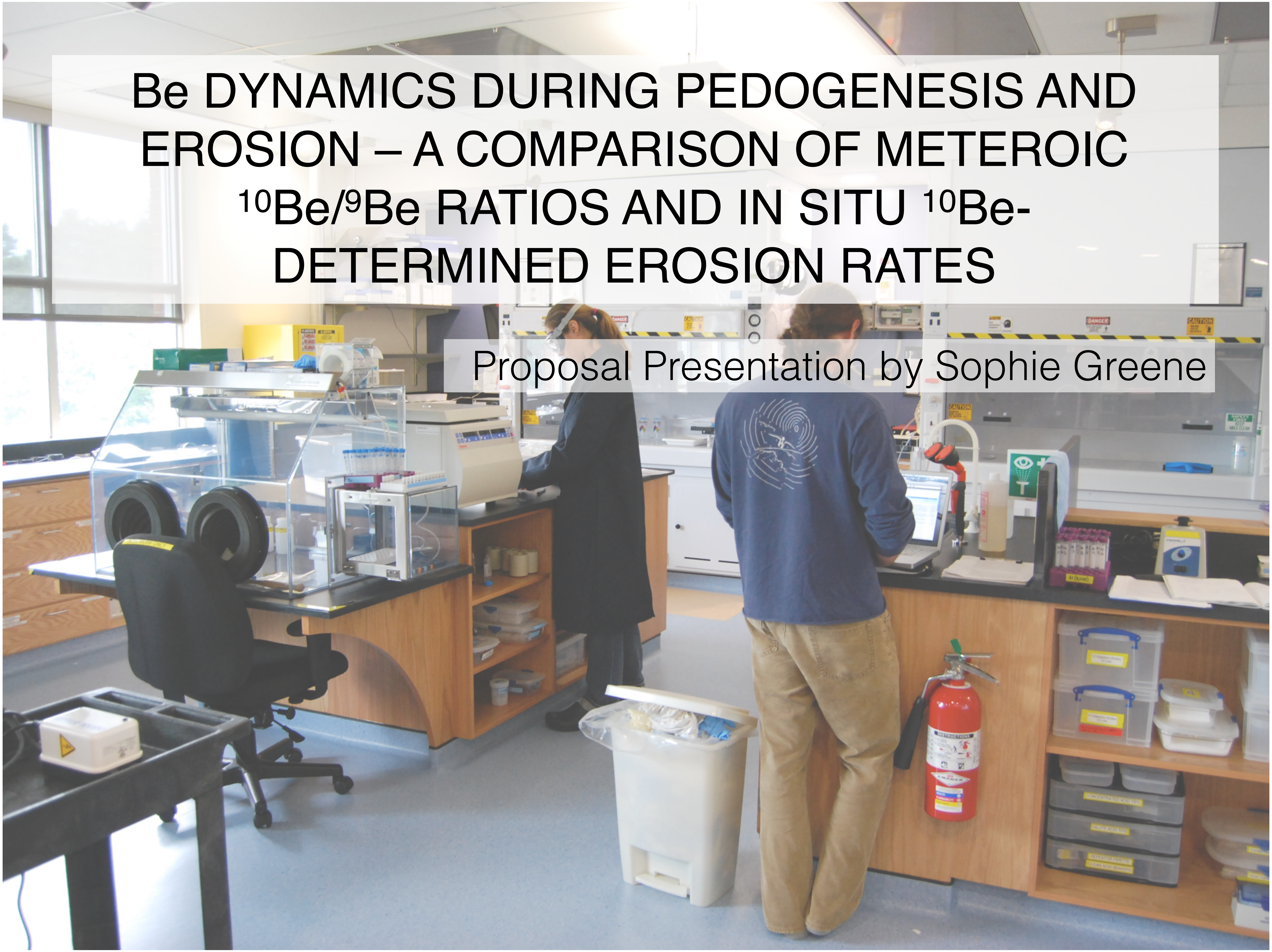
Be DYNAMICS DURING PEDOGENESIS AND EROSION – A COMPARISON OF METEROIC $^{10}Be/^{9}Be$ RATIOS AND IN SITU ^{10}Be-DETERMINED EROSION RATES

Proposal Presentation by Sophie Greene



In a nutshell…

	"meteoric-10" $^{10}Be_{met}$	"9" ^{9}Be	"in situ -10" $^{10}Be_{is}$	"meteoric:9 ratio" $\frac{^{10}Be_{met}}{^{9}Be}$
Ease of measurement				(Hopefully) 
Ease of interpretation		X		(Hopefully) 

Types of questions Be isotope data could address:

- Do tropical environments erode faster than arid environments? By how much?

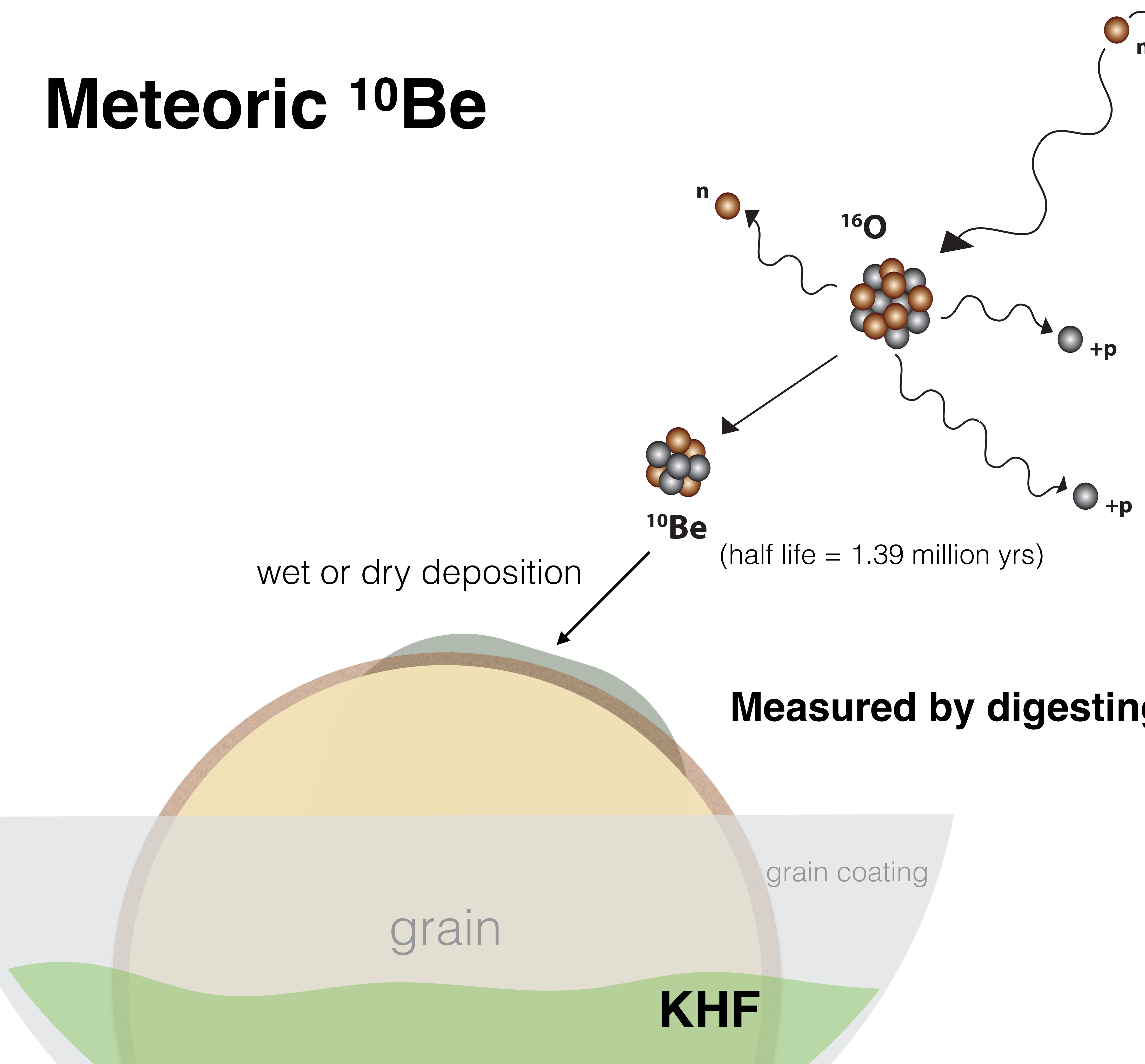
- How are trace metals transported during soil formation?

- How long does it take for soils to redevelop after a historic glaciation?

Outline

- Meteoric ^{10}Be
    - formation, measurement, erosion rate proxy?
- In situ ^{10}Be
    - formation, measurement, erosion rate proxy?
- ^{9}Be
    - distribution, measurement, tool for improving meteoric interpretations?
- Overview of initial sample sets
- Project logistics

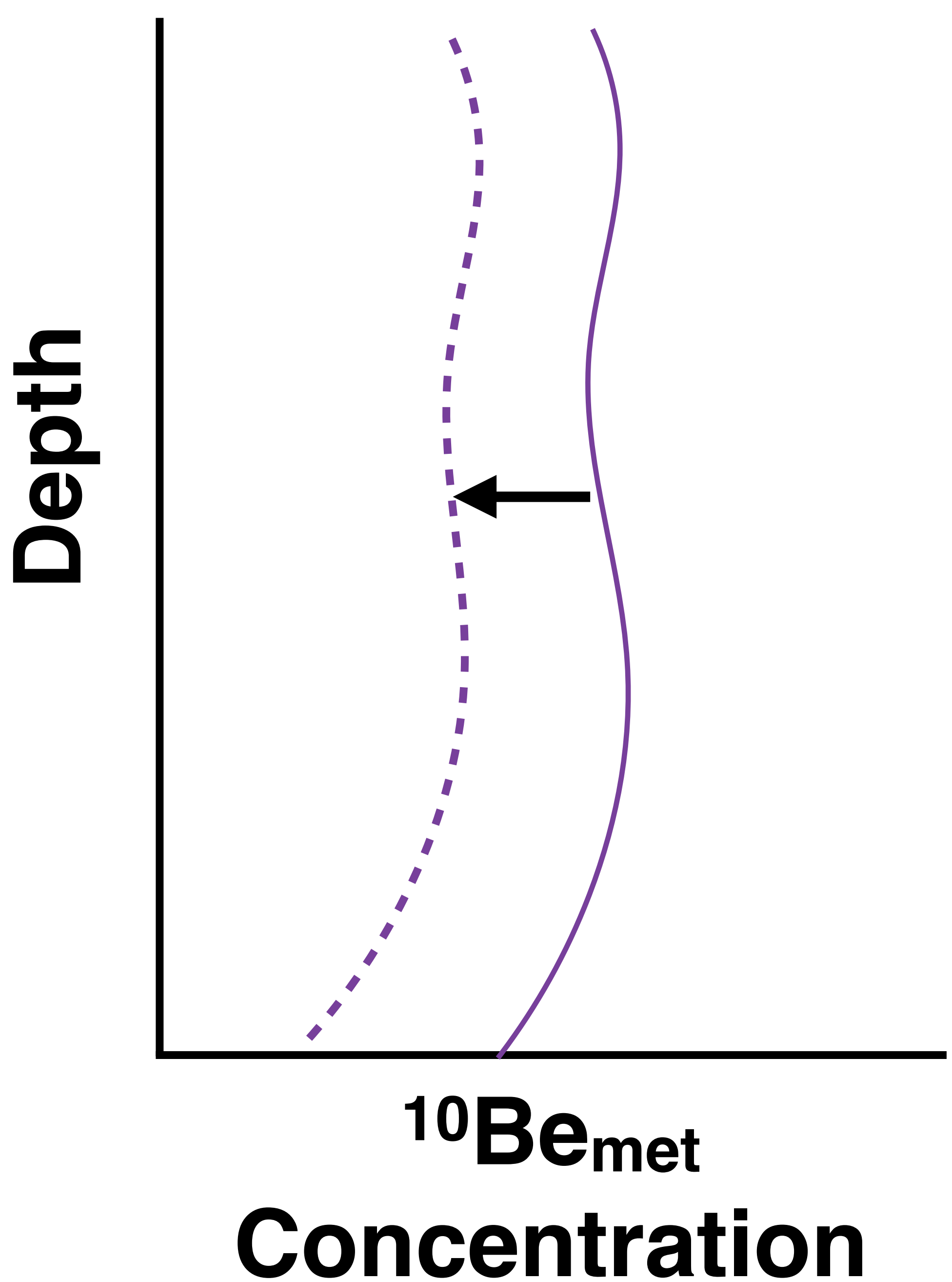
Meteoric ^{10}Be



Measured by digesting total grain

A perfect world: soil profiles of $^{10}Be_{met}$

Known meteoric ^{10}Be Flux



well mixed soil

Erosion rate


soil


fluvial sands


lake sediments

Measured Meteoric ^{10}Be in soil profiles

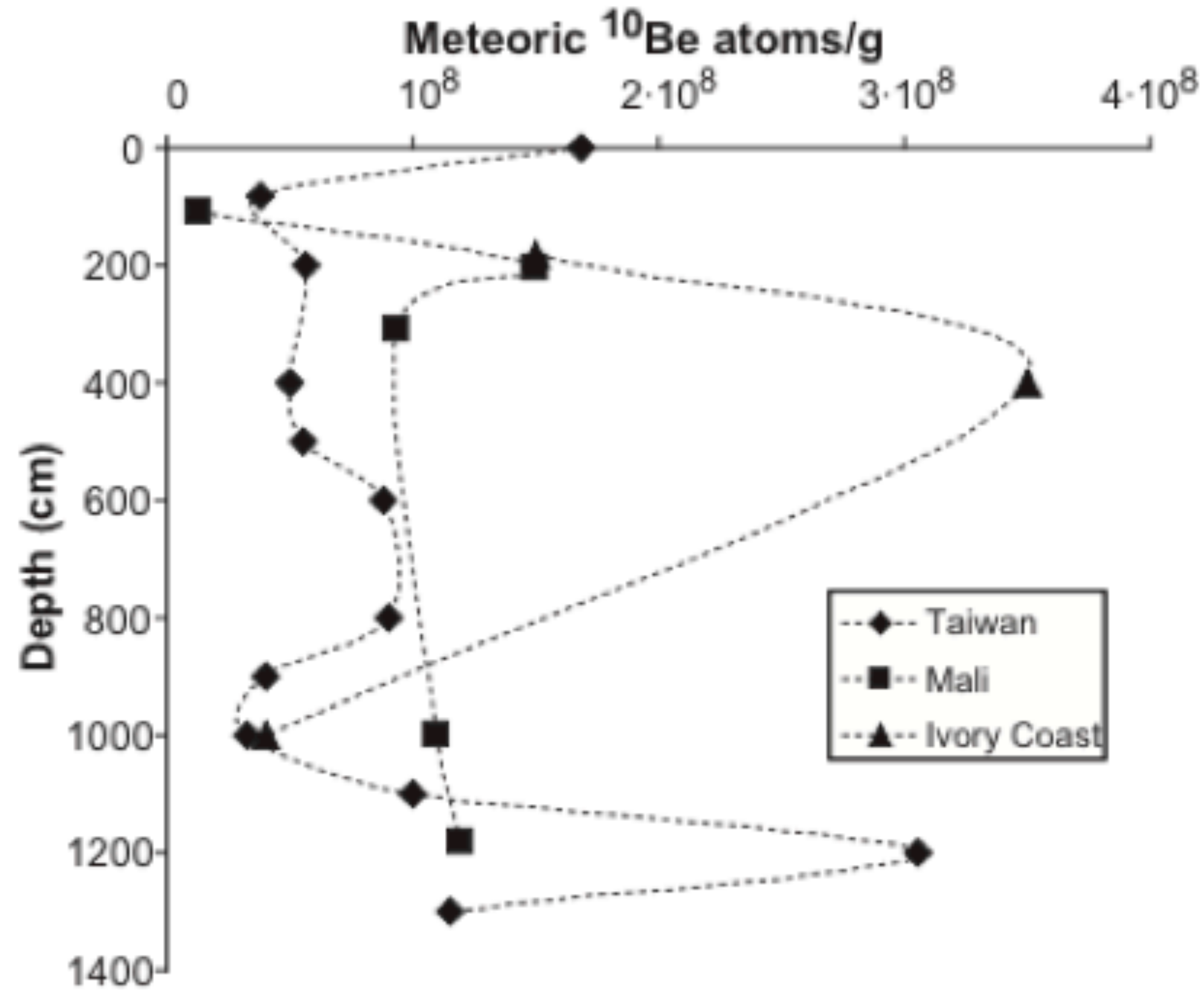
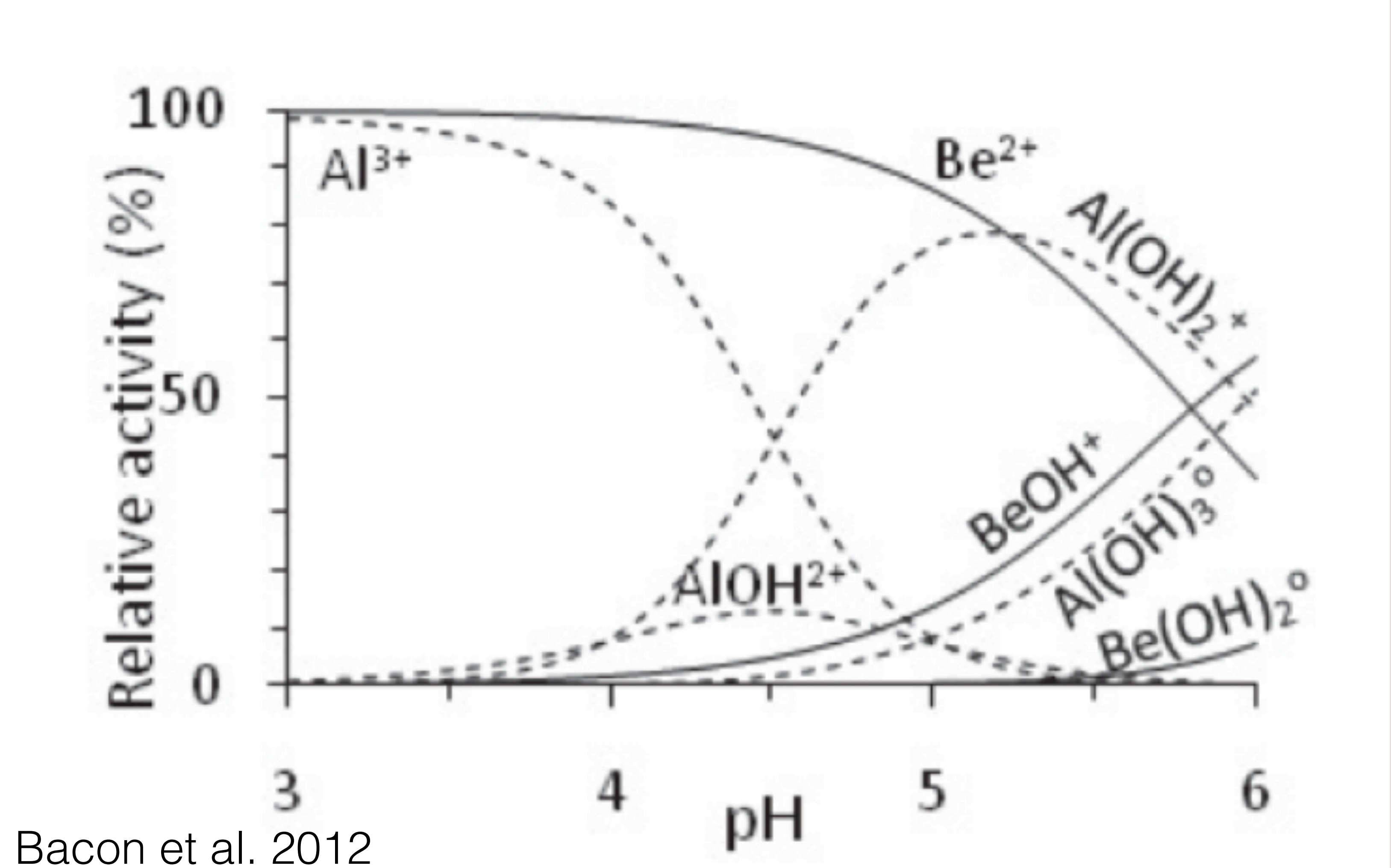


Fig. 9. Tropical and subtropical oxic soils (Barg et al., 1997; You et al., 1989) showing deeper infiltration of meteoric ^{10}Be and different profile shape dynamics than temperate soil profiles. Dashed lines indicate interpolation between point-sampled measurements.

Graly et al. 2010

Remobilization of $^{10}Be_{met}$

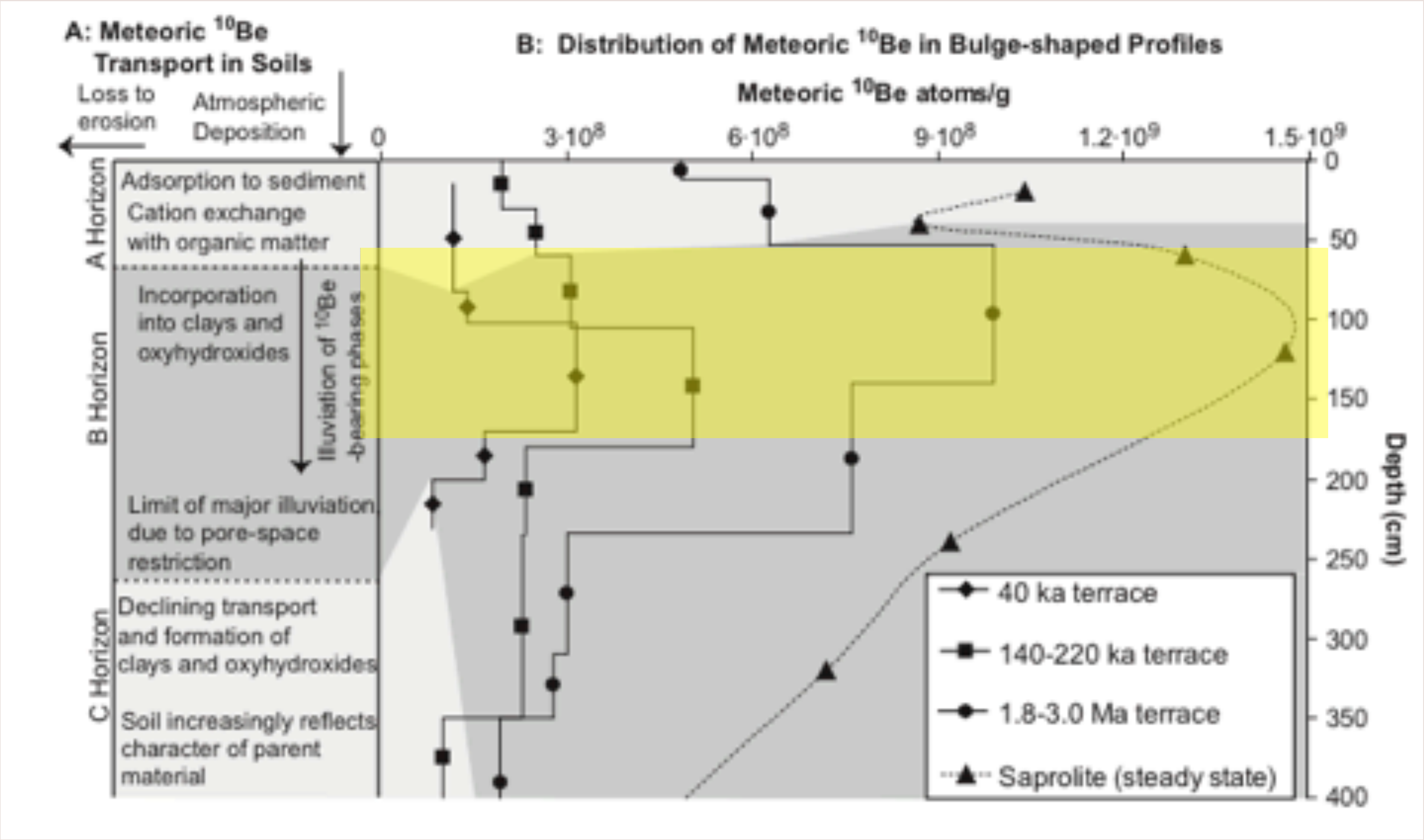
Be^{2+} = soluble in water



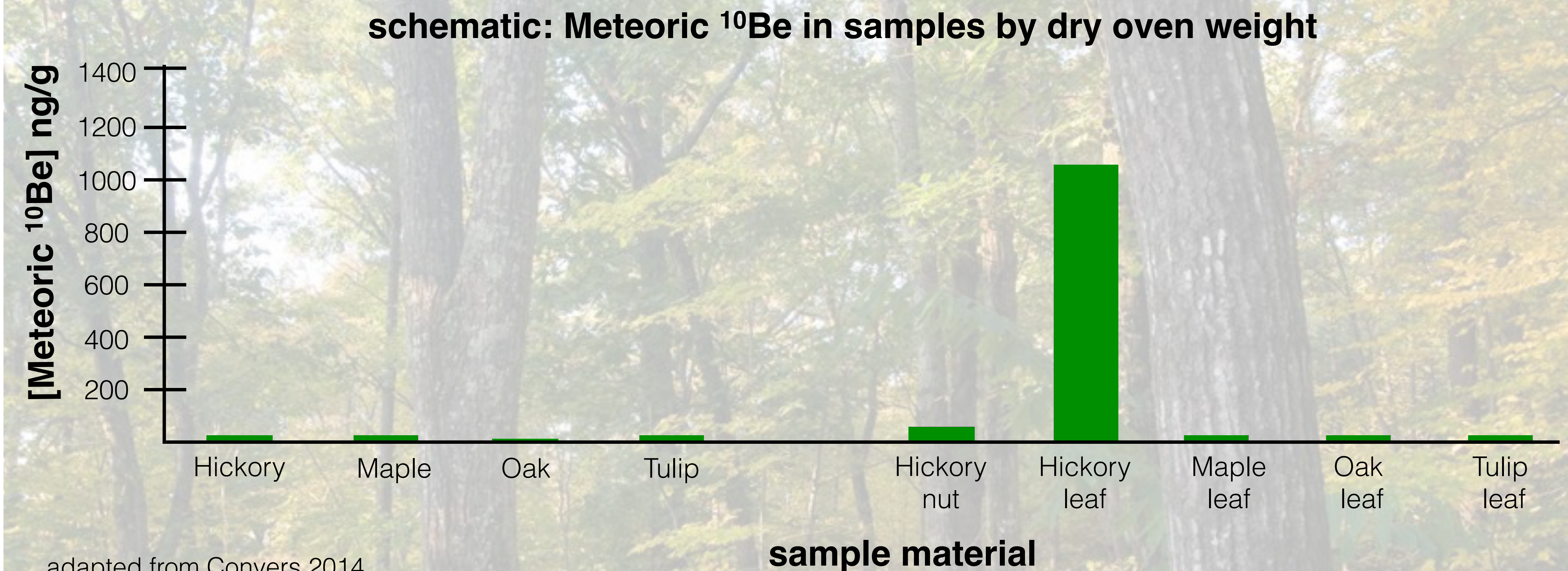
Bacon et al. 2012

Meteoric ^{10}Be concentration is grain size dependent

$^{10}Be_{met}$ concentrations ~ 1 x 10^8 **atoms/gram**



Does meteoric ^{10}Be bioaccumulate?



adapted from Conyers 2014

Several orders of magnitude difference between ^{10}Be in Hickory and surrounding soils

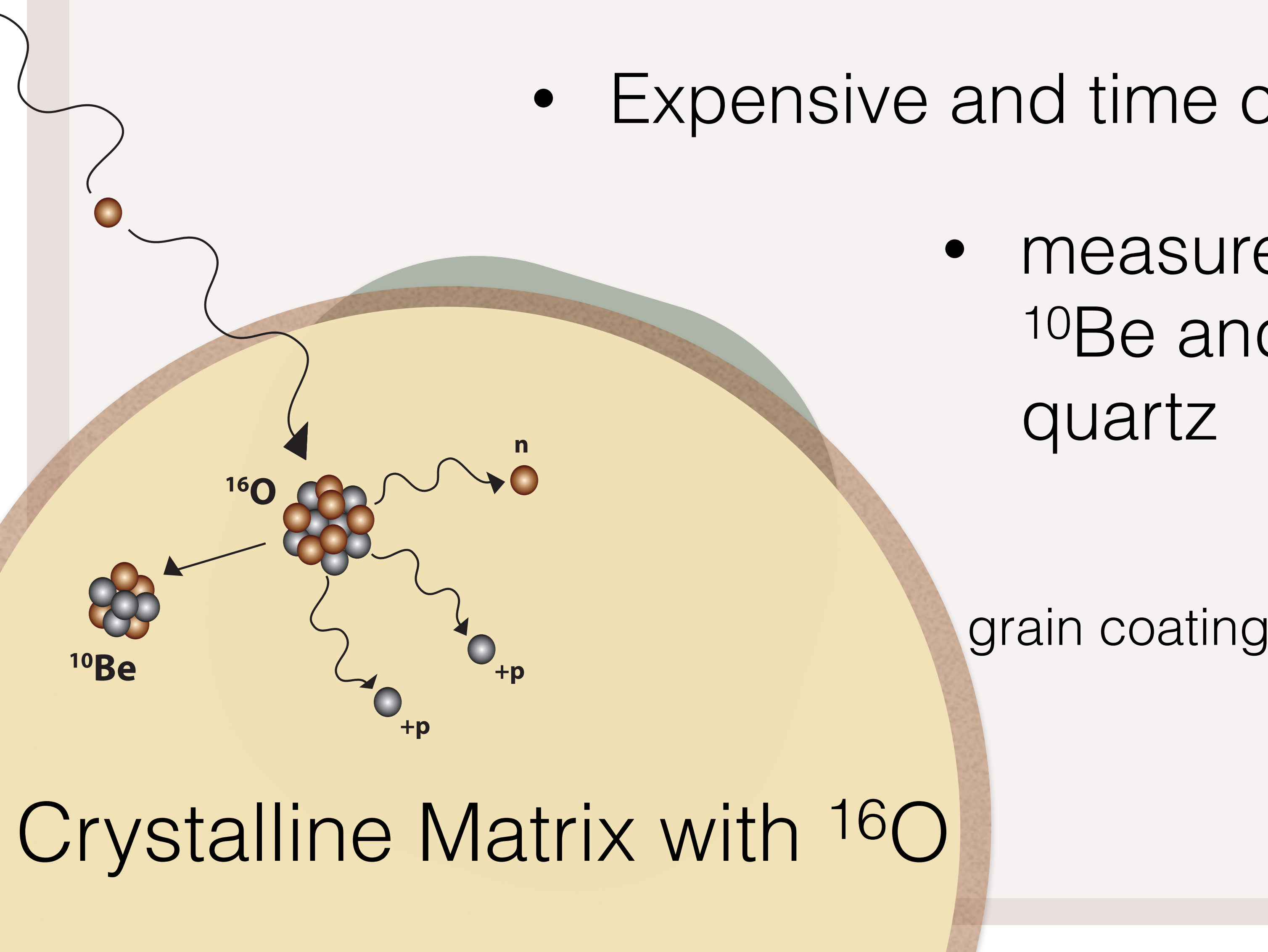
In Summary: Difficulties in $^{10}Be_{met}$ interpretations

- Could be leached from soils in acidic environments
- Has grain size dependent concentrations
- Bioaccumulates in some species

Remobilizes in unpredictable ways

in situ ^{10}Be

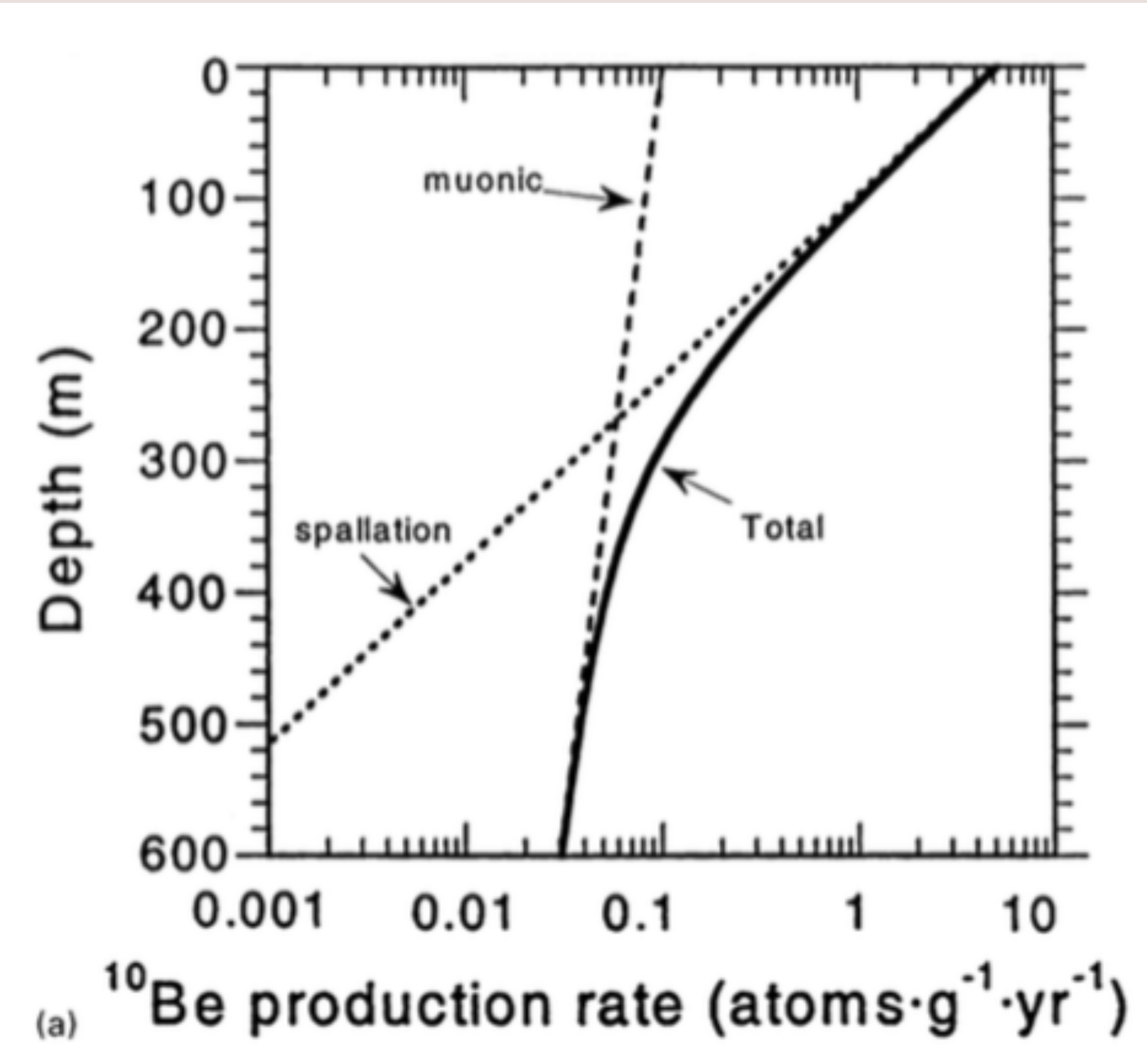
- concentrations many orders of magnitude lower than meteoric ^{10}Be
- Can only measure in sand-sized quartz
- Expensive and time consuming
  - measured by stripping off meteoric ^{10}Be and dissolving the residual quartz



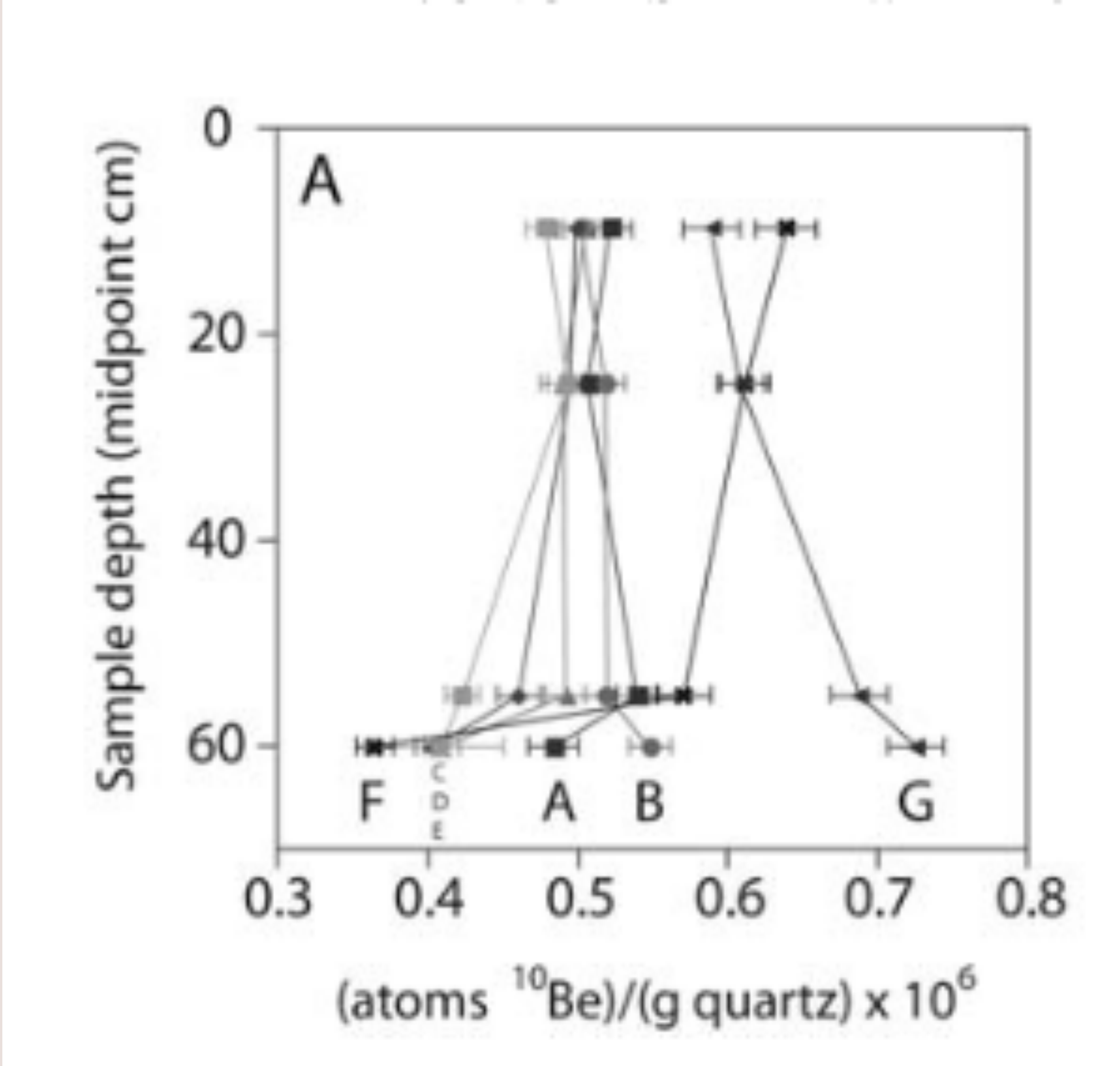
Benefits of in situ ^{10}Be

Known production rates with depth

No remobilization

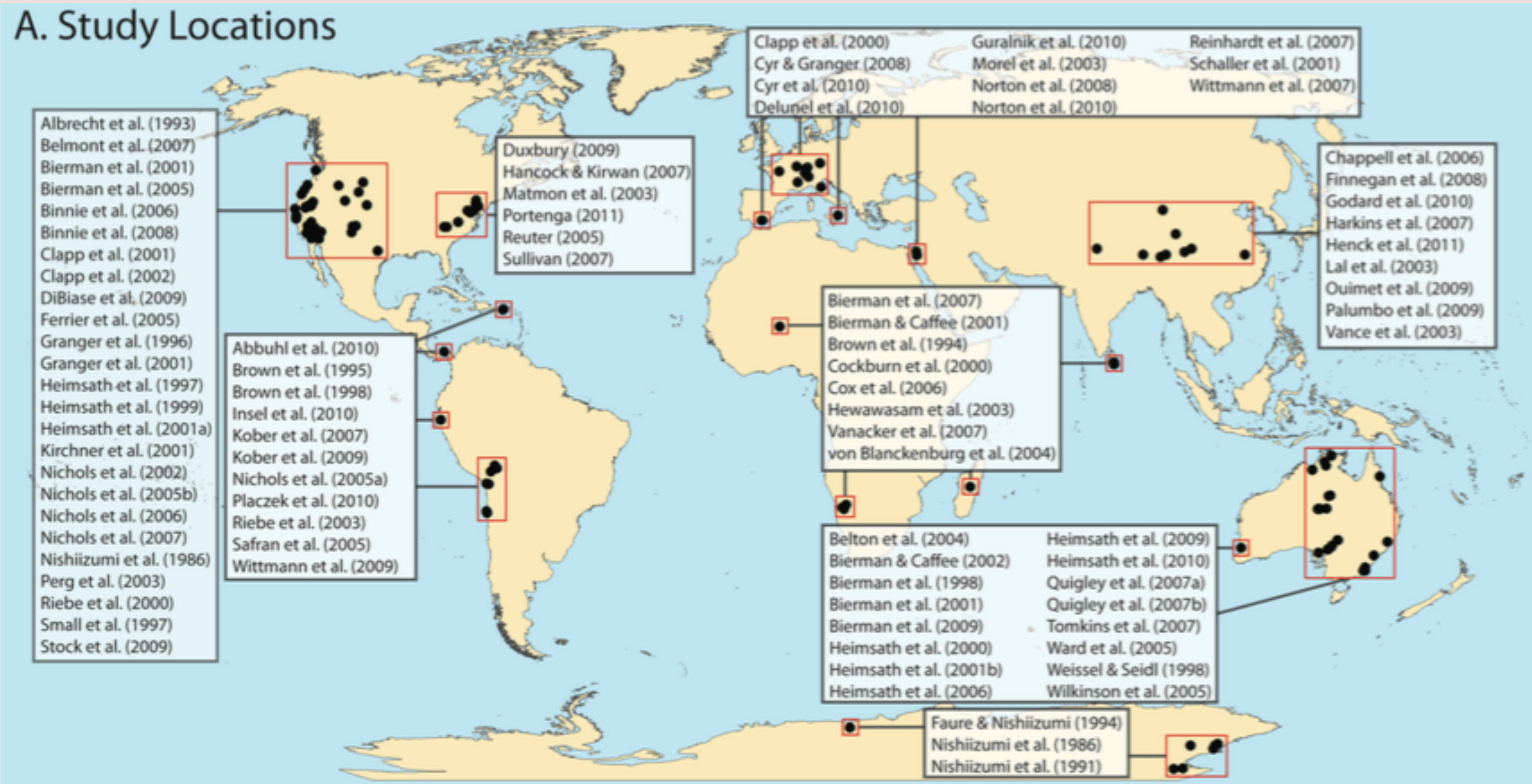


Gosse and Phillips 2011



Jungers et al. 2009

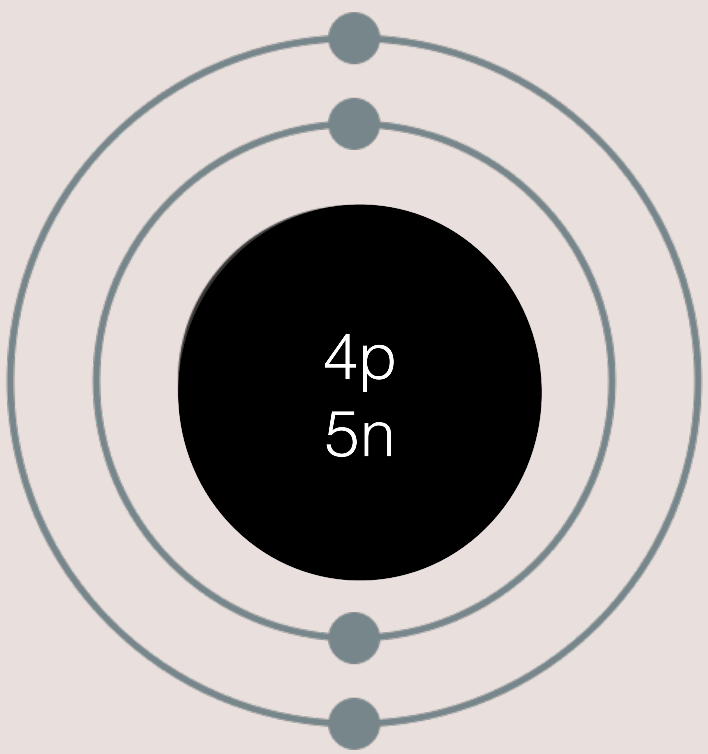
Sites around the world with known in situ-derived erosion rates



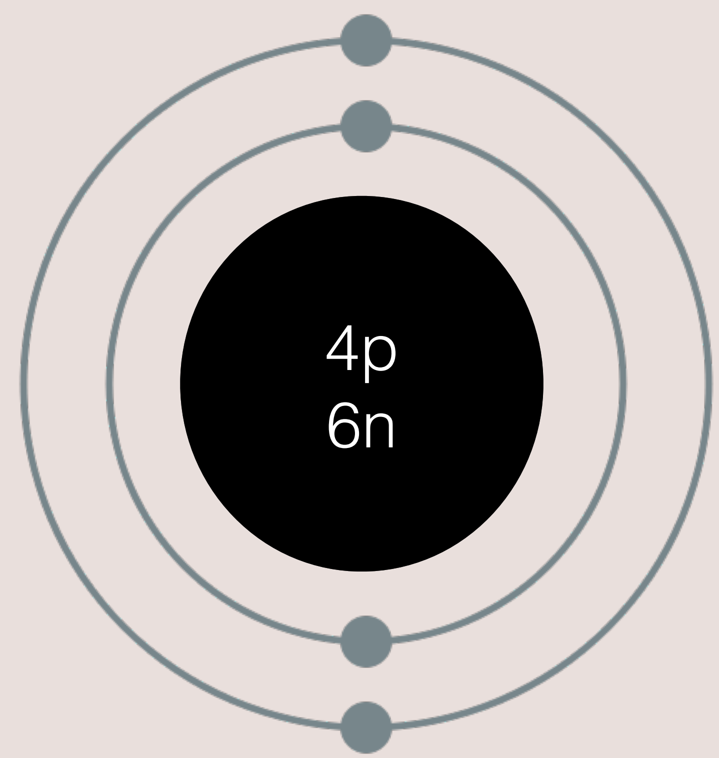
Portega and Bierman 2011

The best of both worlds?

- Measuring meteoric ^{10}Be, but normalizing for grain size and remobilization
- What has a similar reactivity as meteoric ^{10}Be that is also present in surficial materials?



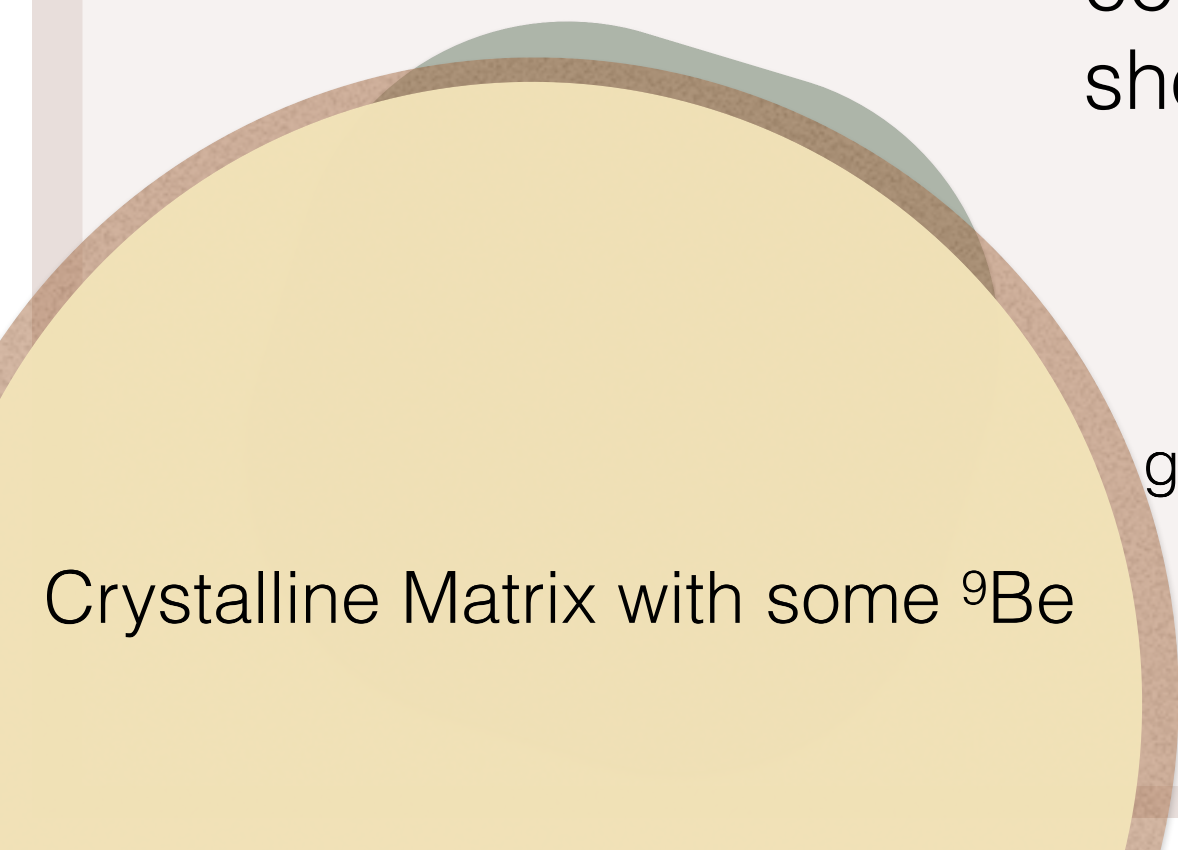
^{9}Be



^{10}Be

^{9}Be

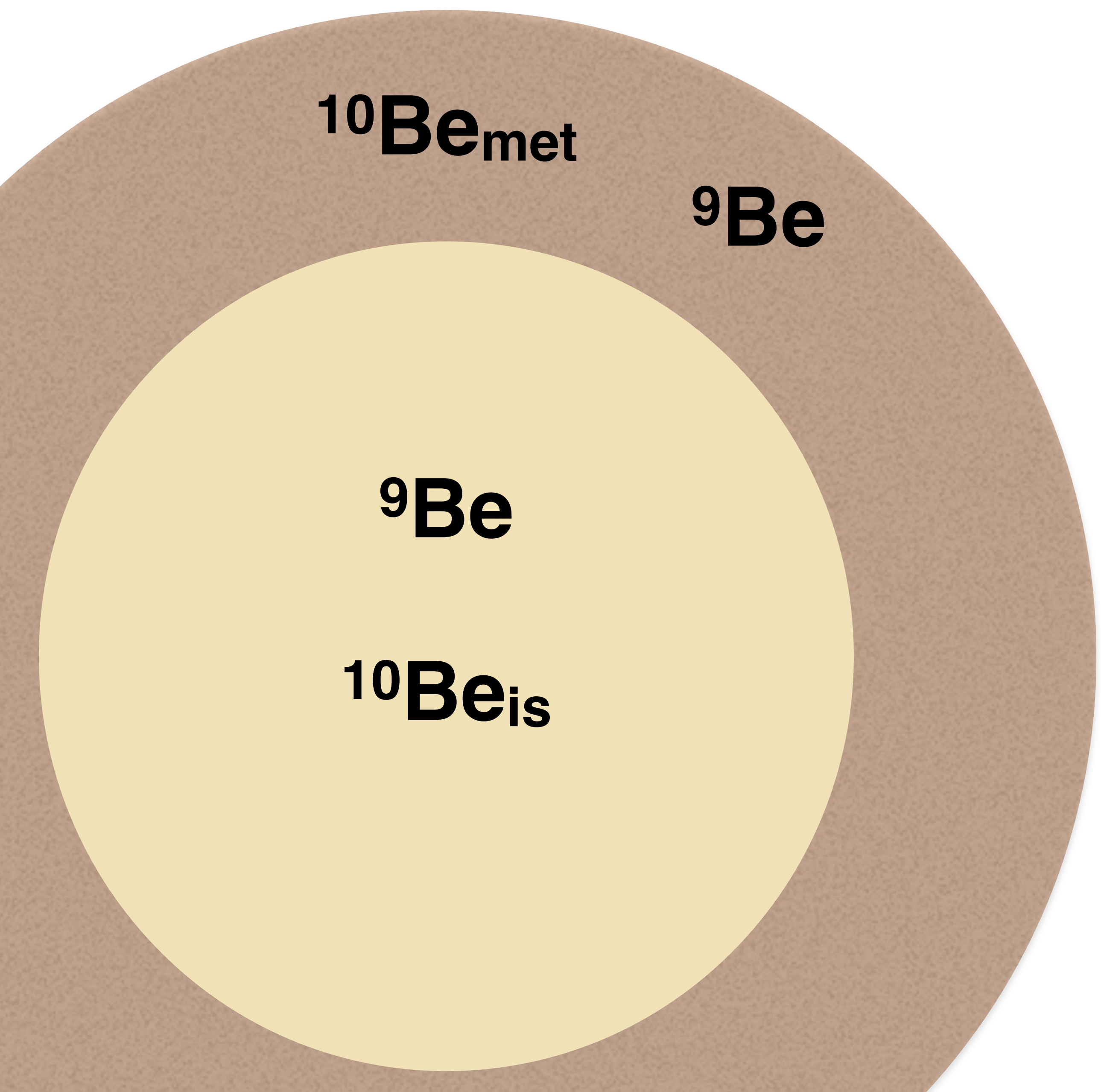
- Weathers out of bedrock
- Not limited to sand-sized quartz grains
    - ^{9}Be present in grains and grain coatings, but only the grain coating should relate to meteoric ^{10}Be

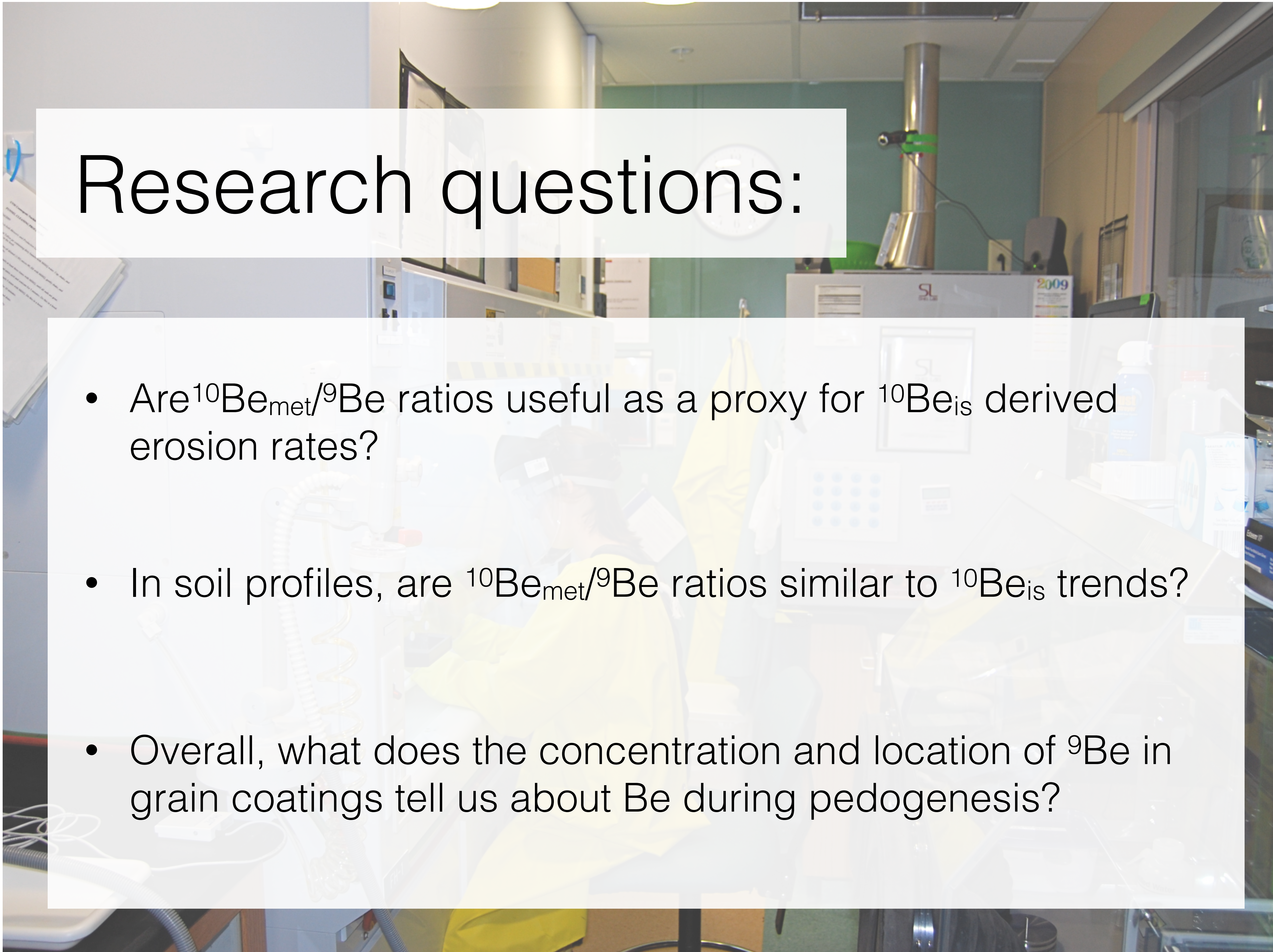


grain coating with “mobile” ^{9}Be

In Review:

$$\frac{^{10}Be_{met}}{^{9}Be} \propto {}^{10}Be_{is}$$





Research questions:

- Are $^{10}Be_{met}/^{9}Be$ ratios useful as a proxy for $^{10}Be_{is}$ derived erosion rates?
- In soil profiles, are $^{10}Be_{met}/^{9}Be$ ratios similar to $^{10}Be_{is}$ trends?
- Overall, what does the concentration and location of ^{9}Be in grain coatings tell us about Be during pedogenesis?

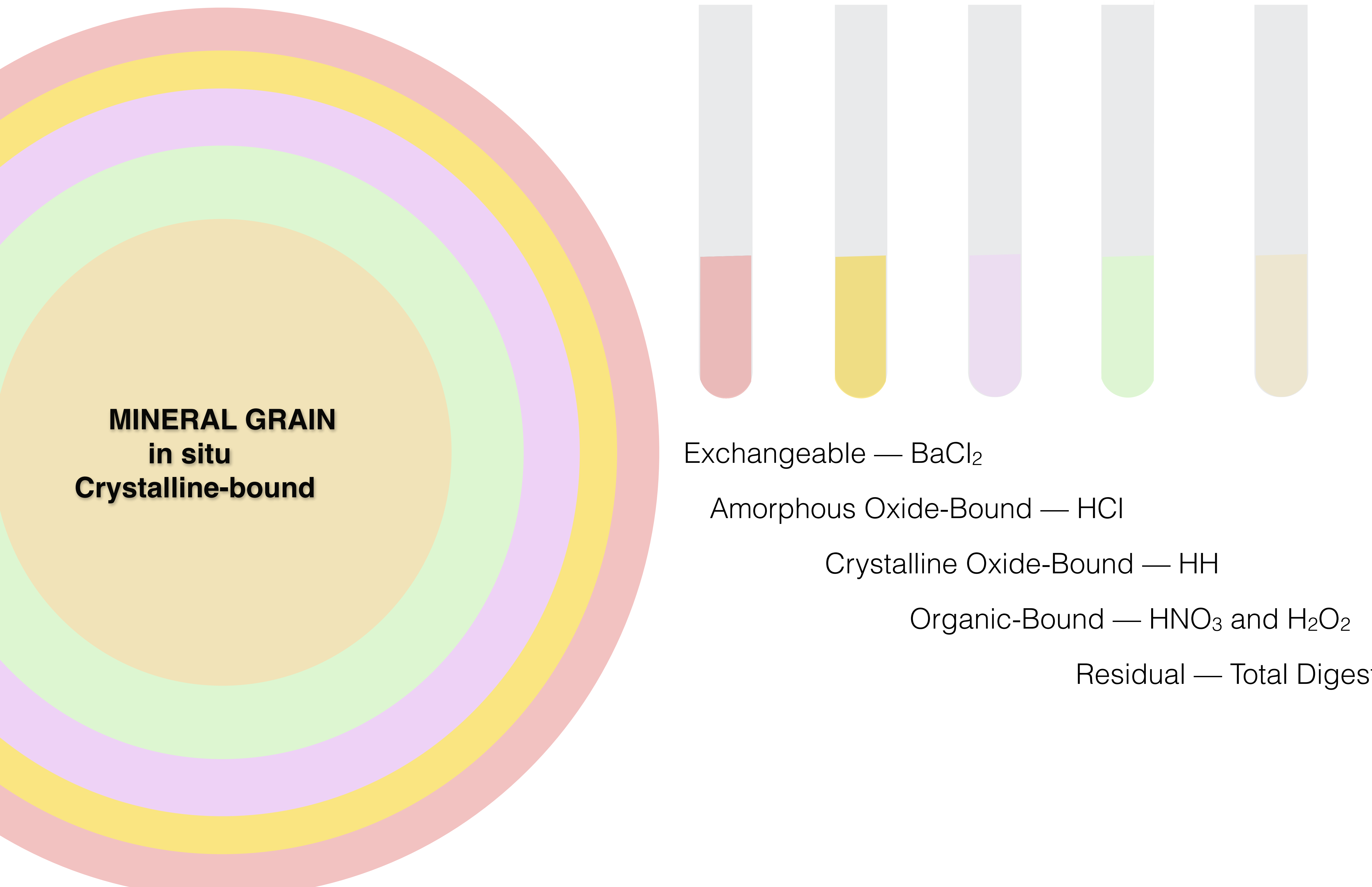
What I have:

- Access to 10 sample sets that have already be analyzed for $^{10}Be_{met}$ and $^{10}Be_{is}$

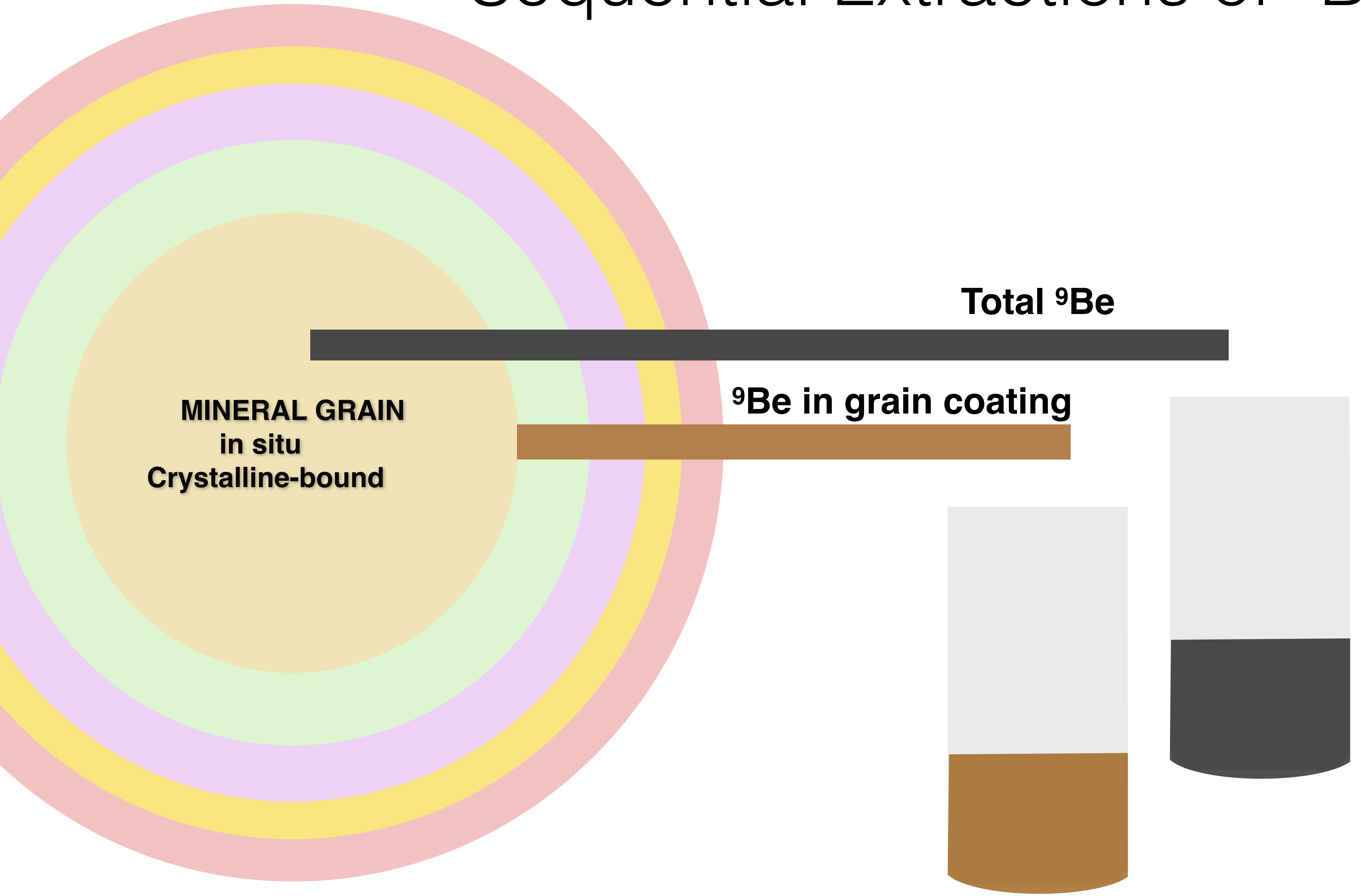
What I have to do:

- Extract ^{9}Be from those samples both by stripping the entire grain coating and extracting from the grain sequentially.
- Compare $^{10}Be_{met}/^{9}Be$ ratios to existing erosion rate data to determine if correlations exist.
- Use ^{9}Be sequential extraction results to determine if the nature of the Be-grain association corresponds to Be mobility.

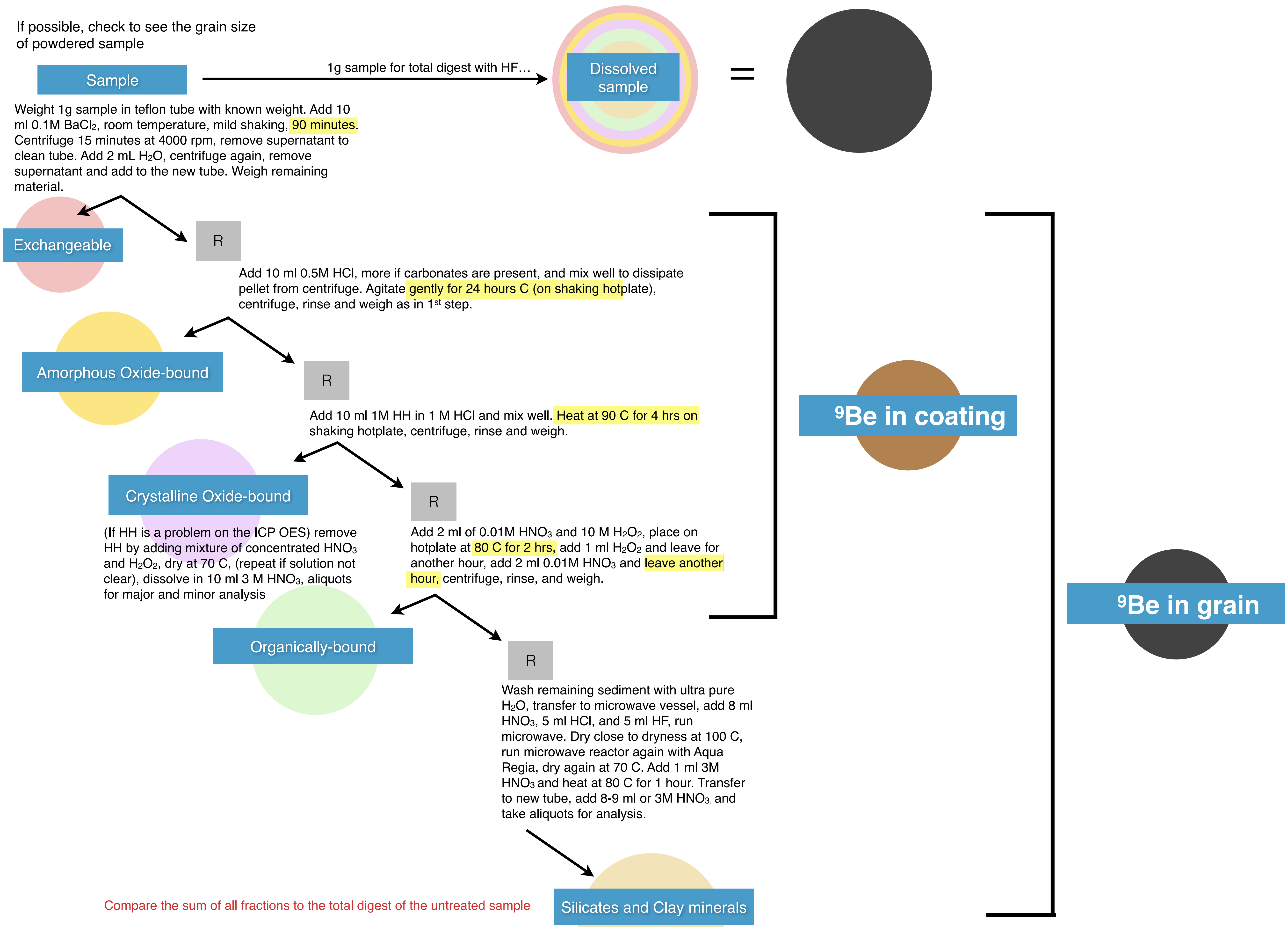
Sequential Extractions of ^{9}Be



Sequential Extractions of ^{9}Be



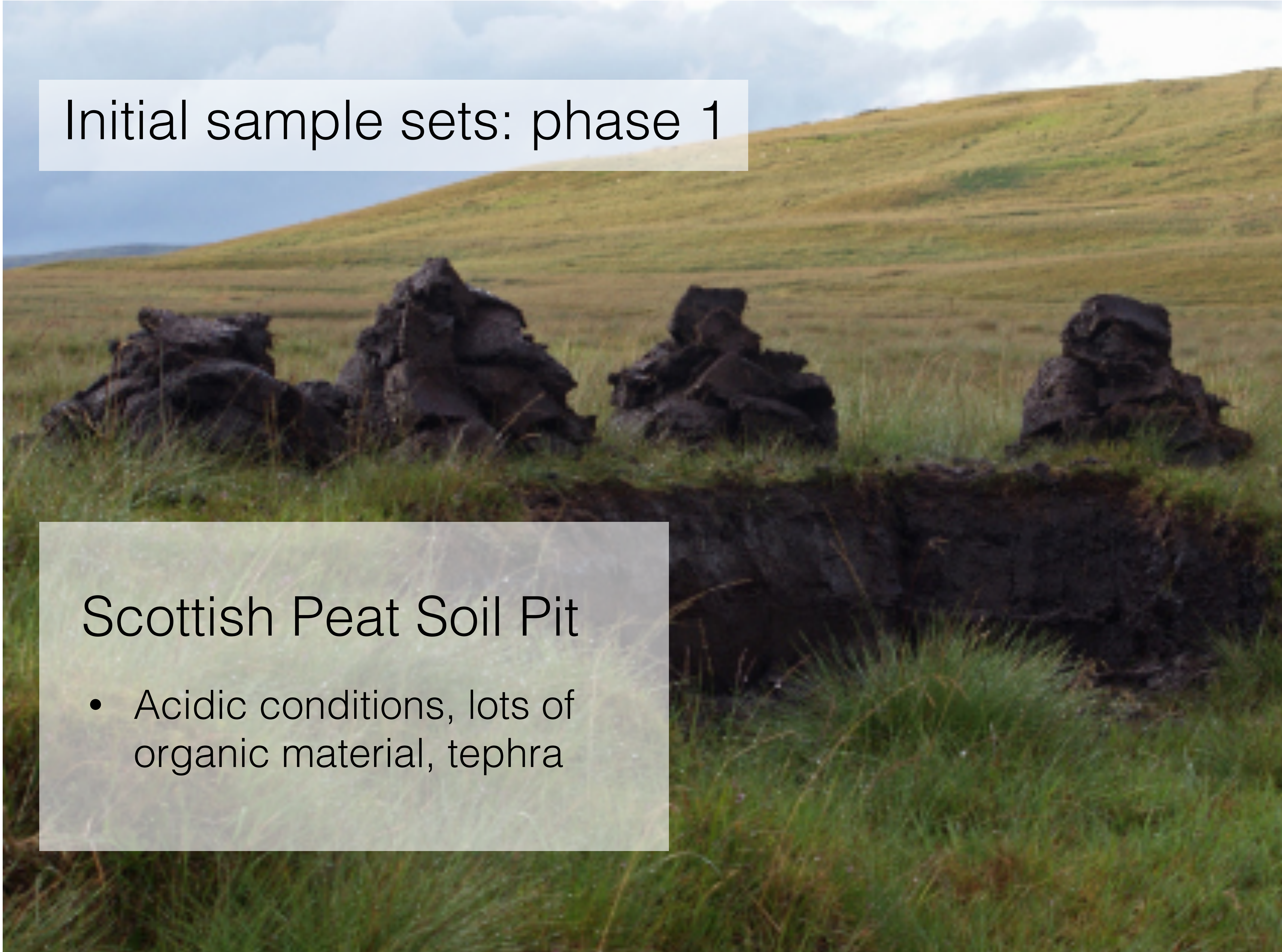
Sequential Extractions Method (modified from Wittmann et al. 2012)



Measuring concentrations on the ICP-OES

- Installing the ultrasonic nebulizer to decrease detection limits

- Monitor Si content



Initial sample sets: phase 1

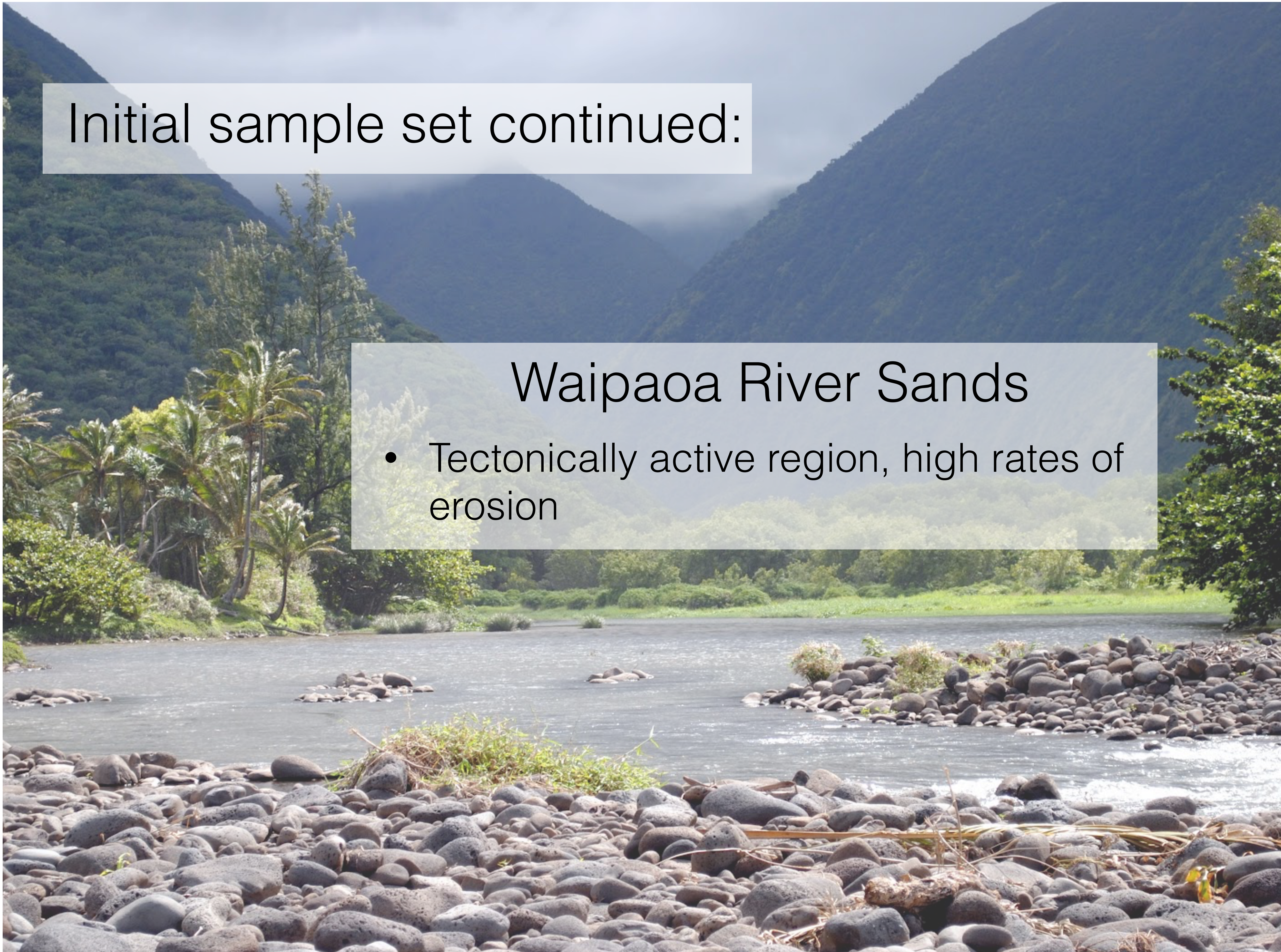
Scottish Peat Soil Pit

- Acidic conditions, lots of organic material, tephra

Initial sample set continued:

Waipaoa River Sands

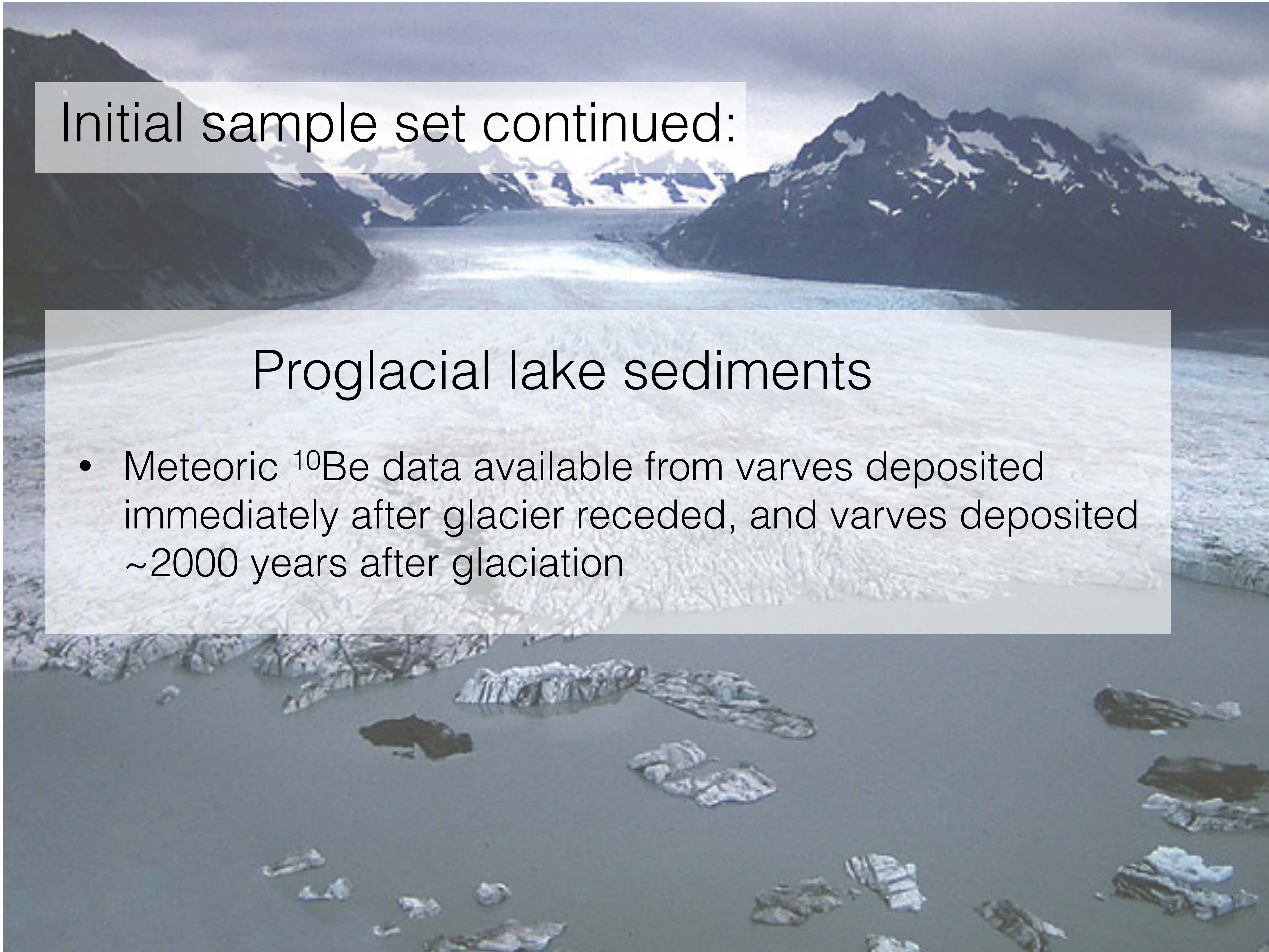
- Tectonically active region, high rates of erosion



Initial sample set continued:

Proglacial lake sediments

- Meteoric ^{10}Be data available from varves deposited immediately after glacier receded, and varves deposited ~2000 years after glaciation

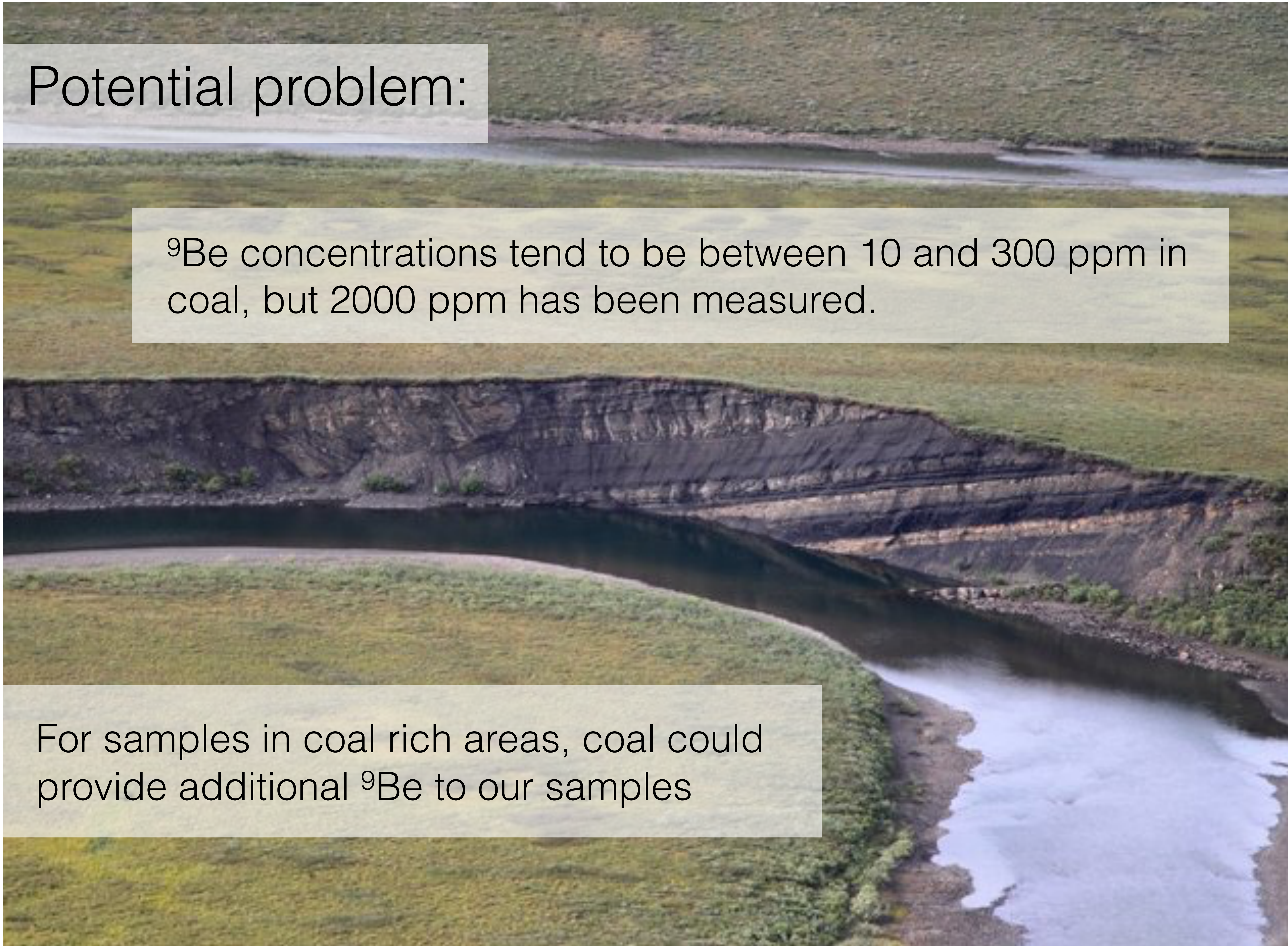


Phase 2: testing ratio across climatic and tectonic regimes

sample	climate	soil type	tectonic setting	rock type/parent material	precip (mm/yr)	pub sources	in situ met sample pairs	sediment yield data?
Susquehanna River Sands	humid temperate, glaciated	n/a	passive margin	deformed metamorphic rocks, fold and thrust belt with sandstone, shale, and carbonate, far N and W sandstone and shale	800-1300	Joanna Reuter, UVM thesis	17 paired	yes
NAVC varves	glacial and immediately post glacial	n/a	passive margin	metamorphic and igneous intrusive (granites)	no data	NAVC proposal	200+ met only	sort of...varve thickness
Scottish soil profile	humid temperate, glaciated	blanket bog peat over glacial till	passive margin	metamorphic and igneous instrusive	~1100	Fuklop et al. 2015	18 paired	n/a
Potomac River Sands	humid temperate, never glaciated	n/a	passive margin	deformed metamorphic rocks, sandstone, shale, and carbonate	890-1320	Trodick 2011	62 met, 8 paired	yes
Barron River Sands (NE Australia)	humid, tropical, never glaciated	n/a	passive margin	granitic and biogenetic carbonate	900-2500	Nichols et al. 2014	15 paired	modeled
Georges River Sands (SE Austrailia)	humid temperate, never glaciated	n/a	passive margin	**triassic sandstone, granodiorite**	800-1300	not published	9 paired	modeled
China, 3 Rivers Region Sands	tropical, never glaciated	n/a	tectonically active	lightly metamorphosed granite and sedementary	500-1000	not published	>120 paired	some
Nambian River Sands	sub-humid to hyperarid, tropical, never glaciated	n/a	passive margin	granitic and gneissic	25-400	Some in Bierman and Caffee, 2001	12 paired	no
Waipoia River Sands	temperate, humid, never glaciated	n/a	tectonically active	carbonate bearing silt and sandstone	1000-1500	Reusser and Bierman 2010, not all data published	90 met; 18 paired	yes
Waipoia River Soil Pit	temperate, humid, never glaciated	pumice and podzol	tectonically active	river terrace sand and silt derived from carbonate bearing silt and sandstone	1000-1500	Reusser et al. 2010	13 met only	n/a
Great Smokey Mountains soil profiles	temperate, never glaciated	Inceptisols	passive margin	meta-siltstone, metamorphosed conglomeratic sandstone, carbonates and gneiss	1400-2300	Jungers et al., 2009	59 paired	n/a

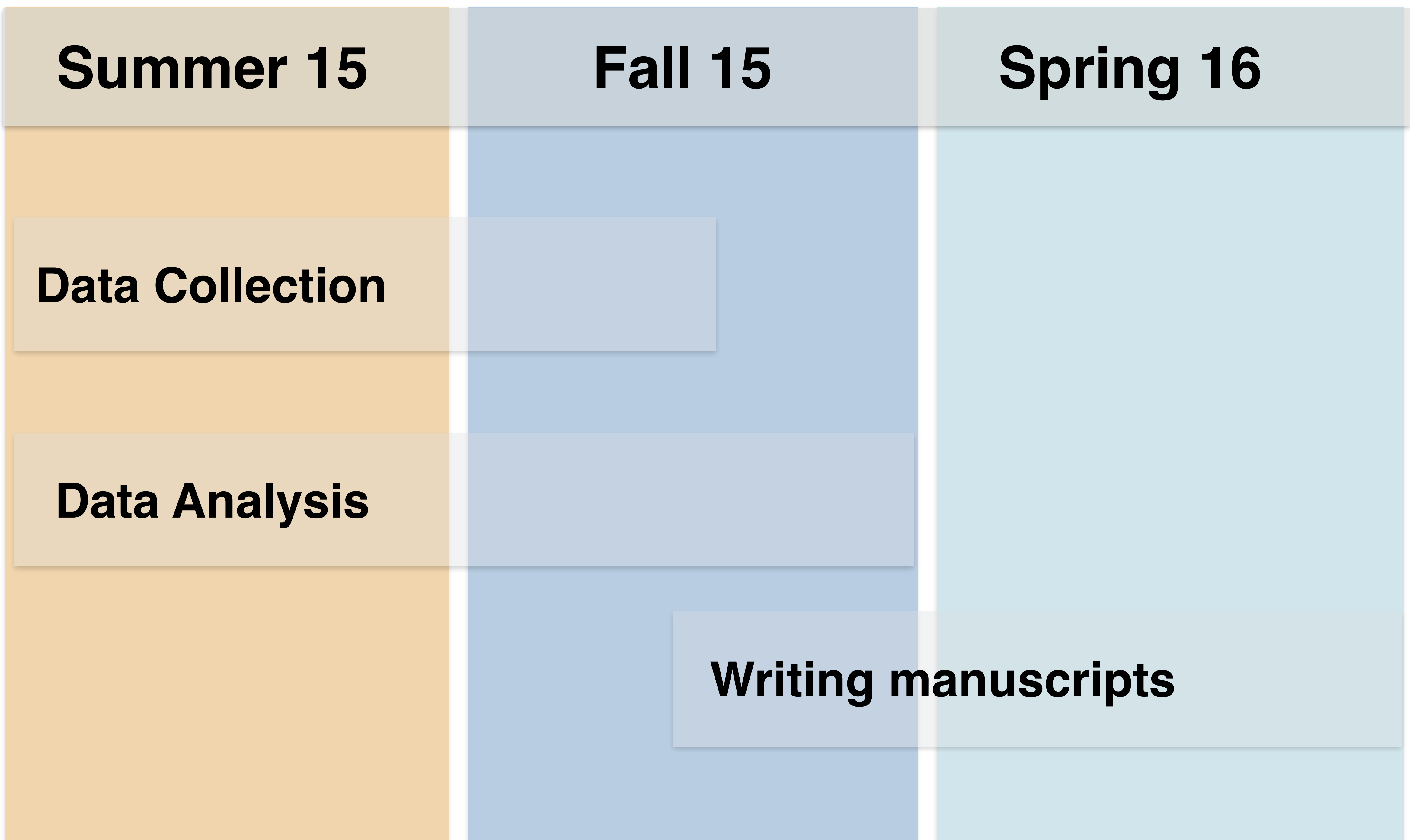
Potential problem:

^{9}Be concentrations tend to be between 10 and 300 ppm in coal, but 2000 ppm has been measured.



For samples in coal rich areas, coal could provide additional ^{9}Be to our samples

Timeline

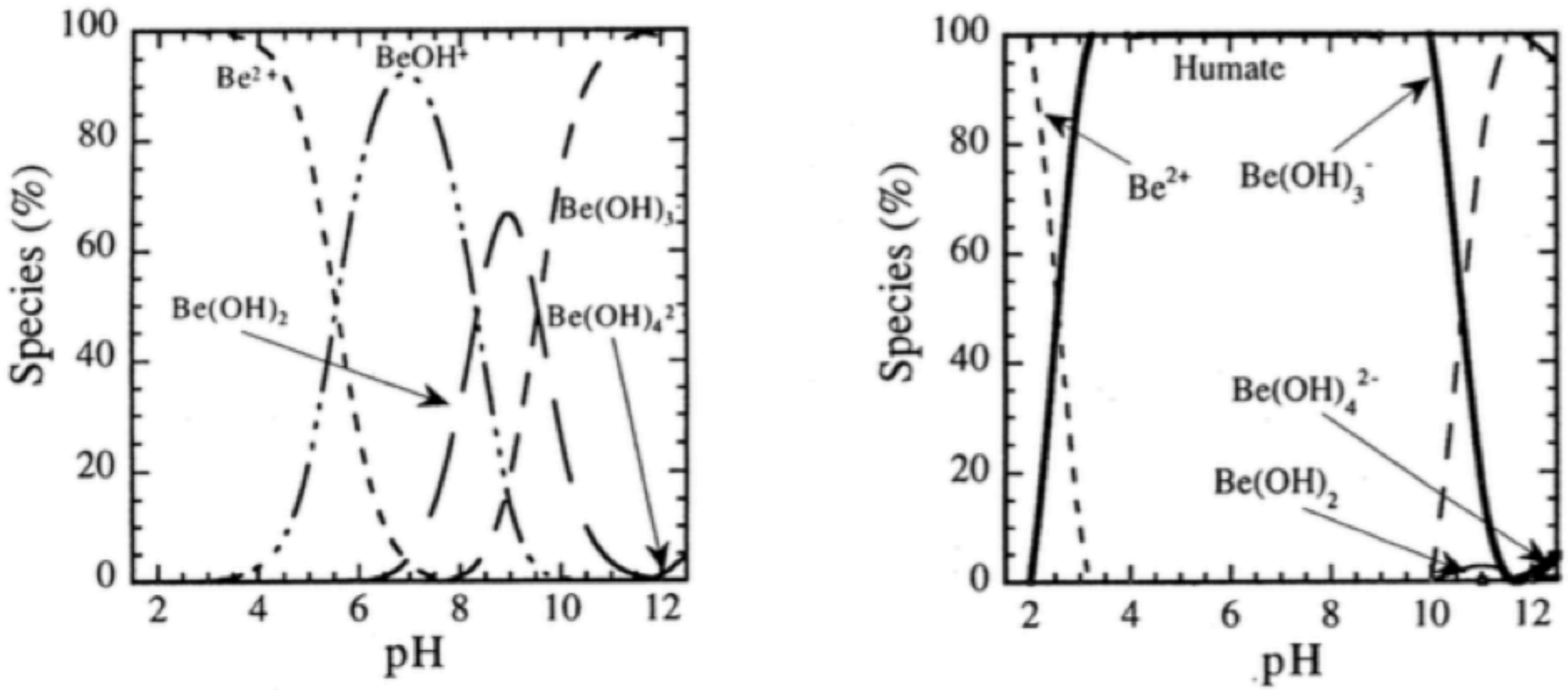

Summer 15
Fall 15
Spring 16
Data Collection
Data Analysis
Writing manuscripts


Thanks! Any Questions?

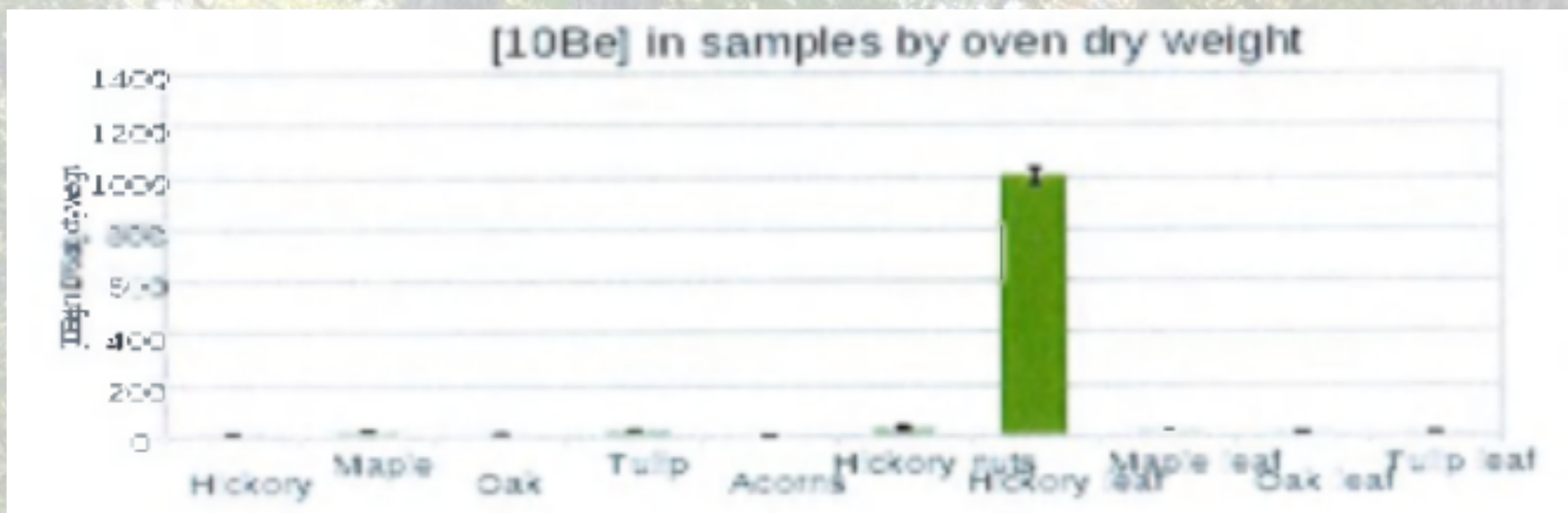
(A)

B e

In the absence of humic acid | In the presence of humic acid



Does meteoric ^{10}Be bioaccumulate?

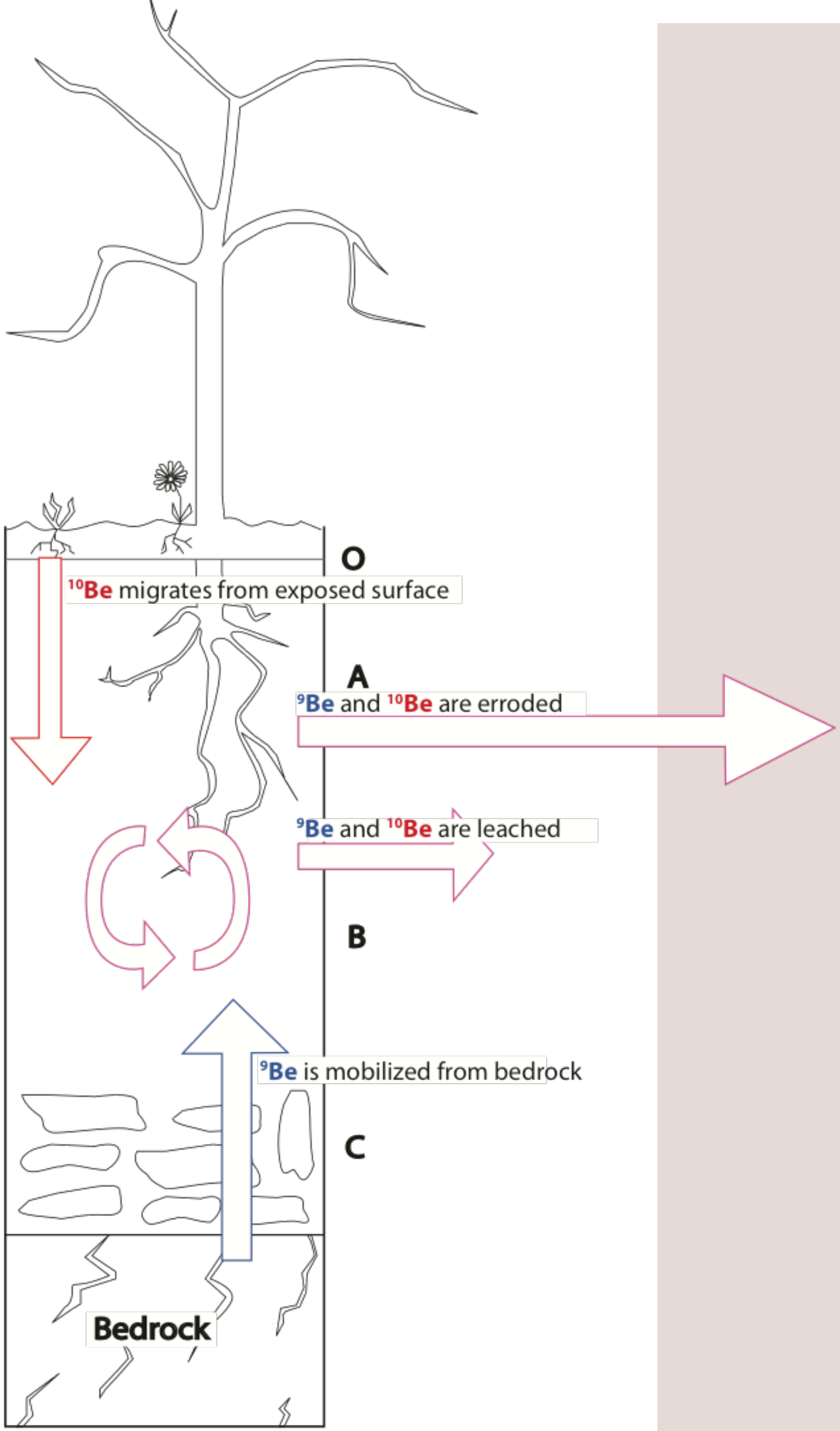


Conyers 2014

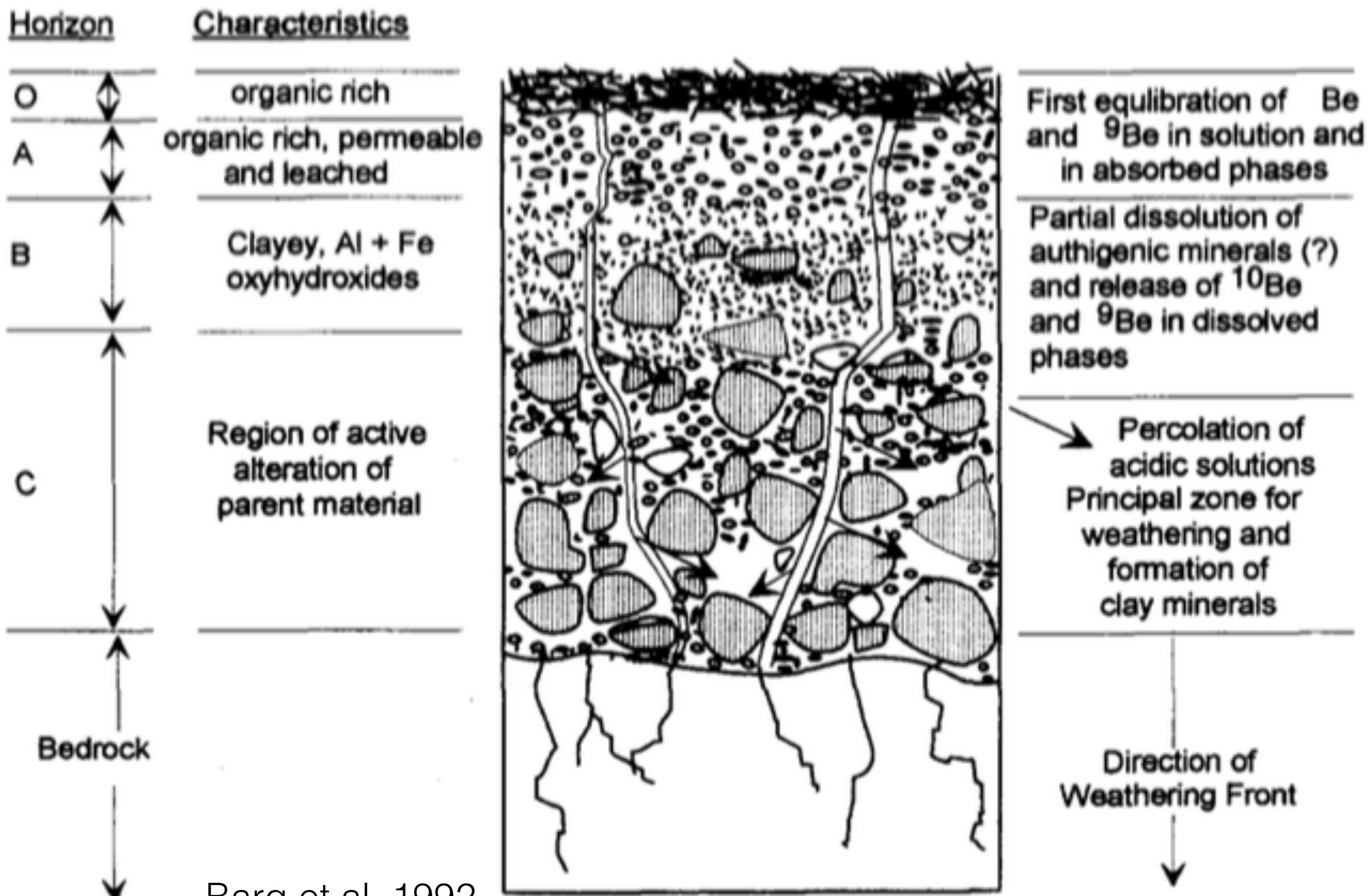
3 orders of magnitude difference between ^{10}Be in Hickory and other trees measured and surrounding soils

All samples, biomass and soil, within an order of magnitude

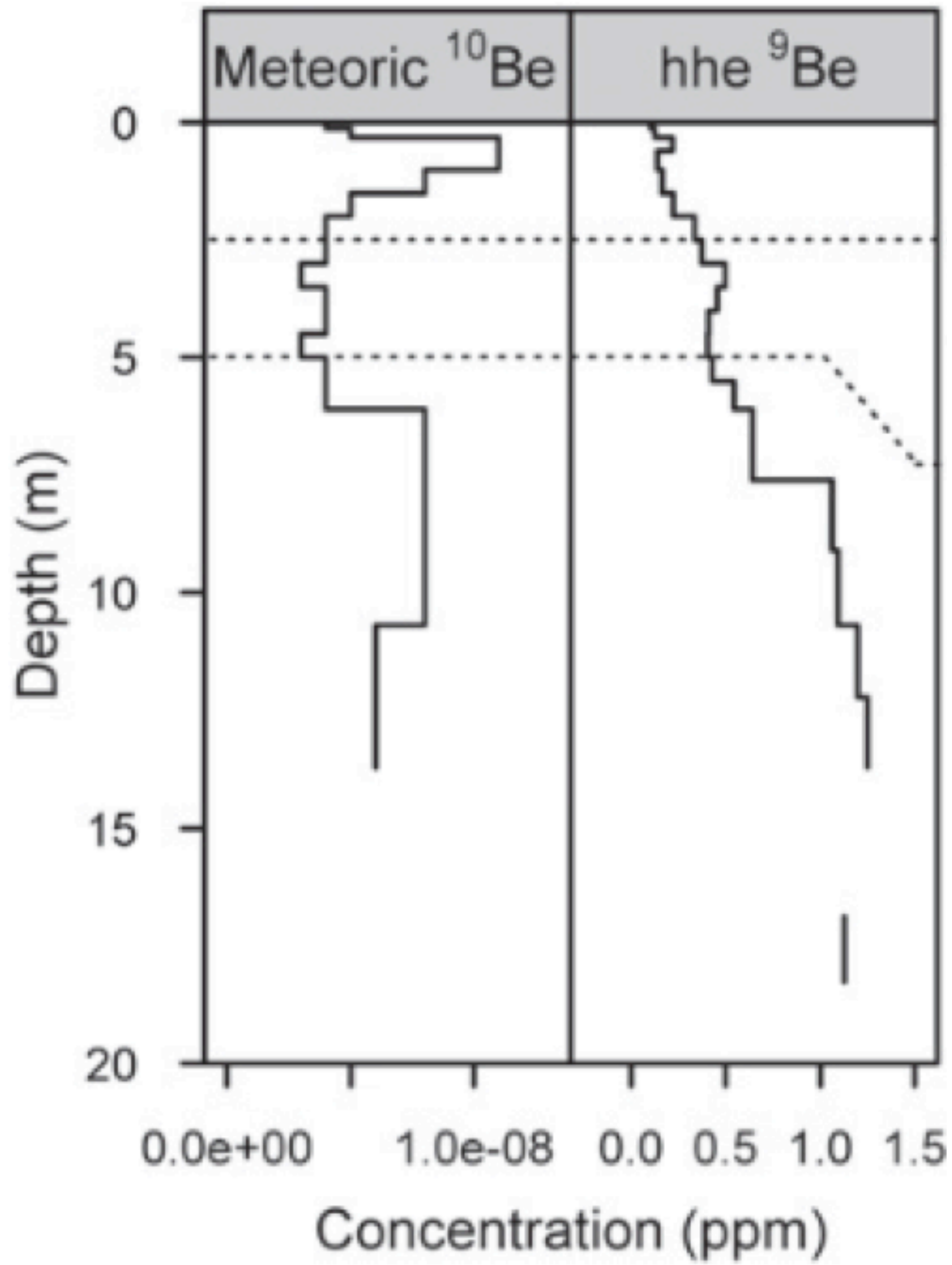
Conyers 2014



O
^{10}Be migrates from exposed surface
A
^{9}Be and ^{10}Be are erroded
^{9}Be and ^{10}Be are leached
B
^{9}Be is mobilized from bedrock
C
Bedrock



Barg et al. 1992


Meteoric ^{10}Be
hhe ^{9}Be
Depth (m)
0
5
10
15
20
0.0e+00
1.0e-08
0.0
0.5
1.0
1.5
Concentration (ppm)

Hypotheses

Relatively few studies of ^{9}Be sequential extractions from soils and sediments have been performed (Barg et al. 1997, Bacon et al. 2012, Wittmann et al. 2012), so it is difficult to predict which fractions of sequential Be extraction will have the highest ^{9}Be concentrations. Barg et al. (1997) and Wittmann et al. (2012) show that Be accumulates in organic-rich and clay-rich layers of soils. I therefore hypothesize that the sequential extraction fractions that selectively dissolve organic and exchangeable phases will liberate the largest quantity of Be. However, in samples with significant amounts of humic acids, I hypothesize that the crystalline oxide and amorphous oxide-bound fractions will contain significant amount of ^{9}Be (Taskahashi et al. 1998). Because the total grain coating is extracted for $^{10}Be_{met}$ analysis, I hypothesize that the ^{9}Be from the total grain coating will result in the most meaningful relationship between ^{9}Be, $^{10}Be_{met}$, and long-term erosion rates. I hypothesize that there will be an increased concentration of ^{9}Be in grain coatings in the distal glacial lake sediments than the proximal sediments because ^{9}Be will have become more mobile during pedogenesis in the time after glaciation.

Many published reports show results that indicate the $^{10}Be_{met}/^{9}Be$ ratio normalizes $^{10}Be_{met}$ data to account for grain size effects, $^{10}Be_{met}$ remobilizing and/or $^{10}Be_{met}$ leaching (Merrill et al. 1959, Barg et al. 1997, Bacon et al. 2012, Conyers 2014, Von Blanckenburg et al. 2012, Wittmann et al. 2010, Willenbring and von Blanckenburg 2010). Because publications indicate that $^{10}Be_{met}/^{9}Be$ ratios could be meaningful indicators of erosion, I hypothesize that a $^{10}Be_{met}/^{9}Be$ ratio that includes the total ^{9}Be in the outside coating of grains will correlate with erosion rates calculated using $^{10}Be_{is}$ data.