A NEODYMIUM ISOTOPE INVESTIGATION OF SEDIMENT SOURCES FOR THE MIDDLE DEVONIAN MARCELLUS FORMATION, PENNSYLVANIA, USA

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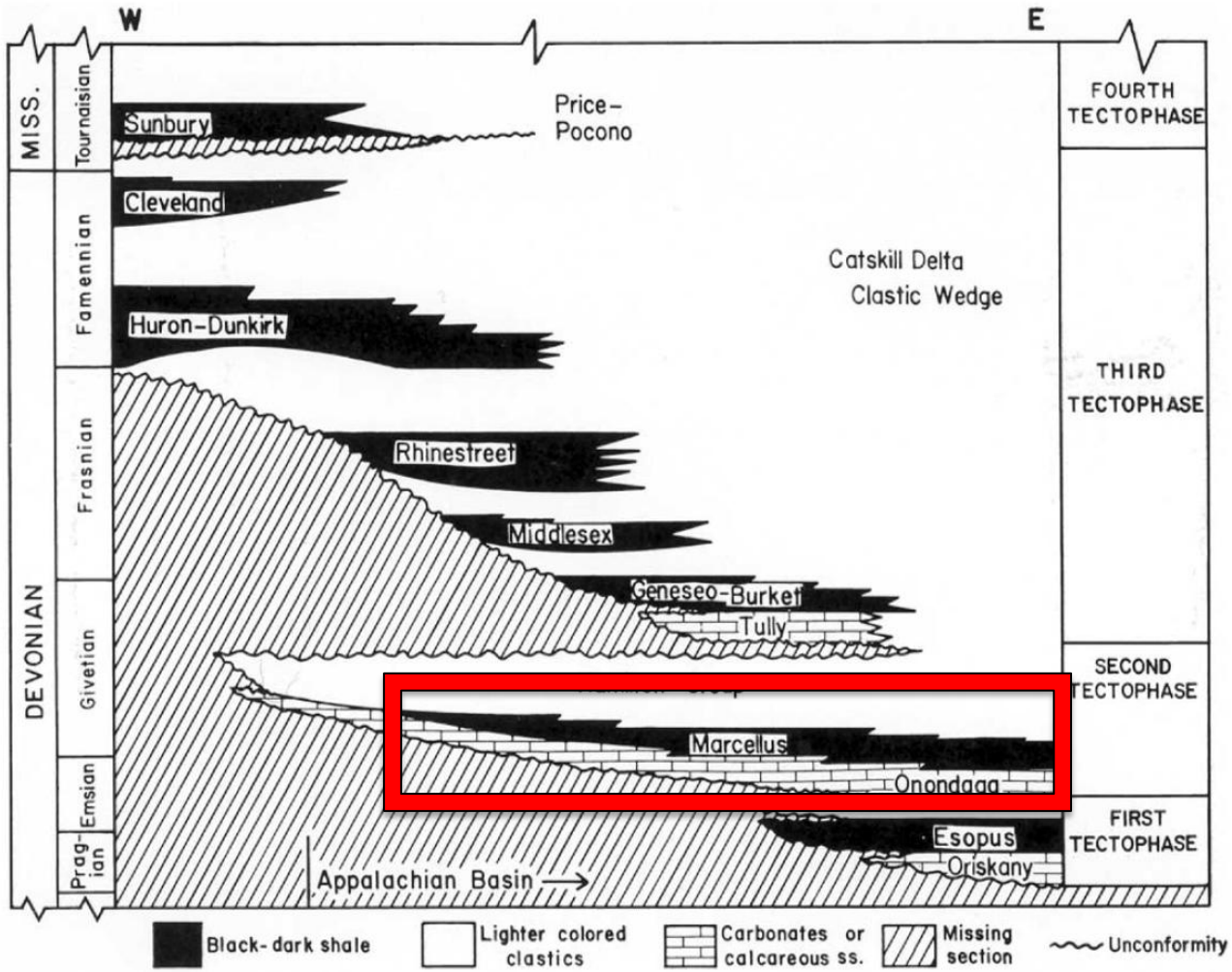
Introduction –Marcellus Shale



Ettensohn, 2004

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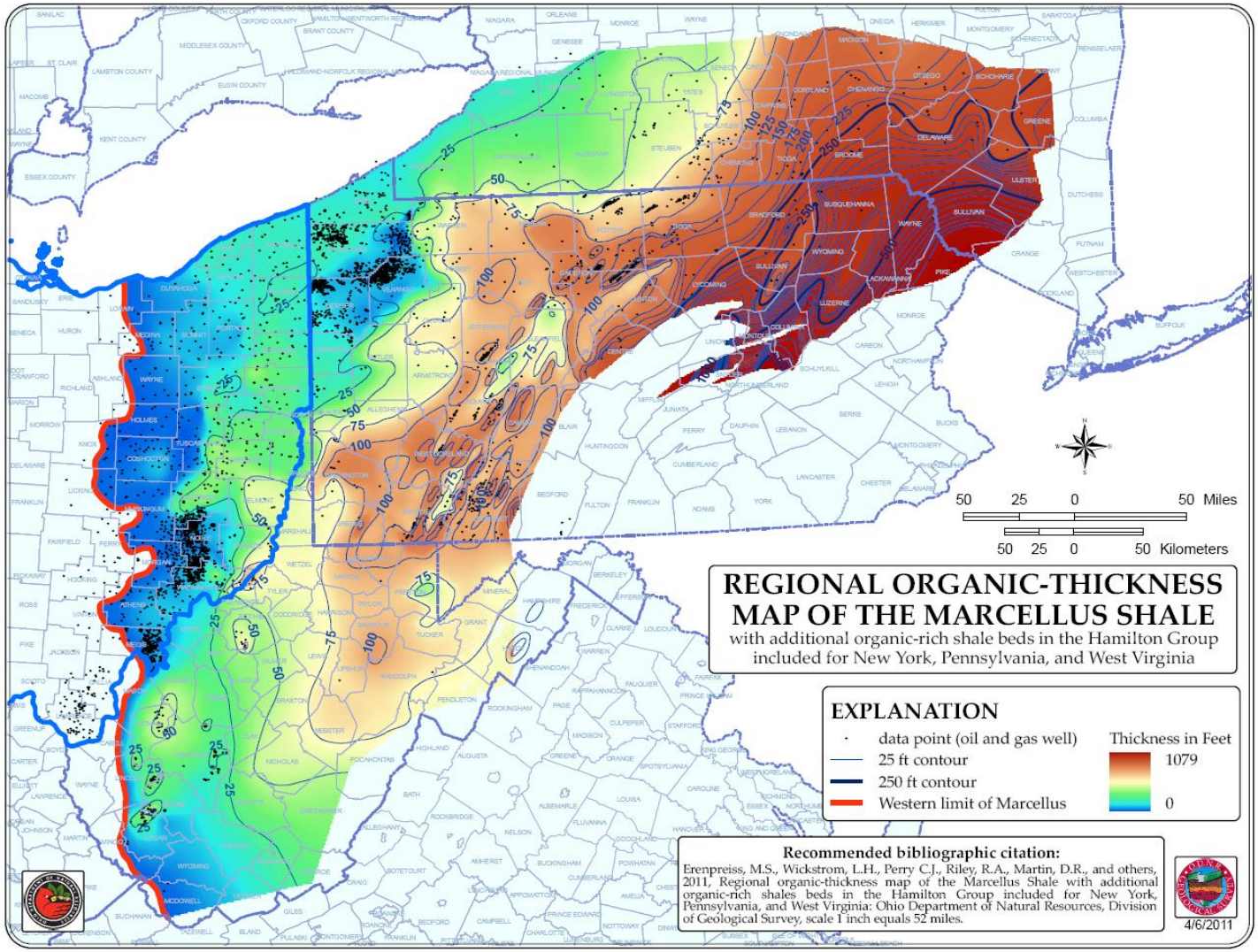
Introduction – Marcellus Shale



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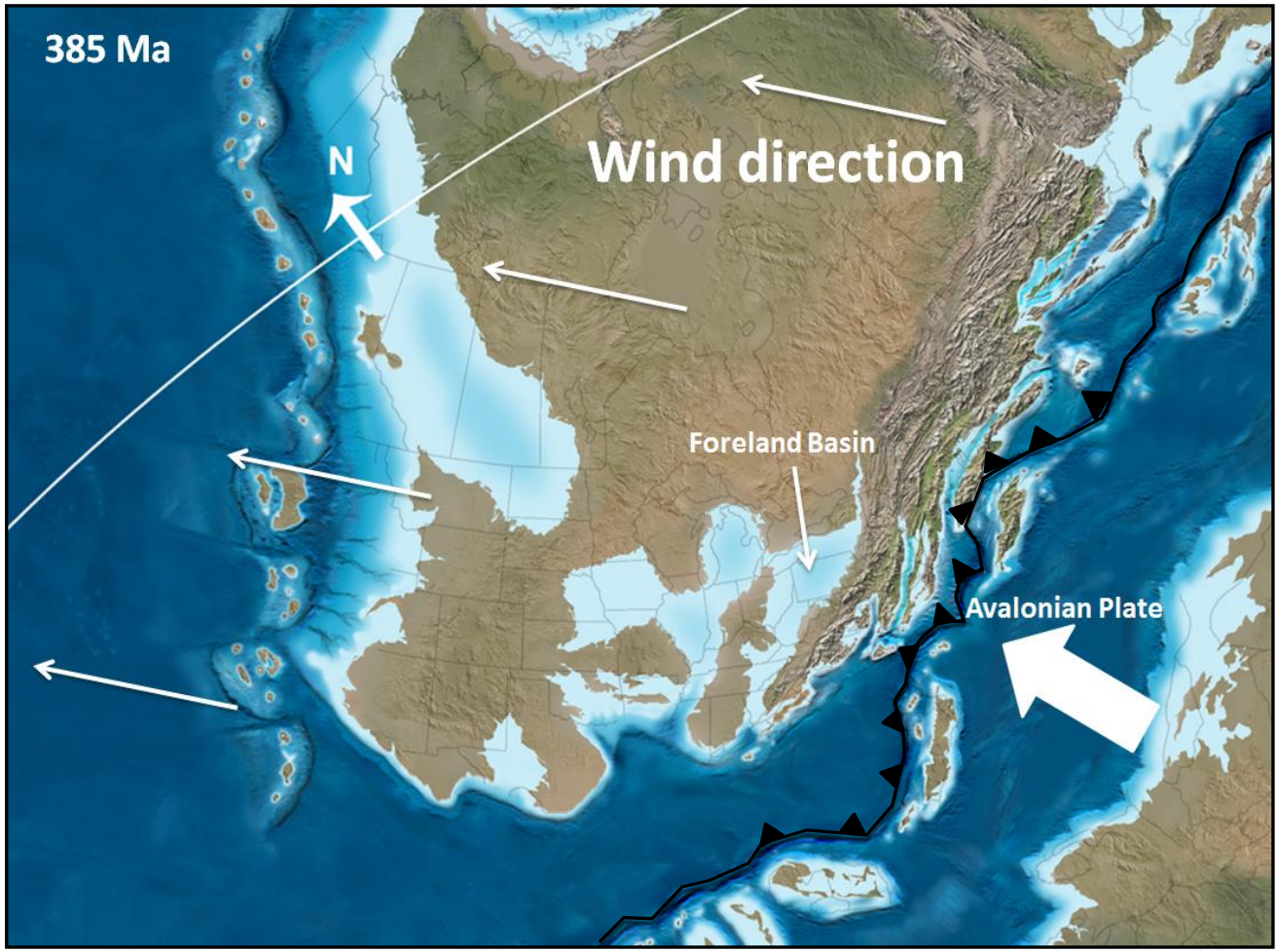
Introduction – Marcellus Shale

Restricted foreland basin deposition



Blakey Paleogeography Maps
Wind direction from Parrish (1982)

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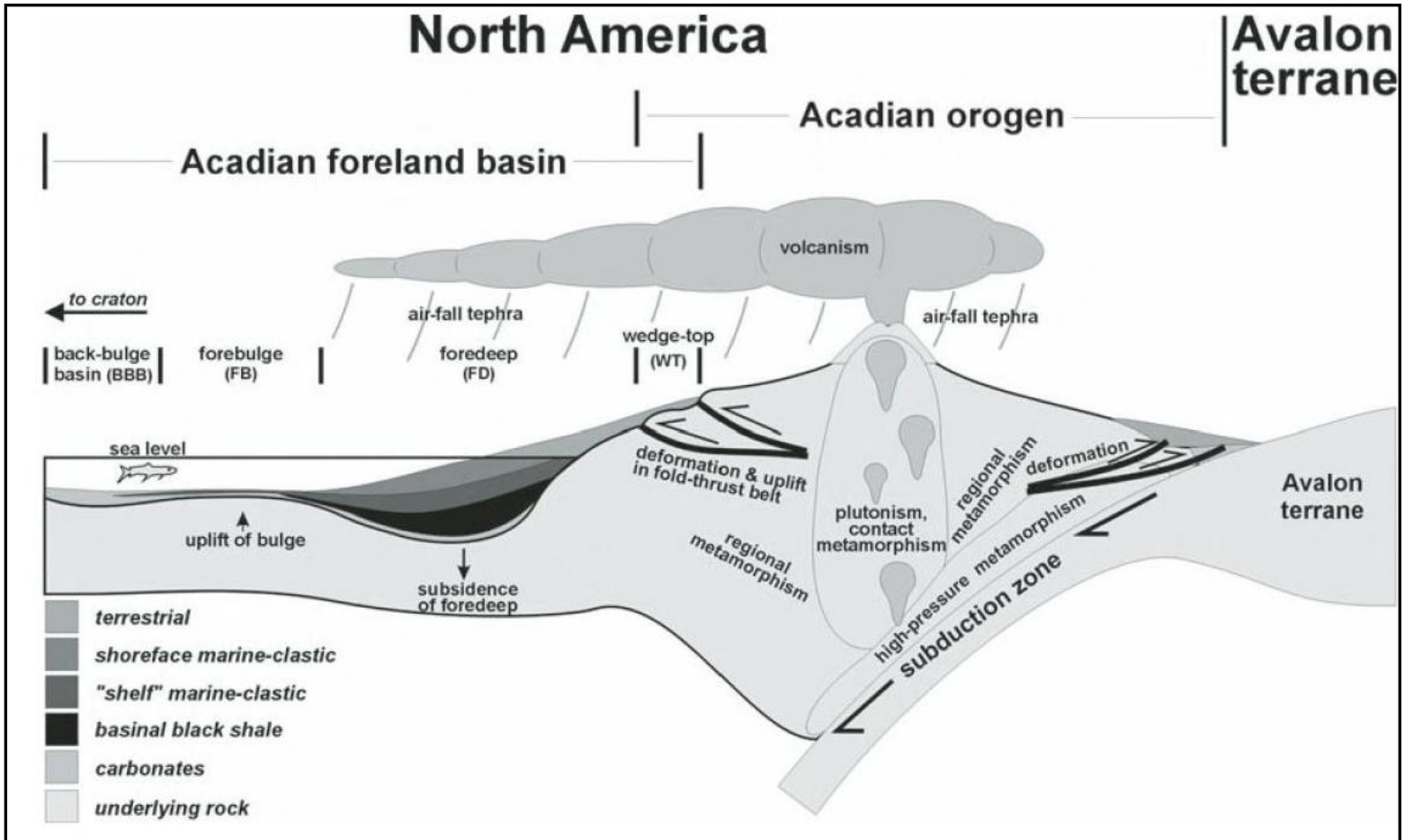
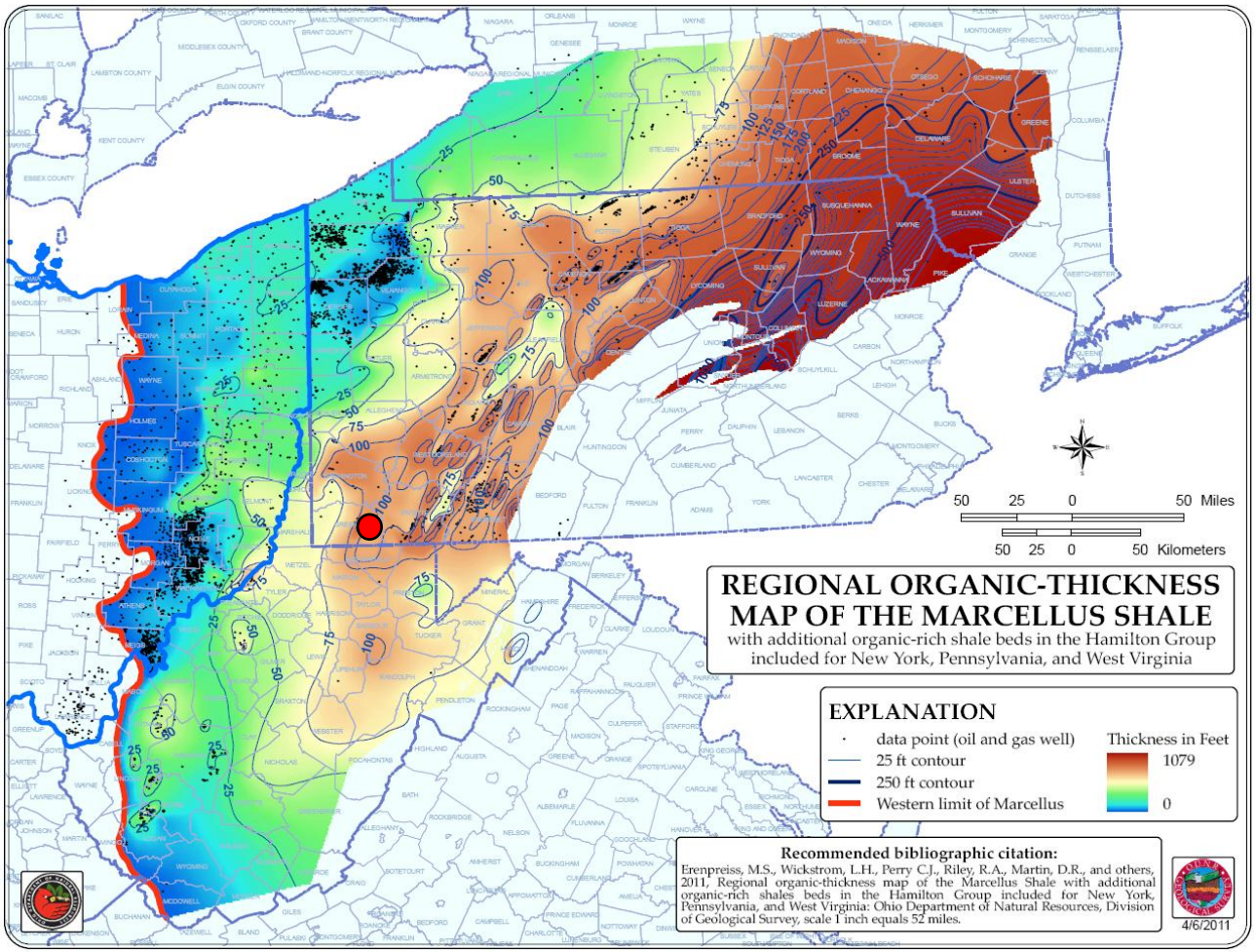
Goals

Investigate

- Sediment sources
- Depositional environment
- Post depositional processes – diagenesis, thermal events



Study Focus: Core from Greene County



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Marcellus Shale - Outcrop

Outcrops exhibiting effects of subaerial weathering

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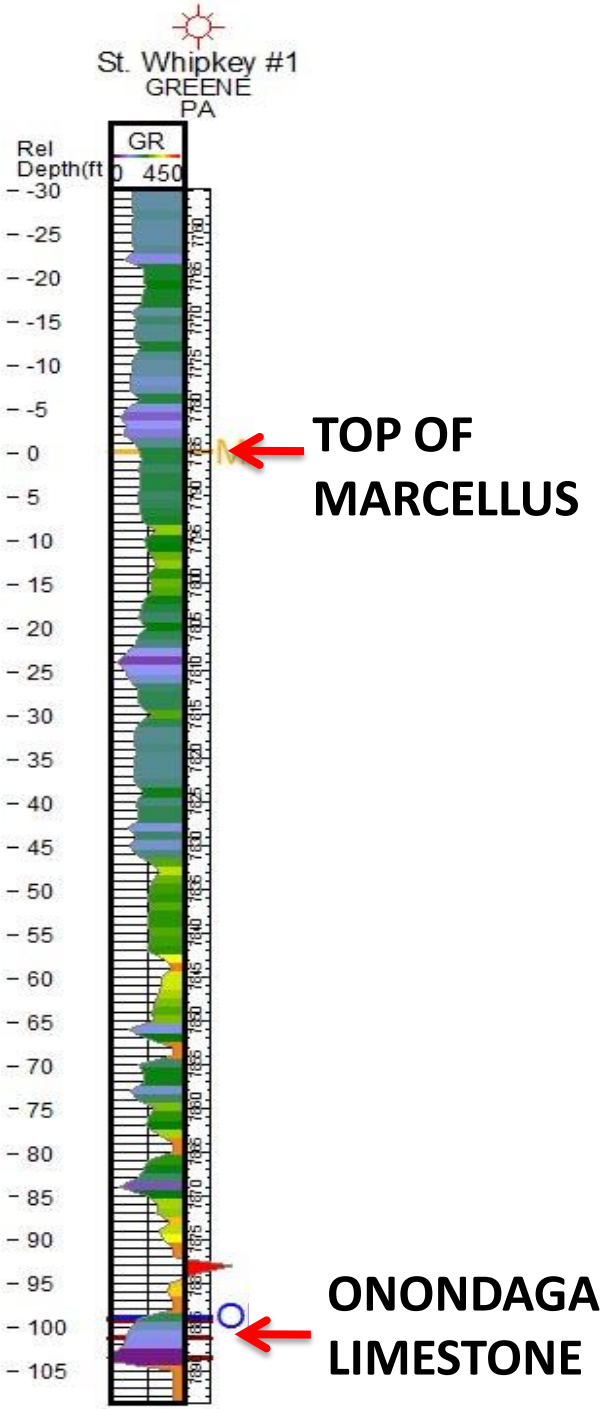
Core

Depth 2374 to 2398 m (25 m)

- Top of Marcellus shale to
- Onondaga (Selinsgrove) limestone



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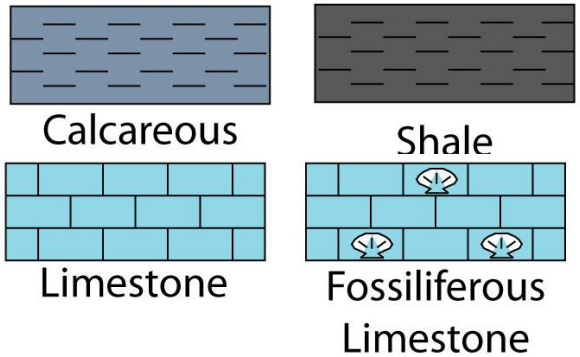
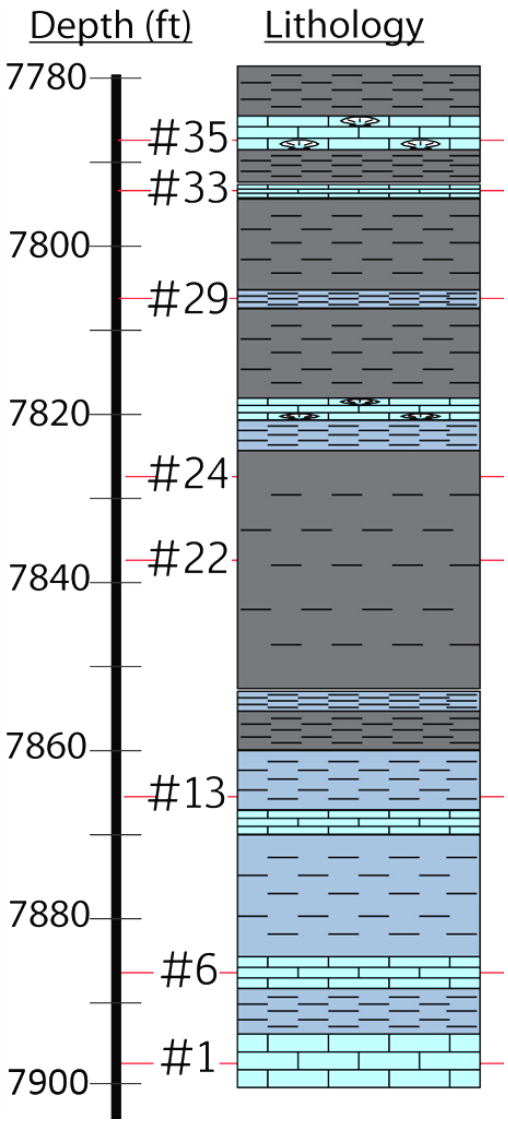
Lithologies analyzed

- **Marcellus shale**
  - Black shale
  - Calcareous shale
- **Limestone/marl**
  - Lenses within Marcellus Formation
  - Underlying Onondaga limestone





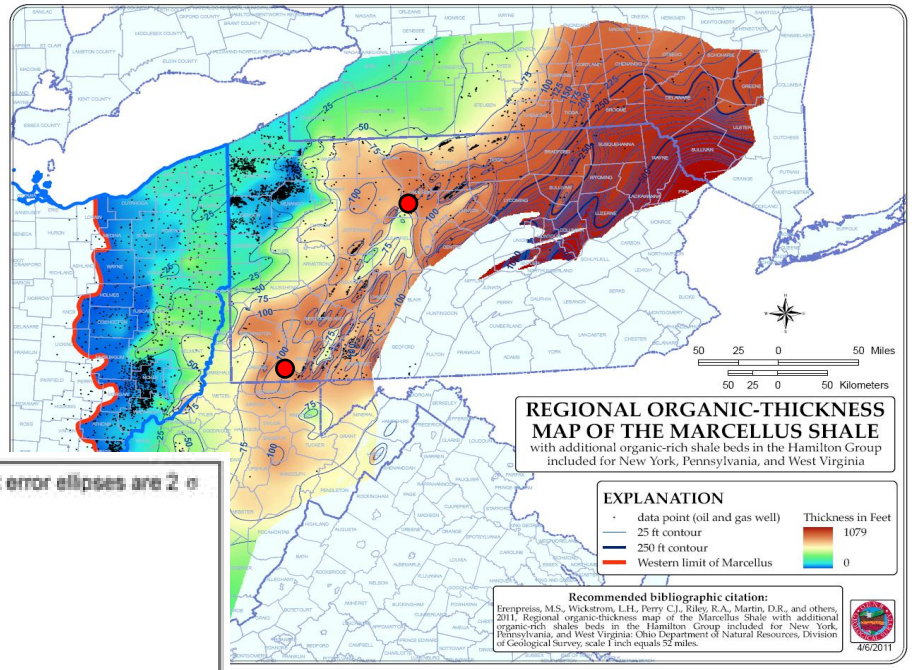
Volcanic Ash

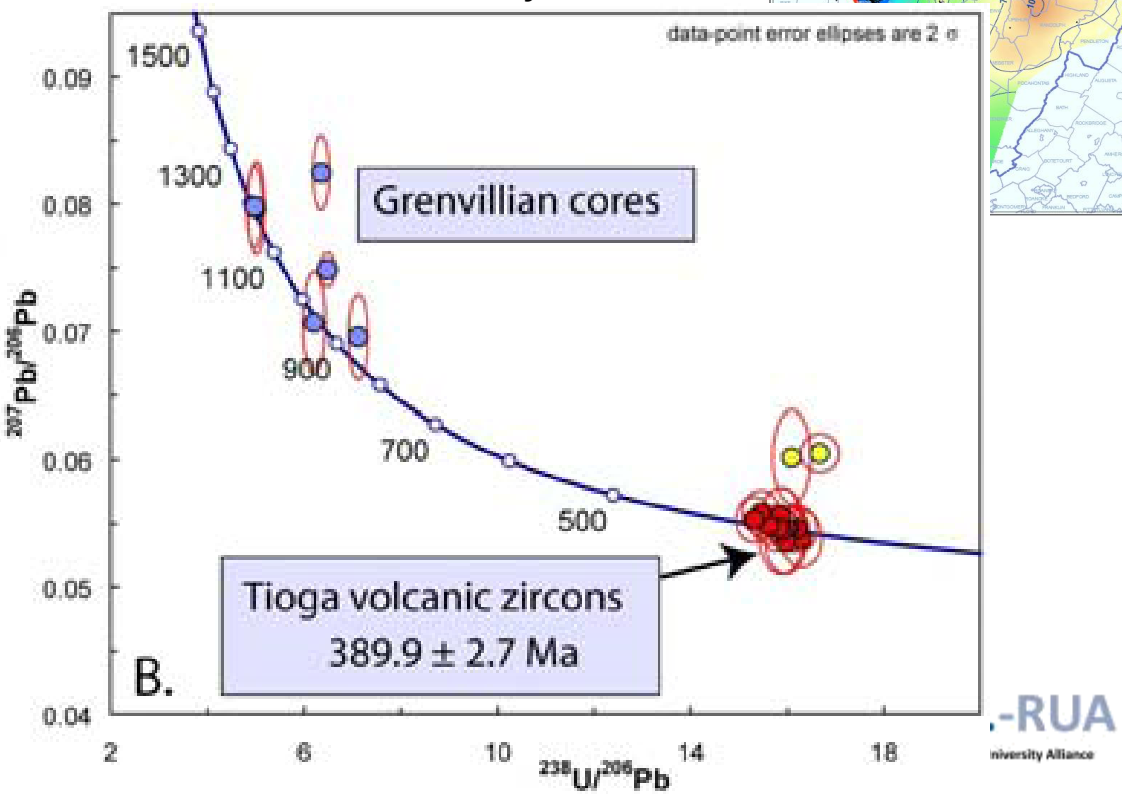
Discontinuous but widespread volcanic ashes within the Appalachian Basin

→ Tioga K-Bentonites

→ Two ashes analyzed

- → Clearfield County
- → Greene County





Methods

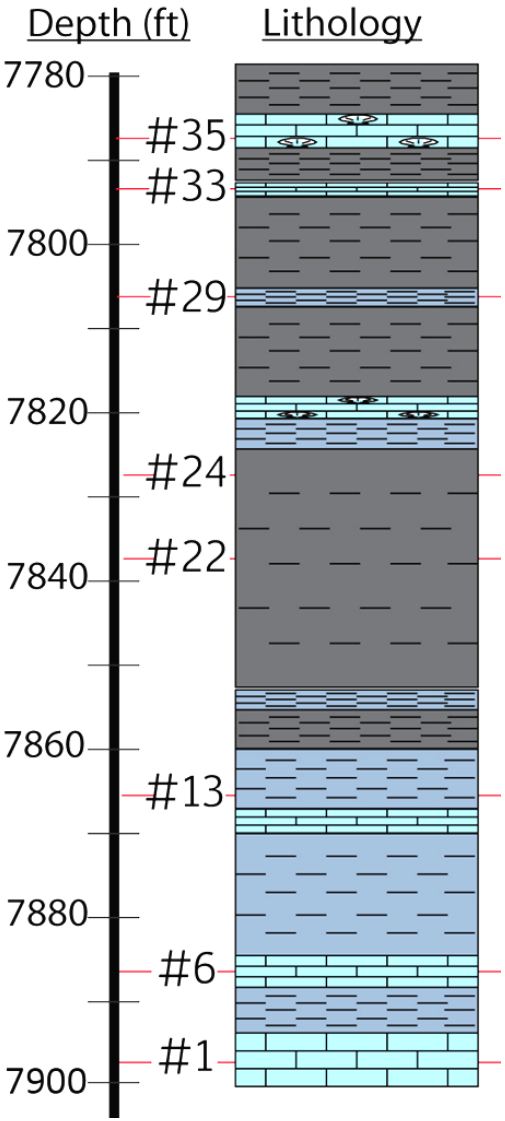
Shale and limestones

- Sequential extraction
  - Acetic acid soluble fraction → carbonate minerals
  - Residue → clastic silicates, organic matter

Volcanic ashes

- Total dissolution (HNO_3-HF-$HClO_4$)

- Nd isotopes by TIMS
- Sr isotopes by MC-ICP-MS

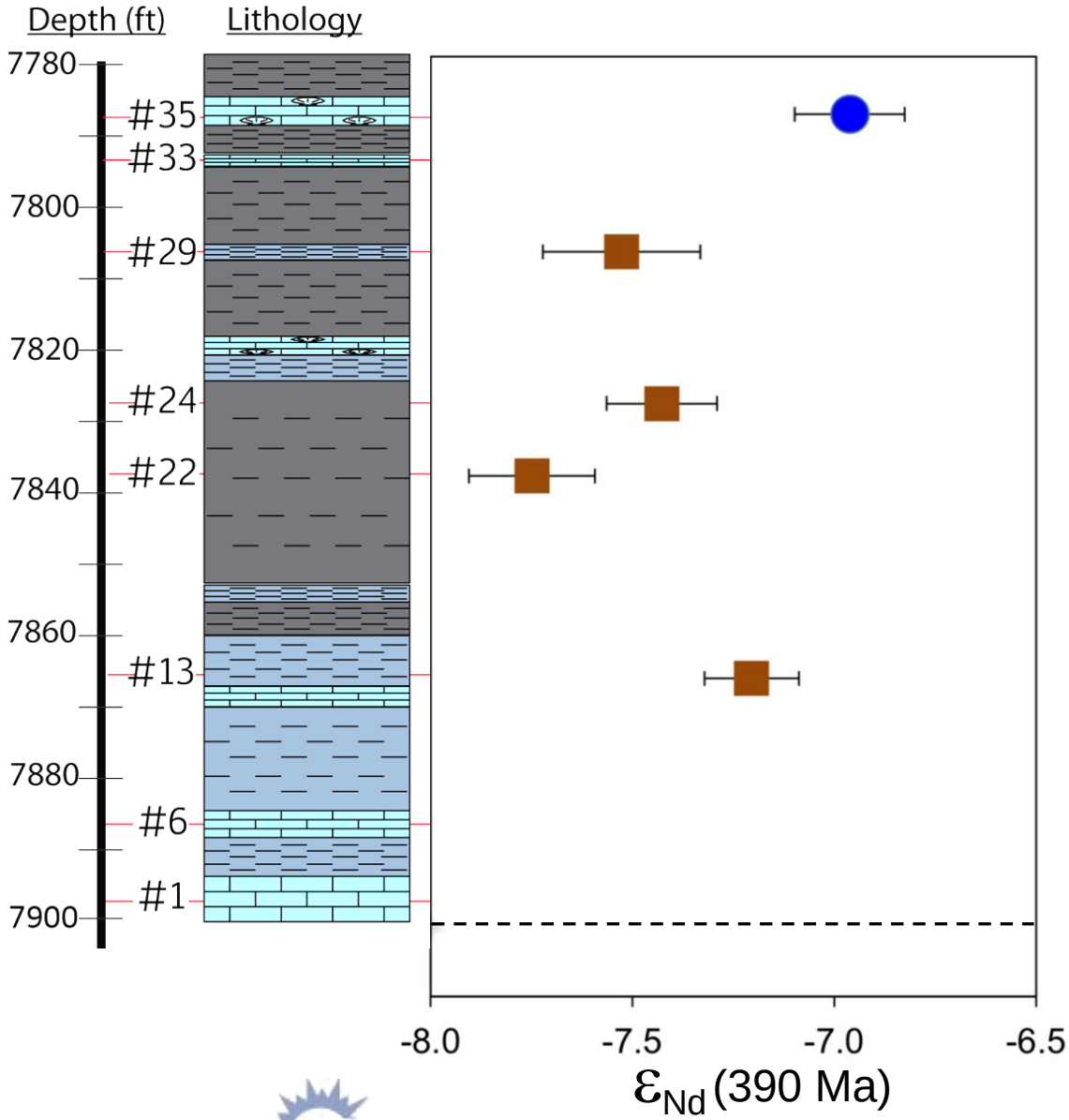


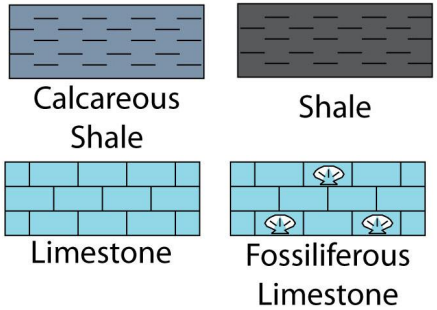
Results: Neodymium isotopes

Silicate/organic residue from shale and limestone

- narrow range
- ε_{Nd}: -7.0 to -7.8

Both derived from older crustal source





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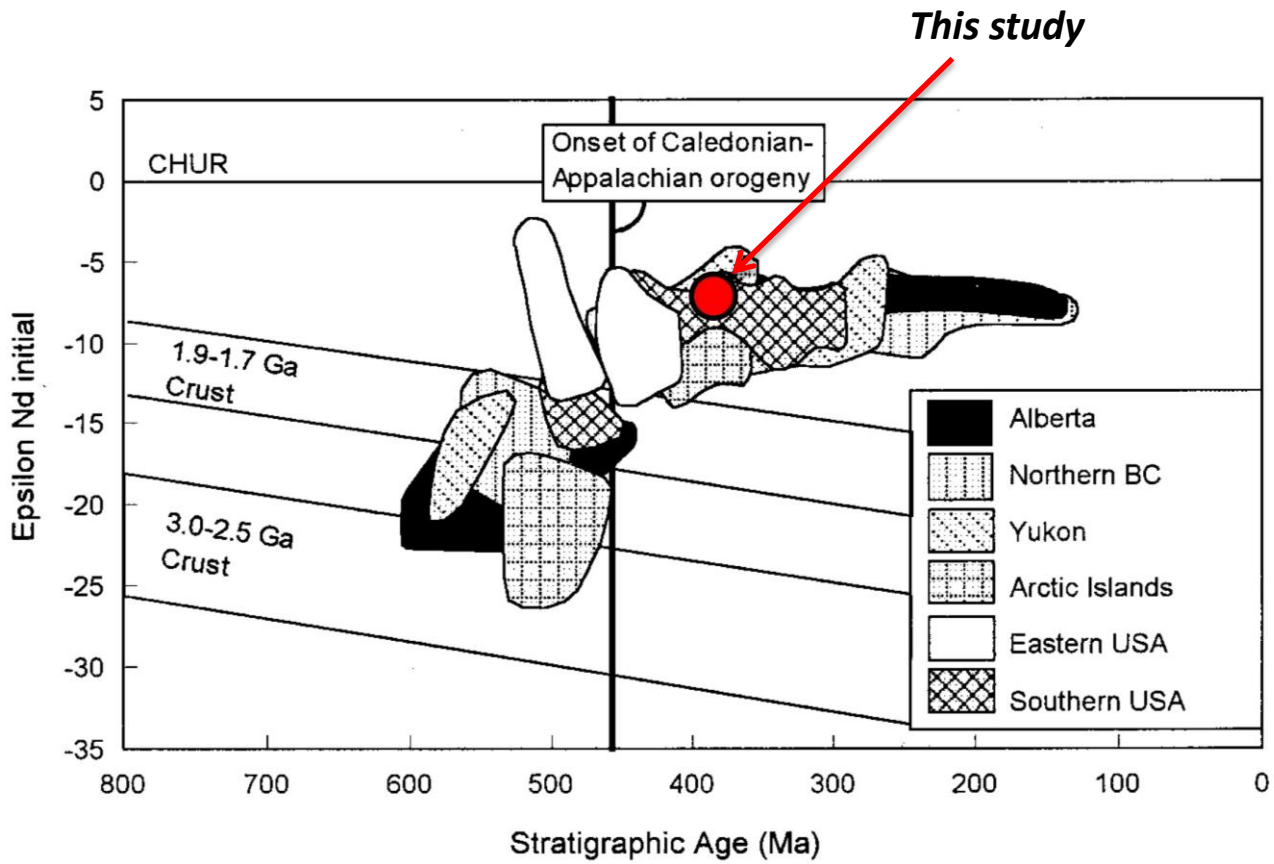
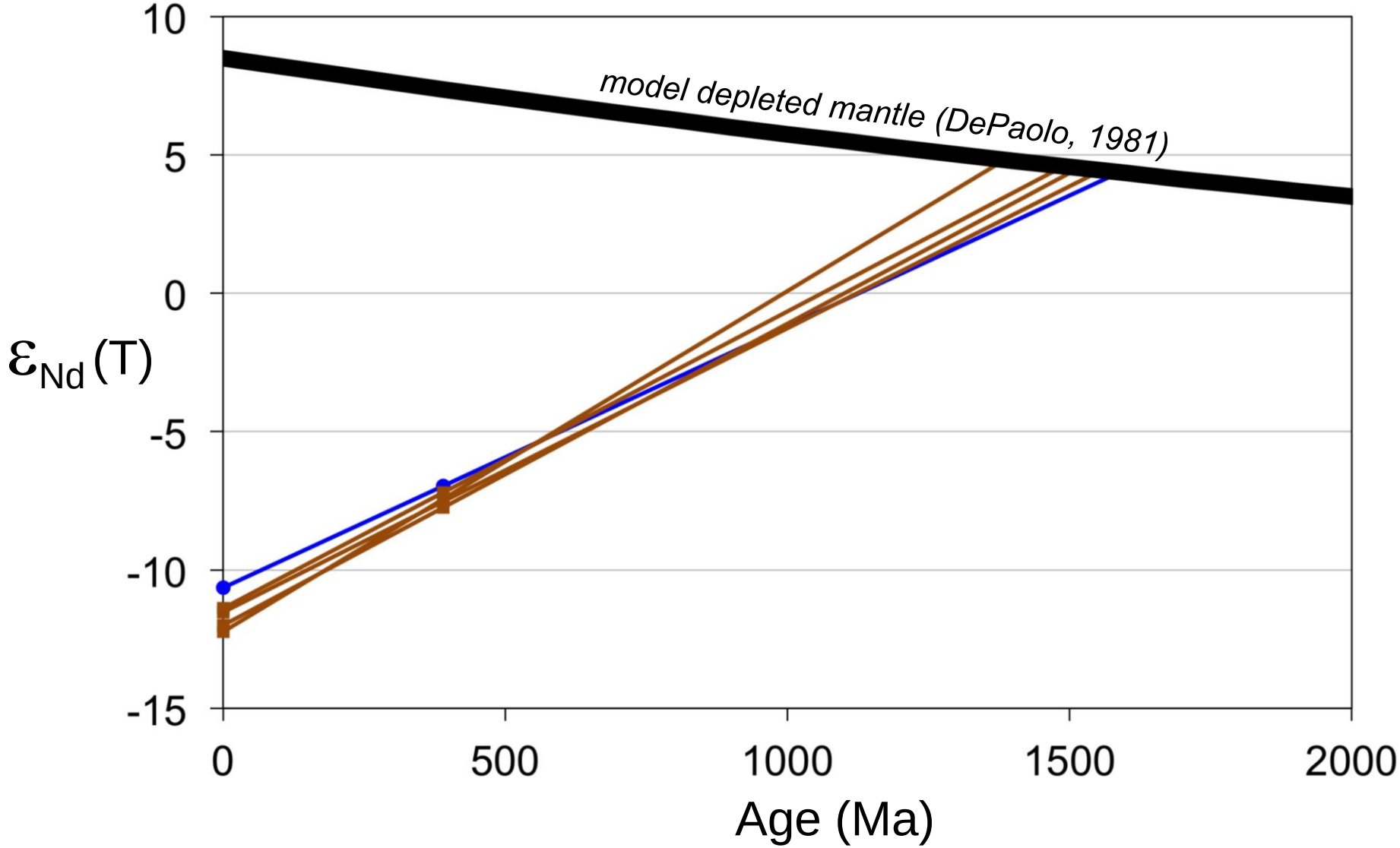
Results: Neodymium isotopes

- Consistent with other Appalachian sediment sources in eastern/southern USA



Patchett et al. 1999

Neodymium isotopes: Model ages



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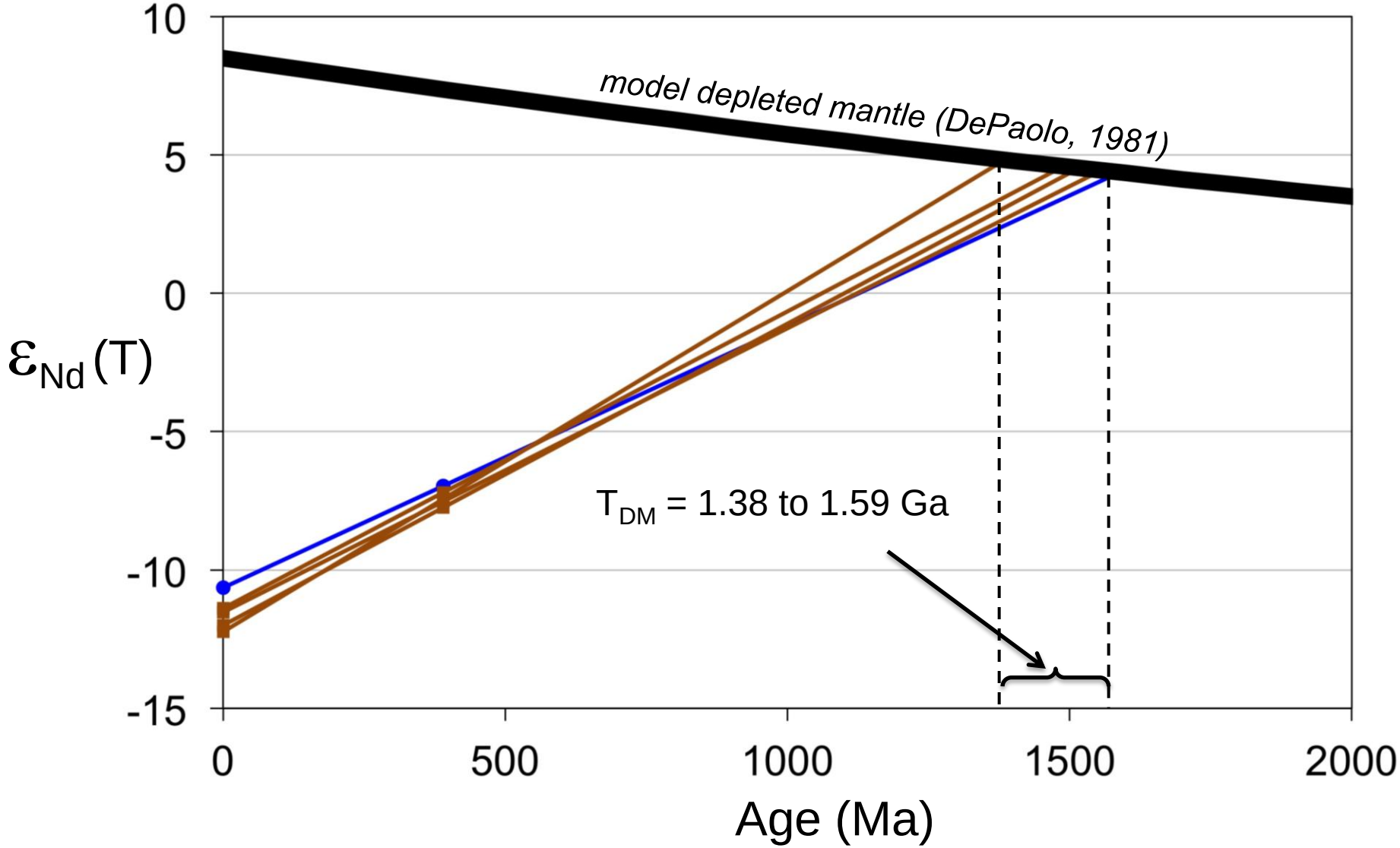
Neodymium isotopes: Model ages



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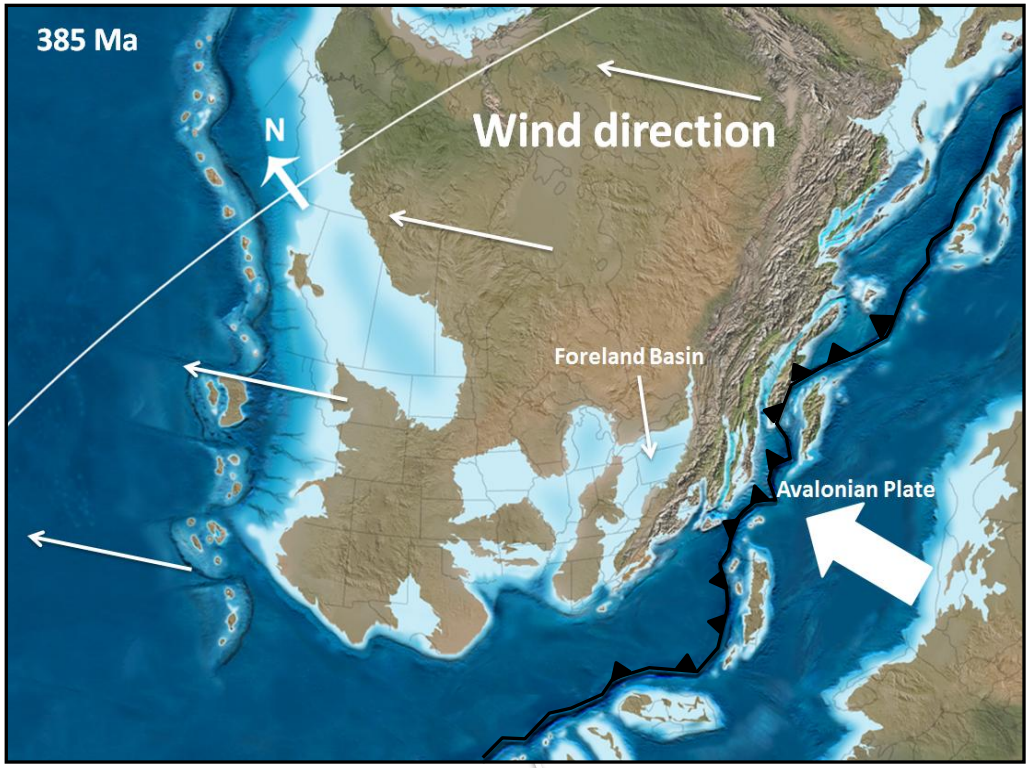
Acadian Paleogeography

→ Grenville and older Laurentian (1.8 Ga) rocks and recycled sediments



Blakey Paleogeography Maps
Wind direction from Parrish (1982)

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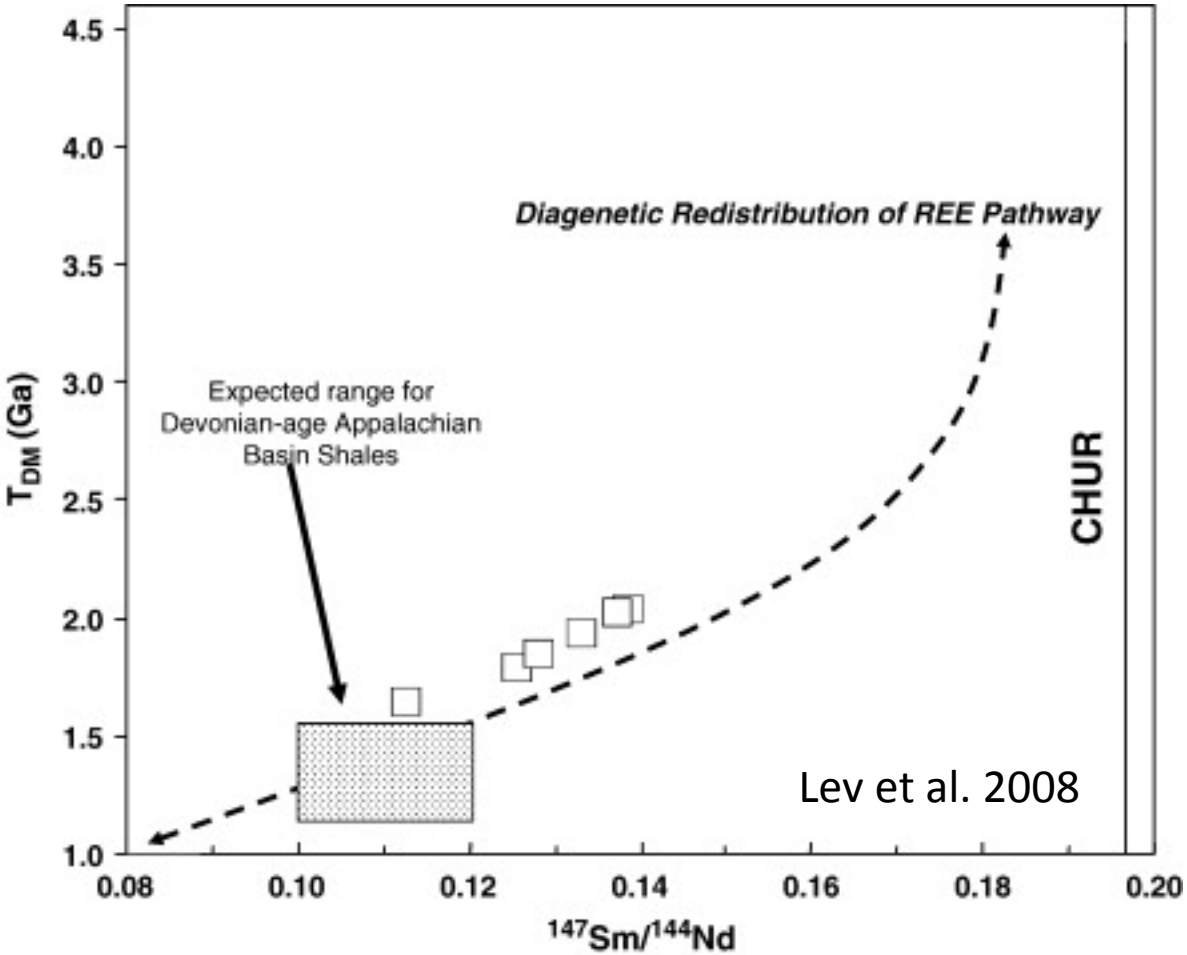
ε_{Nd} initial vs. Stratigraphic Age

Disturbance indicated by elevated Sm/Nd (Lev et al 2008)



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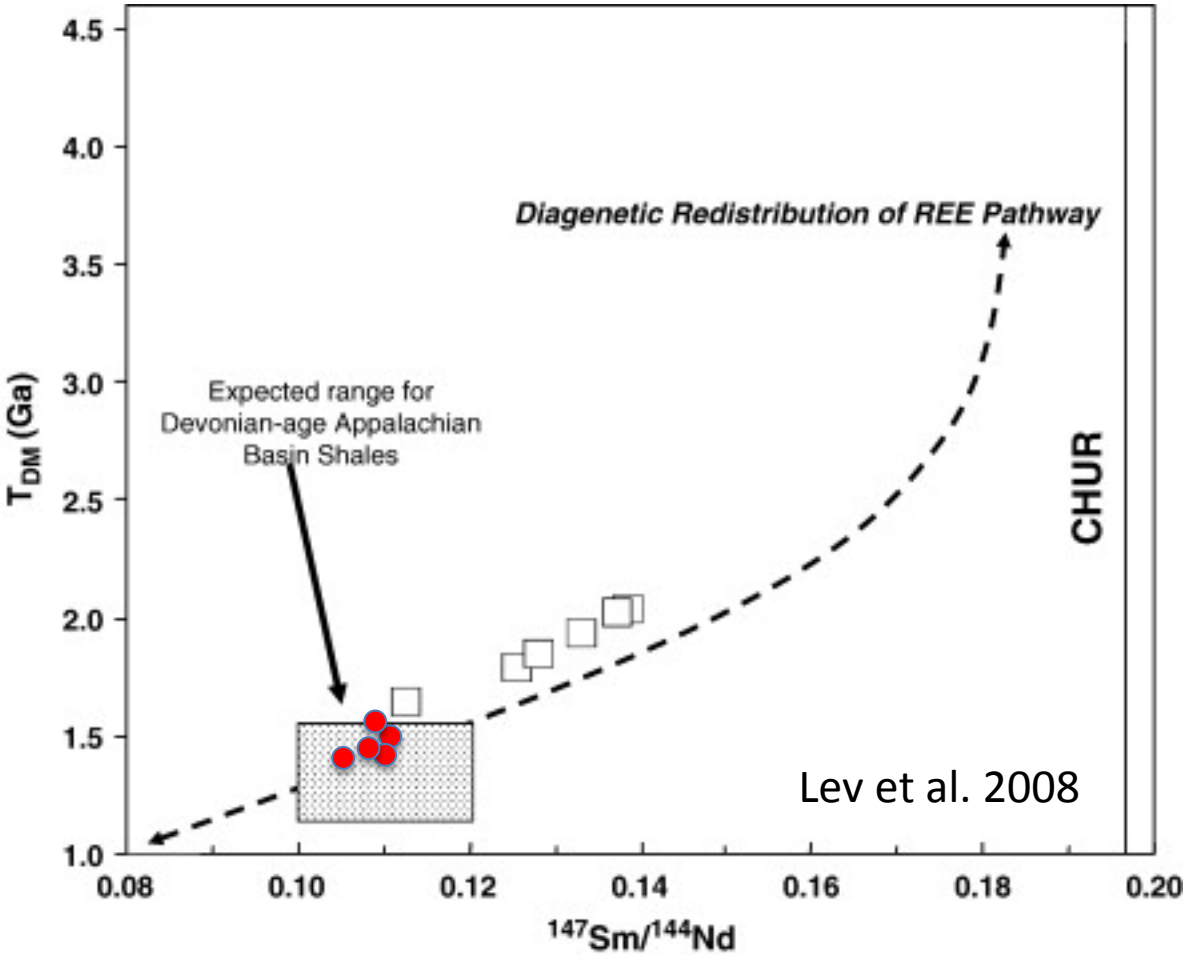
ε_{Nd} initial vs. Stratigraphic Age

Disturbance indicated by elevated Sm/Nd (Lev et al 2008)

Marcellus shales appear to be unaffected by diagenesis



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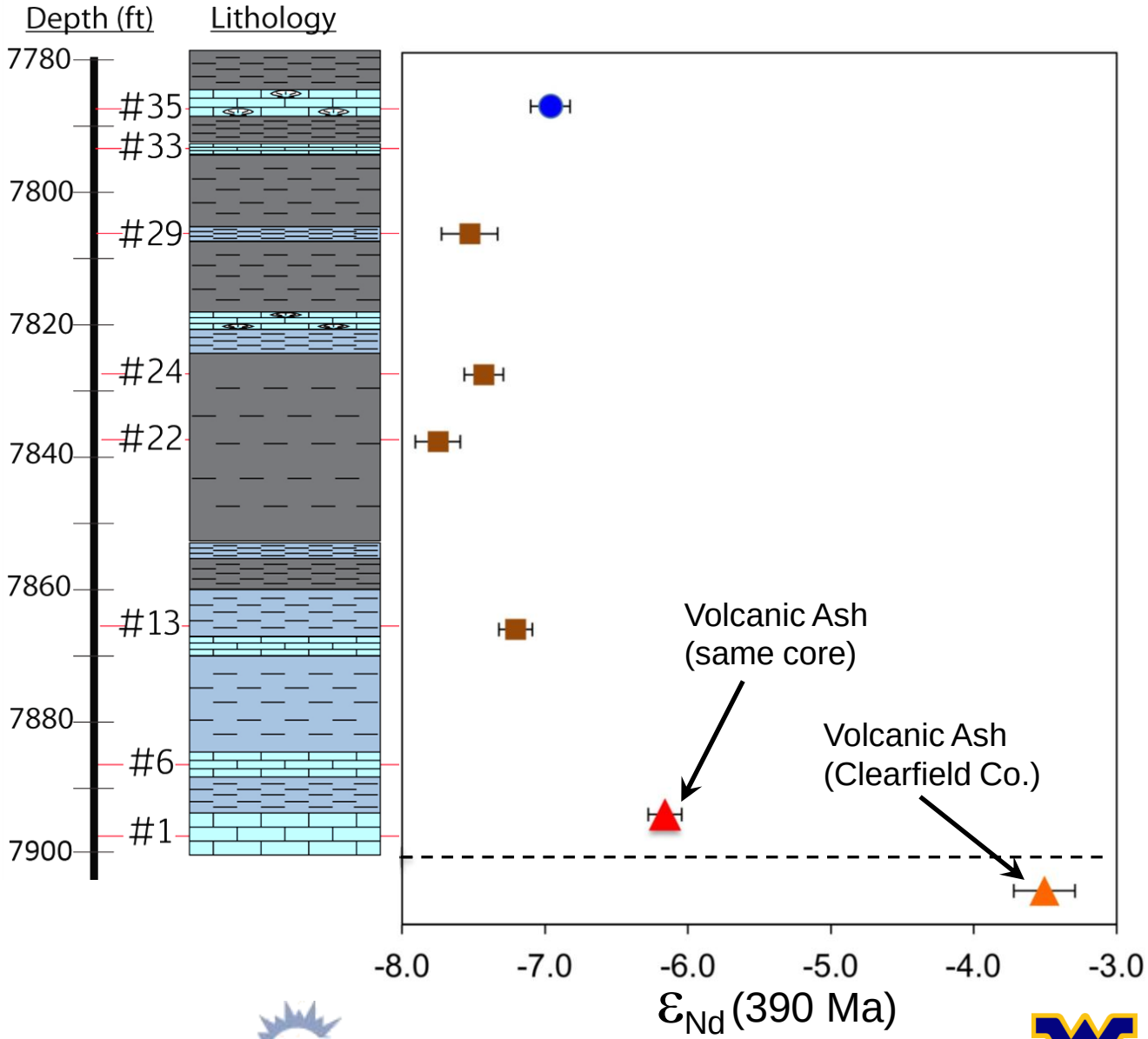
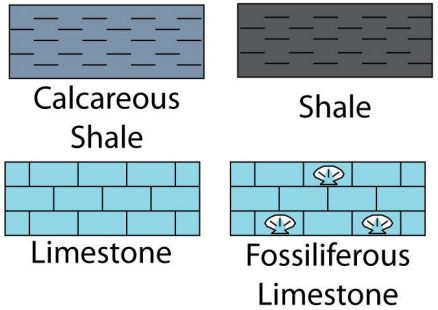
Results: Neodymium isotopes

- Volcanic ash generally higher ε_{Nd} values
- Probably mixtures of Grenville age crust and juvenile mantle component





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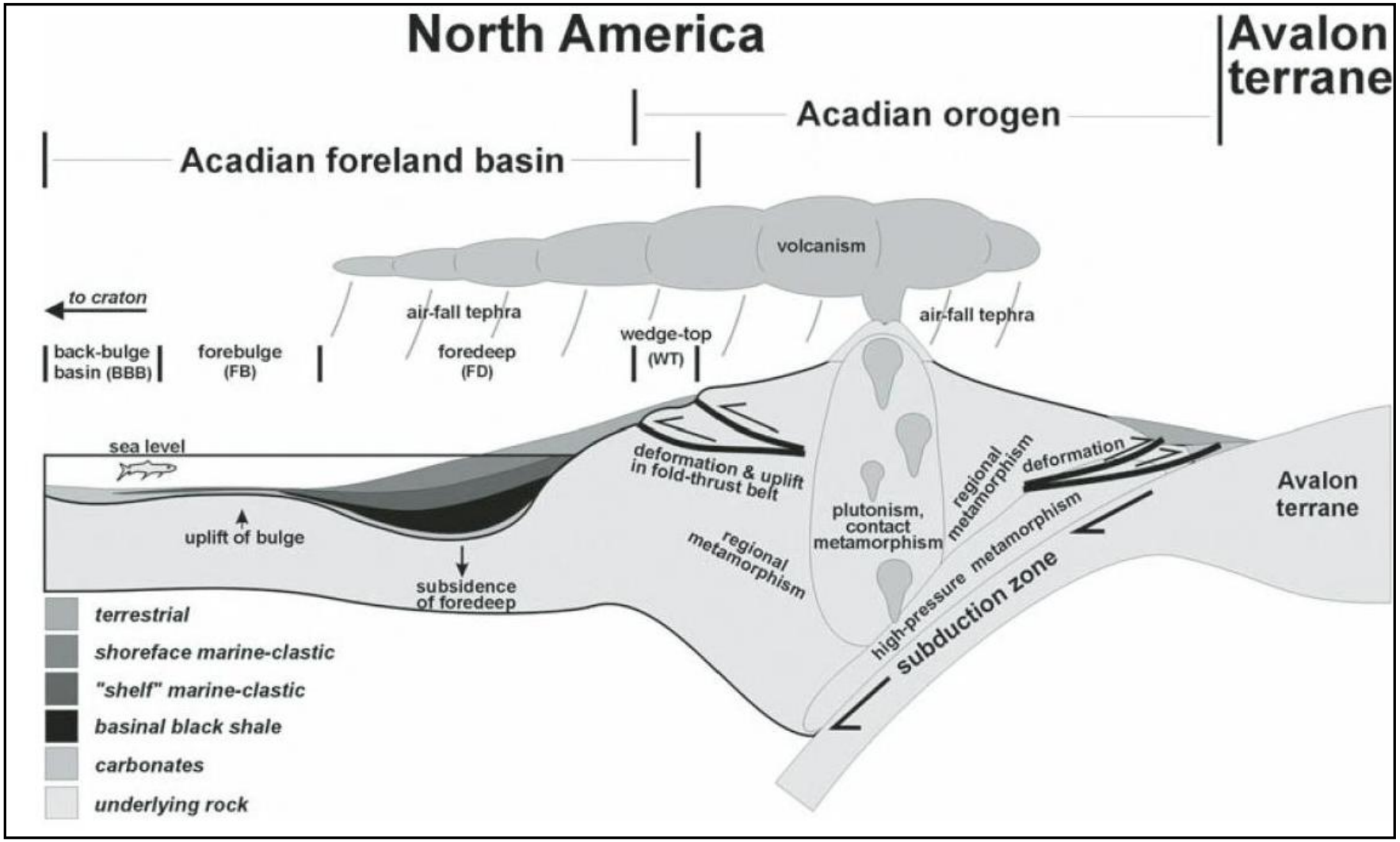
Volcanic ash



Ver Straeten, 1994

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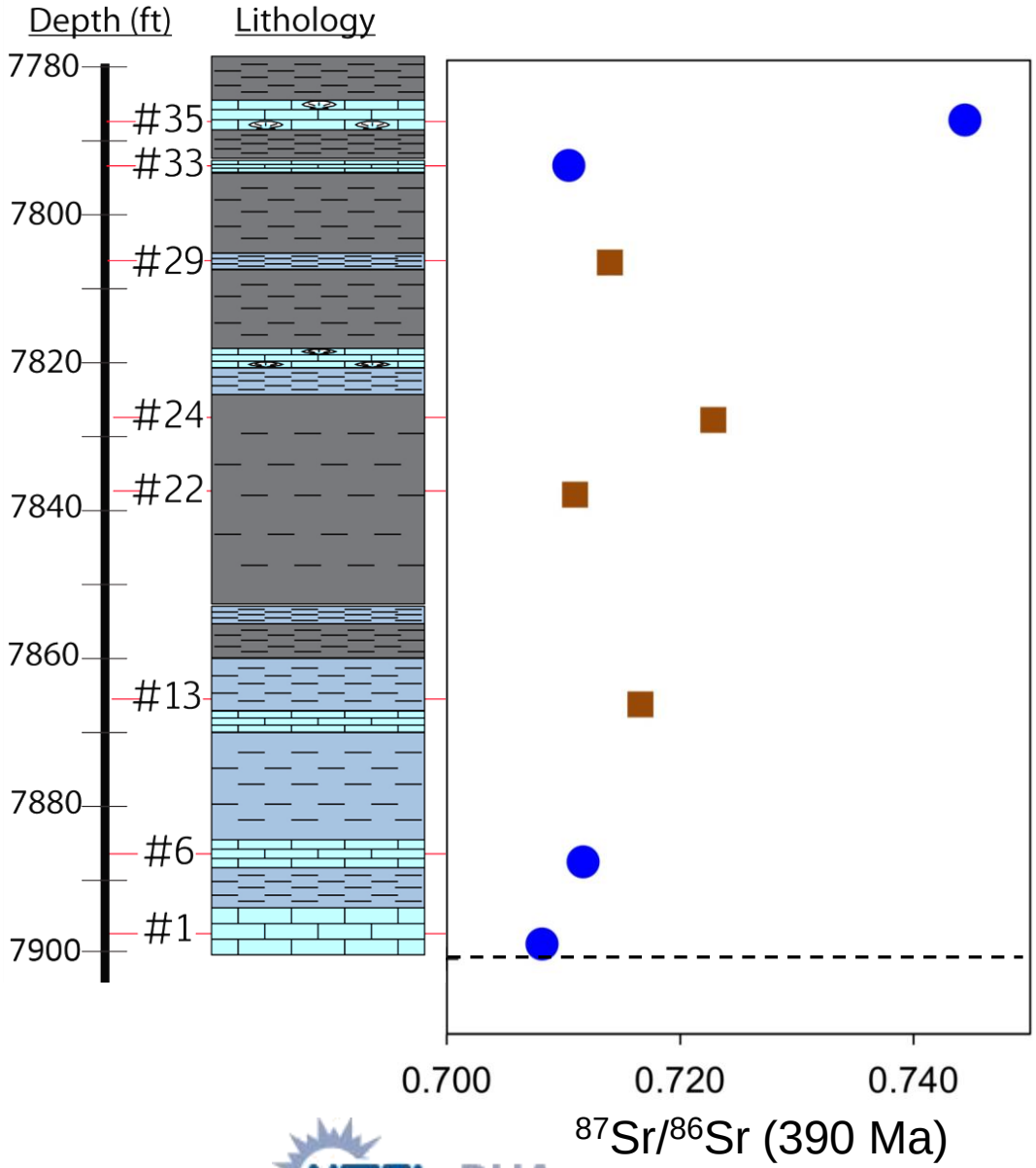
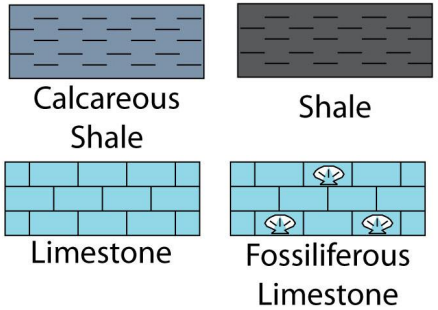
Results: Strontium isotopes

Residues: wide range of initial $^{87}Sr/^{86}Sr$

No systematic difference between limestone and shale residues





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Results: Strontium isotopes

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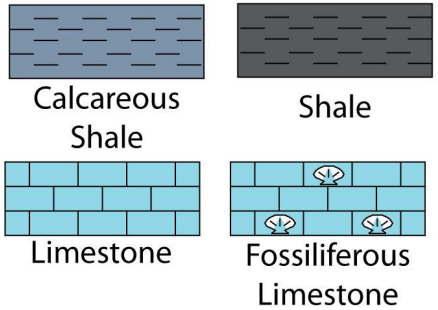
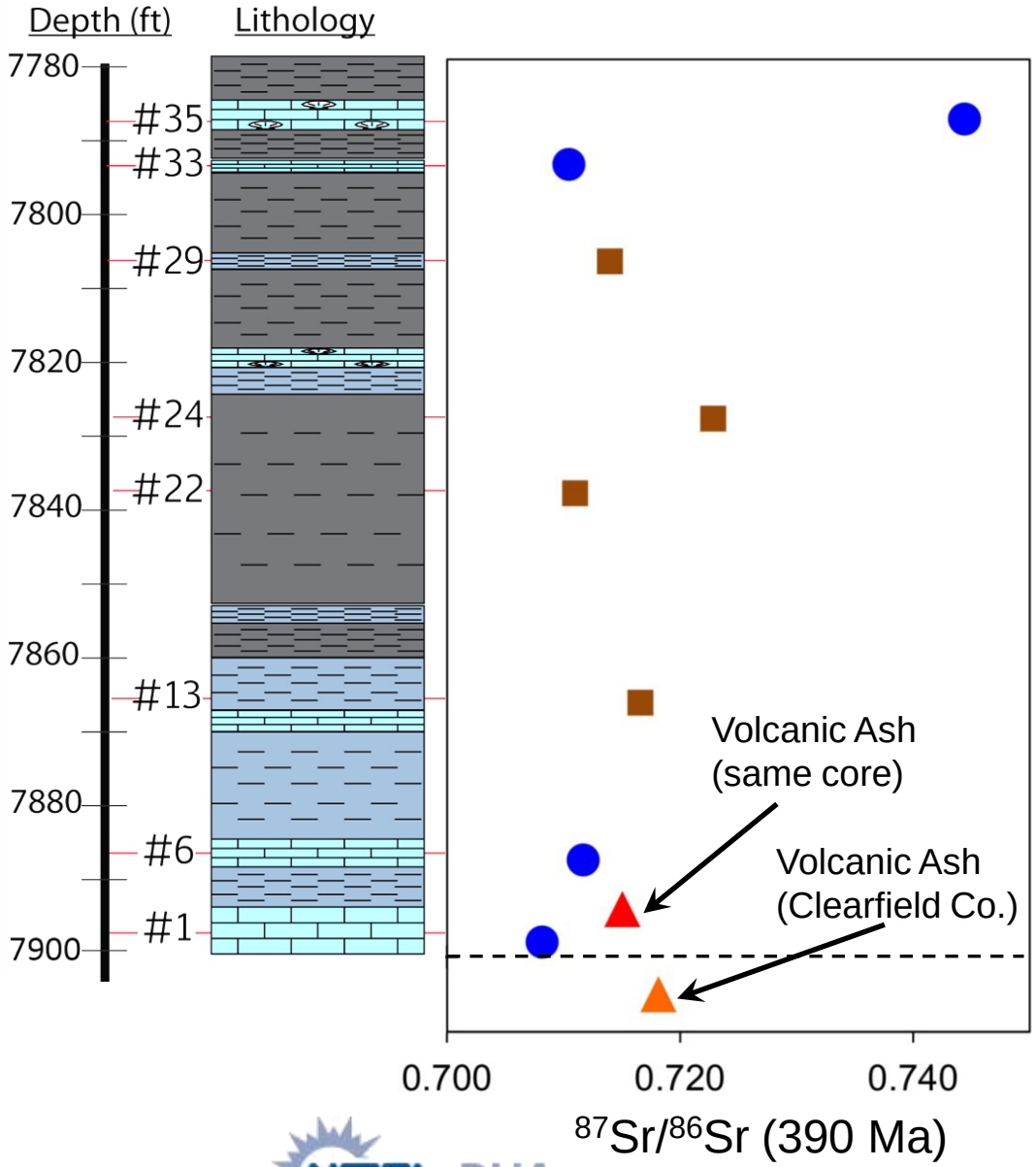
Volcanic ash values within range of clastic sediment residues





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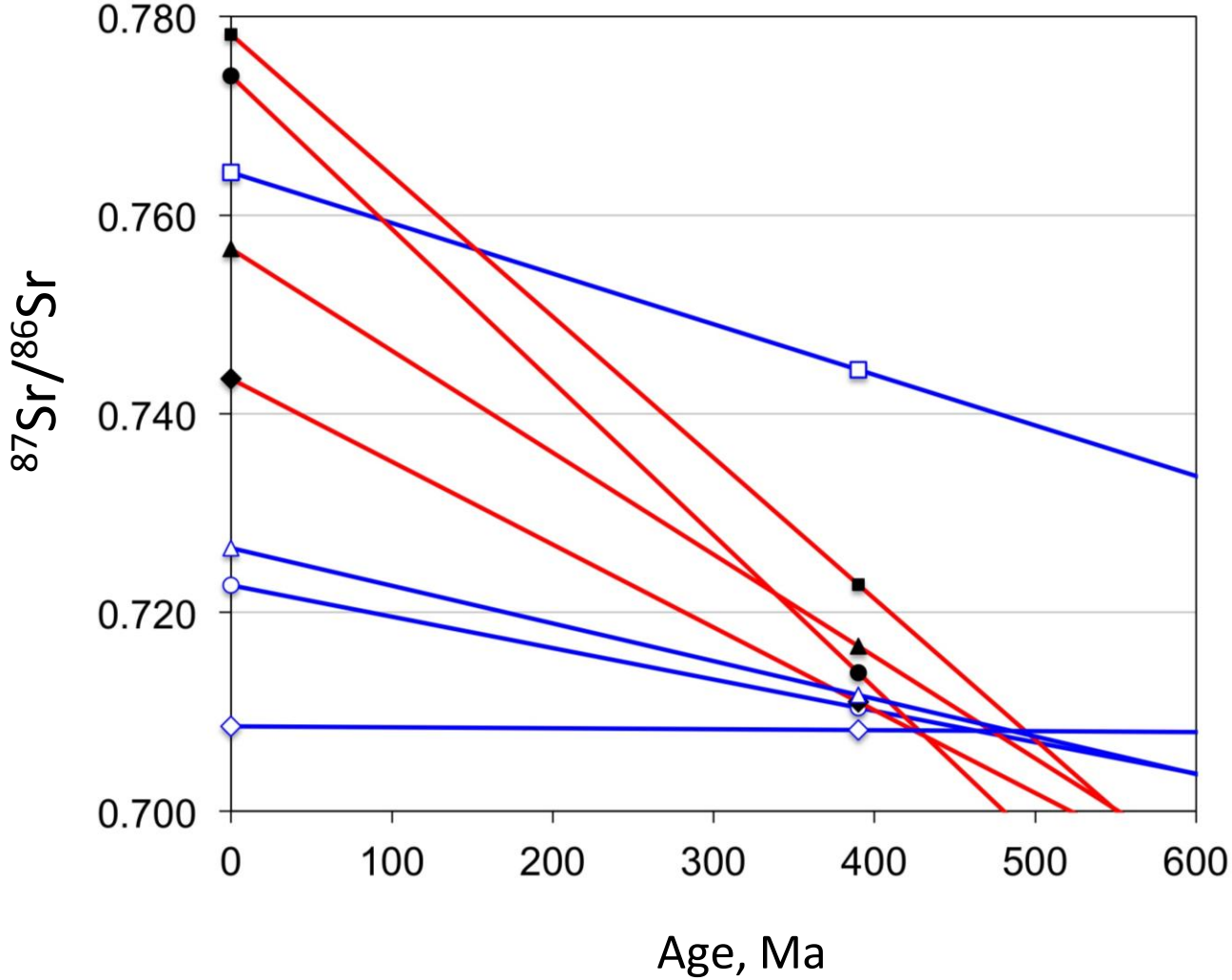
Strontium isotopes *vs*. age

Values corrected back to 390 Ma

- Converge to middle Paleozoic
- **No evidence for later resetting**



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Conclusions

Nd isotope data are consistent with a sediment source dominated by orogenic highlands to the east

- Clastic silicate minerals and organic matter yield ε_{Nd}(390 Ma) values within a tight range of -7.4±0.4
- Depleted mantle model ages for the residue samples range from 1.4 to 1.6 Ga, consistent with Grenville age crust

Tight clustering of model ages and Sm/Nd ratios suggest minimal post-depositional disturbance to the organic and clastic portion of the shale lithologies from this core

- Sr isotope data show no evidence of major disturbance to silicate portion subsequent to Devonian

Acknowledgements

Funding: NETL RUA

Megan Achille, Kelley Flannery, Courtney Kolesar, Sara Lavin, Gwen MacPherson, Chantelle Parrish, Katherine Roll, and Andy Wall

Disclaimer

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