Erosion rate variability in steady state landscapes: sources and implications

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Overview
Erosion rate variability is:

- **Strong** (order 1 variability)
- *Autogenic* at steady forcing
- Spatially *organized*
- Topographically *recognizable* in the landscape
Erosion facility

video camera
digital cameras

rainfall ($r$)
to water supply

experimental drainage basin

relief ($H_r$)
ground surface

sliding gate ($U$)
overflow

gearbox and motor
cable to sliding gate

‘flux-o-meter’
Constant forcing conditions

![Graph showing water and sediment flux vs. runtime (s) with base level and runoff lines.](image)

- Water and sediment flux (g/s) on the y-axis.
- Runtime (s) on the x-axis.
- Base level and runoff lines plotted over time.
Erosional processes include:

- Surface runoff (very hard to see, but the dominant process)
- Hillslope failures
- Temporary sediment storage (deposition)
- Knickpoint development and migration

*Autogenic, Strong, Organized, Recognizable*
ridge
asymmetry
deposition
failure
and dam
terrace

0 20 (cm)
Sediment Storage and Excavation

Autogenic, Organized, Recognizable
Erosion rate variability

Autogenic, Strong
Divide Migration

Autogenic, Organized; Recognizable (?)
Divide Migration

Autogenic, Organized; Recognizable (?)
Sequential elevations, spatial erosion rates, and flow changes

$T_i$  

$T_{i+1}$ ($h/H_r = 0.3$)

Strong erosion rates $\pm 1.5 \ U$

Organized flow path change  
black = flow reversal  
white = same flow path
Migration: a result of variability

\[ \frac{\Delta x}{\Delta t} = \frac{\delta z_\alpha - \delta z_\beta}{\tan \alpha + \tan \beta} \]

**Autogenic, Organized**

erosional variability is not just flicker: alters landscape structure
Drainage area capture: positive feedback for migration

• Migrating divide captures runoff from adjacent basin
• Decreased runoff on the scavenged side
• Effects erosion rates over sub-basin, which
• Drives more migration

*Autogenic, Organized; Recognizable (?)*
Divide Migration: Recognizable?

- Asymmetric ridges
- Long narrow perched valleys
- Organized spatial erosion rate patterns
- Sediment flux variations between adjacent sub-basins
To summarize:

- Short term variability in erosion rate due to
  - slope failures, temporary sediment storage, and propagating knickpoints
- Drainage capture: positive feedback for migration
- Migration imposes spatially correlated erosion rate patterns on landscape
- Topographic steady state is dynamic!
Do natural drainage basins behave like this?

- Steady state is at least a plausible condition
  - 1 to 3 units of relief have been exhumed/denuded in many places
- Ridge asymmetry is not uncommon
- Perched, narrow sub-basins are not uncommon
- Terraces, often interpreted as changes in climate/tectonics, may be intrinsic features
A road Les traveled...