for replicate samples of *Calliergon cordifolium* with variable amounts of organic content, and the element(s) that explain the greatest differences between species ("Species effect"). %ORG is the percent organic content which is related to %ASH by: %ORG = 100—%ASH. Analytical replicates are comparative between "a" and "a" or "b" and "b" samples. Field replicates are comparative between "a" and "b" samples. All trace-element concentrations are reported on a dry weight basis in μg/g (ppm) unless otherwise designated. Species codes are keyed to information in Table 1

Sample id.	Species	Sample type	%ORG	Hg	Cu	Pb	Zn	Mn	%Fe	Species effect
CH160	Lr	a	48	153	59	56	168	1135	2.0	Zn
	Lr	a	53	165	53	45	154	1013	1.8	
	Cc	b	47	254	51	50	269	1048	1.9	
	Cc	b	51	242	49	57	269	1018	1.9	
CH519	Cg	a	72	204	23	11	79	419	2.0	Zn
	Cg	a	79	203	21	10	71	349	1.7	
	Cc	b	79	281	20	10	57	310	1.6	
	Cc	b	80	264	19	8	55	269	1.3	
CH810	Ga	a	85	190	42	6	202	7716	3.7	Cu, Zn
	Cc	b	95	136	18	5	52	1073	2.3	Mn
	Cc	b	93	90	18	5	49	850	2.1	Fe
CH791	Hs	a	81	116	27	10	73	466	2.1	Zn, Fe
	Cc	b	74	83	30	7	52	349	1.3	Mn
CH711	Hs	a	71	83	17	9	48	163	2.1	Mn
	Cc	b	63	109	16	9	54	254	2.5	
CH775	Cg	a	49	6	15	11	67	492	2.3	Zn
	Cg	a	55	65	18	10	84	771	2.3	
	Hs	b	51	31	17	11	104	785	2.2	

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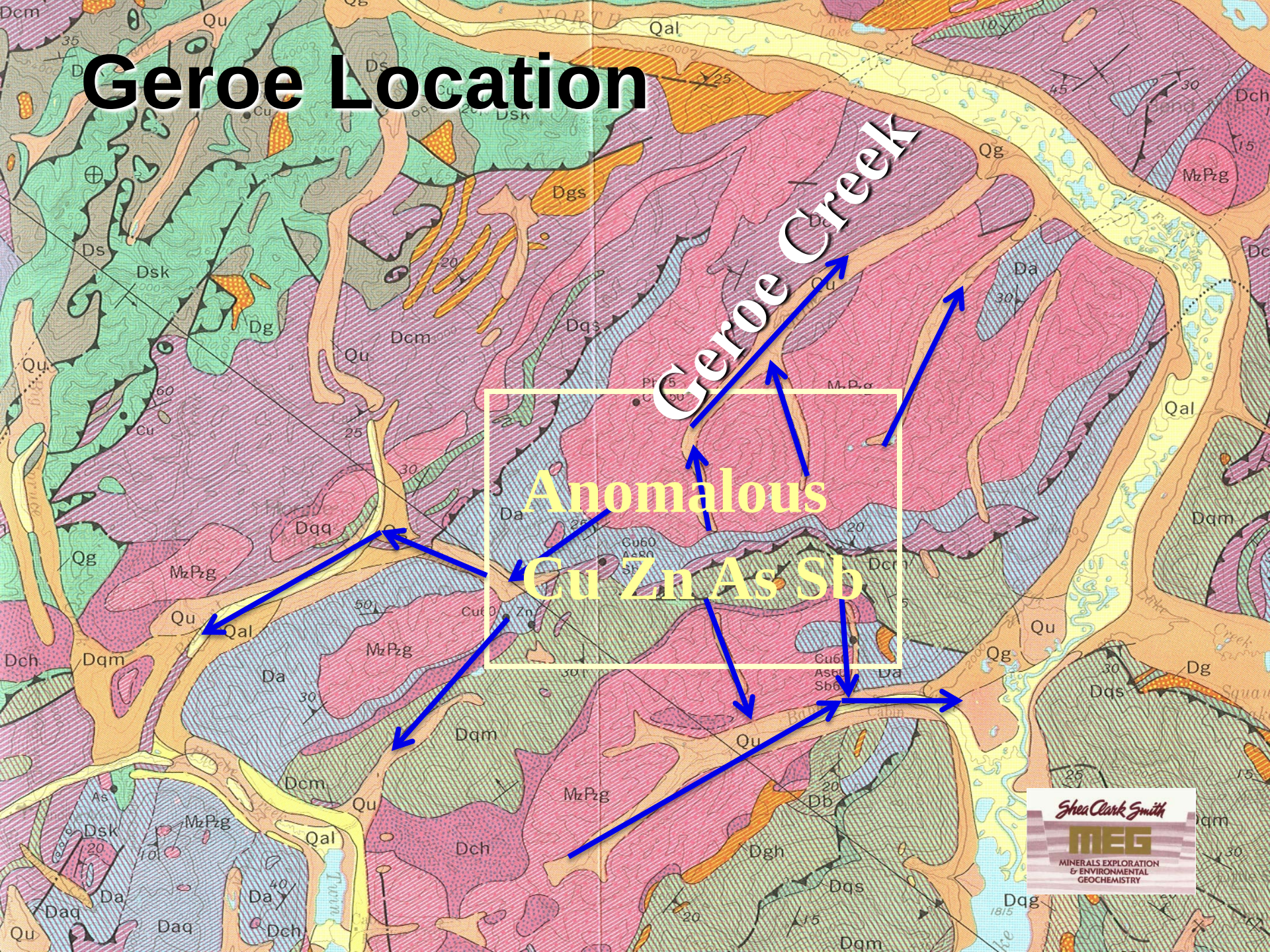
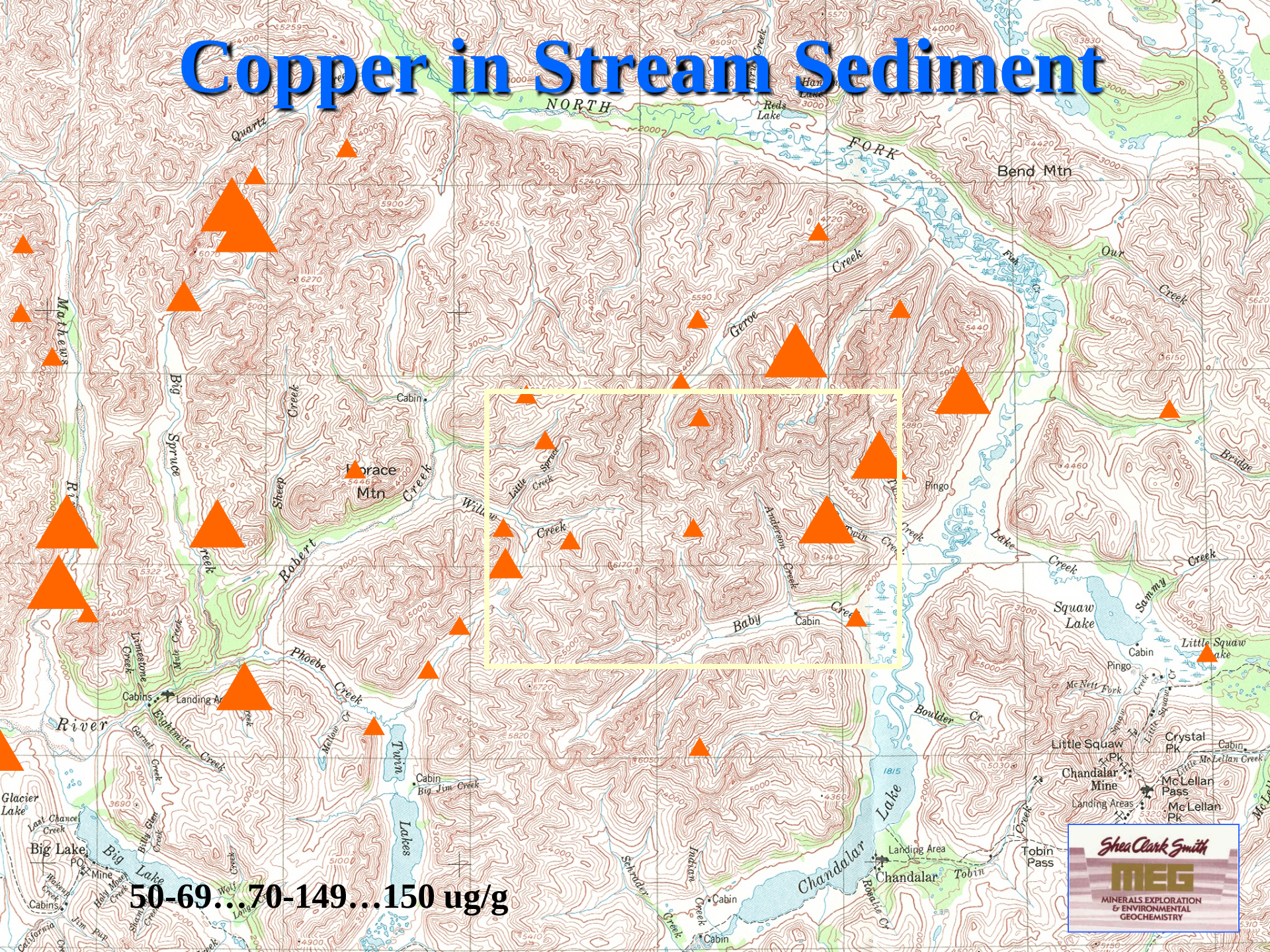
Geroe Location

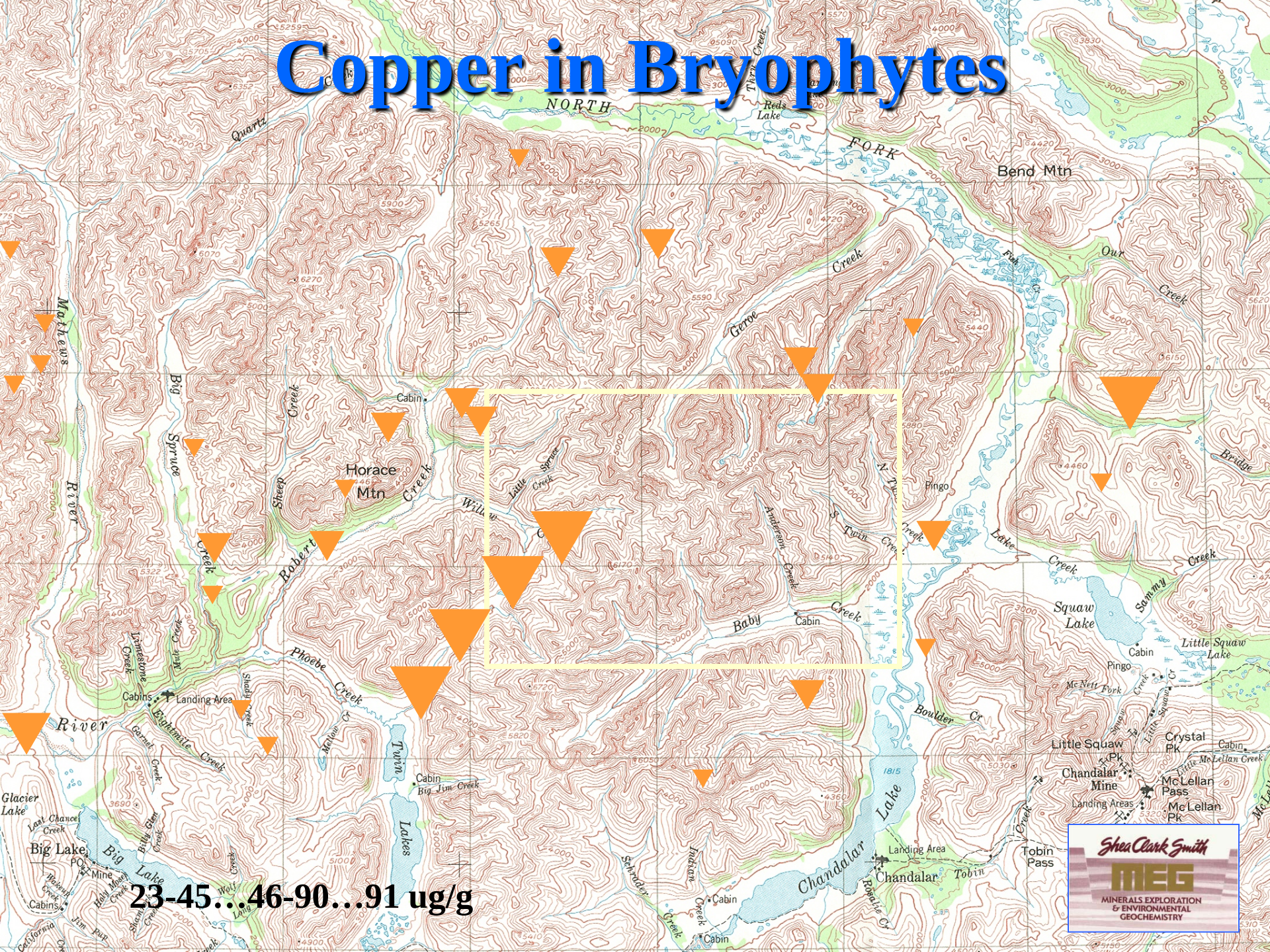


Copper in Stream Sediment



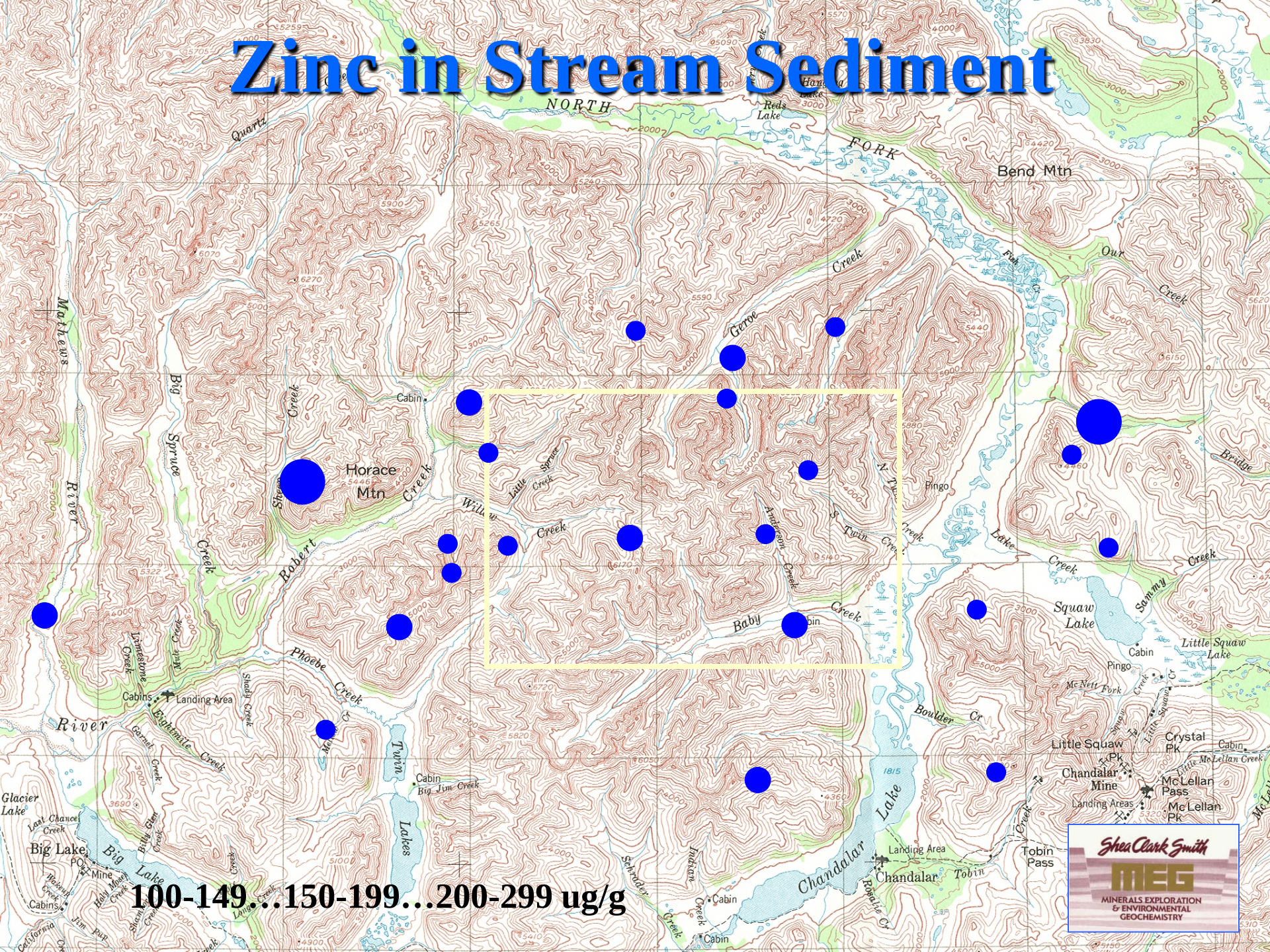
50-69…70-149…150 ug/g

Copper in Bryophytes



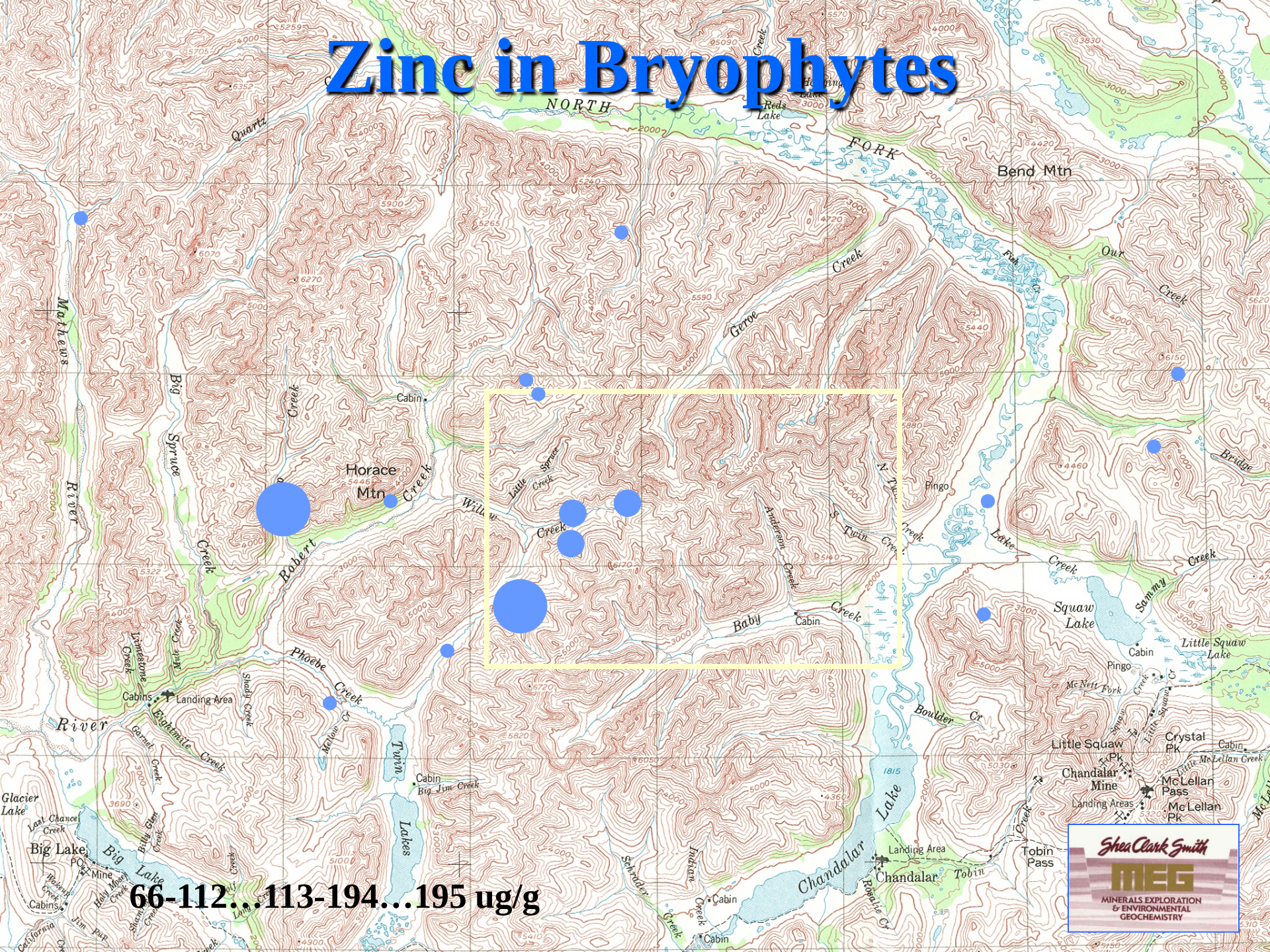
23-45…46-90…91 ug/g

Zinc in Stream Sediment



100-149…150-199…200-299 ug/g

Zinc in Bryophytes



66-112…113-194…195 ug/g

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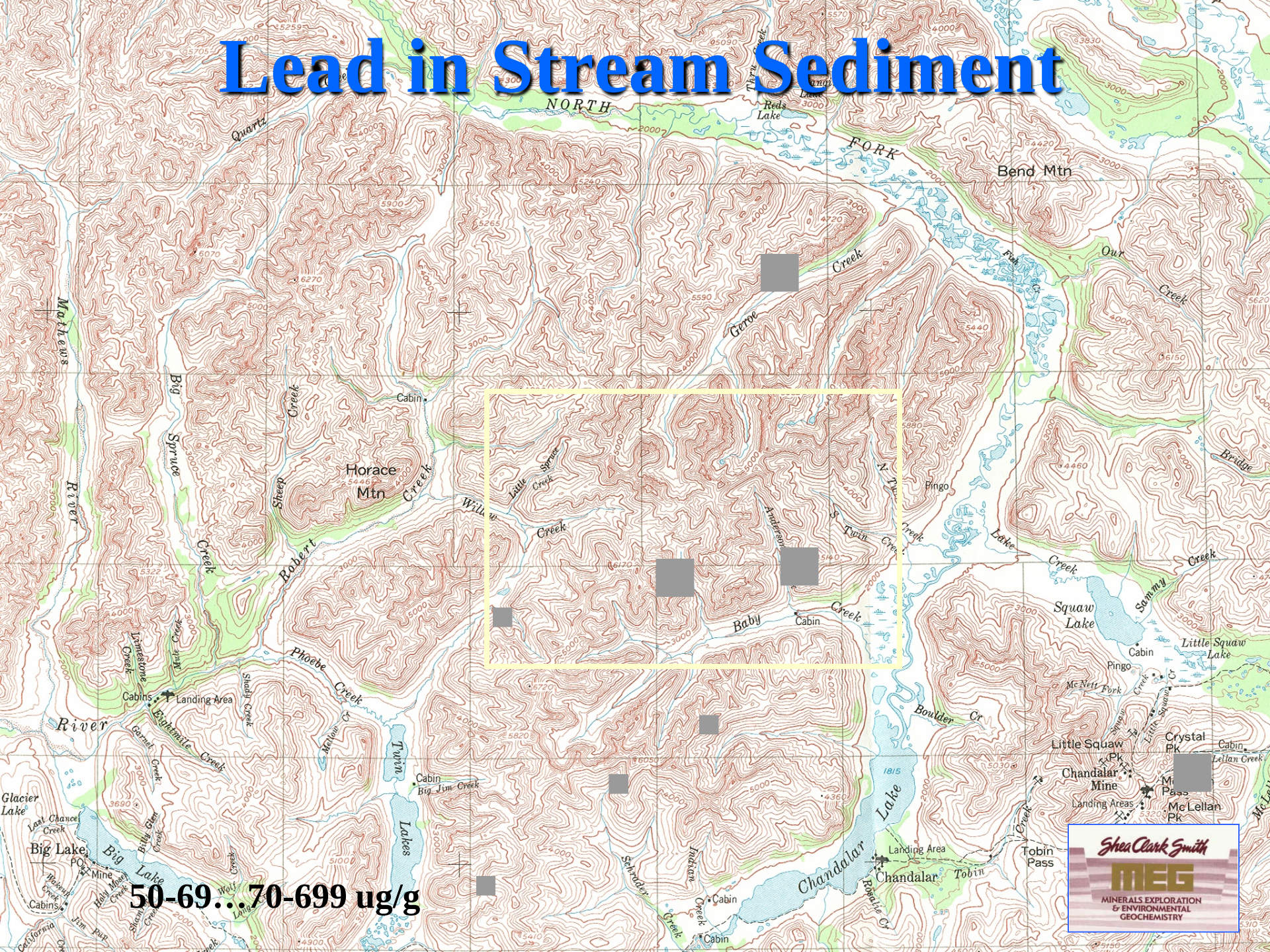
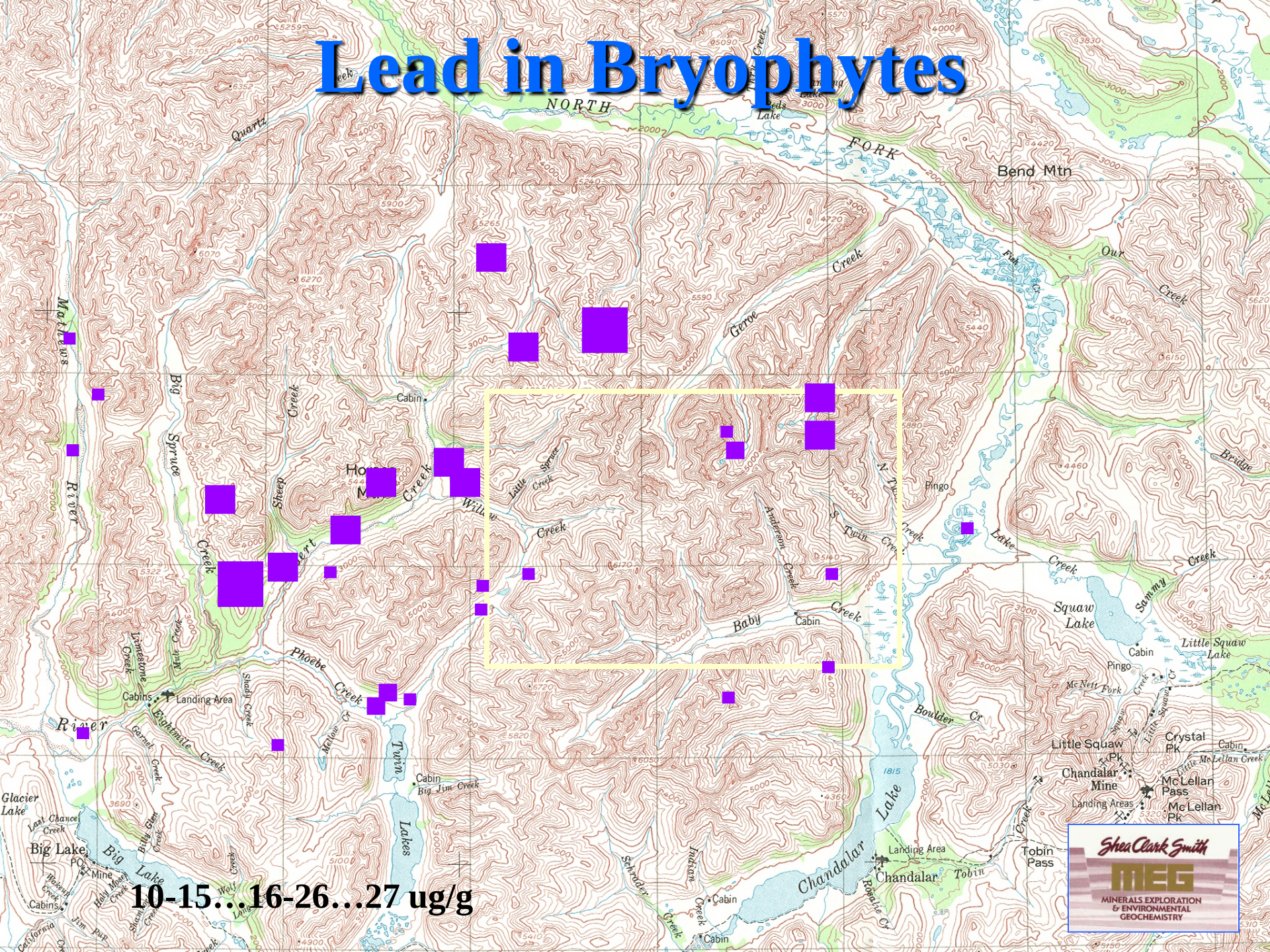
Lead in Stream Sediment



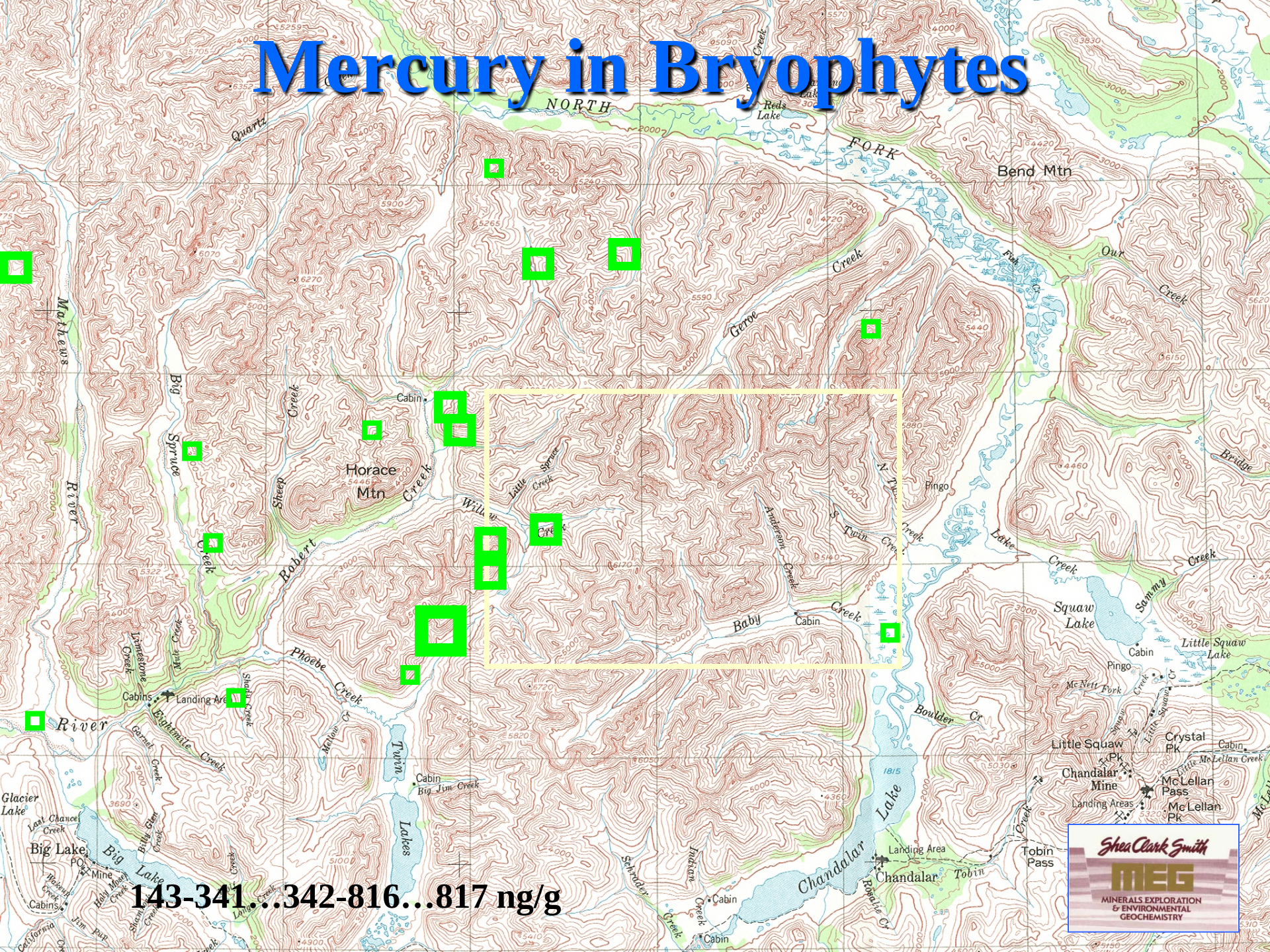
50-69…70-699 ug/g

Lead in Bryophytes

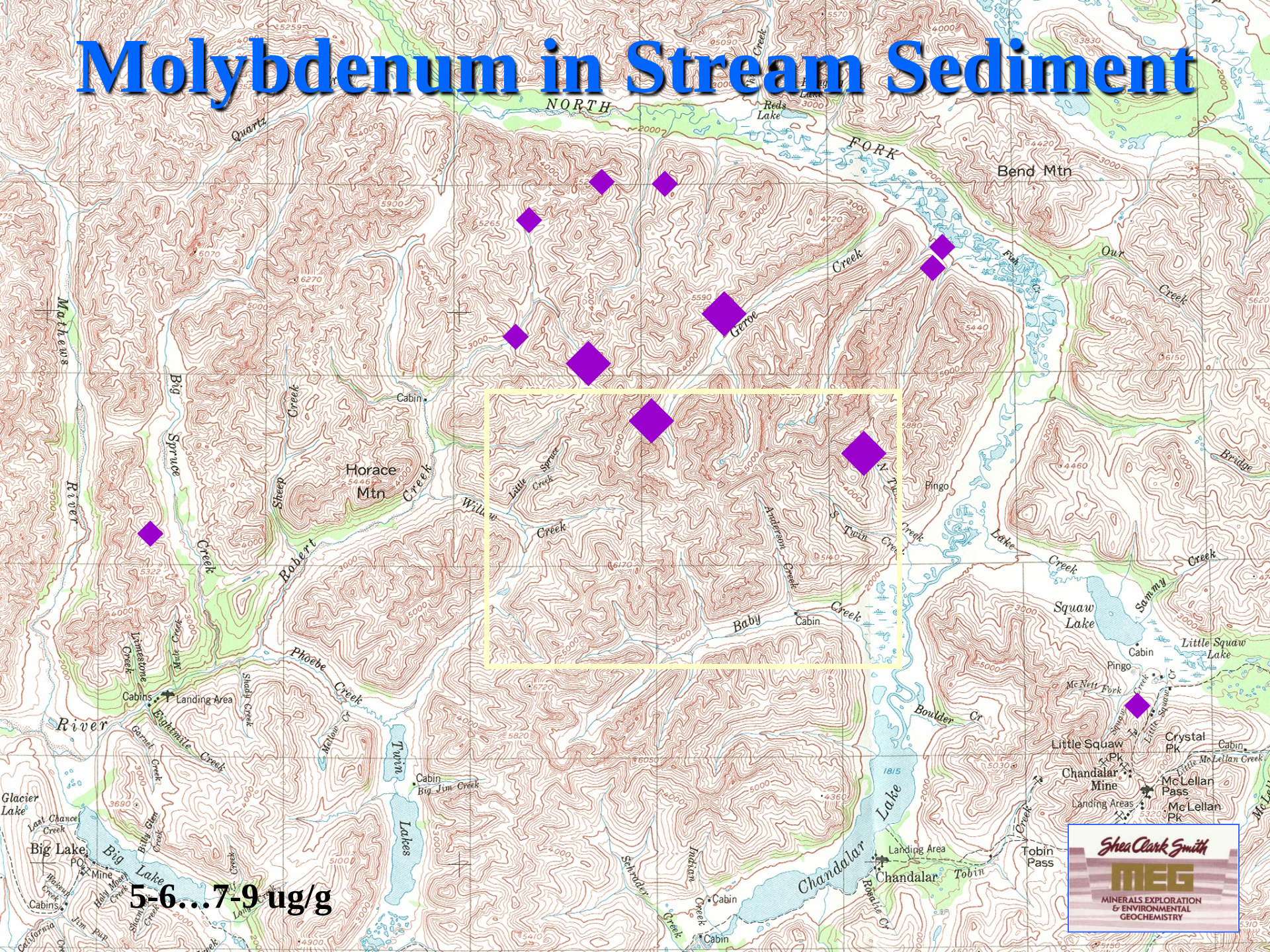


10-15…16-26…27 ug/g

Mercury in Bryophytes

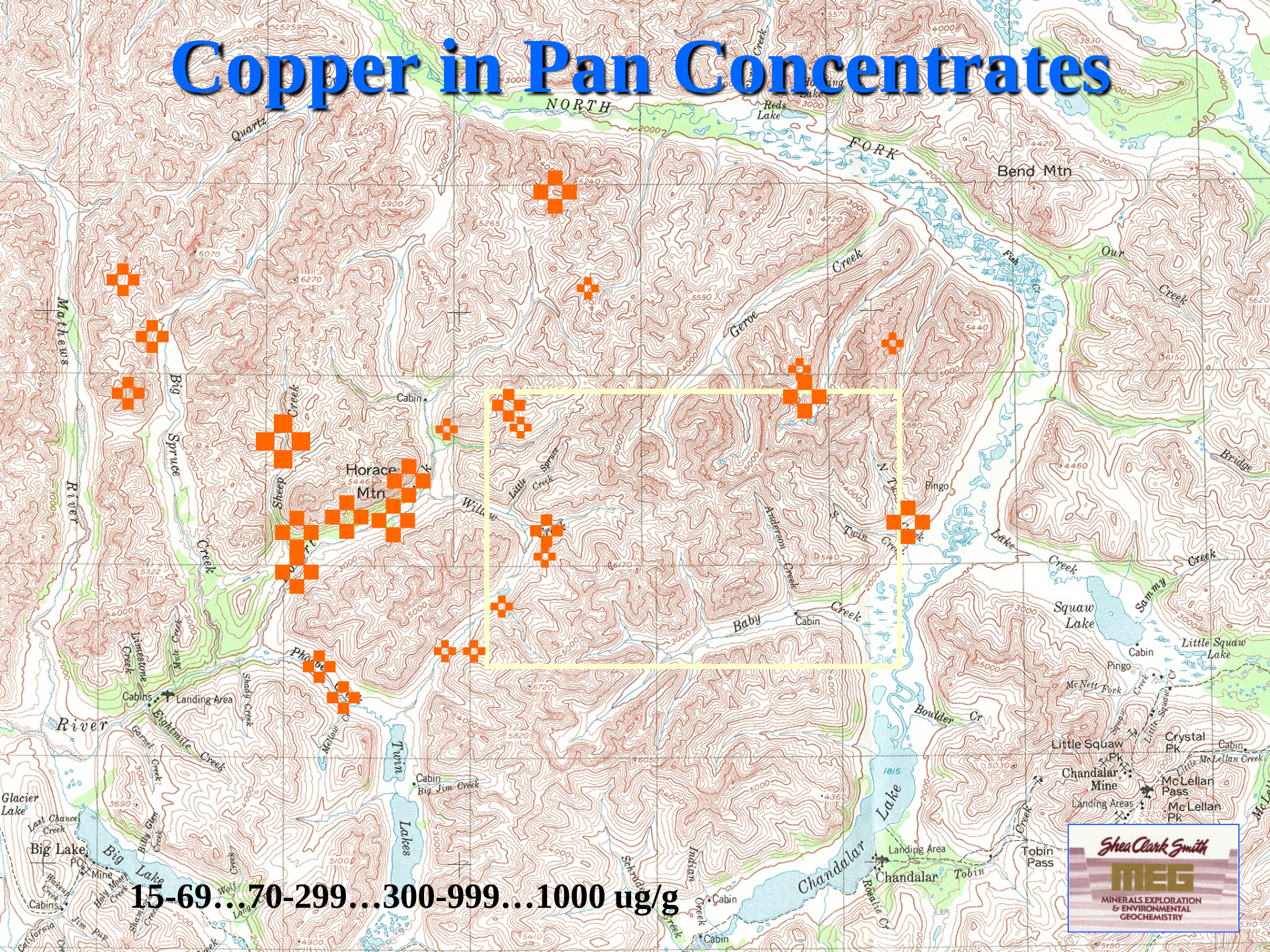


Molybdenum in Stream Sediment



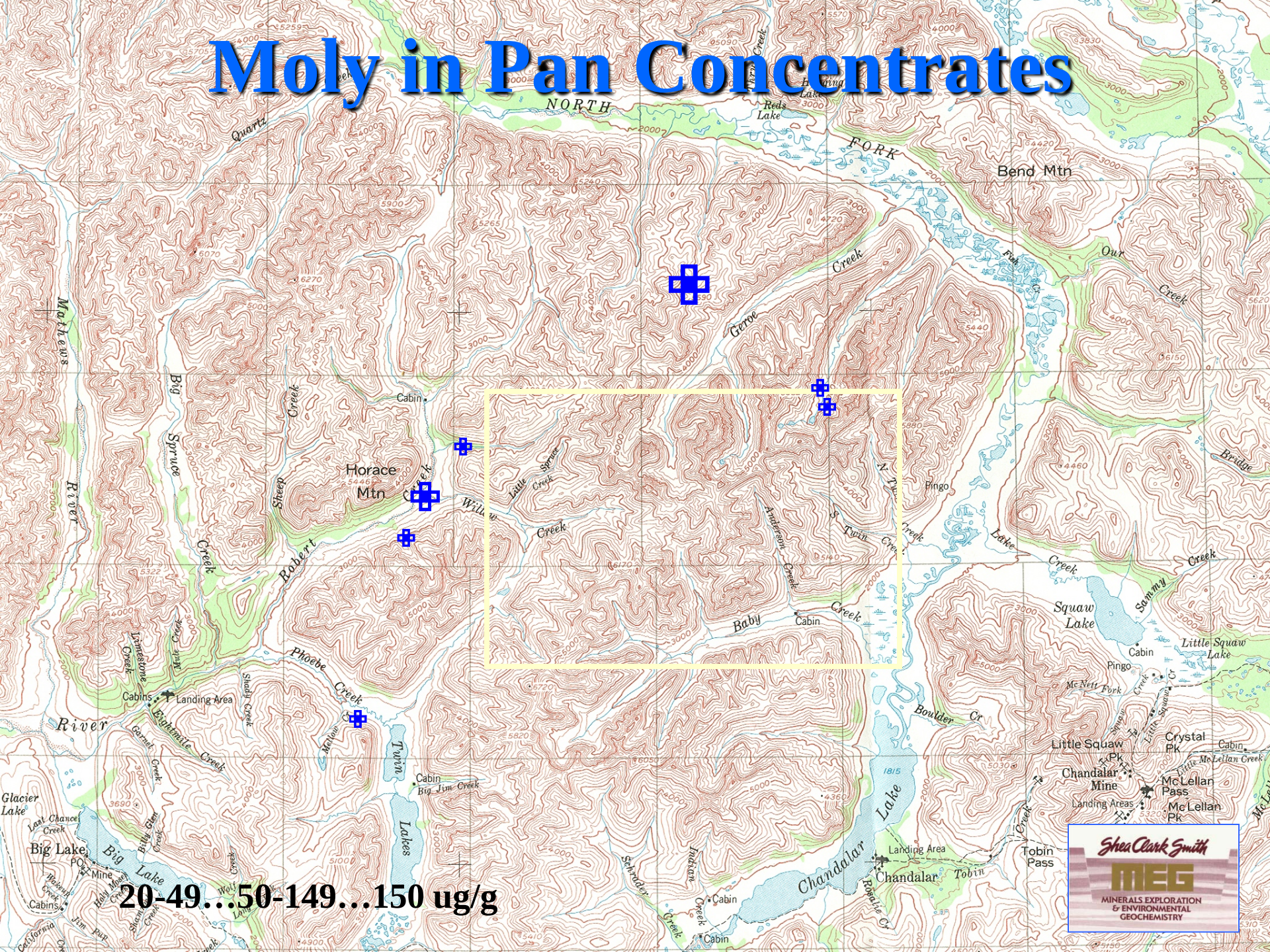
5-6…7-9 ug/g

Copper in Pan Concentrates

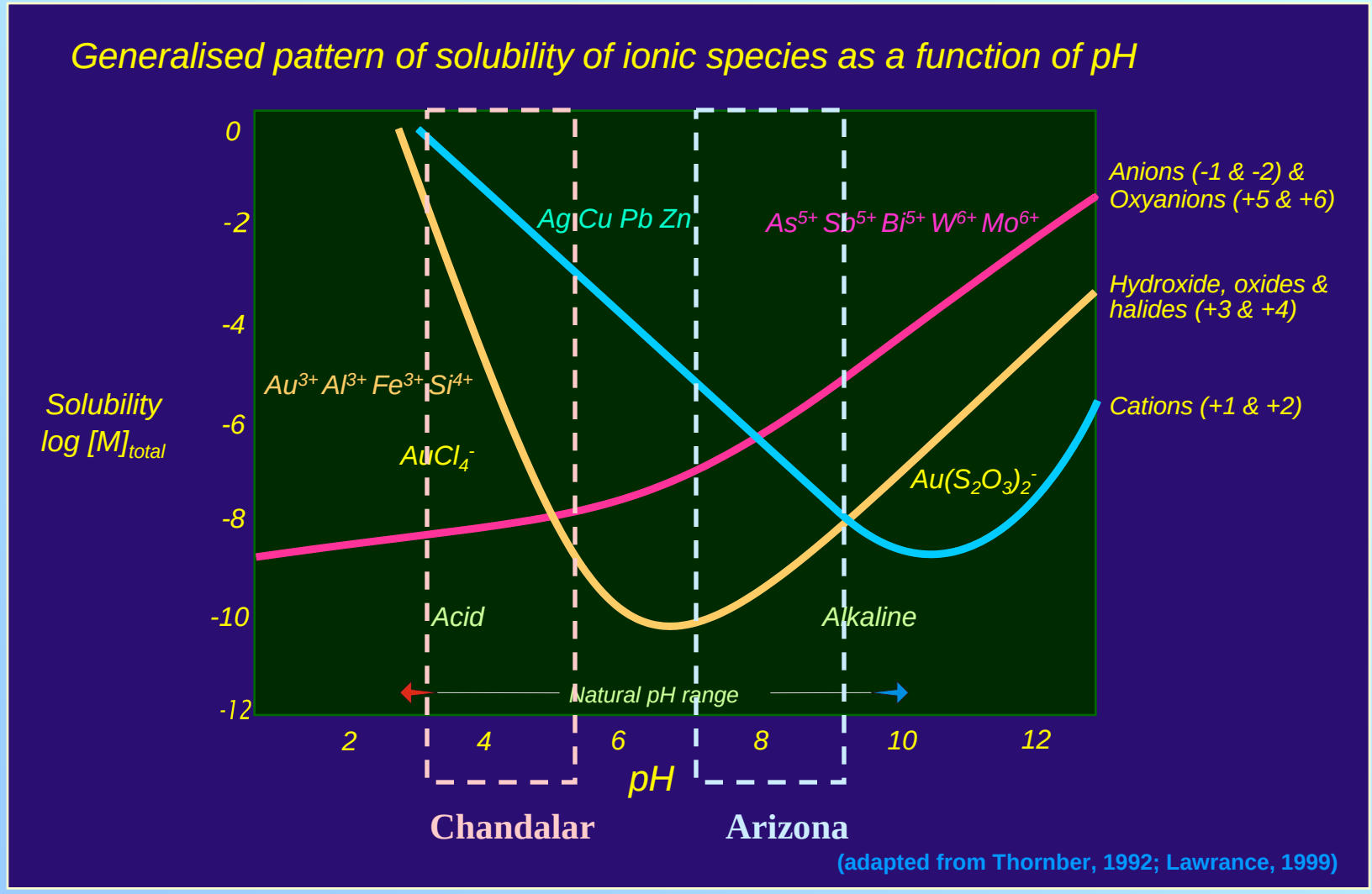


15-69…70-299…300-999…1000 ug/g

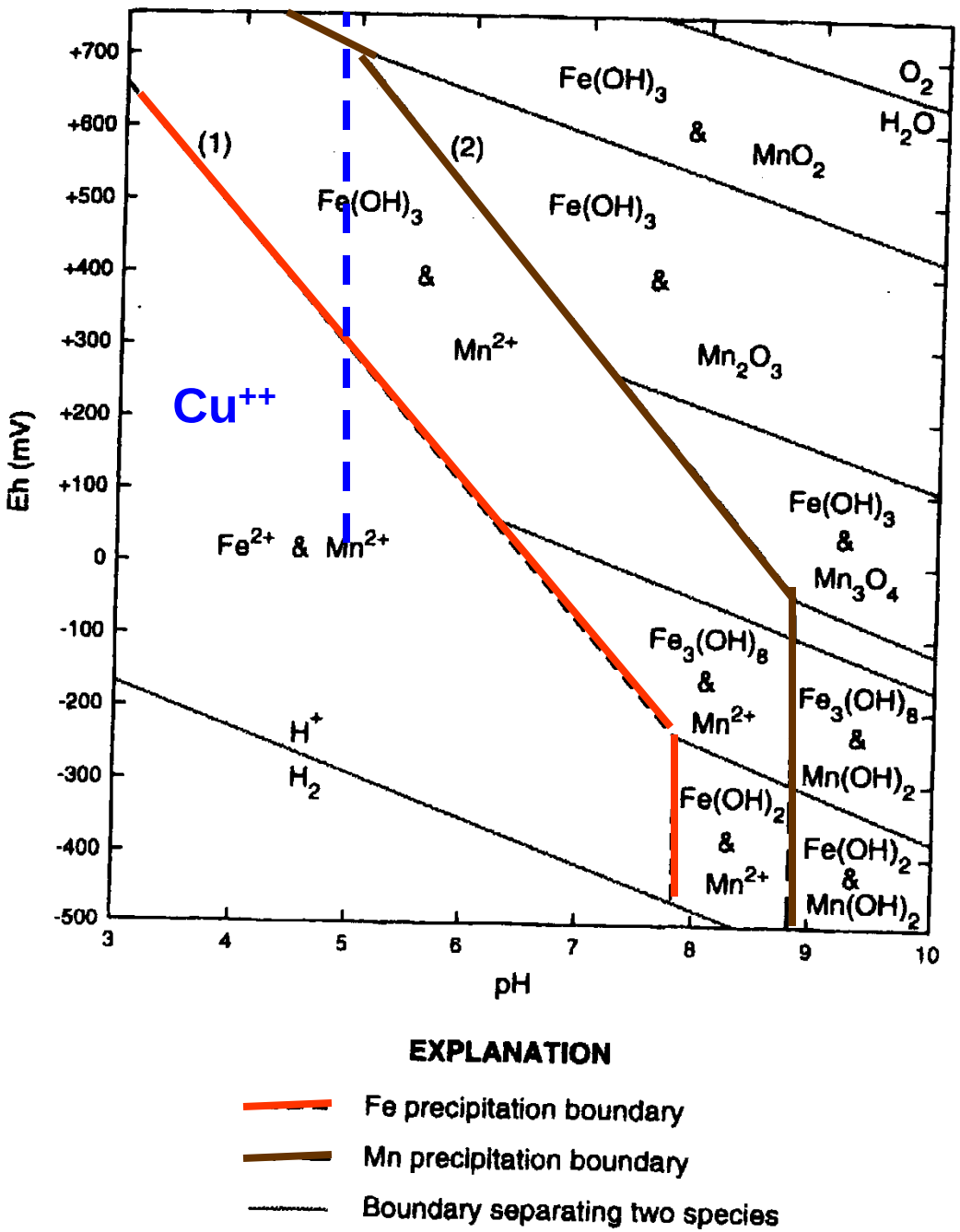
Moly in Pan Concentrates



Geochemical Processes in Weathered Profiles

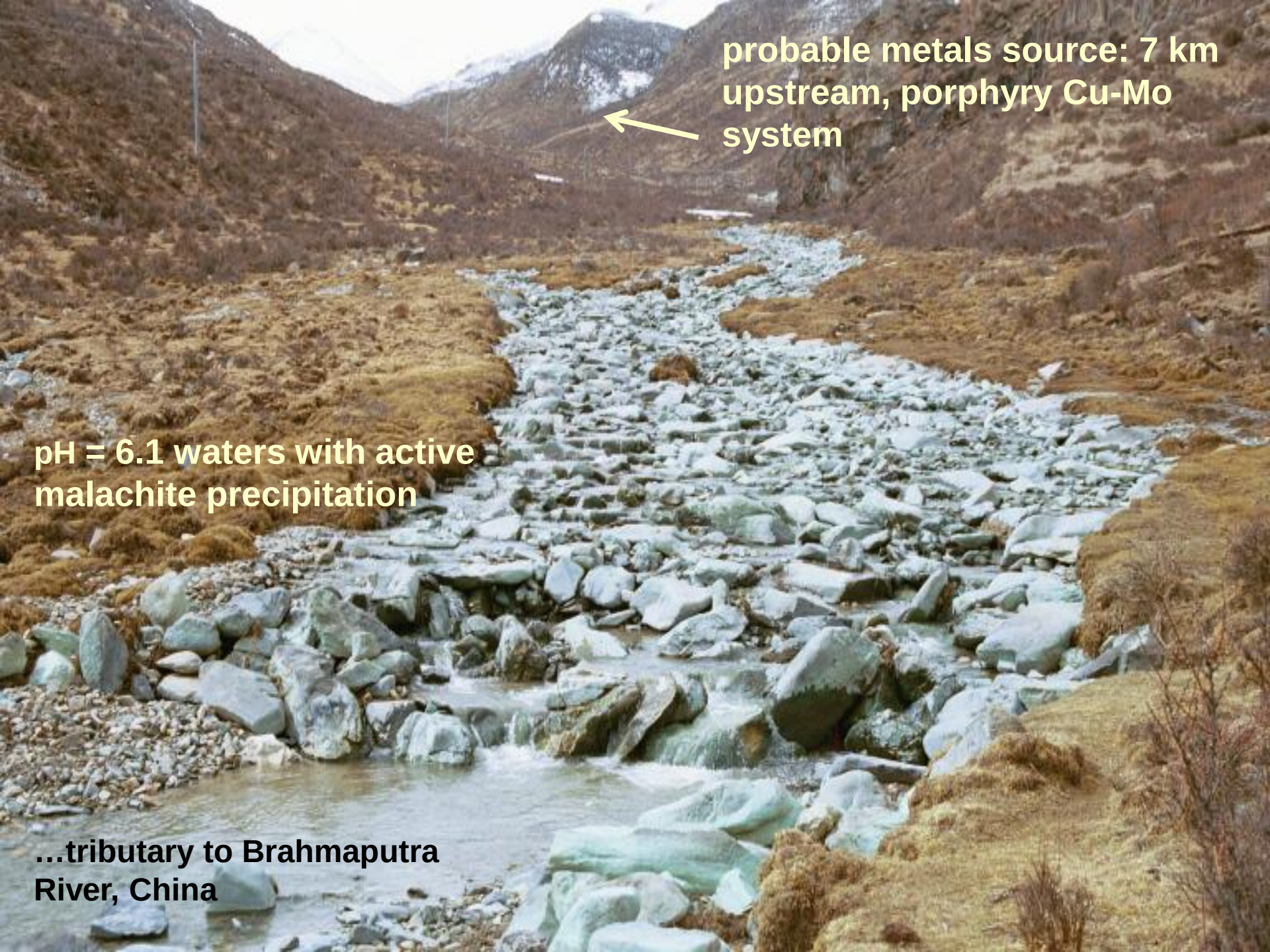


(adapted from Thornber, 1992; Lawrance, 1999)

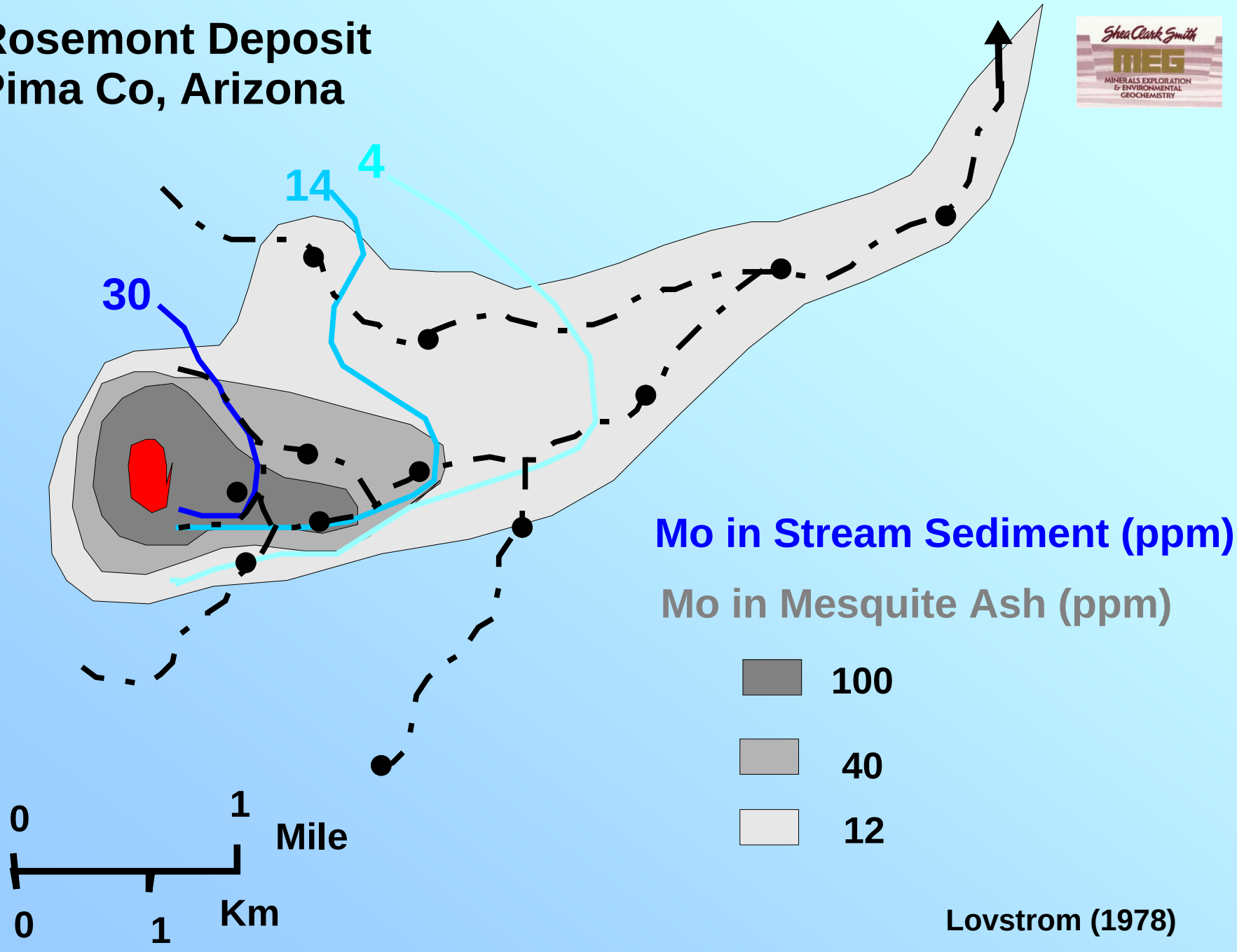


…beyond pH ~ 5, Cu^{++} mobility is substantially limited by hydrolysis reactions…unless an appropriate oxyanion is available to enhance cupric ion solubility…


The geochemistry of weathering:
♦green = Fe^{++},
♦yellow and orange = Fe^{+++},
♦blue = sulfates of Cu^{++}, Al^{+++}
♦white crusts = Ca, Zn, Al
Mineral Park, Arizona

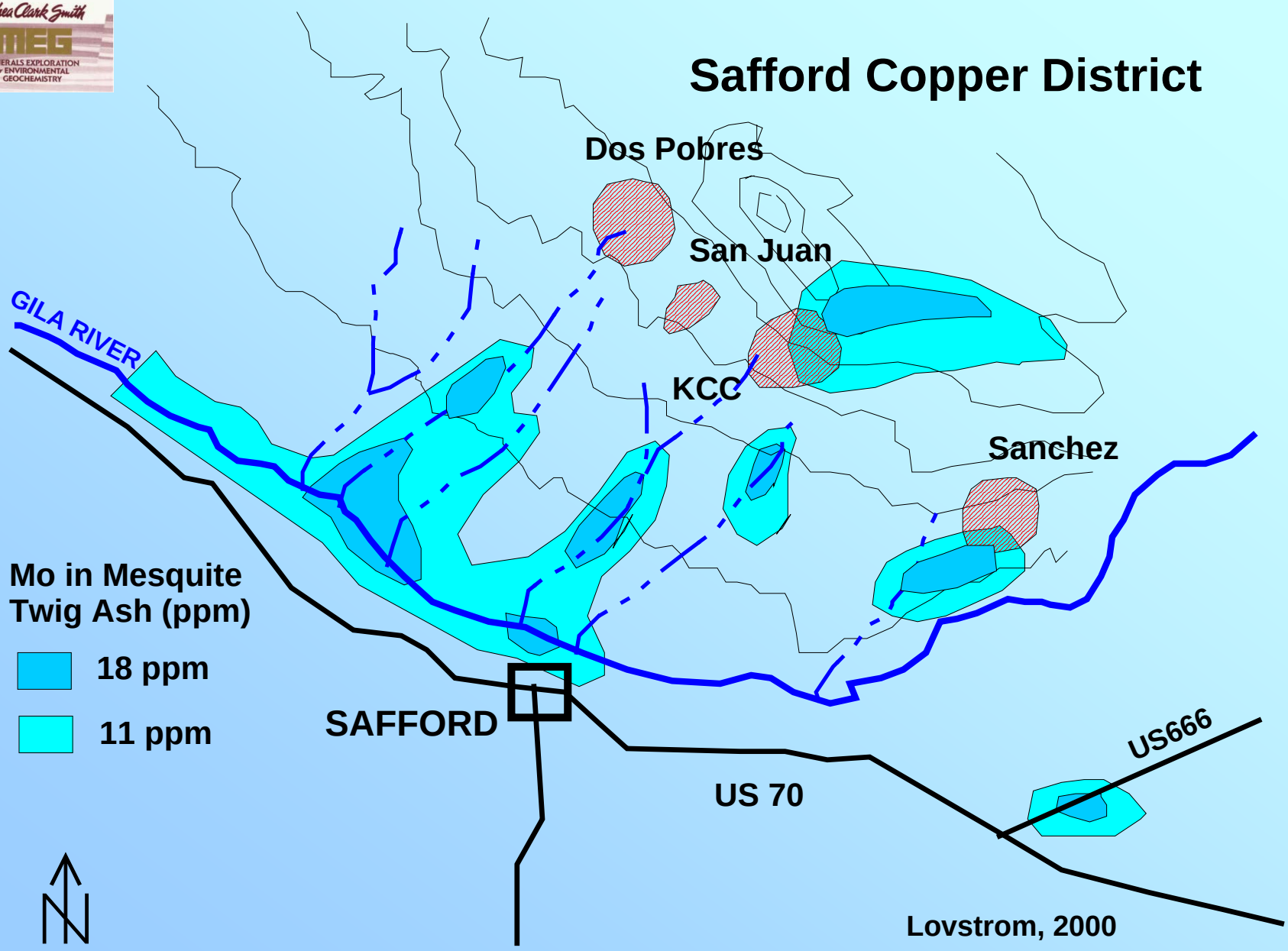

probable metals source: 7 km upstream, porphyry Cu-Mo system
pH = 6.1 waters with active malachite precipitation
…tributary to Brahmaputra River, China

Rosemont Deposit
Pima Co, Arizona



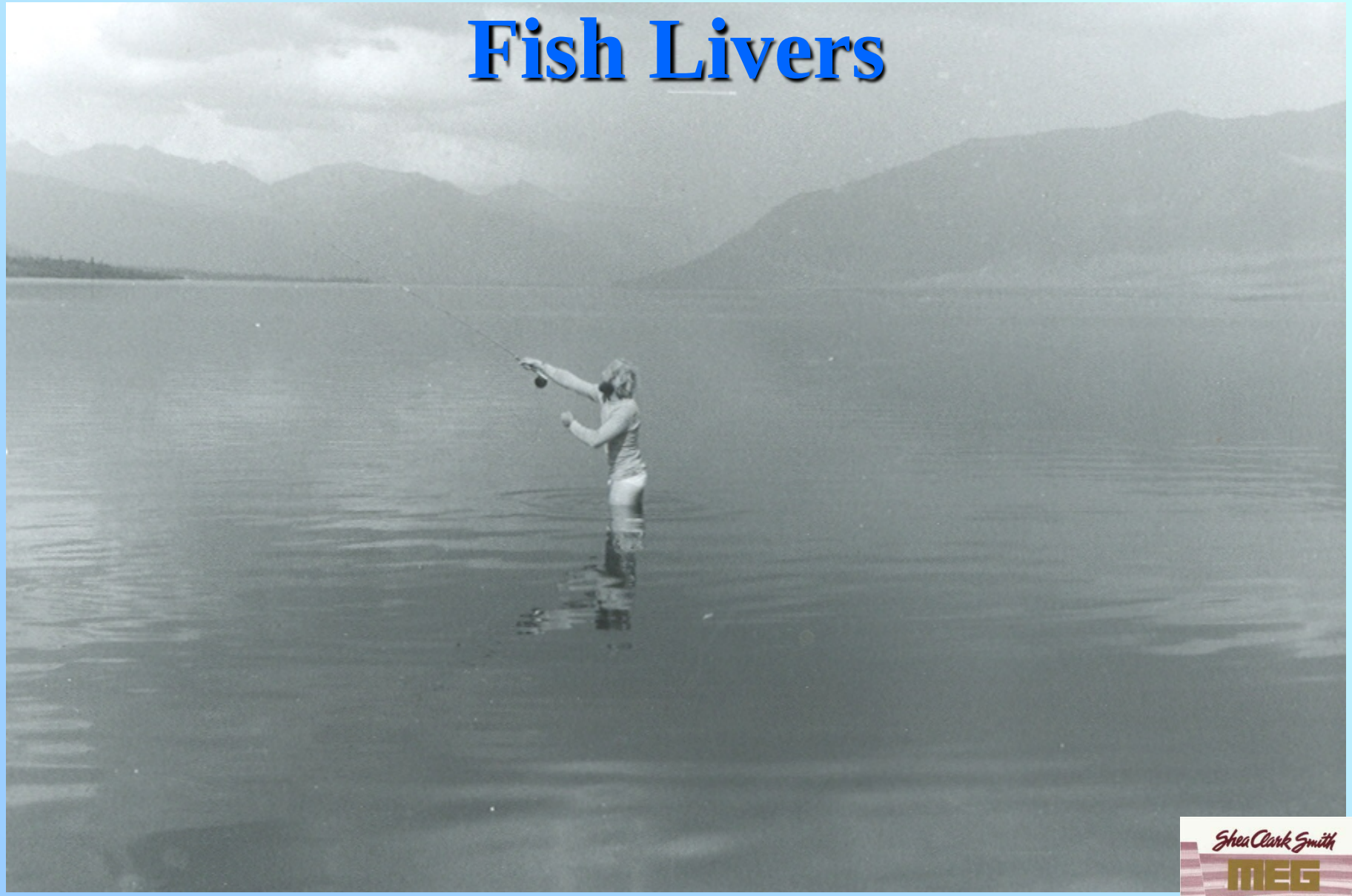
Lovstrom (1978)

Safford Copper District



Lovstrom, 2000

Fish Livers



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CONCLUSIONS

METAL ACCUMULATION IN MOSS

- Plant-Groundwater Link
- Detrital Filters
- Chemical Filters
- Minimal Species Effects
- High Correlation with Stream Sediment
- Low Correlation with Pan Concentrates
- Hg & Mn = biochemical
- Cu Pb Zn Fe = detrital & co-precipitation

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CONCLUSIONS

SURVEY & SAMPLING

- Stream Confluence
- 500m – 1 Km spacing
- No Special Tools
- Wash & Clean in Stream at Sample Site
- 5 x 8 Cloth Bag
- Drip Dry

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CONCLUSIONS

PREP & ANALYSIS

- Wiley Mill, Pelletize, Ash
- Neutron Activation (INAA), ICP-MS
    - Element Suite
- QA/QC: standards, replicates, blanks, RANDOMIZE

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CONCLUSIONS

INTERPRETATION

- Surface Water Source
  - Basin Boundries
- Ground Water Source
  - Structural Geology
- pH-Eh Constraints
- Ion Mobility
- Detrital Mobility
- Metal Zonation
  - Primary
  - Secondary

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