THE DETERMINATION OF MILLENIAL SCALE EROSION RATES USING COSMOGENIC ANALYSIS OF ^{10}Be IN THE SHENANDOAH NATIONAL PARK, VA

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Progress Report

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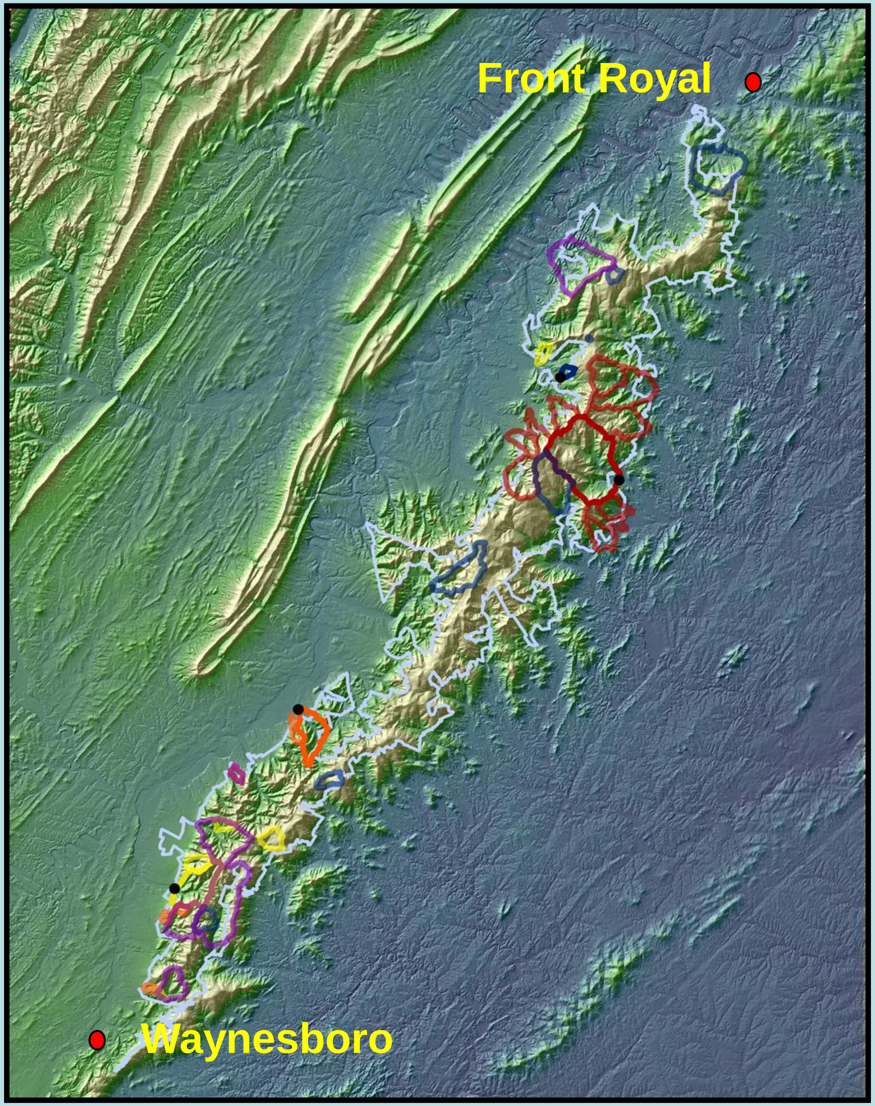
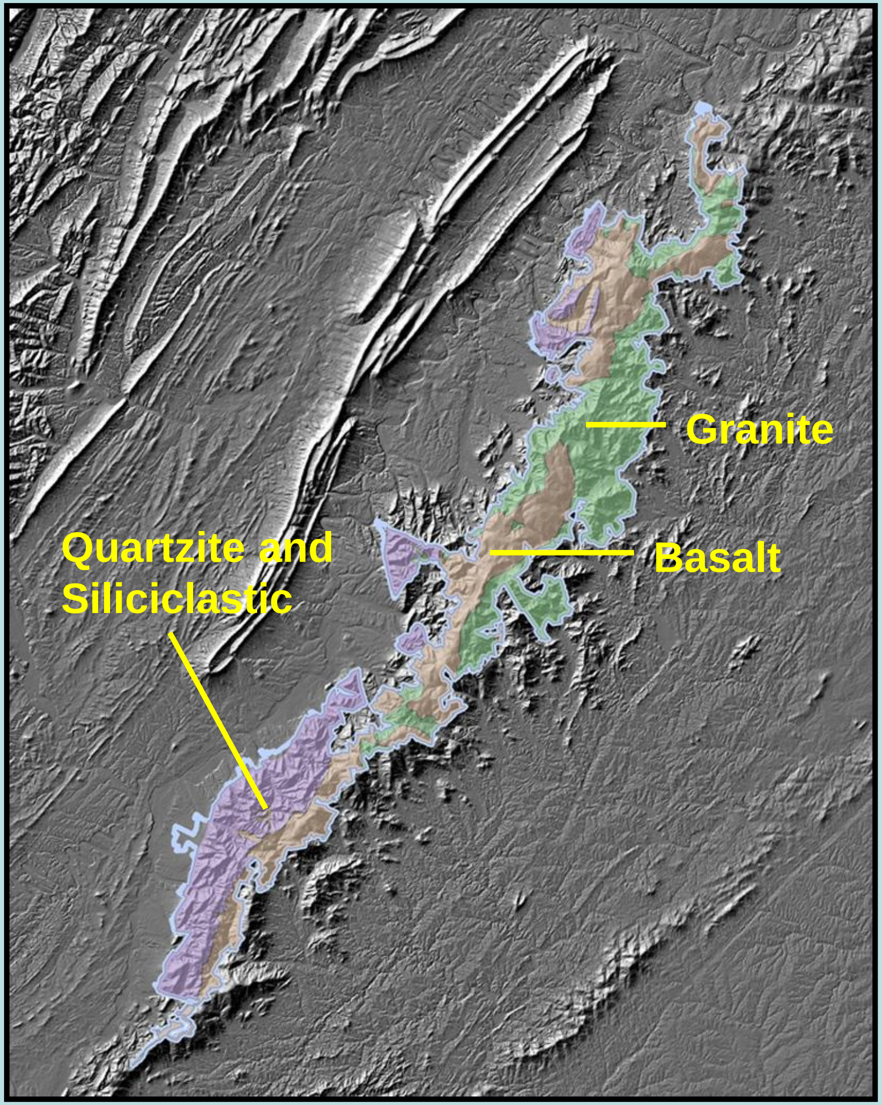
Outline

- Introduction
- Progress to Date
- Data
- Results
- Discussion
- Time line

Physical Setting





Introduction

- ❖ Appalachian Mountains paradox
- ❖ Determine erosion rates within the Park
  a 10^3 to 10^6 year timescale
- ing erosion as a function of lithology
- Hack's (1960) model of dynamic
  ilibrium and steady state erosion
- tionship between grain size and
  ^{10}Be concentration (Matmon et al. 2003)

Paul Bierman:

Proably better as 10^4-10^5 year time scale given the rates you have measured

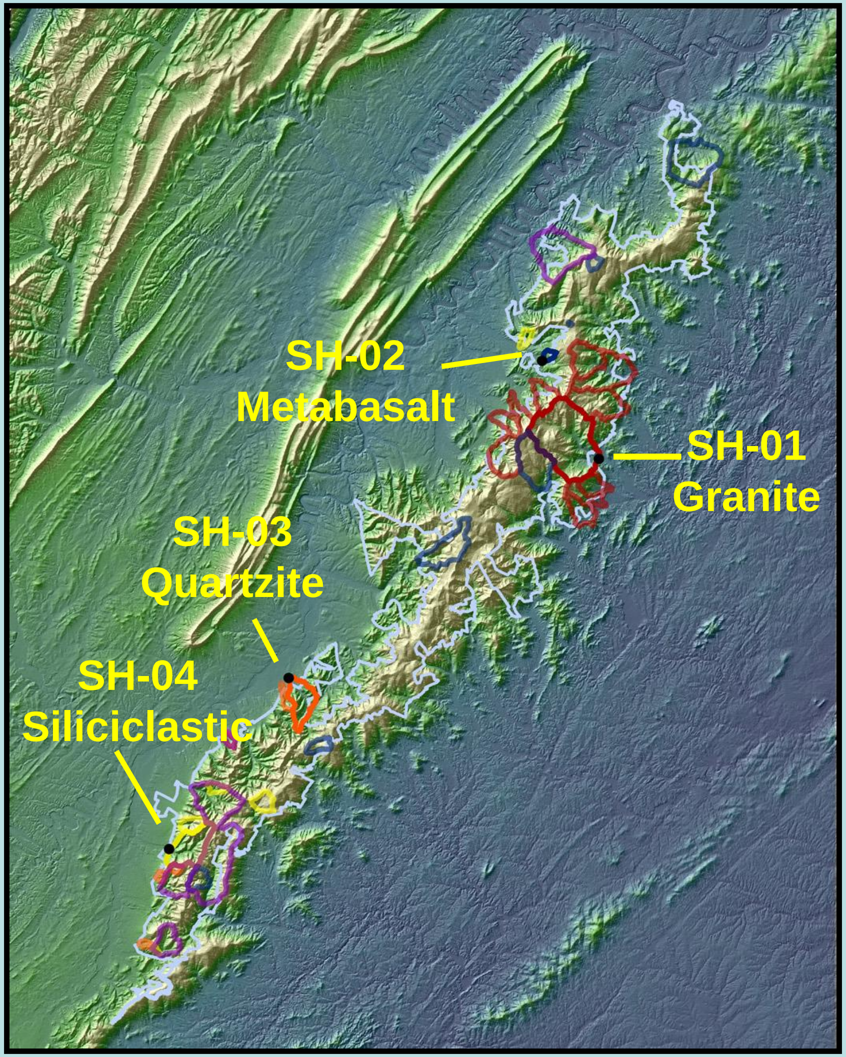
Blue Ridge Mountains, VA

Progress To Date - GIS

- ❖ Generated a database of drainage basins that included criteria such as basin size, location, lithology, mean slope, and elevation range using:

  - DEM's (Digital Elevations Models)
  - NHD Stream Data (National Hydrography Dataset)

Map Showing the delineated basins and sample sites*

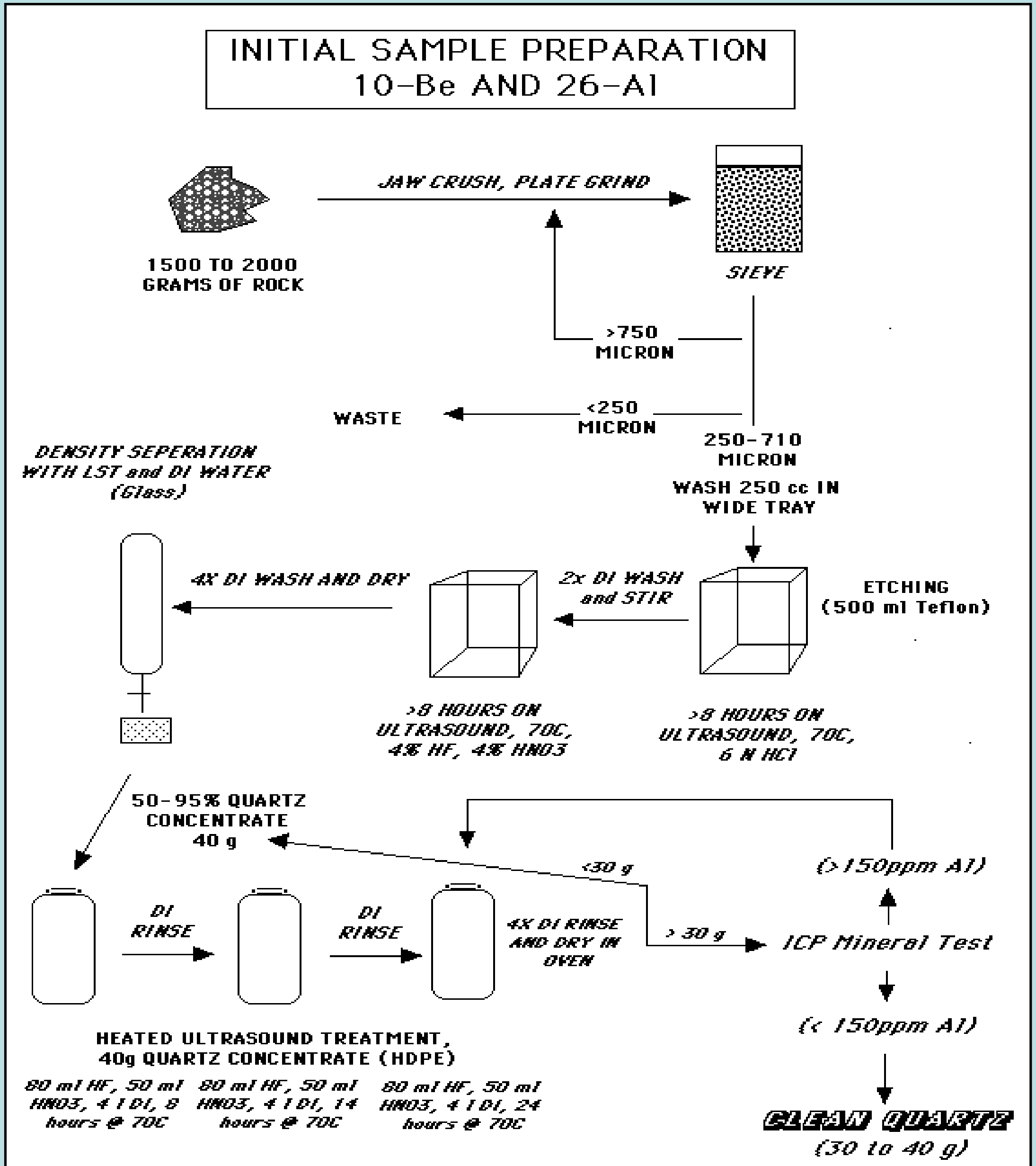


*There are data for these samples sites

Progress To Date - Sample Collection

- 36 samples from active river or stream channels (0.5 - 1 kg of sediment)
- All samples sieved to the 0.25 - 0.85 mm size fraction in the field

Sample Processing

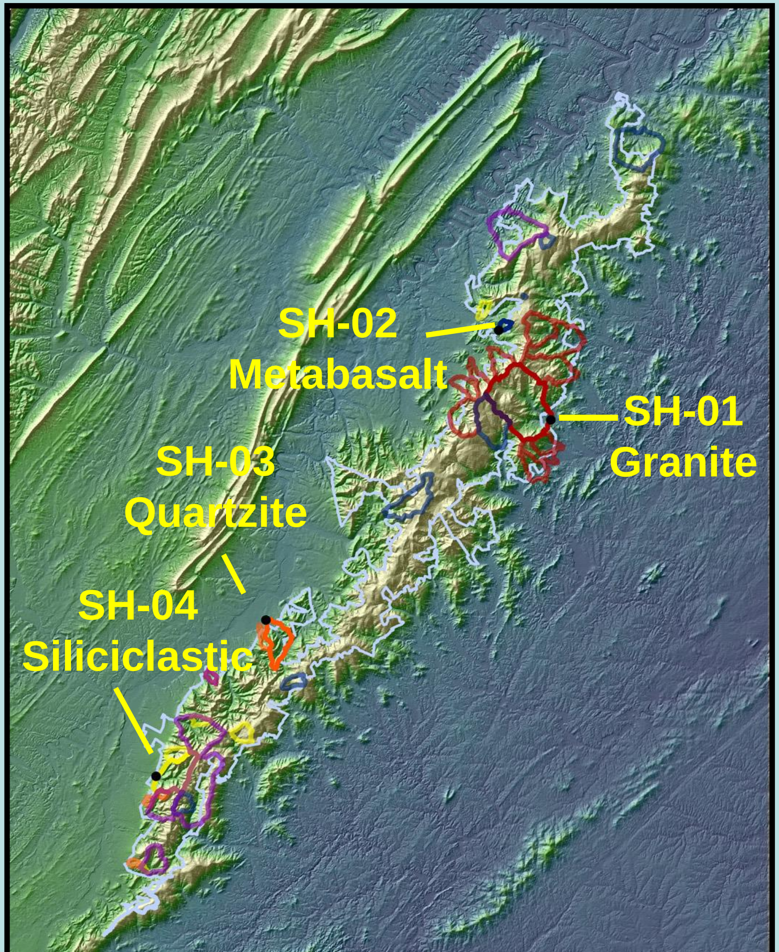


Initial sample preparation followed by quartz dissolution, column separation and target preparation

Data

- The initial 16 samples gathered in the fall of 2005 have been processed. These samples comprised the four grain size splits (0.25 – 0.85 mm, 0.85 – 2 mm, 2 - 10 mm, > 10 mm) of the four lithologies found within the boundaries of the Shenandoah National Park.
- The samples were taken to Lawrence Livermore National Laboratories where they were measured on the accelerator mass spectrometer (AMS) in order to determine the $^{9}Be/^{10}Be$ ratio, and the concentration of ^{10}Be in each sample.
- The concentrations can then be normalized using the altitude-latitude scaling function of Lal (1991) and erosion rates modeled using methods presented in Bierman and Steig (1996).

Results

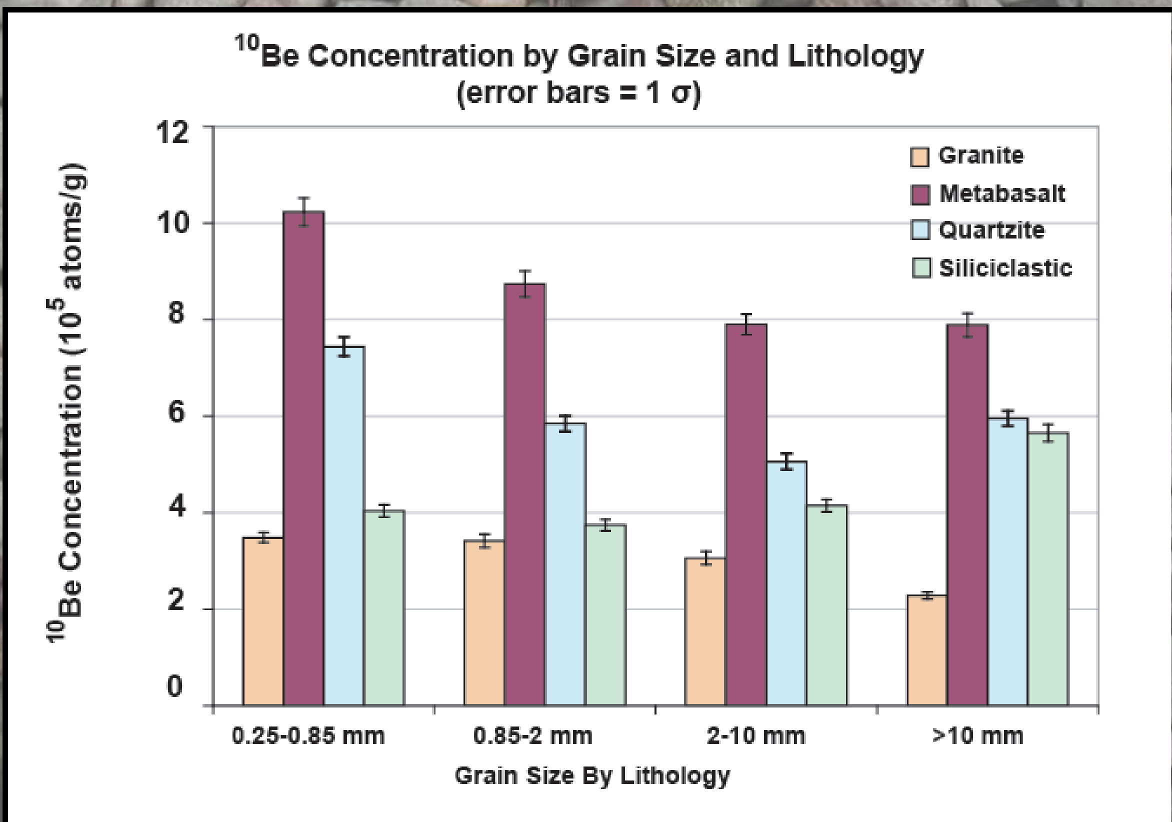


SH-01 - Granite	^{10}Be Conc. (10^5 atoms/g)	ErosionRates (m/My)
0.25-0.85 mm	3.48 ± 0.10	14.67 ± 1.14
0.85-2 mm	3.42 ± 0.14	14.95 ± 1.23
2-10 mm	3.06 ± 0.14	16.74 ± 1.44
>10 mm	2.29 ± 0.07	22.51 ± 1.77
SH-02 - Metabasalt		
0.25-0.85 mm	1.02 ± 0.29	4.25 ± 0.35
0.85-2 mm	8.73	1
2-10 mm	7.90	4
>10 mm	7.89	5
SH-03 - Quartzite		
0.25-0.85 mm	7.44	3
0.85-2 mm	5.84	7
2-10 mm	5.06	0
>10 mm	5.95	7
SH-04 - Siliciclastic		
0.25-0.85 mm	4.04 ± 0.13	12.30 ± 0.97
0.85-2 mm	3.74 ± 0.12	13.32 ±1.05
2-10 mm	4.15 ± 0.13	11.97 ± 0.95
>10 mm	5.65 ± 0.18	8.71 ± 0.69

Paul Bierman:

These are too precise given all the uncertainties..I would round to whole numbers

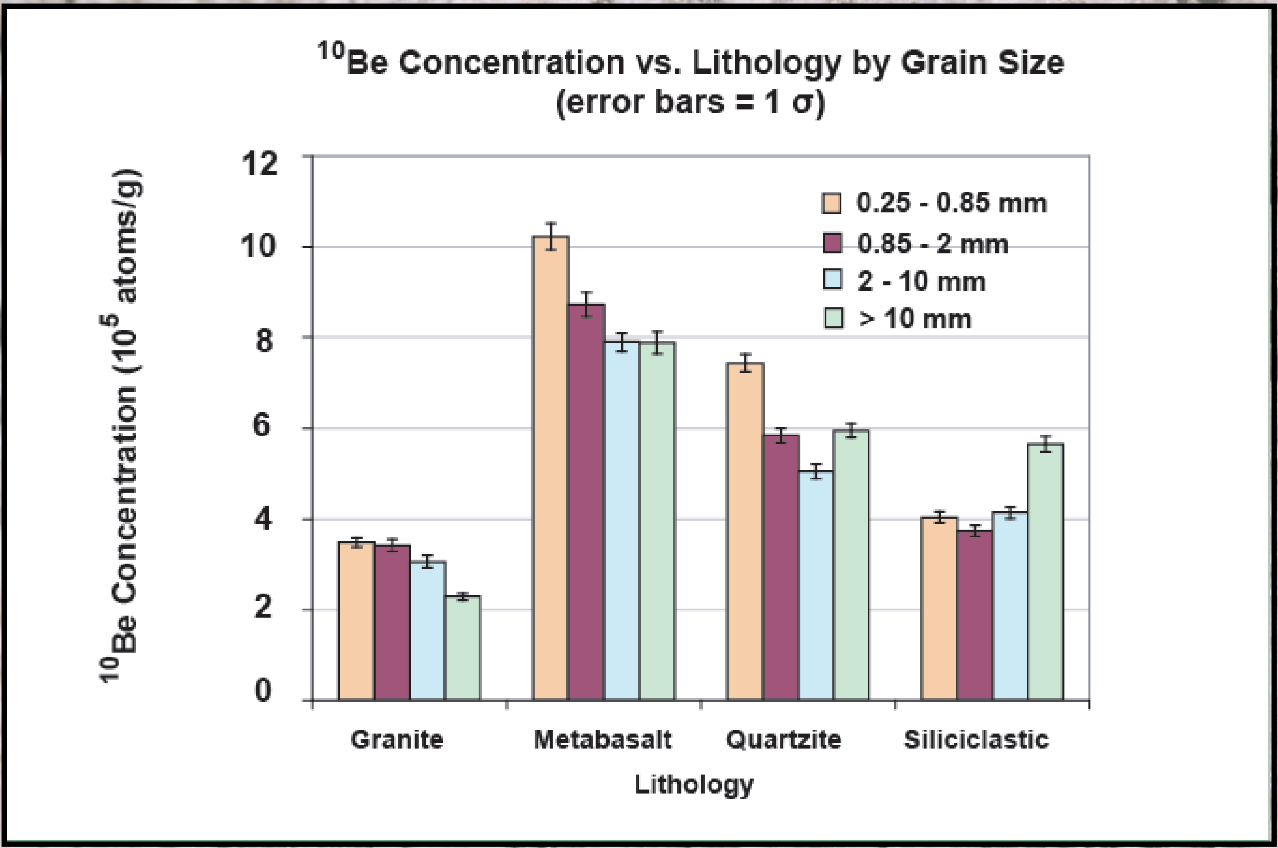
Discussion – Grain Size Analysis



- In 3 of the 4 samples analyzed, smaller grains have a greater ^{10}Be concentration than larger grains.

- The differences in ^{10}Be concentrations are not great, ~23%, indicating that grain size has little consistent effect on measured ^{10}Be concentration and thus modeled erosion rates.

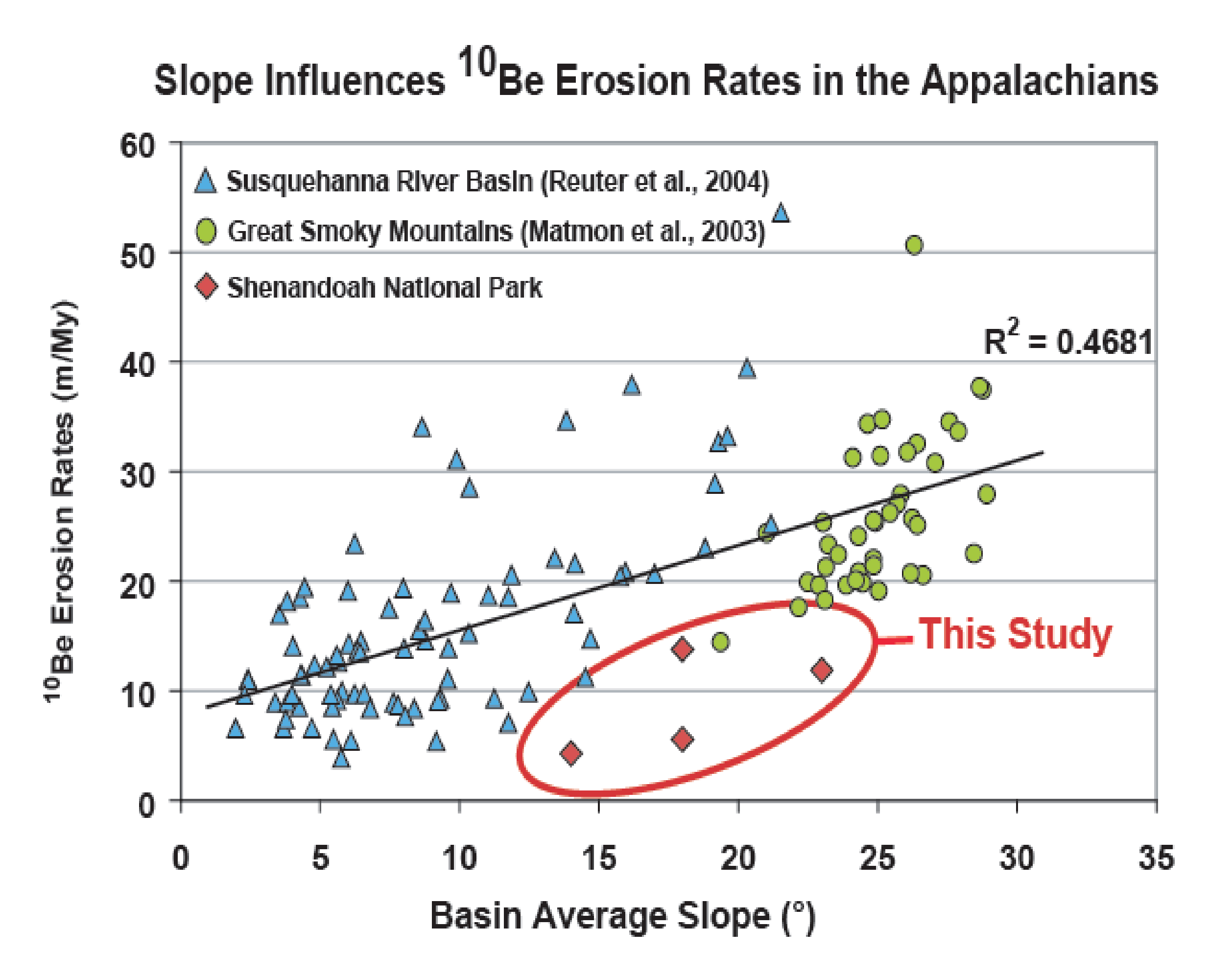
Discussion – Erosion Rate vs. Lithology



Shenandoah Erosion Rates (0.25 - 0.85 mm grain size fraction):

- **granite (14.7 m/My)**
- **metabasalt (4.3 m/My)**
- **quartzite (6.7 m/My)**
- **siliciclastic (12.3 m/My)**

Discussion – Erosion Rates



- Matmon et al., (2003), 25 to 30 m/My for meta-sandstone in the steep Great Smoky Mountains.
- Reuter et al., (2005), 4 - 54 m/My in Susquehanna River basin for shale, sandstone, and schist.
- U/Th/He near the Blue Ridge Escarpment by Spotila et al., (2004).
- Fission tracks in the Blue Ridge and the southern Appalachians by Naeser et al., (2005, 2006),
20 m/My.

Future Work – Statistical Analysis

- To test the significance of erosion rate change as a function of slope and basin size to test the hypothesis that isotope concentration (set by the erosion rate) is a function of slope (linear regression).
- One-way ANOVA analysis for the four lithologies in order to test for significant differences in erosion rates between the lithologies.
- Contrast the four erosion rates of the lithologies to see if there are any differences between them, which will enable me to test Hack’s theory of *dynamic equilibrium*.
- Spatial autocorrelation – to measure the level of interdependence between the variables in order to identification of patterns which may reveal an underlying process.

Timeline

Fall 2006	Presented poster of initial data at GSA Further processing of second sample set
Spring 2007	Take second sample set to LLNL for AMS analysis Data analysis of AMS results (Jan/Feb)
Summer 2007	Start writing thesis
Fall 2007	Complete thesis Prepare papers for journal submissions (including invited GSA special paper- Geology and Related Studies of Shenandoah National Park and Vicinity, Virginia) Present final work at GSA annual meeting Defend Thesis

Acknowledgements

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Questions?