The influence of sandstone caprock material on channel steepness in the Buffalo National River Basin, AR

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Buffalo National River Basin
Ozark and Boston Mountains Region
• Uplift coincident with Ouachita-Appalachian orogeny
  • Tectonically inactive
• Series of uplifted and dissected plateaus
• Gently dipping Ordovician to Pennsylvanian strata
• Integral method of channel profile analysis & chi gradients
  • Perron and Royden (2013)

• Quantify channel steepness with effect of basin area removed using chi gradients

• Analysis was done using LSDTopoToolbox
  • Calculates chi gradient and drainage area at evenly spaced nodes along channel
  • Concavity is 0.45
  • Basins below $10^{5.7} \text{m}^2$ were trimmed

Where

$$m_{\chi} = \left( \frac{U}{K A_0^{m}} \right)^{1/n}$$

$$\chi = \int_{x_0}^{x} \left( \frac{A_0}{A(x)} \right)^{m/n} \text{d}x$$
Map of chi gradient values

Log Chi slope
-3.568 - -0.9225
-0.9224 - -0.4420
-0.4419 - -0.1045
-0.1044 - 0.2179
0.2180 - 0.8779

Geologic unit
- Pennsylvania Sandstones
- Mississippian Fayetteville, Pitkin, Batesville
- Mississippian Boone
- Ordovician Everton
Highest chi gradients in tributary channels below sandstone caprock
Even high chi gradients in channels beneath sandstone islands

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Lowest chi gradients in tributary channels where caprock is absent
Lowest chi gradients in tributary channels where caprock is absent
Segmentation of channels to avoid serial correlation

- Each channel is divided into reaches separates by junctions
- Further subdivided into lithologic reaches
- Node chi gradient values were averaged for each lithologic reach
  - Each reach is represented by a single chi gradient value
- Data showed no serial correlation
- Nemenyi multicomparison test was used to determine if different lithologies have systematic differences in chi gradient
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• Lithology is not the dominant control on channel steepness despite strong contrast in rock properties

• Chi gradients are statistically distinct between capped and uncapped basins
Boulders from Bloyd Fm, the dominant caprock in the basin
• Boone reach has multiple landslides and some large sandstone boulders in channel

• Minimal Influence of sandstone caprock on reaches in Everton Fm
In the Buffalo Basin:

- No constraints on erosion rates or erodibility values

- Can still use ratios of chi gradients to get relative erosion rates or relative erodibility under certain assumptions
  - $n=1$
• Assume erodibility is solely a function of lithology
  - Allows maps of relative erosion rates in a given lithology

• Assume erosion rates of Boone and Everton are equal in the main stem
Relative erosion rates

Relative E

- 0.00 - 0.66
- 0.67 - 1.54
- 1.55 - 2.96
- 2.97 - 5.19
- 5.20 - 10.05

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Assume erosion rates throughout the basin are equal

Don’t assume erodibility is solely a function of lithology
  • Determine relative erodibility

n=1

Reference chi gradient value is the mean of all chi gradient values in the basin
Relative erodibility

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<thead>
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Conclusions

- Dominant control on bedrock channel steepness is not substrate lithology, but sediment supply from sandstone caprock
  - Overwhelm channel’s ability to mobilize sediment
  - Removal of caprock material limits the rate of tributary channel erosion
- Ratio of chi gradients
  - Highest relative erosion rates beneath sandstone caprock
  - Lowest relative erodibility beneath sandstone caprock
    - Boulders armor channel and prevent erosion (Sklar and Dietrich, 2004)
- The main stem of the Buffalo is less affected by the sandstone caprock
Questions?
Schmidt Hammer scores of the dominant lithologies in the basin