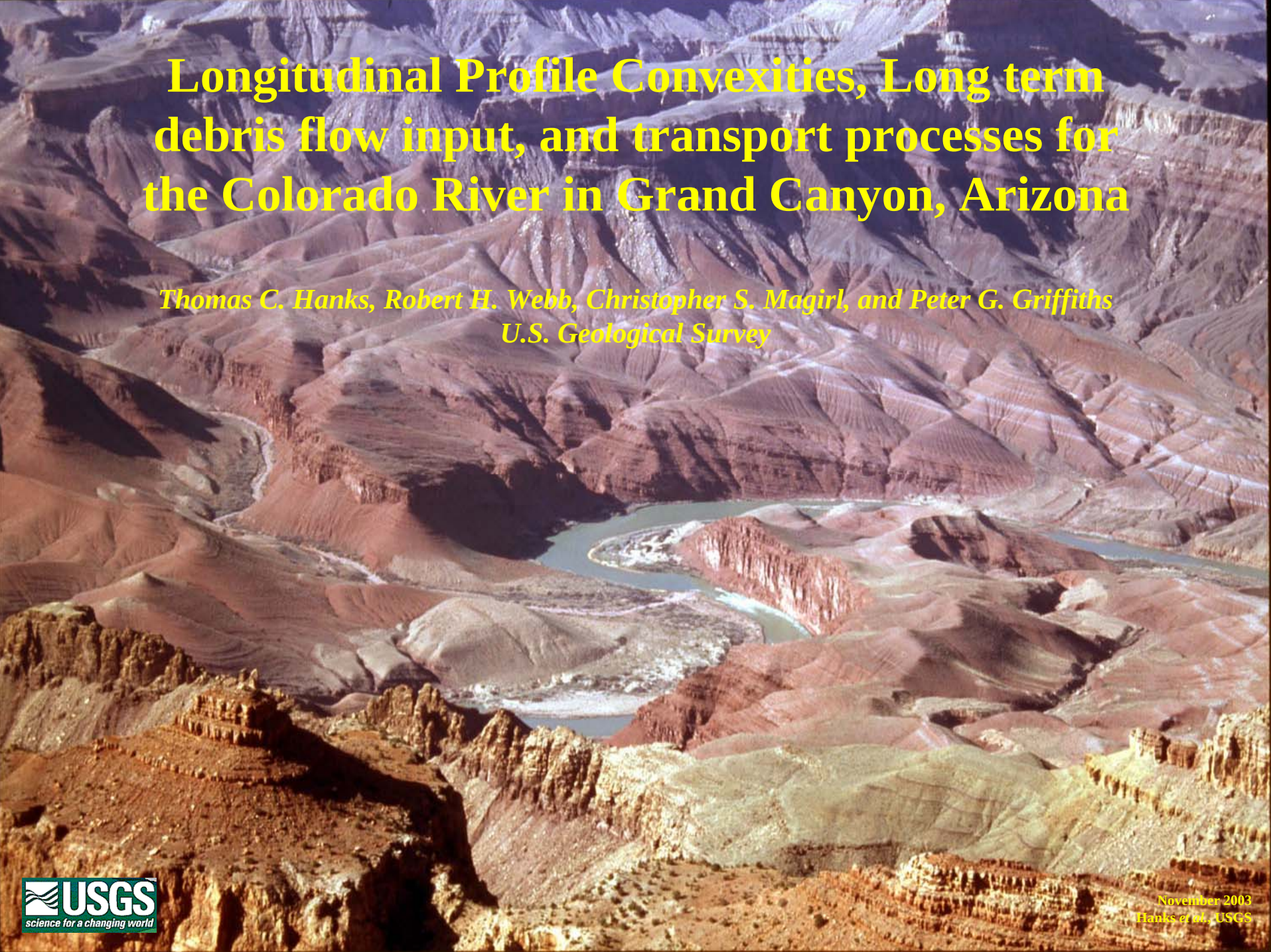
Longitudinal Profile Convexities, Long term debris flow input, and transport processes for the Colorado River in Grand Canyon, Arizona

Thomas C. Hanks, Robert H. Webb, Christopher S. Magirl, and Peter G. Griffiths
U.S. Geological Survey



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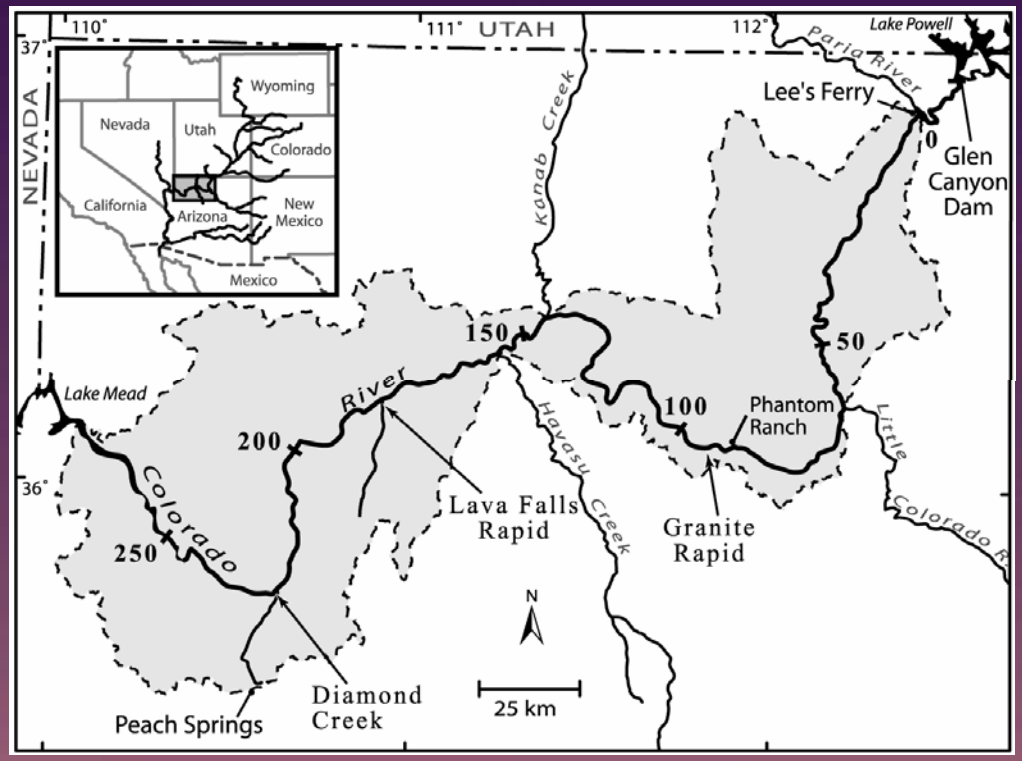
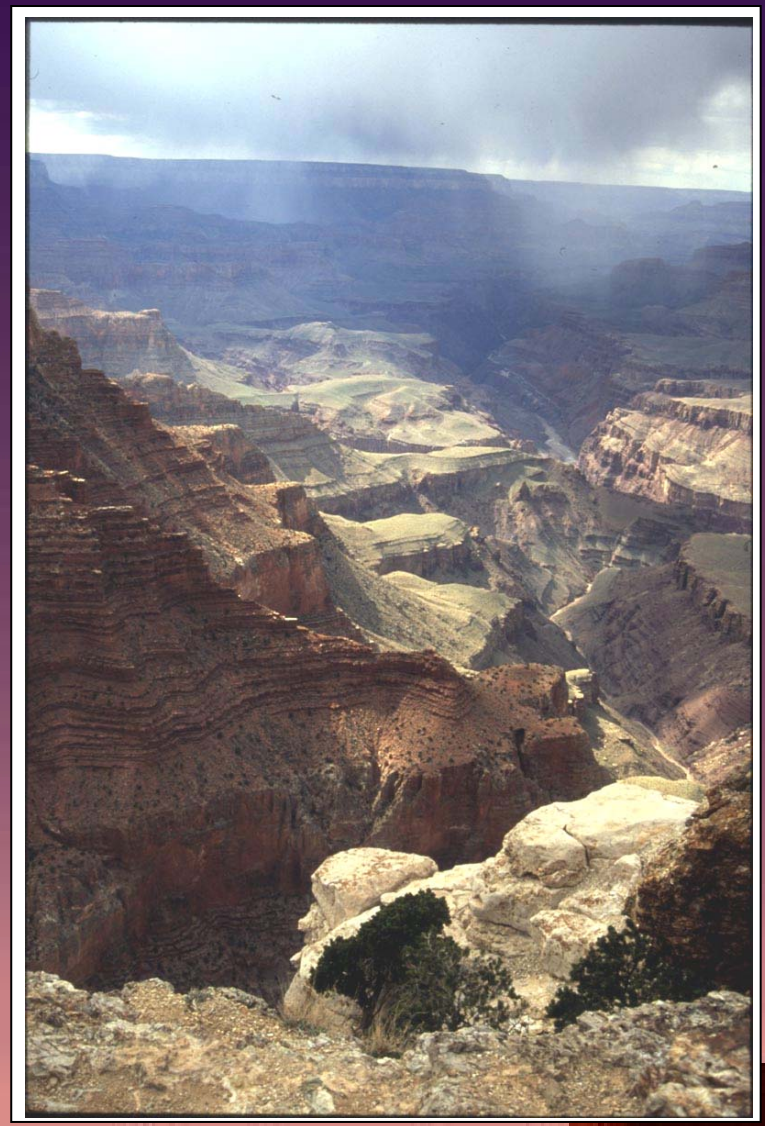
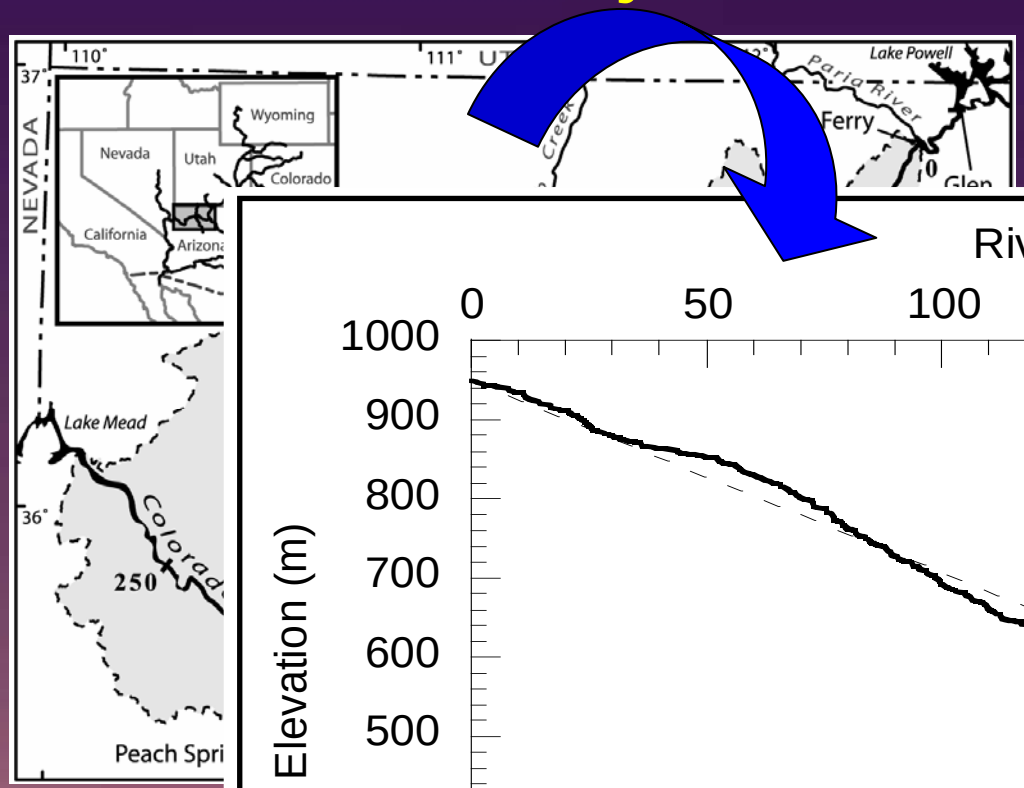
Grand Canyon and the Colorado River





Grand Canyon and the Colorado River

Longitudinal Profile:
USGS, 1923



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Small Scale Convexities—Rapids

Granite Rapid (RM 93.7)

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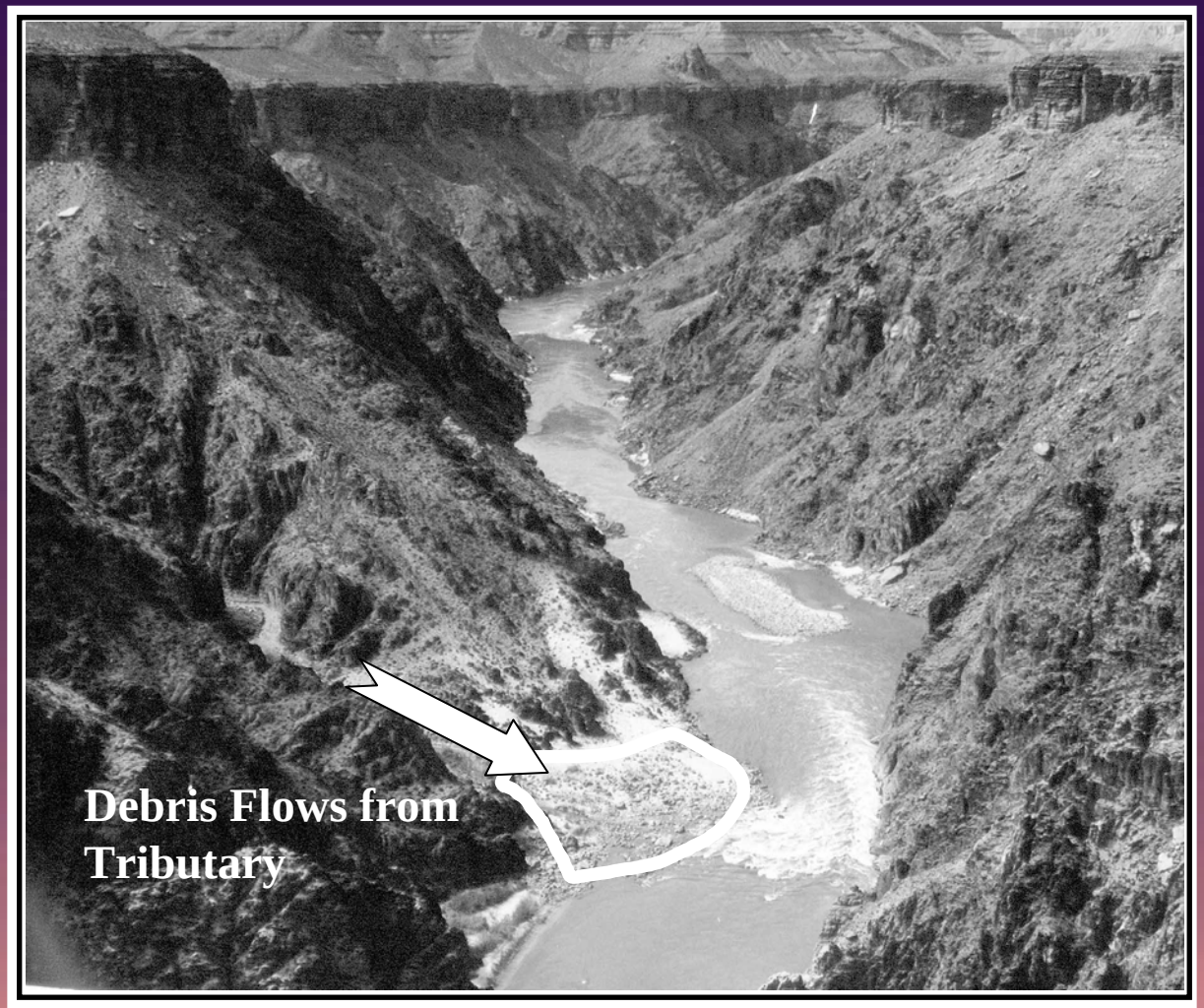
Small Scale Convexities—Rapids



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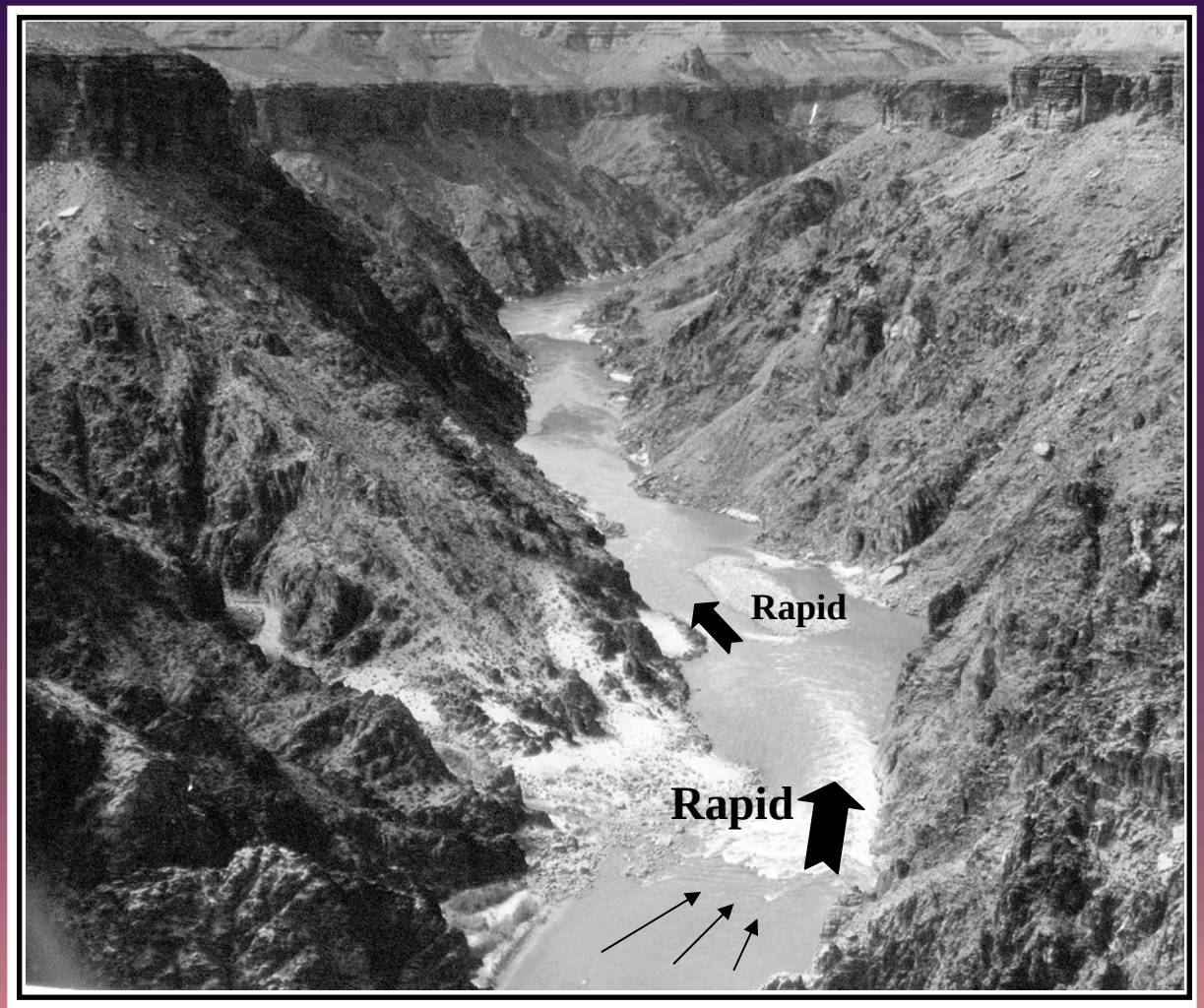

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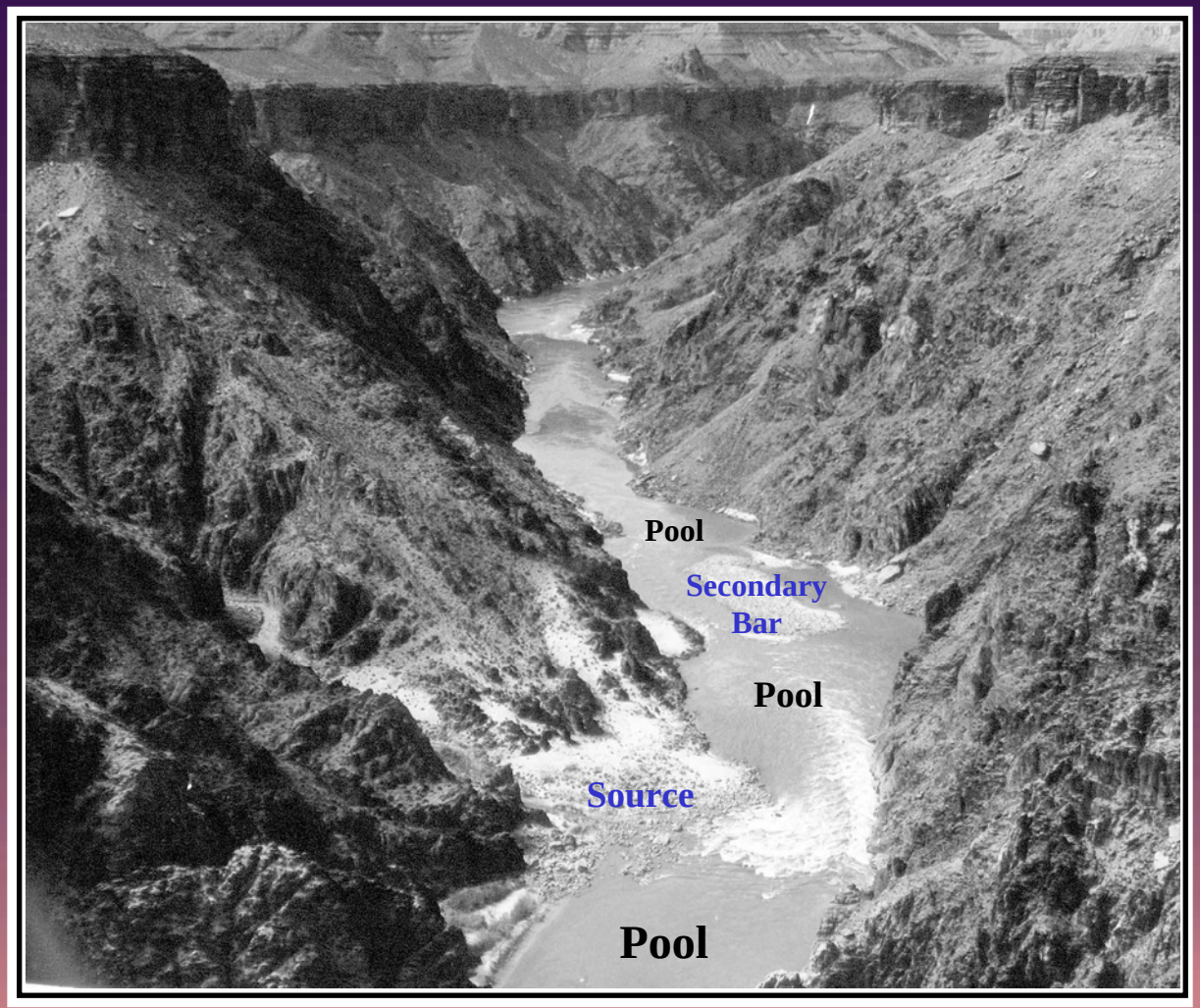

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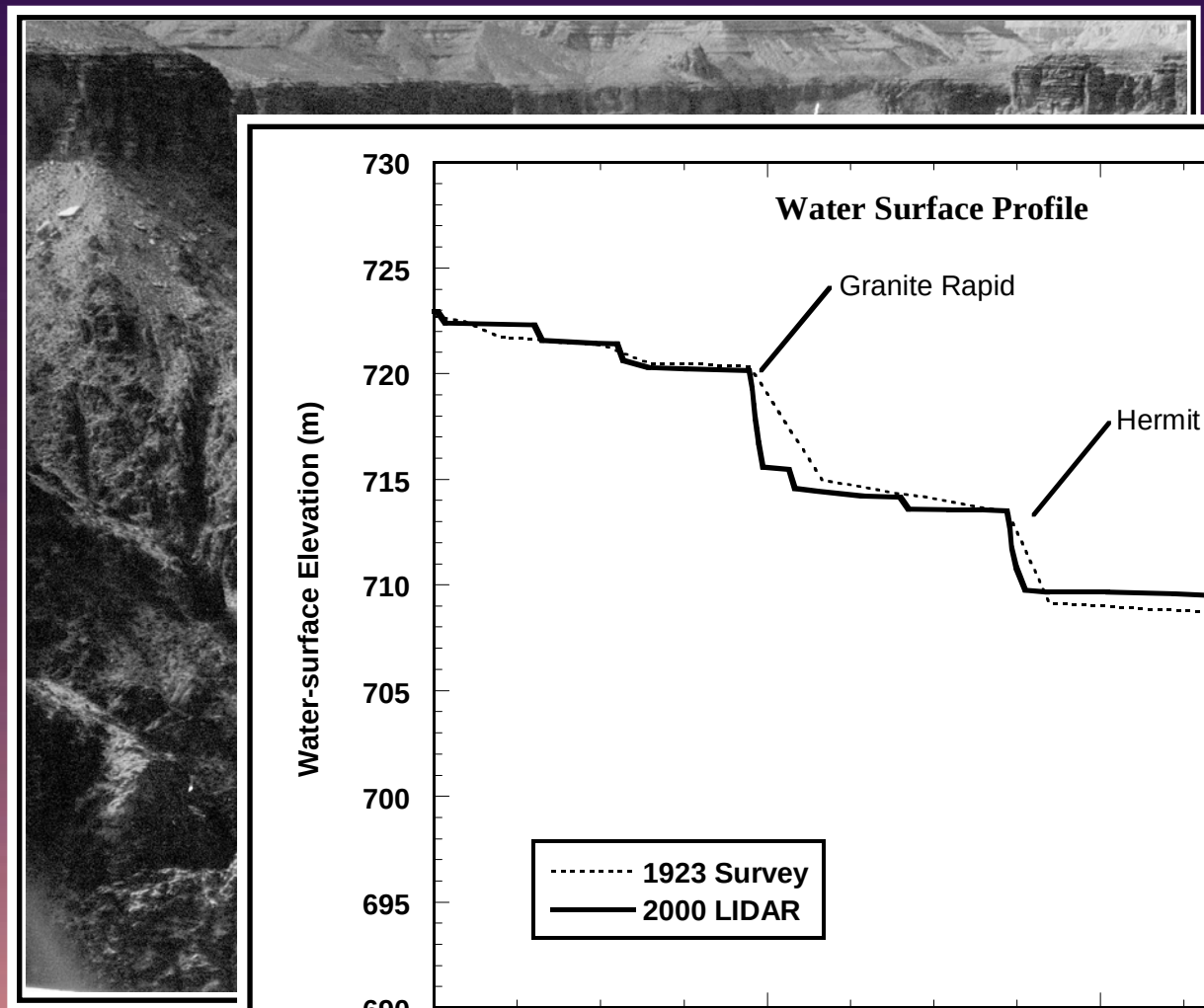
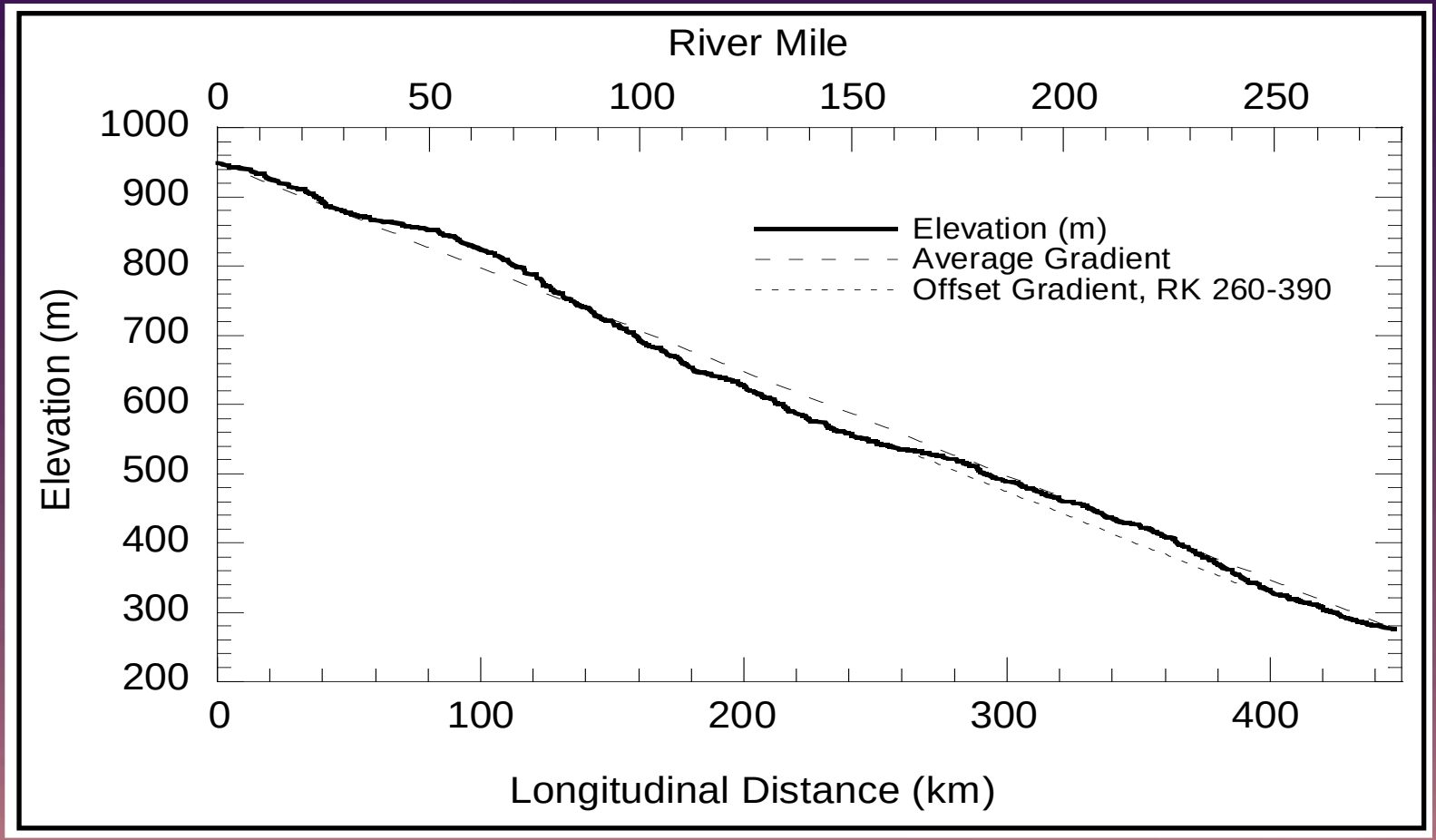


Longitudinal Profile shows long wavelength convexities



Deviation from the average slope is apparent

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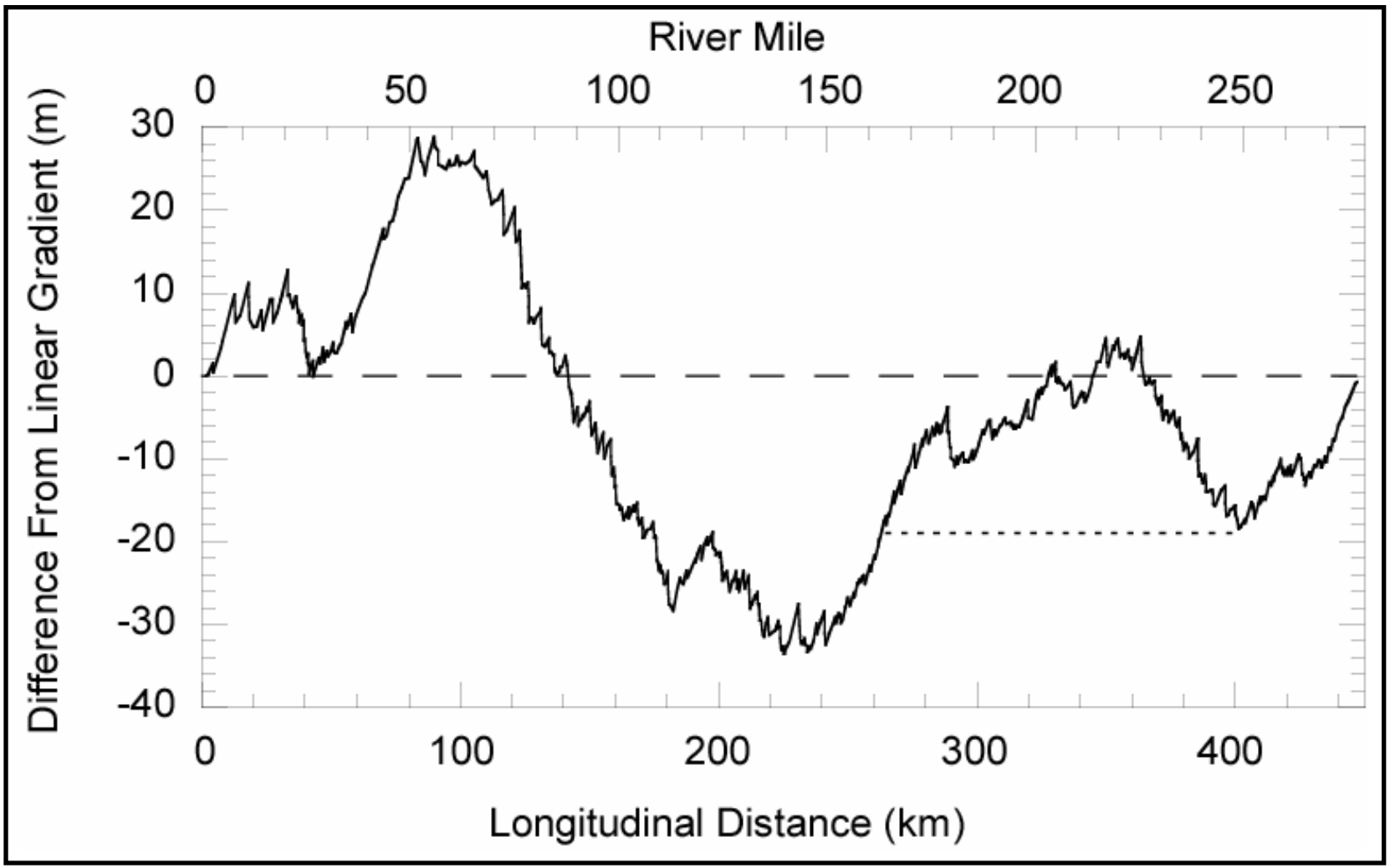
De-trended River Profile



Each scale of convexity becomes visible

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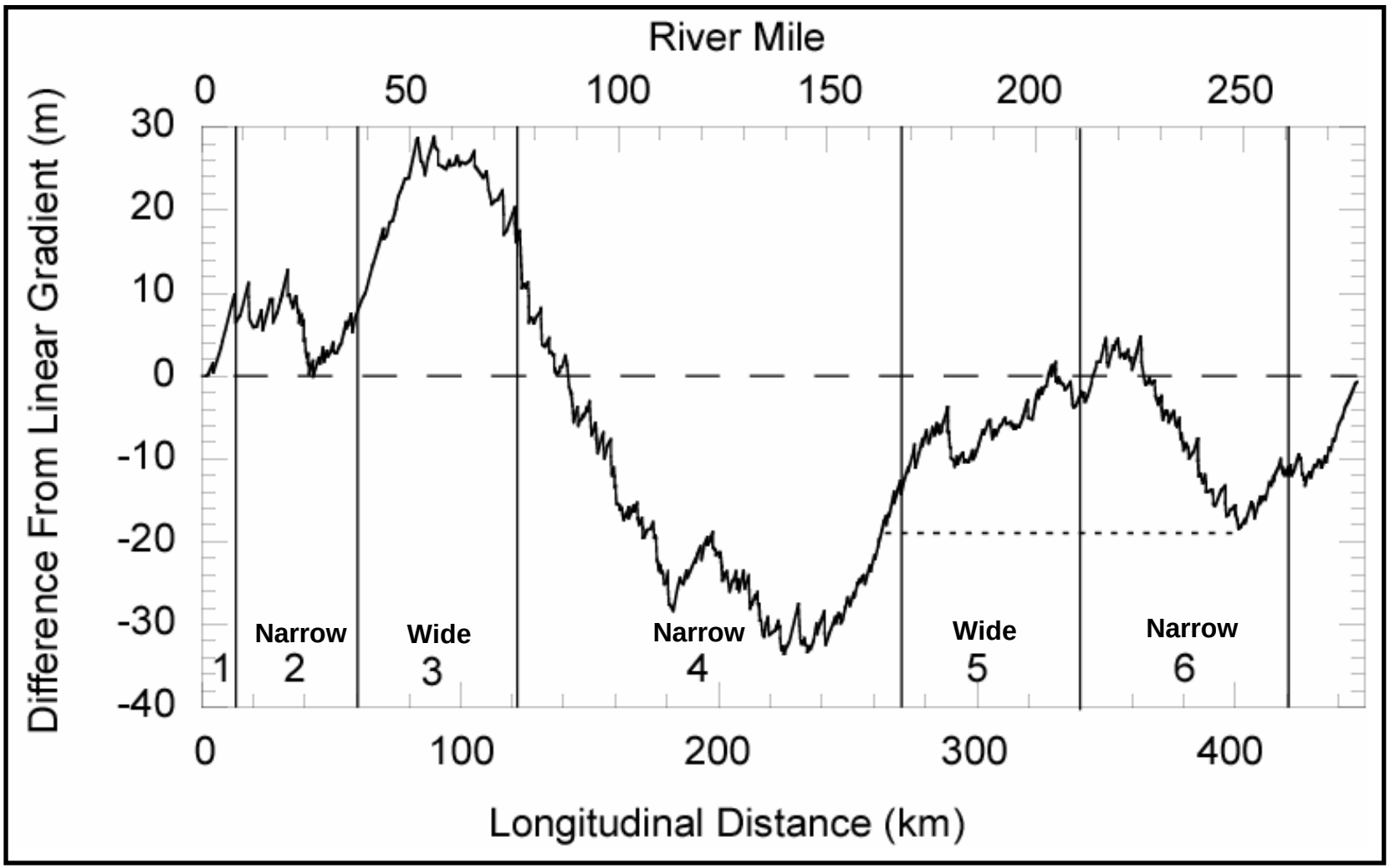
De-trended River Profile



Strong Correlation between convexities and geomorphic reach (Melis 1997)

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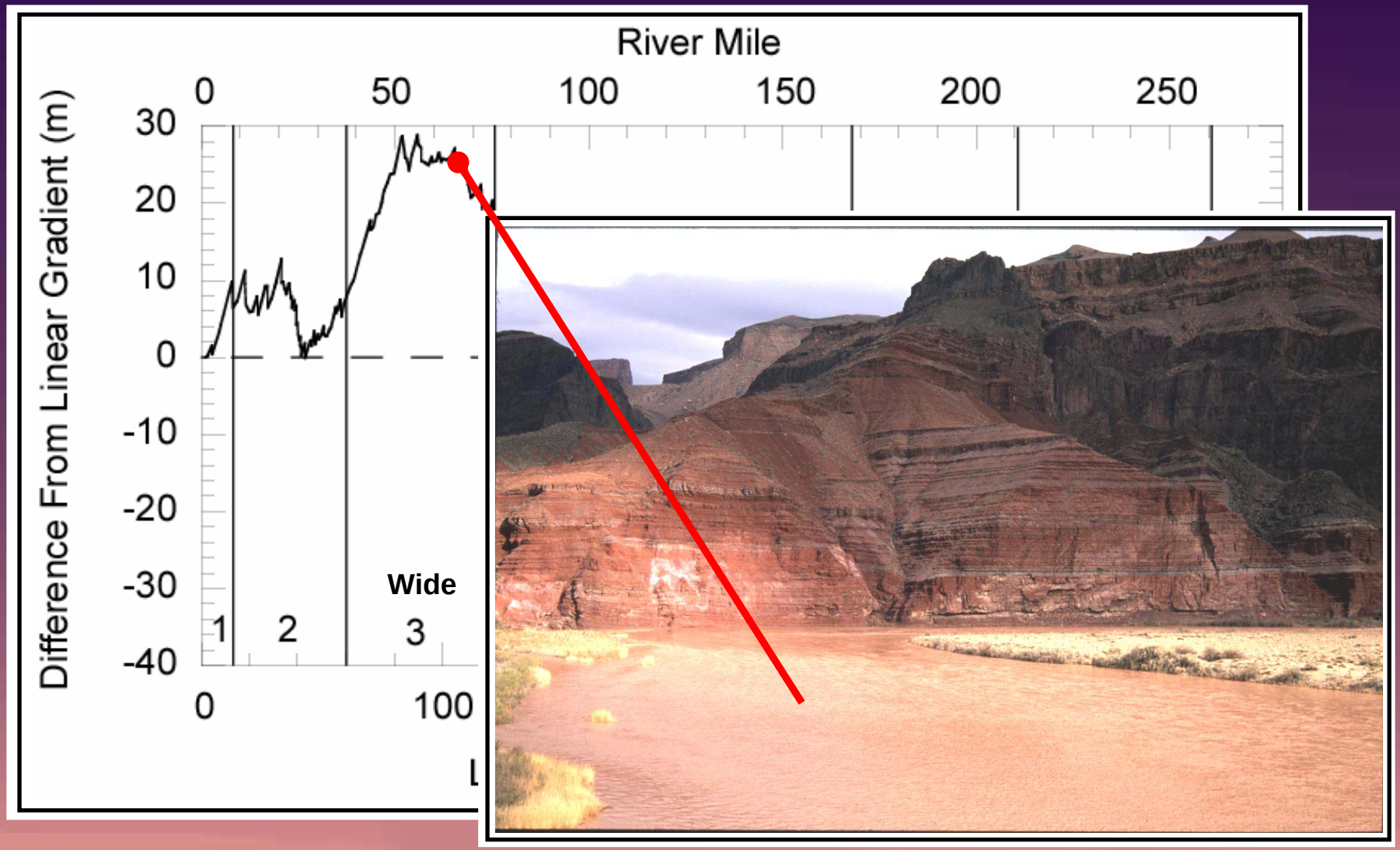
De-trended River Profile



Wide Reach 3—Furnace Flats

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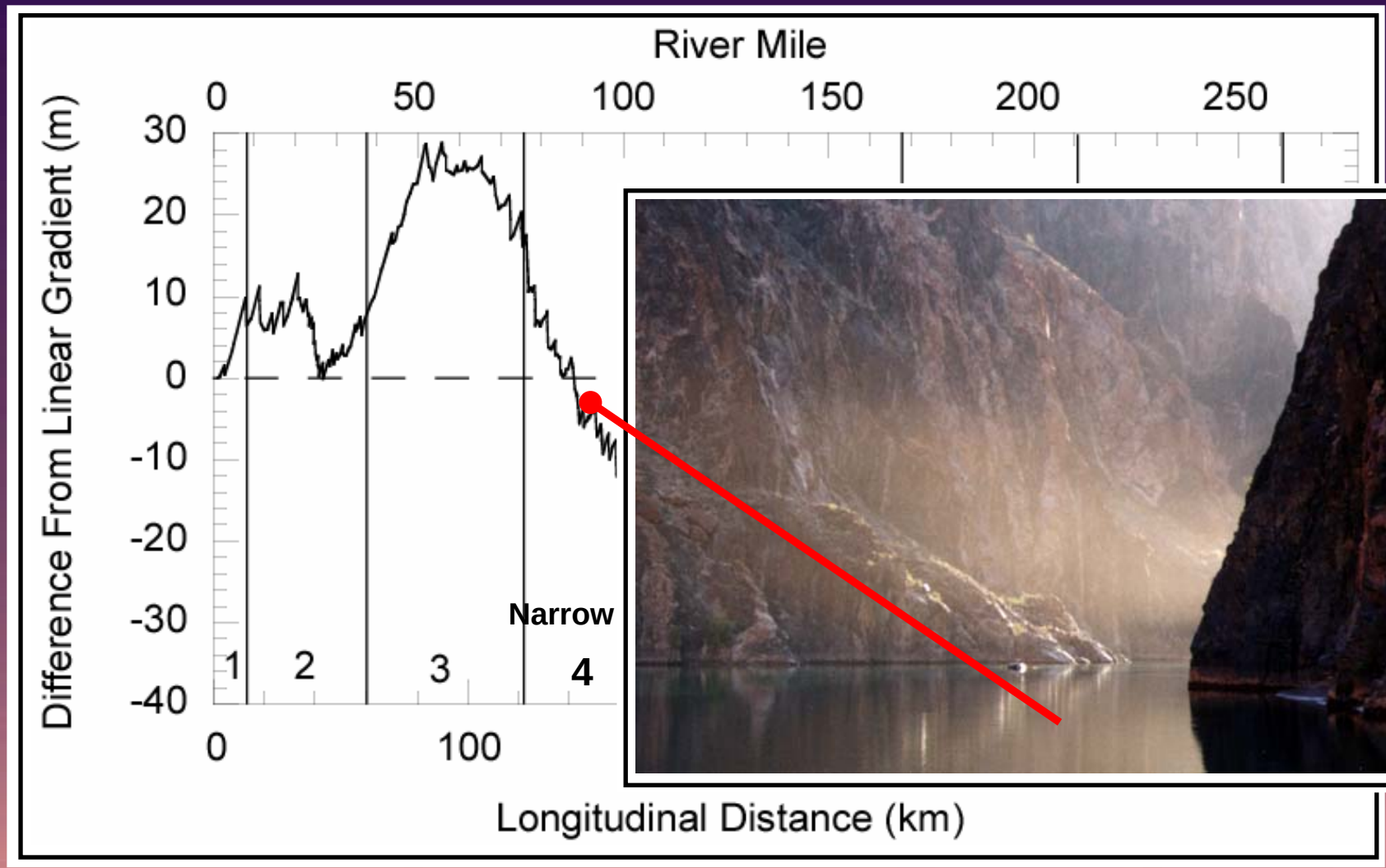
De-trended River Profile



Inner Granite Gorge (Narrow)

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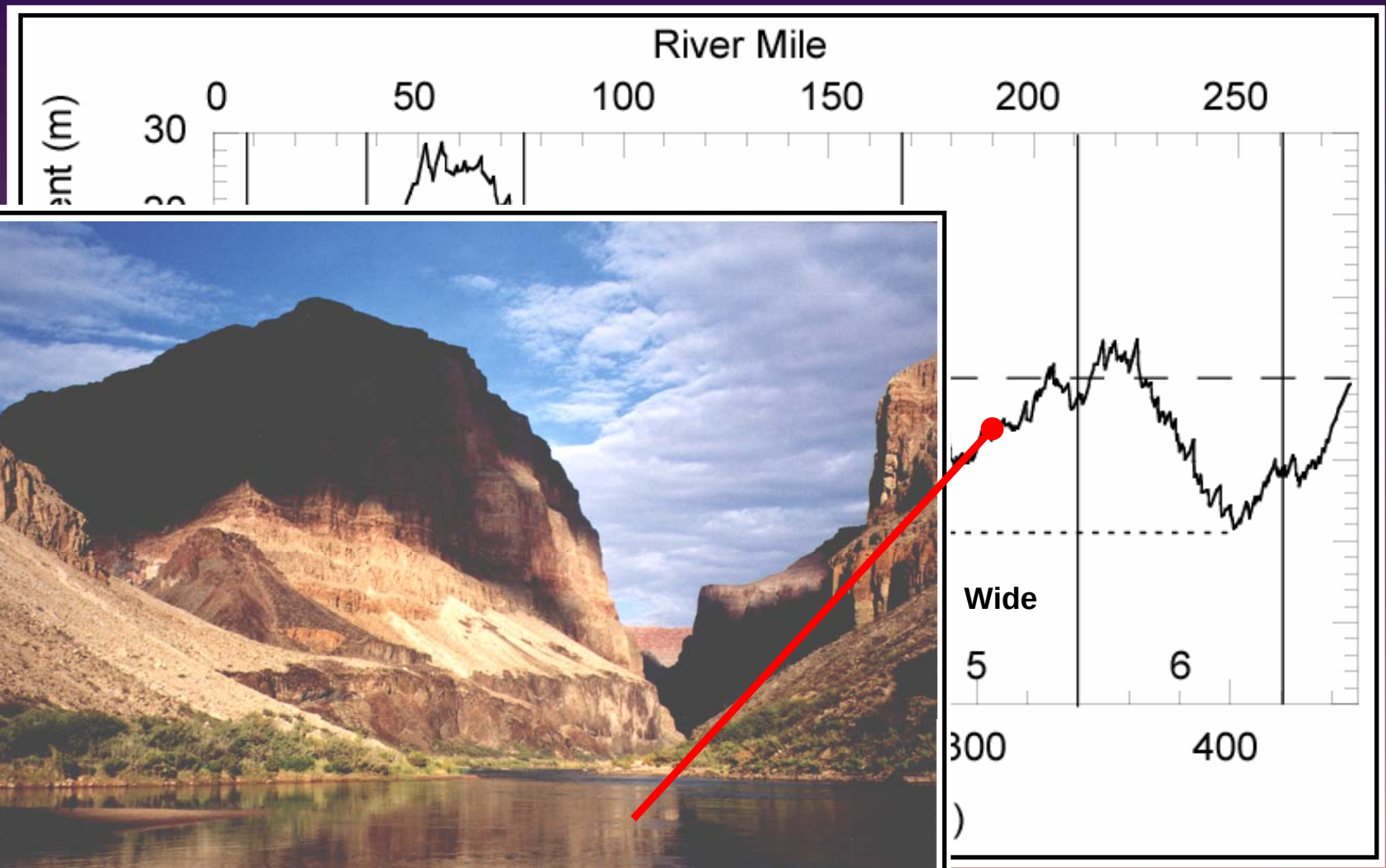
De-trended River Profile



Wide Reach in Western GC

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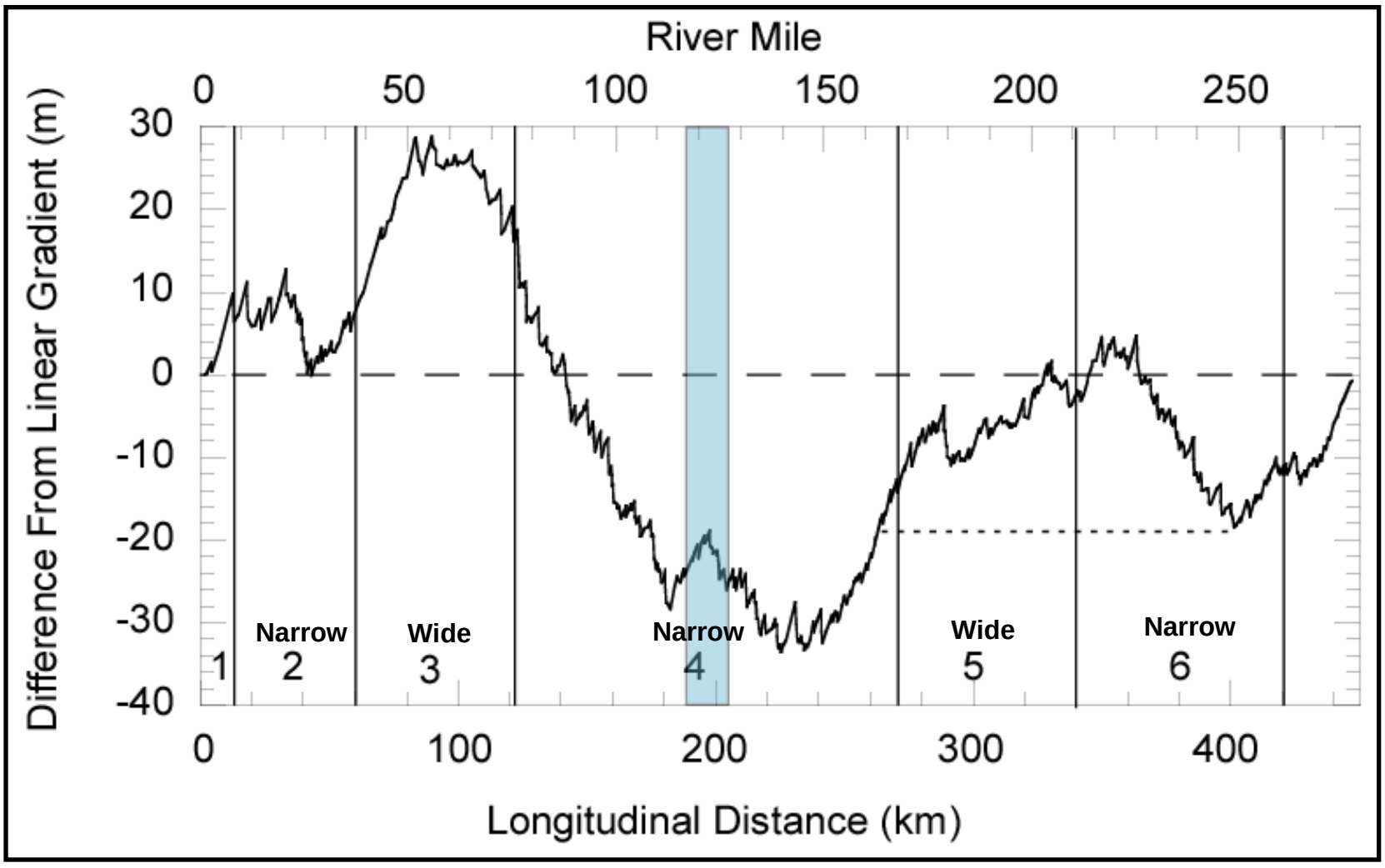
De-trended River Profile



Within Inner Gorge (reach 4) Melis defined a wide subreach

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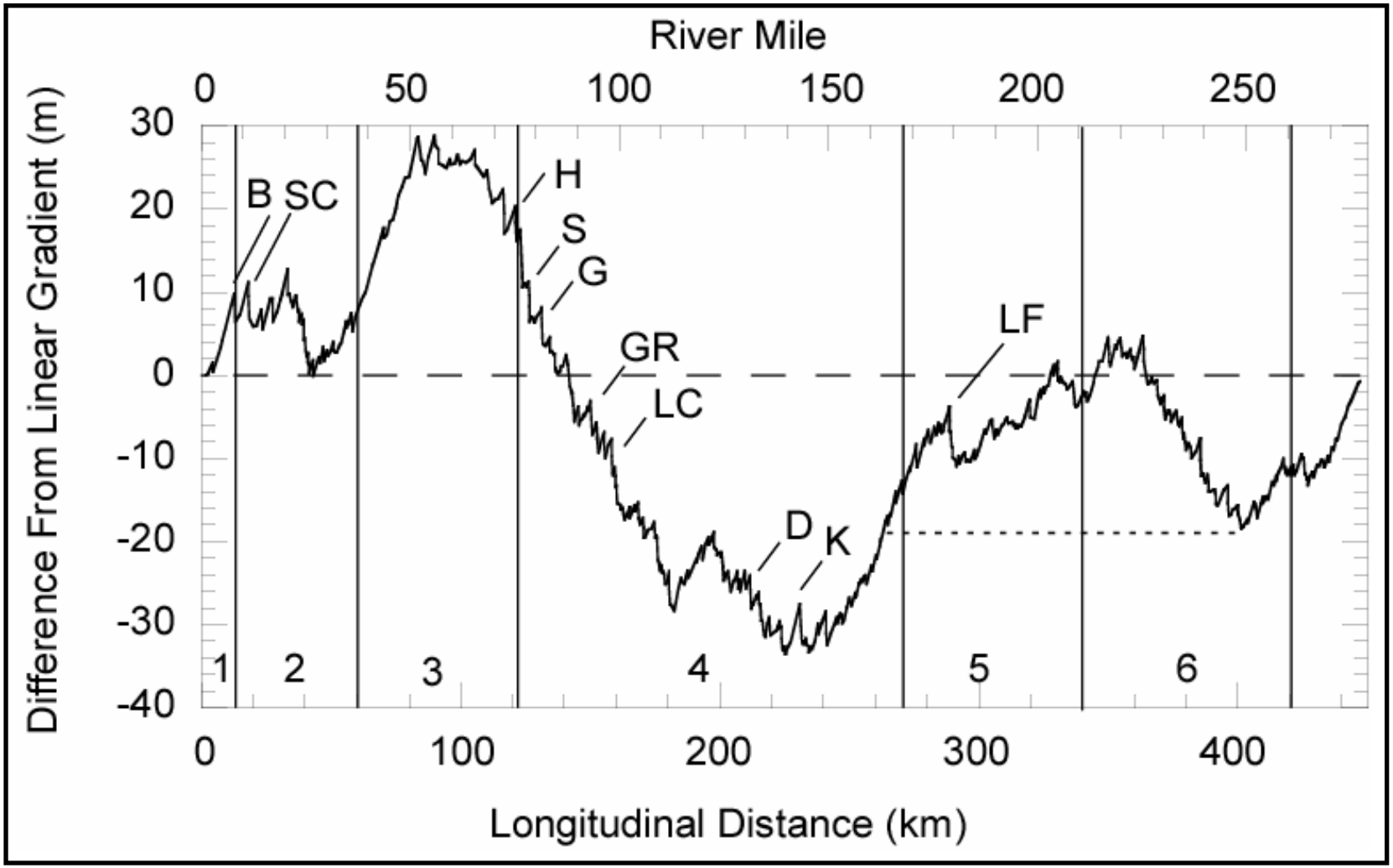
De-trended River Profile



Most large rapids occur on the downside or backslope of convexity

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Exceptional Alluvial Input

Lava Falls Rapid

- Six Historic Debris Flows
- Prospect Canyon dumps voluminous alluvium
- Pool/Riffle morphology

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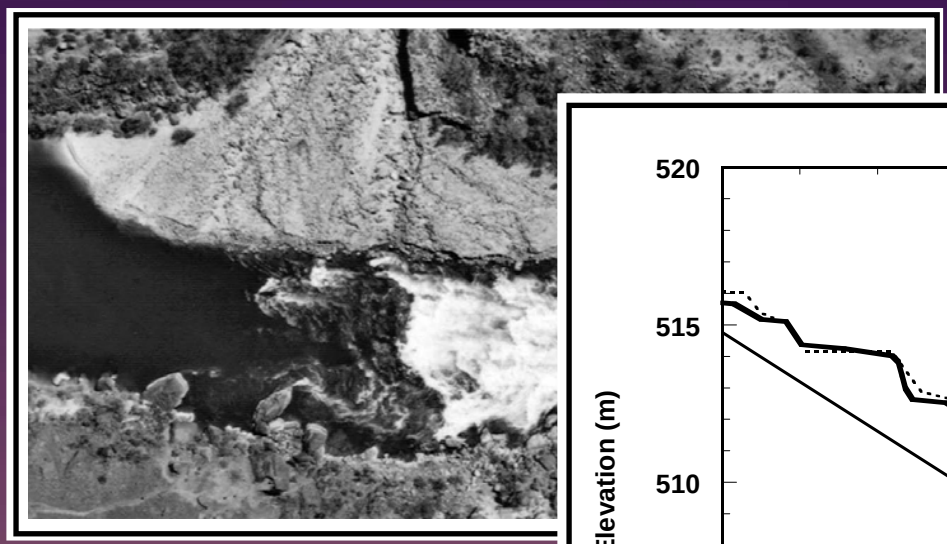
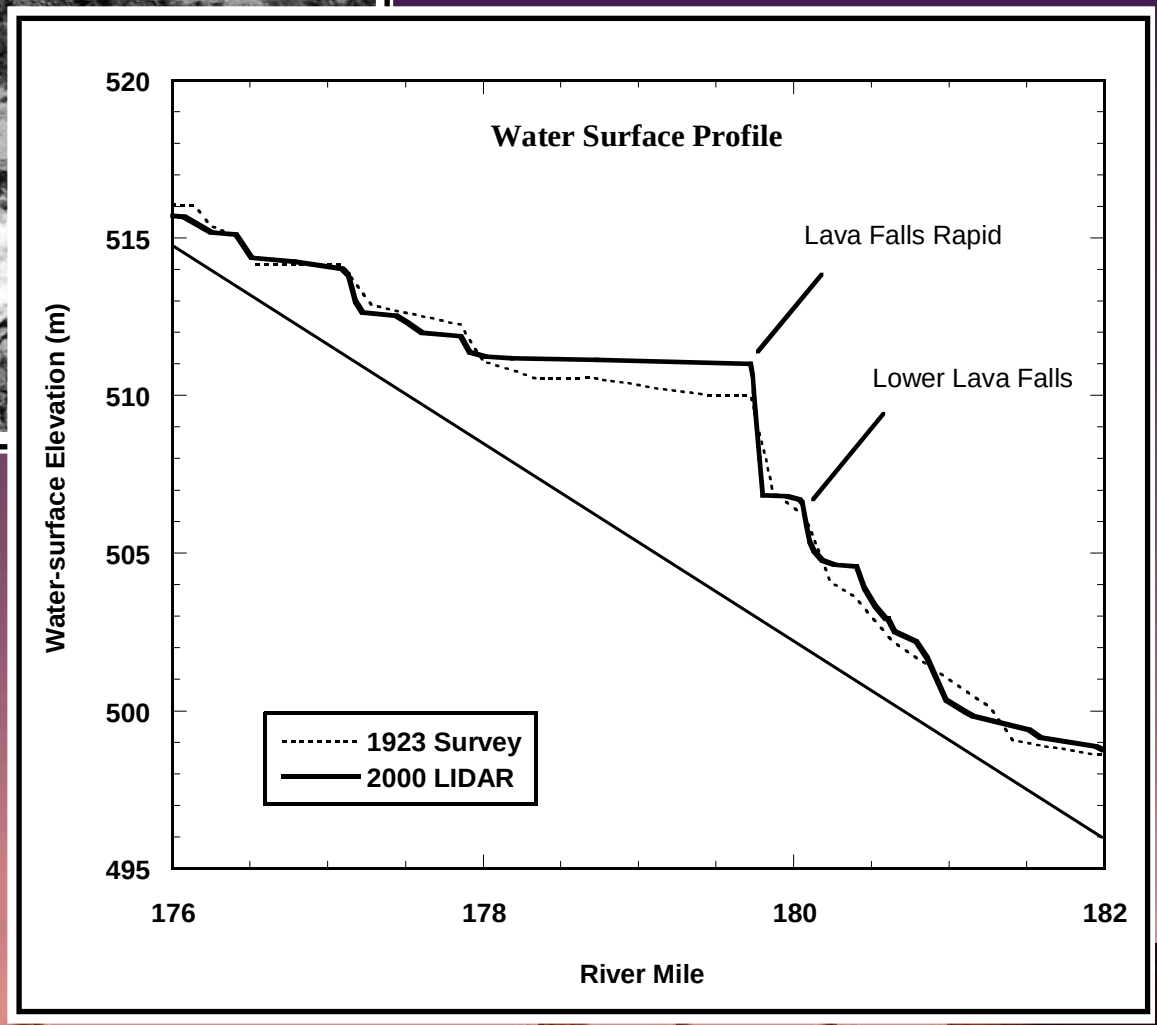
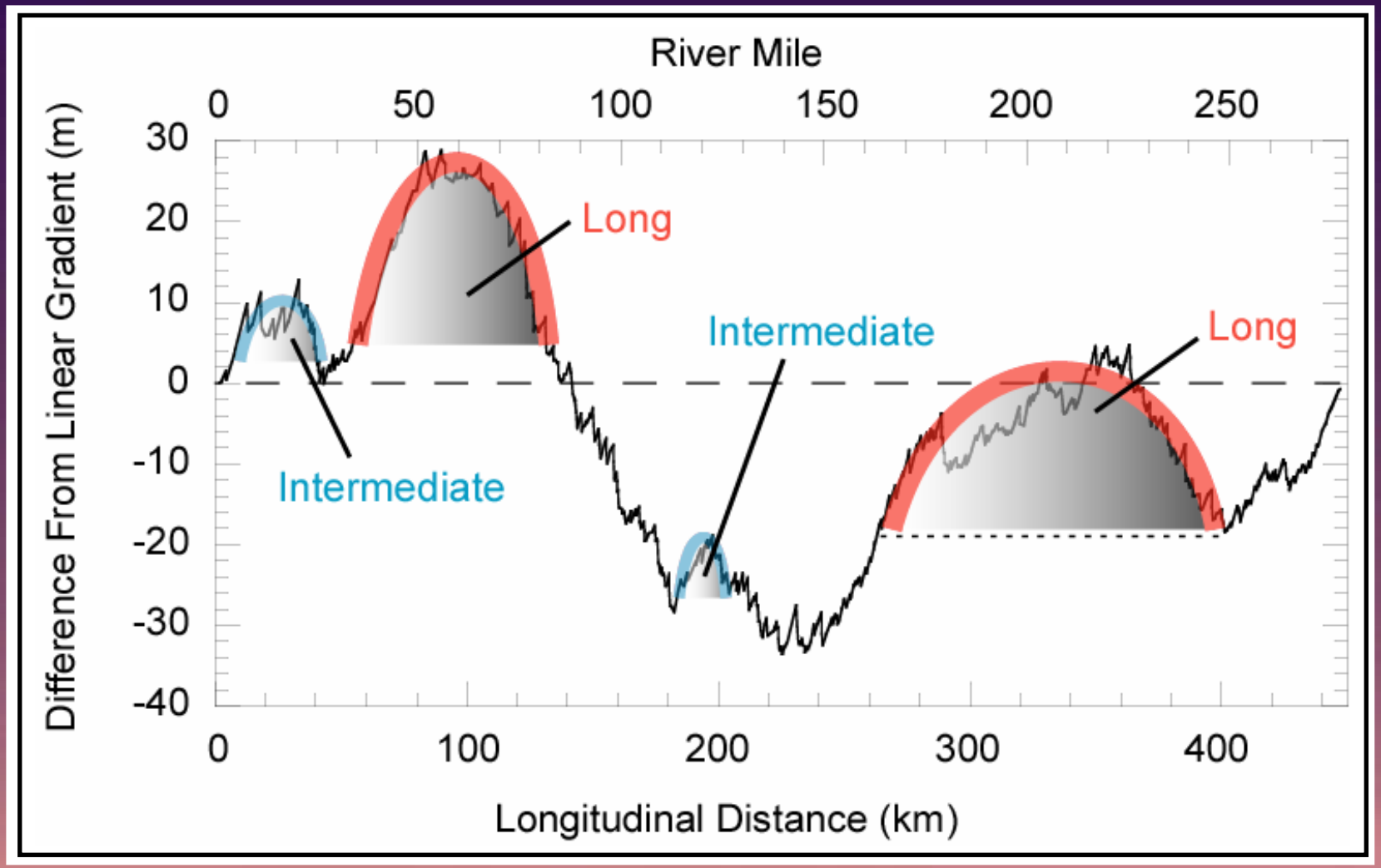
Exceptional Alluvial Input



Lava Falls



Profile Convexities



Short, Intermediate, and Long Wavelength Convexities all resulting from alluvial input

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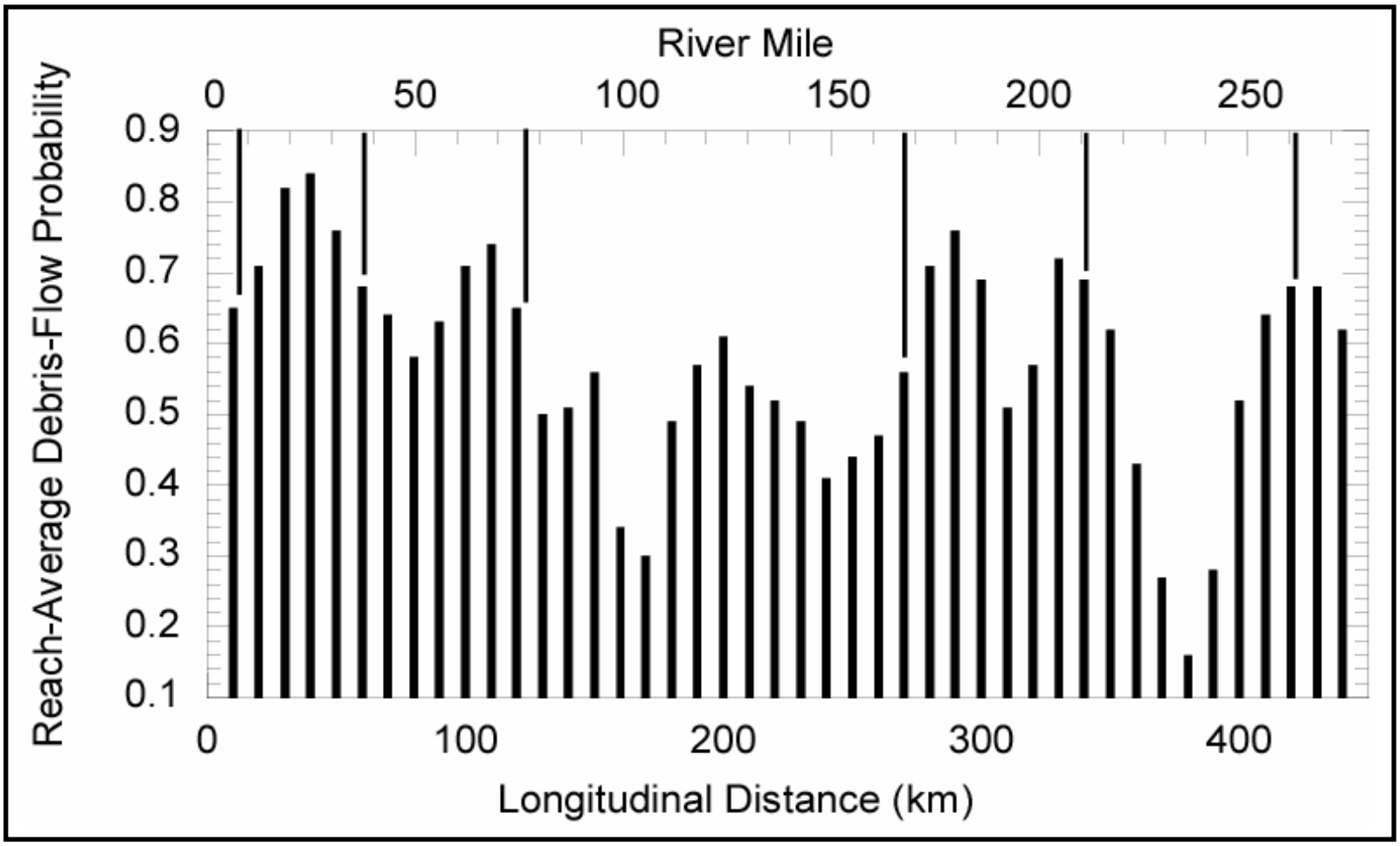
Debris Flow Probability



Higher probability tends to occur in geomorphically wider reaches (Griffiths et al., 2003)

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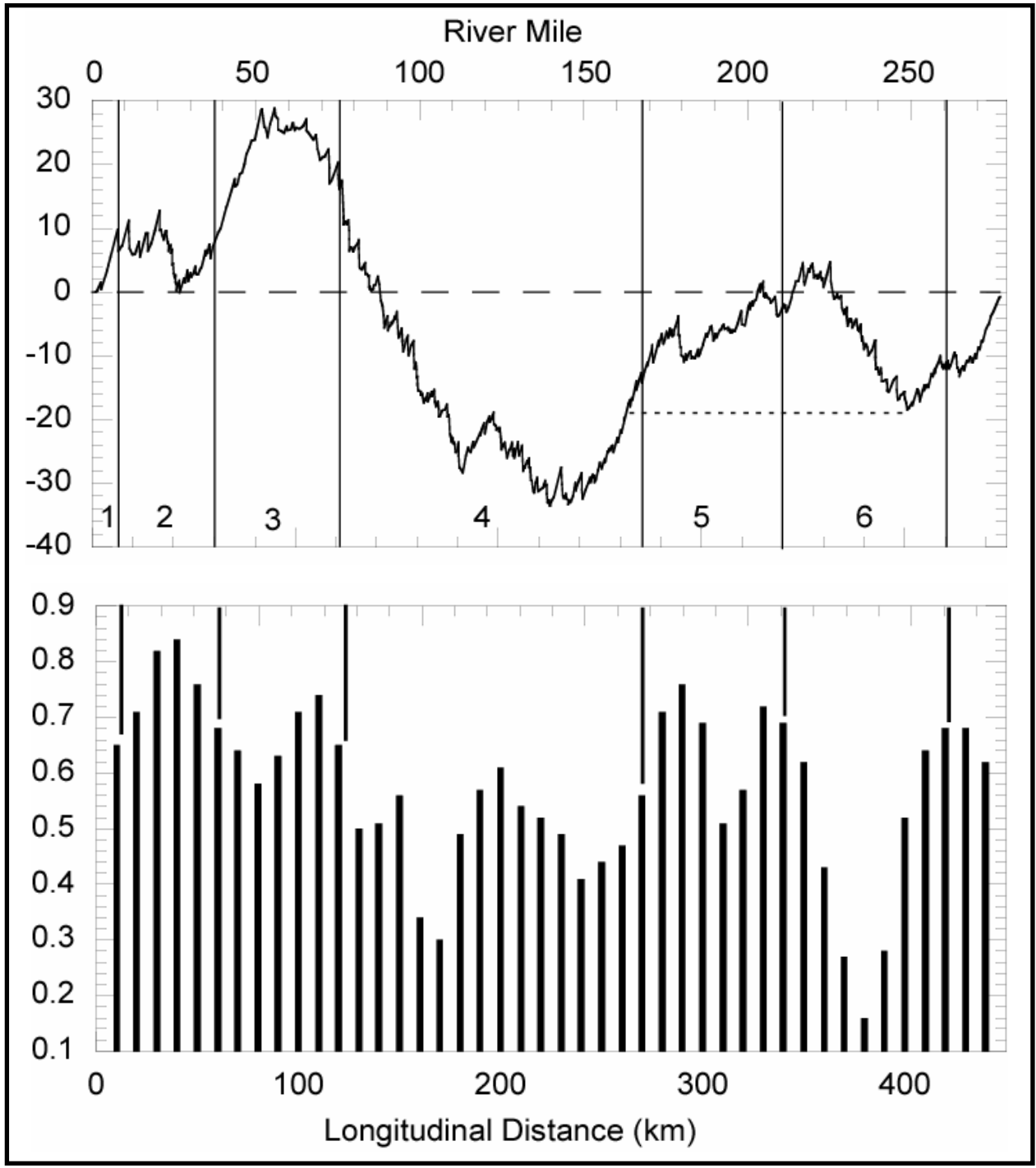
We find a strong link between debris flow probability and alluvial convexities.



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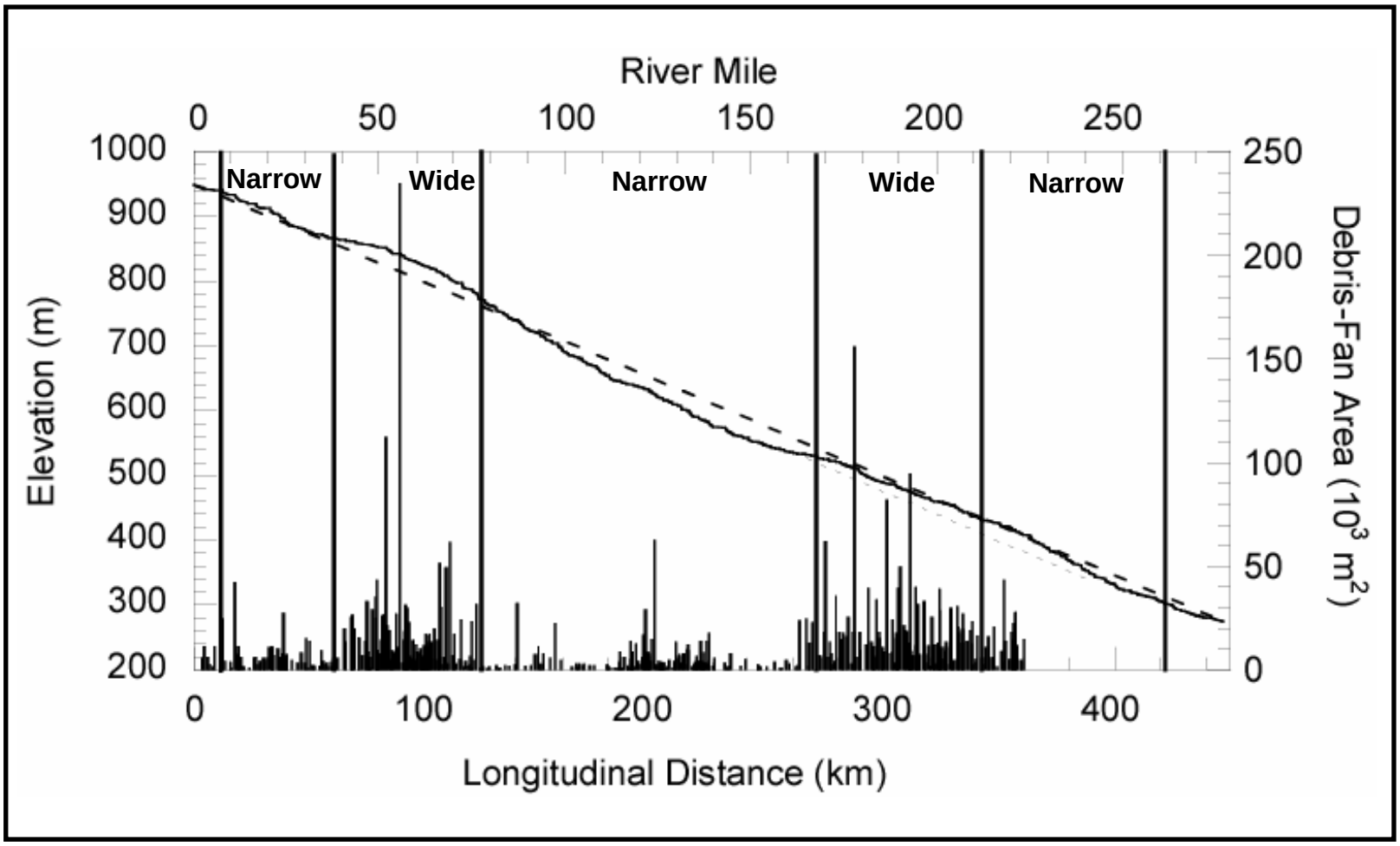
Alluvial Fan Area



Alluvial material fills the river corridor, creating profile convexities

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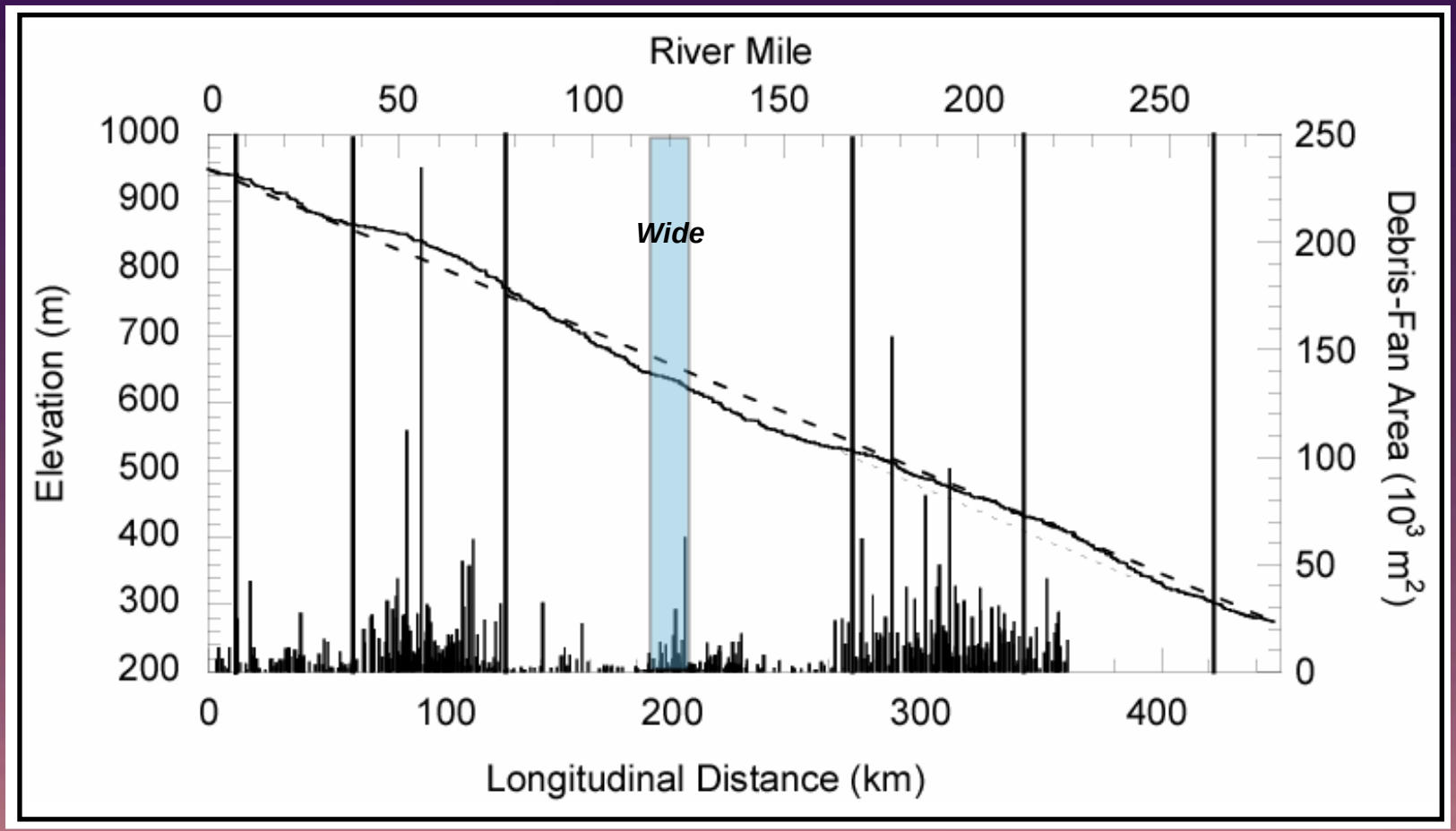
Alluvial Fan Area



Within narrow Granite Gorge, wider sub-reach generates convexity

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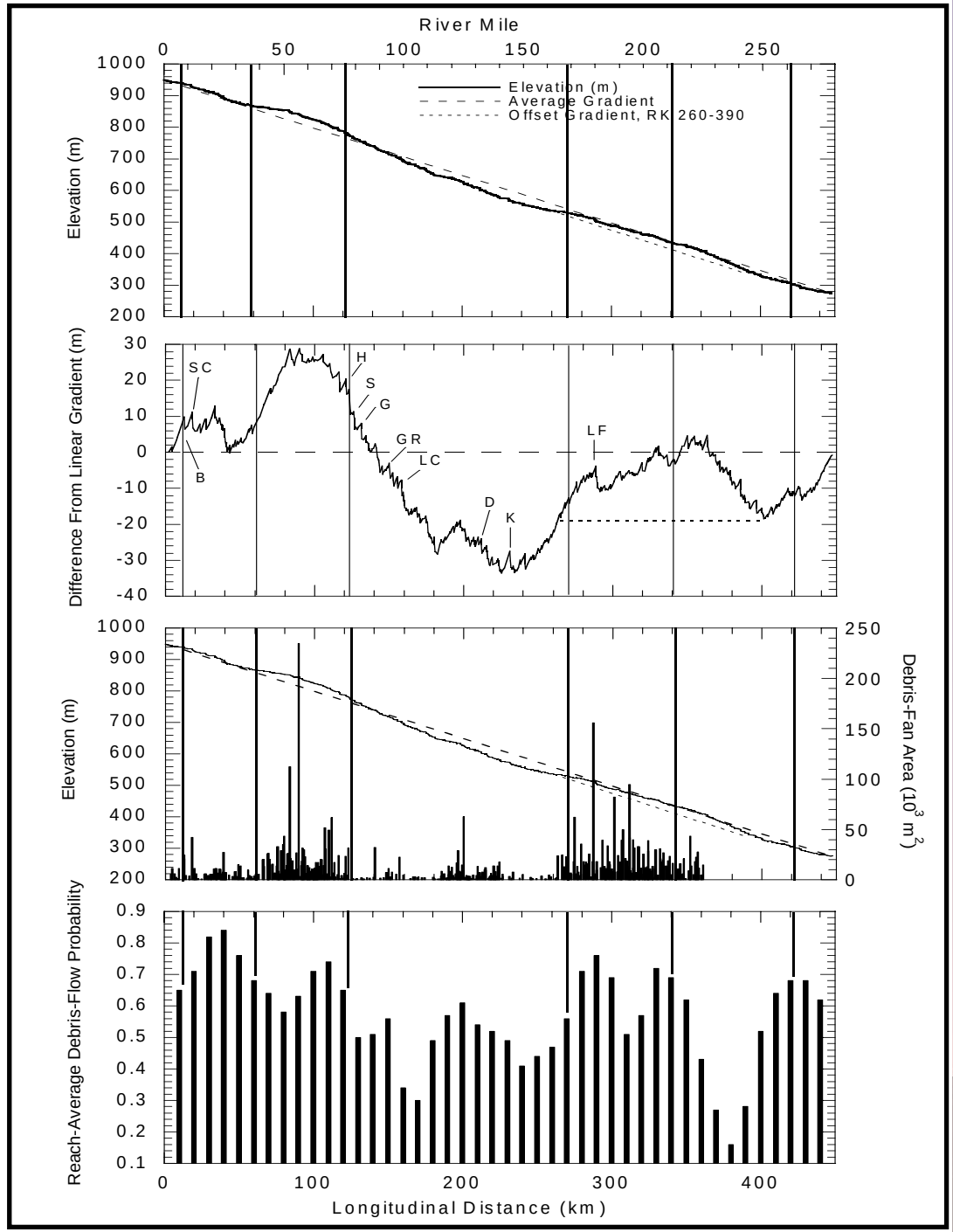
- We have profile convexities at all scales: rapids to nearly the length of GC
- At any scale, there is a strong correlation with debris delivery to the river and debris flow probability.
- The short wavelength features are integrated into the long wavelength features.



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Conclusions

- Convexities in Grand Canyon driven at multiple scales by the accumulation of coarse-grained alluvium from tributaries.
- Rapids and riffles primarily formed by debris flows create dynamic, small-scale convexities.
- Identified 2 major and 5 intermediate wavelength, stable convexities representing a reach-wide bulge of alluvium.
- Most of these bulges (~30 m of alluvium) probably created over the Holocene.
- River today expends its work removing coarse-grained sediment, not in cutting into fresh bedrock.

Acknowledgements:

Grand Canyon Monitoring and Research (GCMRC)

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