PALEO-STREAM COMPETENCY AS A TEST OF THE DISTRIBUTARY FLUVIAL SYSTEM MODEL: UPPER DEVONIAN CATSKILL FORMATION, CENTRAL PENNSYLVANIA

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1. Abstract

Fluvial deposition in actively aggrading basins is dominated by distributary fluvial systems (DFS). DFS have a fan morphology resulting from a decrease in channel size, increase in channel bifurcation, and less channelized flow downstream. Depositional style varies across DFS as a function of these geomorphic elements, with channel deposition dominating proximal DFS environments and overbank deposition characteristic of distal regions. A prograding DFS will therefore result in a vertical succession from small, relatively fine-grained to large, coarser-grained channels. These properties may serve as criteria for identifying DFS in the rock record. The Upper Devonian Catskill Formation has been interpreted as a DFS based on variability in paleosol macro- and micromorphology and increased channel sandstone body size and grain size up-section (Oest, in prep.). The goal of this study is to quantify channel sandstone grain size throughout the section to support qualitative field observations. Channel sandstones were sampled from the top, middle and bottom of each of the four members of the Catskill Formation near Selinsgrove and Duncannon, Pennsylvania for petrographic analysis. Although median grain size varies minimally through the Catskill Formation, the 90th percentile grain size (D_{90}) of channel sandstones increases from approximately 0.10 mm (very fine sand) at the base of the section to 0.45 mm (medium sand) at the top of the section. Critical shear stress (τ_c) was calculated using D_{90} for each sample to assess variability in paleo-flow competency through time. We show τ_c increases from approximately 0.08-0.12 Pa at the base of the section to 0.20-0.45 Pa at the top of the section. The range in calculated values is due to fitting parameters used in these equations to account for unknown channel bed roughness. An increase in D_{90} and calculated τ_c coincides with qualitative observations of increased channel body size and grain size up-section through the Catskill Formation. These results demonstrate the utility of paleo-flow competency analysis in identifying DFS in the fluvial sedimentary record.

2. Methods

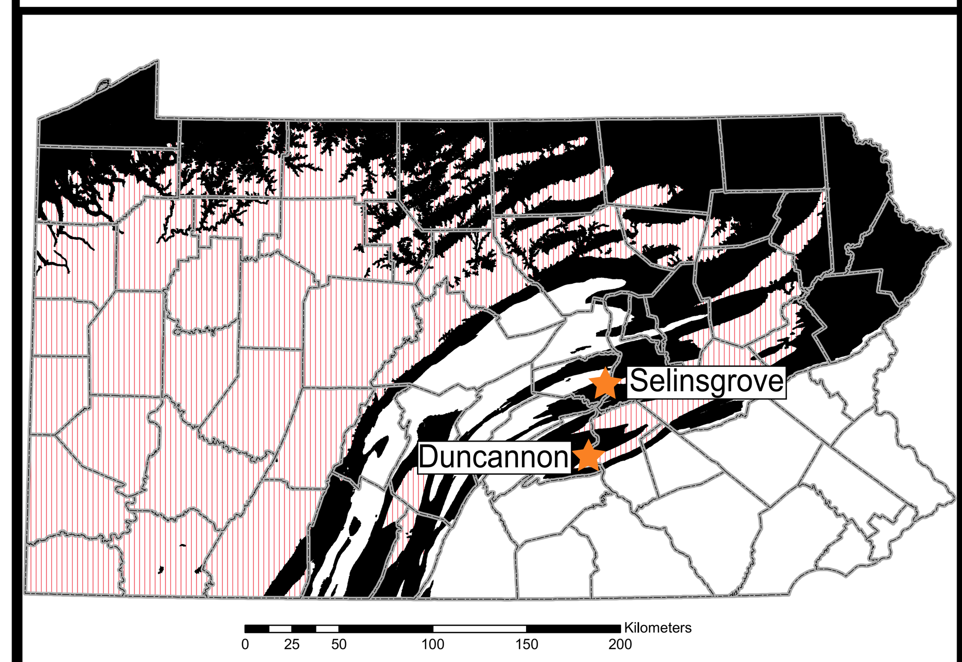
Site and Sample Locations

- Oriented samples were taken from channel sandstones from the base, middle, and top of each of lithostratigraphic unit of the Catskill Formation located near Selinsgrove and Duncannon, PA.
- Twenty one oriented samples were collected and cut into thin sections perpendicular to bedding. Thin sections were stained with sodium cobaltinitrite and amaranth for quick differentiation between plagioclase and K-feldspar.

Lab Analysis

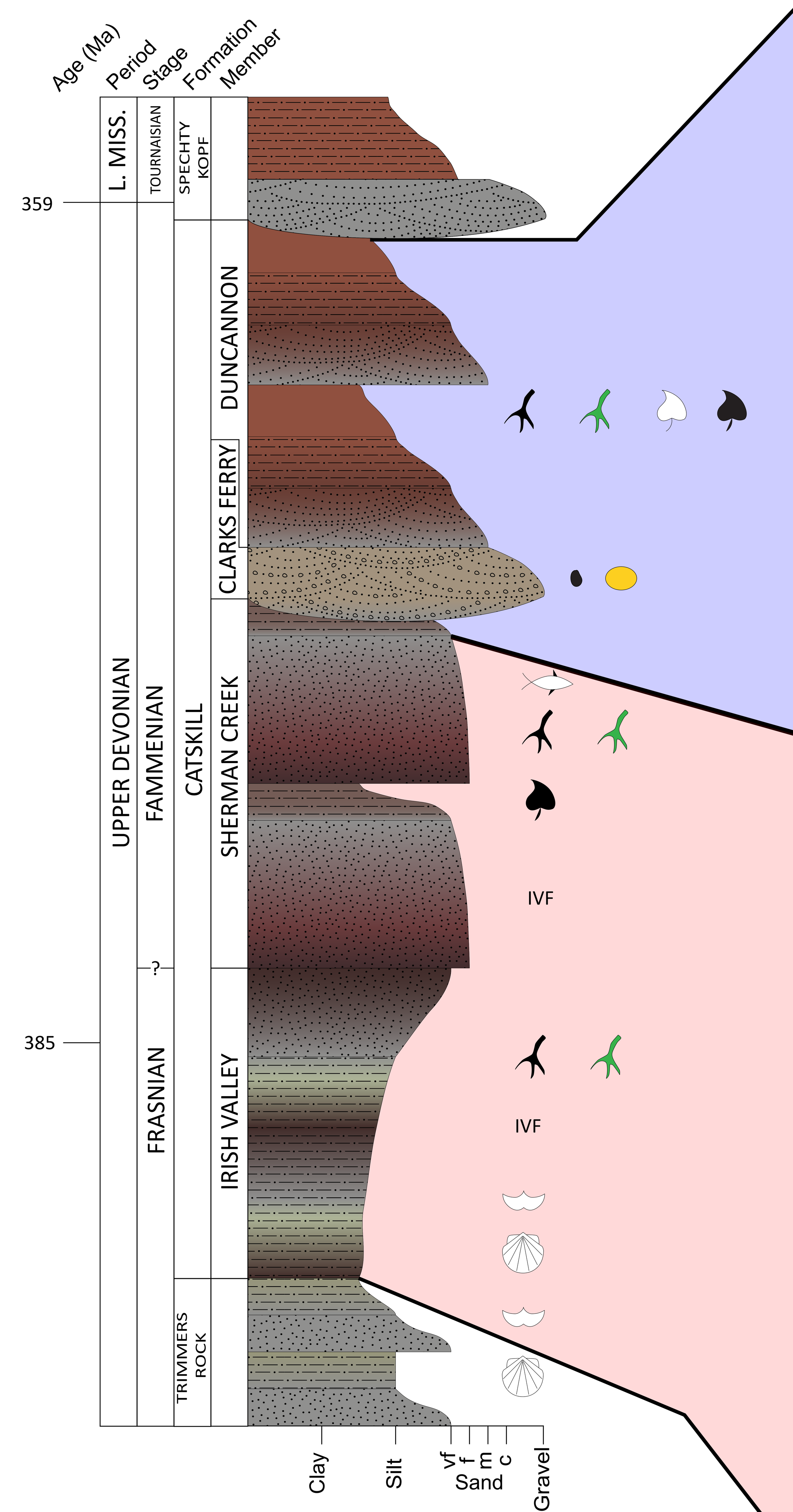
- Point counting (n = 400) was performed on a Pelcon automatic point counting stage to determine mineralogical composition.
- Maximum diameters of each grain where measured using Nikon's NIS Elements image acquisition software by fitting five point ellipses to grain boundaries.

3. Study Locations



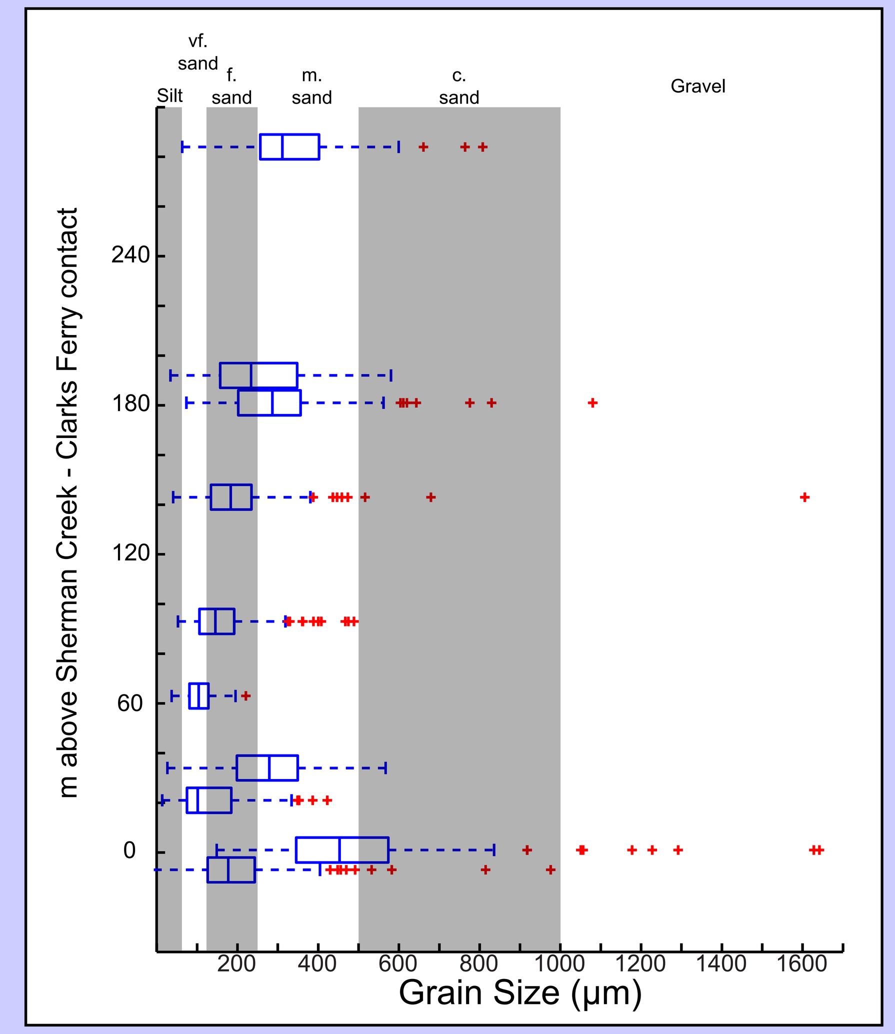
Modified from Miles and Whitfield, 2001 and Harper, 2002

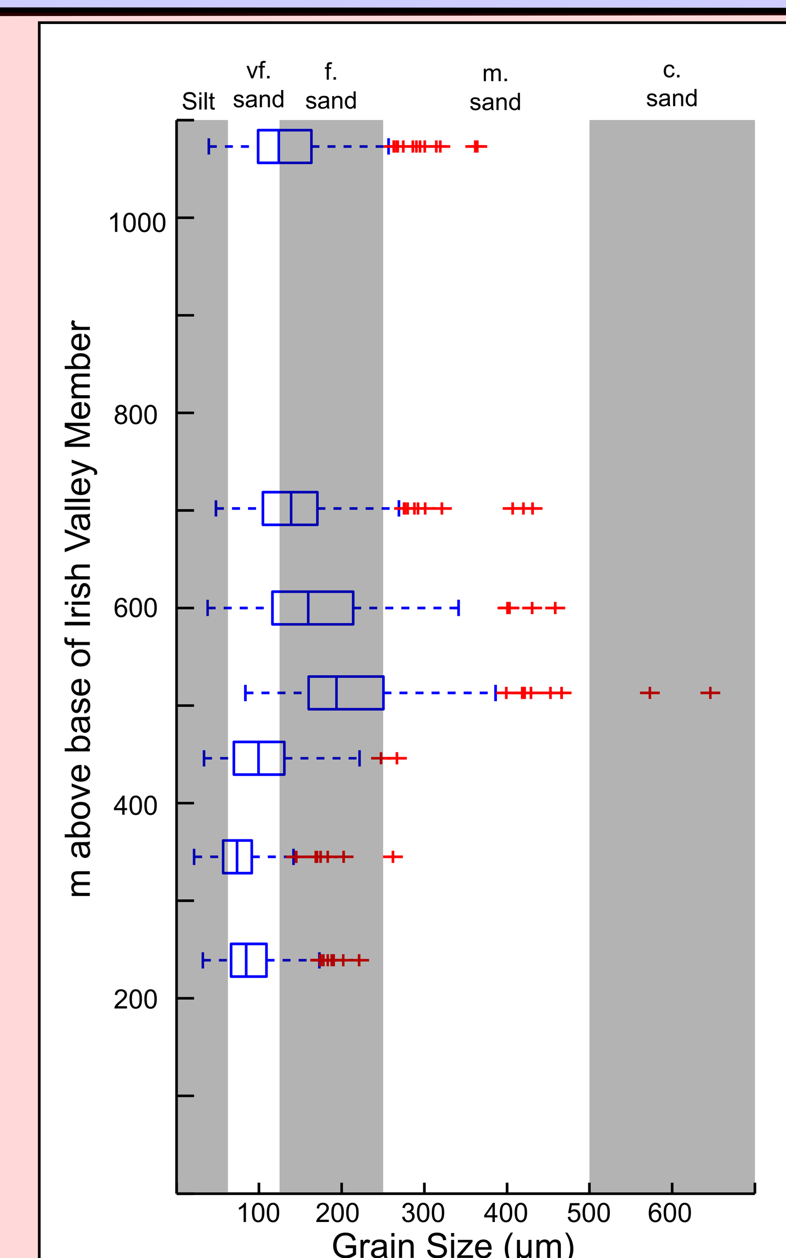
4. Generalized Stratigraphy



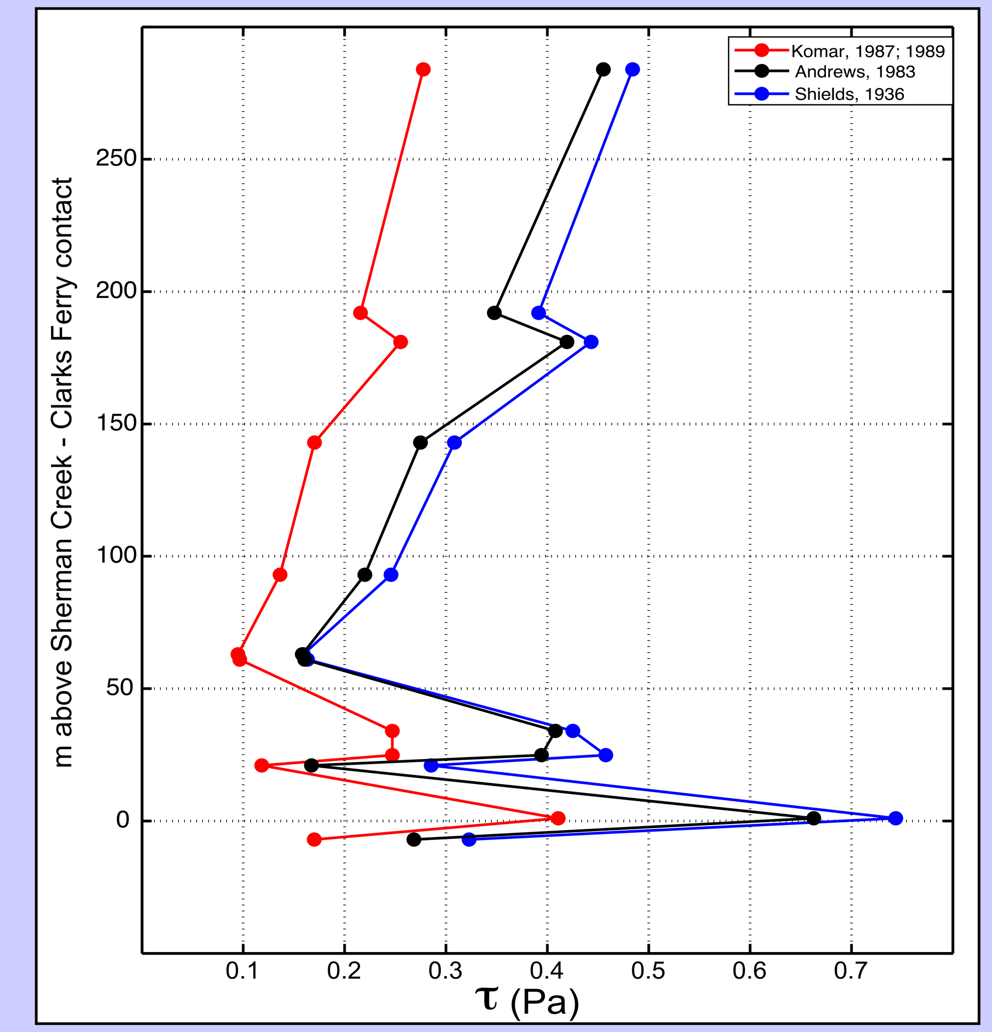
Irish Valley and Sherman Creek data from Cotter and Driese, 1998

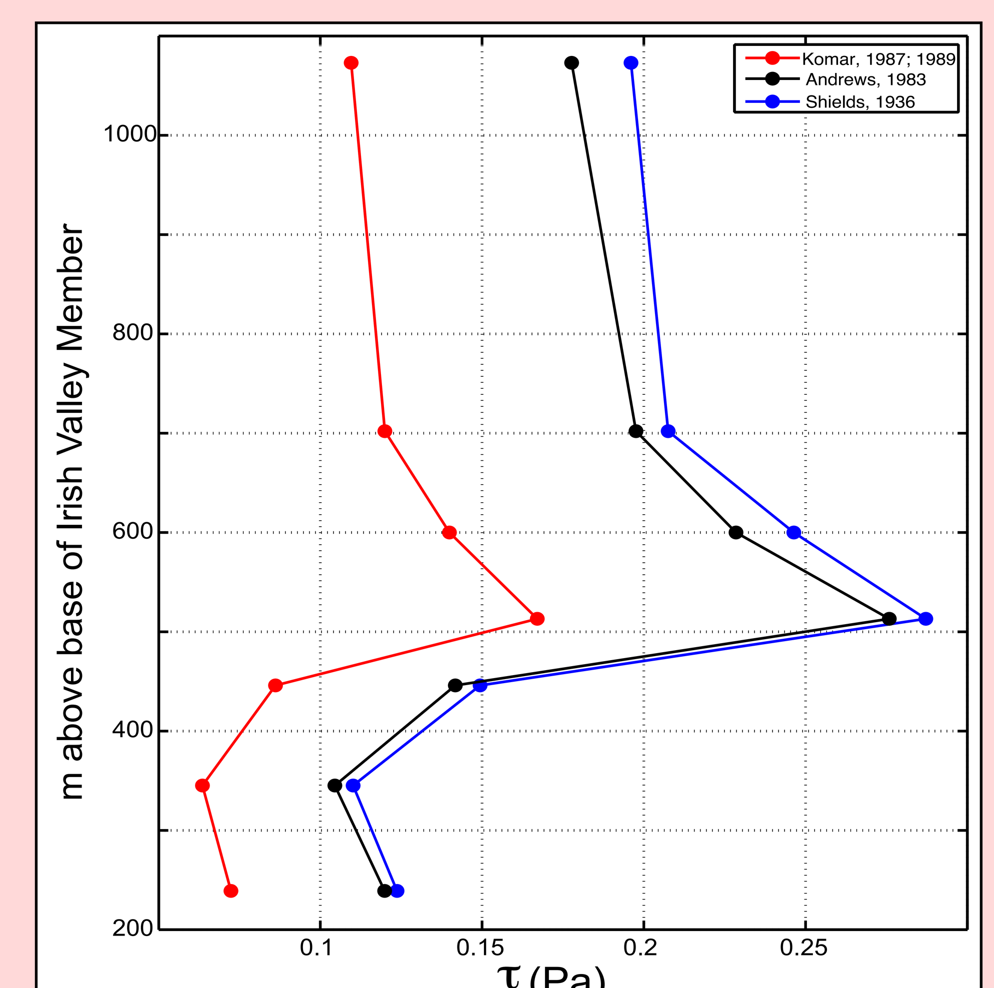
5. Textural Trends



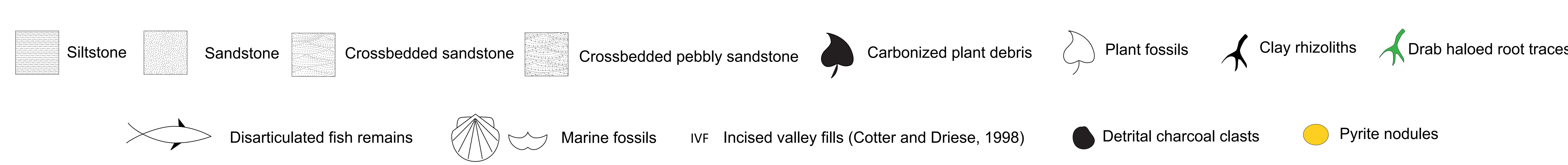


6. Shear Stress

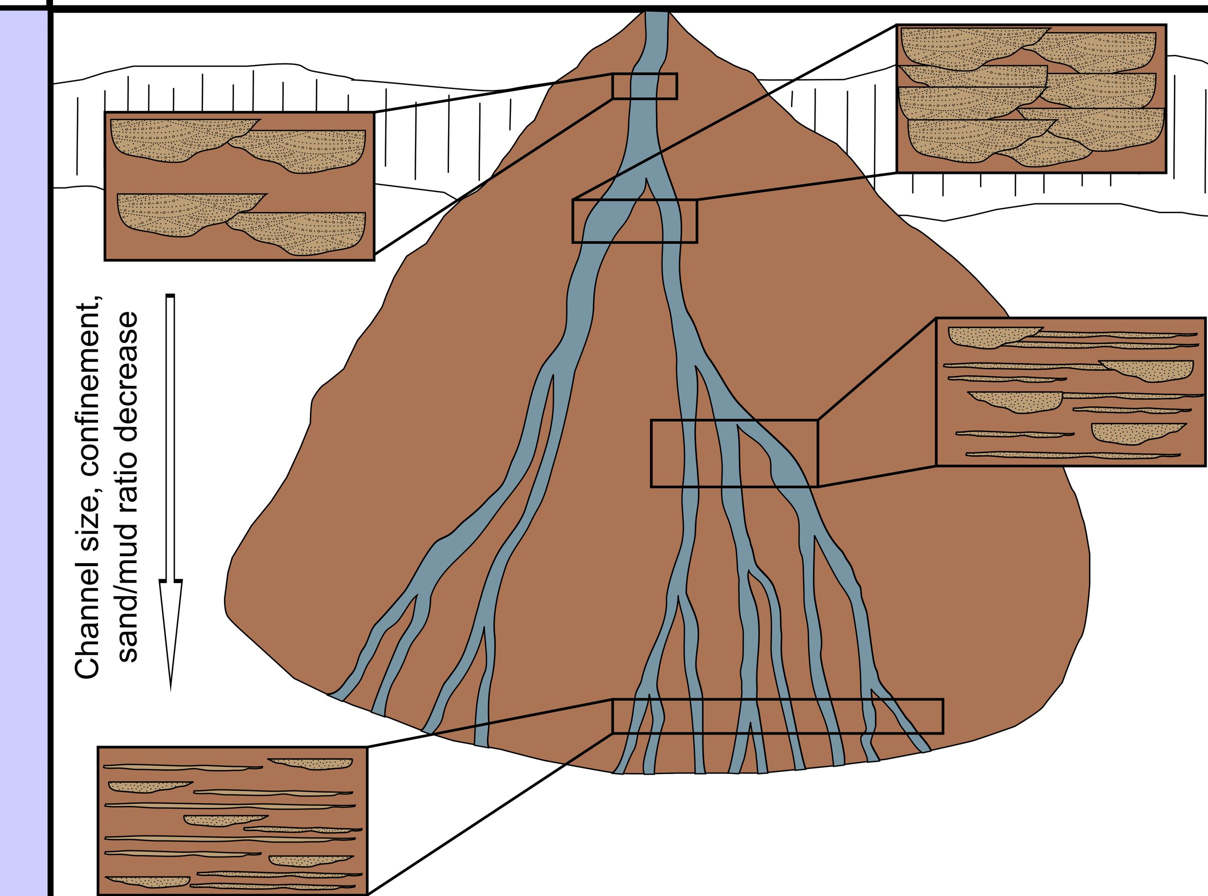




			Bed Surface
Shields, 1936	$\tau_C = \tau_{C*}(\rho_s - \rho_f)gD_{90}$		Glass spheres
Andrews, 1983	$\tau_C = \tau_{C50*}(\rho_s - \rho_f)gD_{50}^{b}D_{90}^{1-b}$	$\tau_{C50*} = 0.0834$, $b = 0.872$	C. Sand to pebbles
Komar, 1987; 1989	$\tau_C = \tau_{C50*}(\rho_s - \rho_f)gD_{50}^{b}D_{90}^{1-b}$	$\tau_{C50*} = 0.045$, $b = 0.60$	Pebbles



7. Conceptual Model



Modified from Nichols and Fisher, 2007 and Weissmann et al., 2013

8. Conclusions

- Although median grain size does not substantially change, D_{90} and maximum grain sizes increase up-section

- As grain size increases, critical shear stress necessary to entrain sediment also increases

- Increased grain size and shear stress can be attributed to greater stream competency as channels transition from bifurcated, wide, shallow, and poorly-confined- to isolated, wide, relatively deeper, and well-confined up-section

- These trends are consistent with distributary fluvial systems, where channel depth and water velocity decrease downstream

9. References

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