Variations in Fluvial Styles Related to Climatic and Topographic Controls Cambrian-Ordovician Potsdam Group, Ottawa Embayment and Quebec Basin*

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Abtract

Siliciclastic braided fluvial deposits are common in the lower part of the Potsdam Group in the Ottawa Embayment and Quebec Basin. Four end-member types of braided fluvial deposits are recognized in the Potsdam, including: A: poorly channelized perennial, B: well channelized perennial, C: poorly channelized ephemeral and D: well channelized ephemeral. Type A consists of 30-90cm sheet-like packages of coarse cross-stratified sandstone forming low-angle downstream and lateral accretion elements bounded by sharp sub-horizontal bounding surfaces. It forms 30-100 m thick units that can be correlated over 10's of km. Type B consists of 2–4m packages of coarse sandstone and conglomerate that form steep downstream- and lateral accretion elements, well defined channel margins and scour hollows. Type C consists of medium to coarse sandstone dominated by upper stage planar lamination, antidune stratification and hydraulic jump scour fills, forming sheet-like packages bounded by sub-horizontal bounding surfaces and interbedded with 5-30cm thick eolian sand-flat deposits. Type D is characterized by 20-100-wide and 1.5-3.5-m-deep channel scours filled with 10-30-cm waterlain dune and ripple deposits at the base overlain by medium- to coarse-grained, eolian wind ripple stratification onlapping the channel margins. Deposition of each end-member type is controlled primarily by two important variables: climate and topography. Types A and B are interpreted to represent steady, quasi-stable fluvial systems fed by perennial runoff in a humid climatic setting; types C and D, on the other hand, record brief, episodic high-energy flows during periods of aridity. Nevertheless, types A and C exhibit a similar sheet-like geometry, most likely reflecting deposition on broad, open channels on extensive braidplains. Types B and D, however, suggest flow confinement, most probably related to local topography, including fault scarps. This is supported by stratigraphic data that show a consistent intercalation of Type A and C deposits and Type B deposits D deposits, suggesting that topographical effects (or lack thereof) persisted irrespective of changes in climate, and accordingly fluvial conditions. Moreover, surfaces that separate strata deposited during humid versus aridconditions can be traced regionally, suggesting that they can form reliable markers that can aid in correlating coeval braided fluvial deposits separated by paleotopography.

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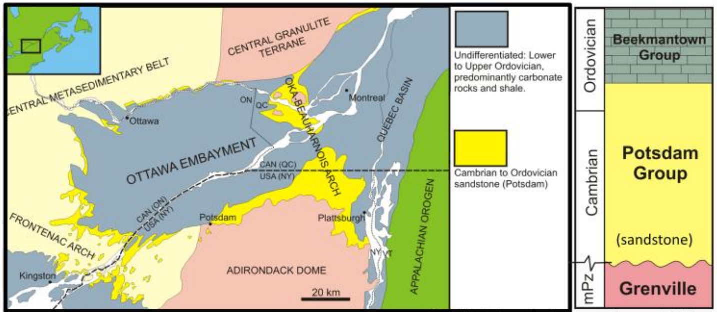
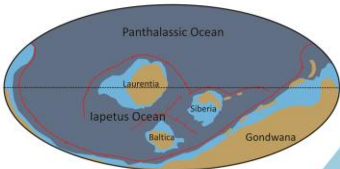
The Potsdam Group: Regional and Paleogeographic Context

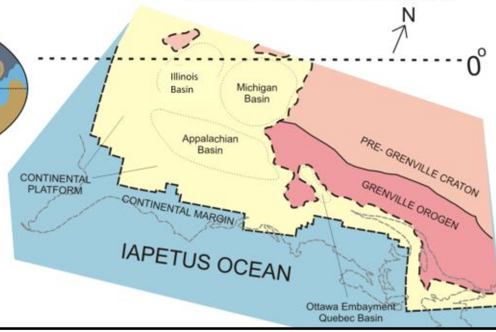


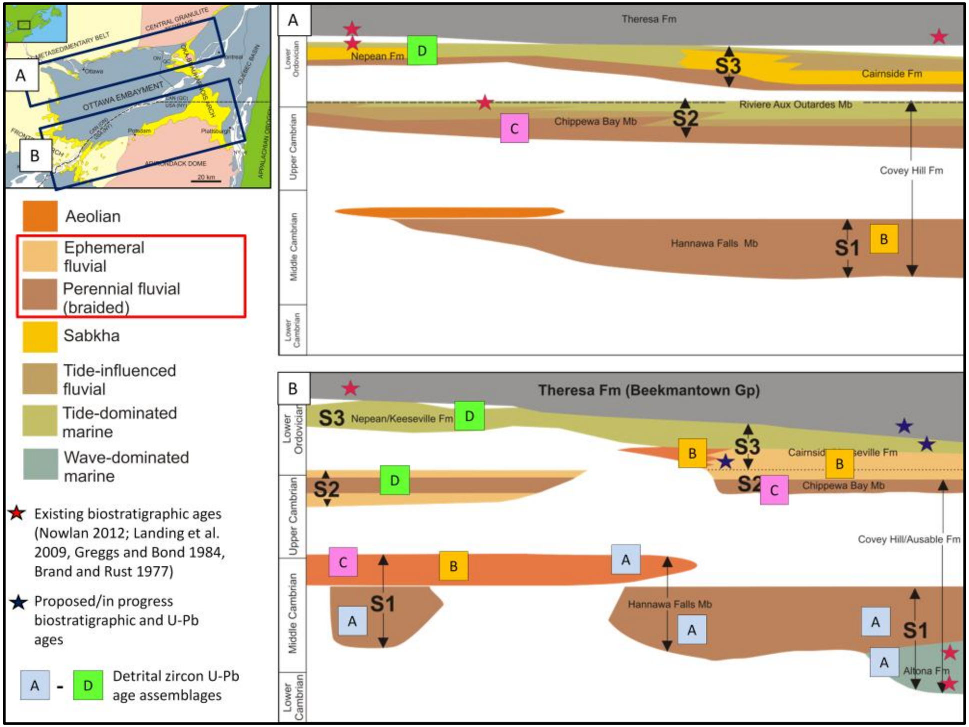
Modified from Sanford and Arnott (2010)



Late Cambrian (514 Ma)

(Scotese, C.R., 2002)





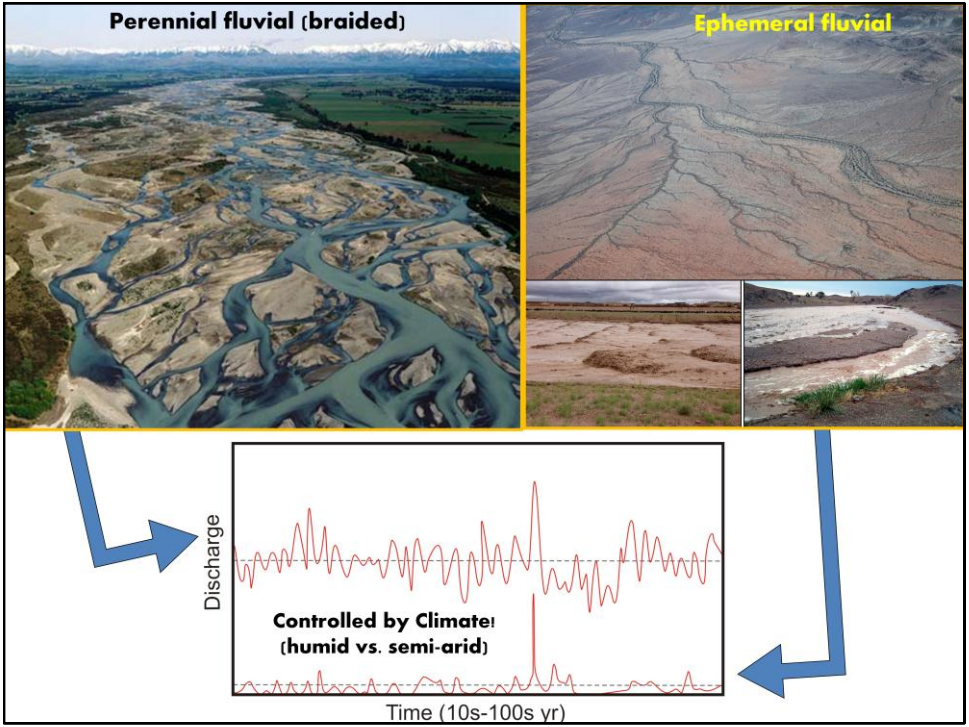
Presenter's notes: First a general summary of: age, units, sequences/allostratigraphic units recognized, facies/depositional environments, detrital composiition. Note eastern and western successions; here, focus is on the relationships in the south.

Outline

- Two major controls of fluvial deposition:
- Part I: Climate as an influence on fluvial systems.
- Part II: Controls imposed by bedrock topography.

Part I: Climate as an influence on fluvial systems:

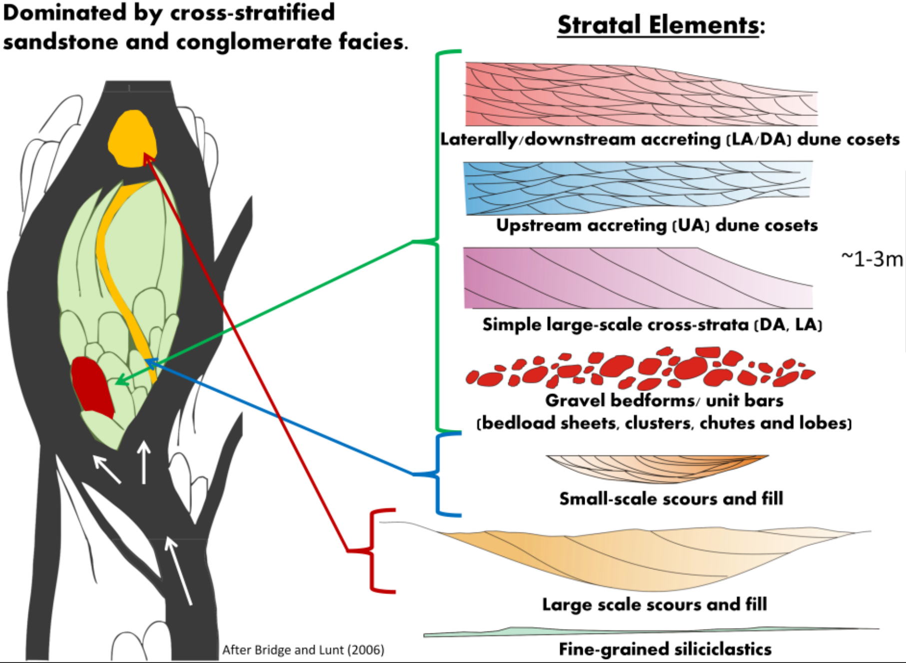
Perennial and Ephemeral fluvial deposits and their regionally significant contacts.

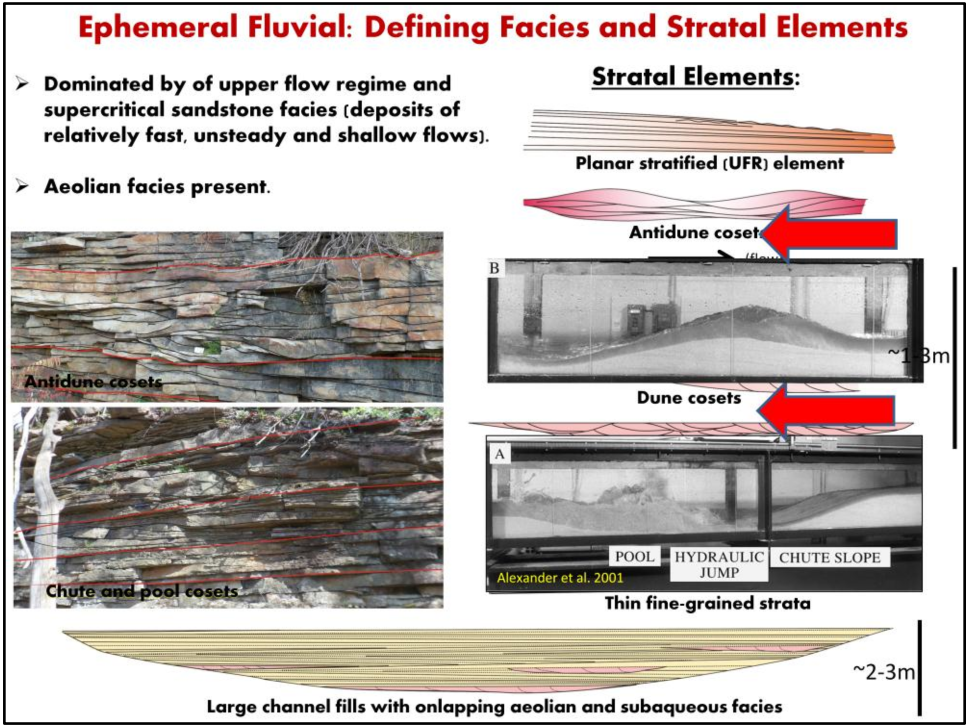


Presenter's notes: Ephemeral vs perennial fluvial, difference in discharge, controlling factor in related facies and stratal elements.

Perennial Fluvial (Braided) : Defining Facies/ Stratal Elements

- Dominated by cross-stratified sandstone and conglomerate facies.

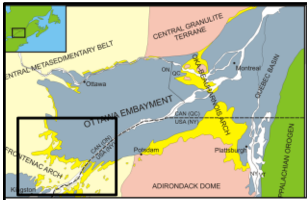


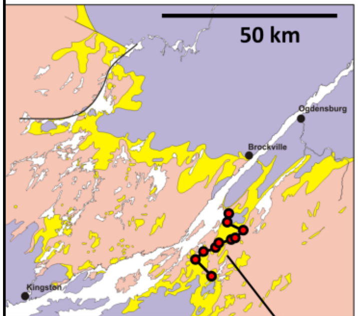


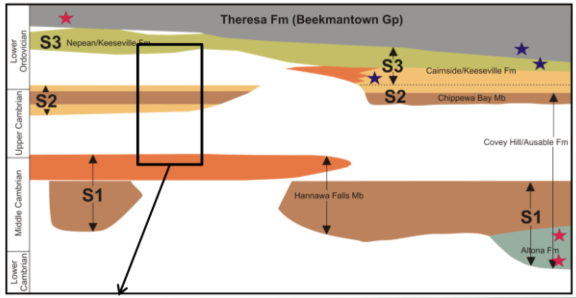
Presenter's notes: Ephemeral fluvial--dominated by planar strata with UFR and supercritical facies common (upper plane bed); generally highly unsteady flows averaged over long periods of time.

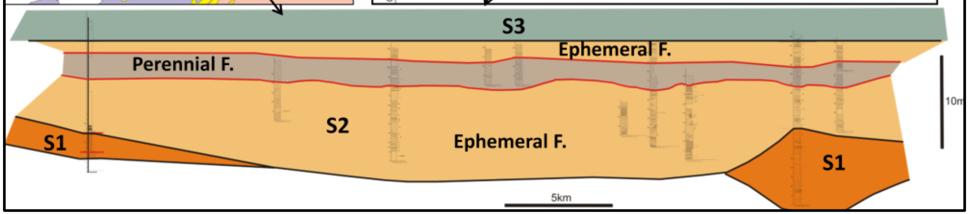
Ephemeral – Perennial contacts: Use for regional correlations

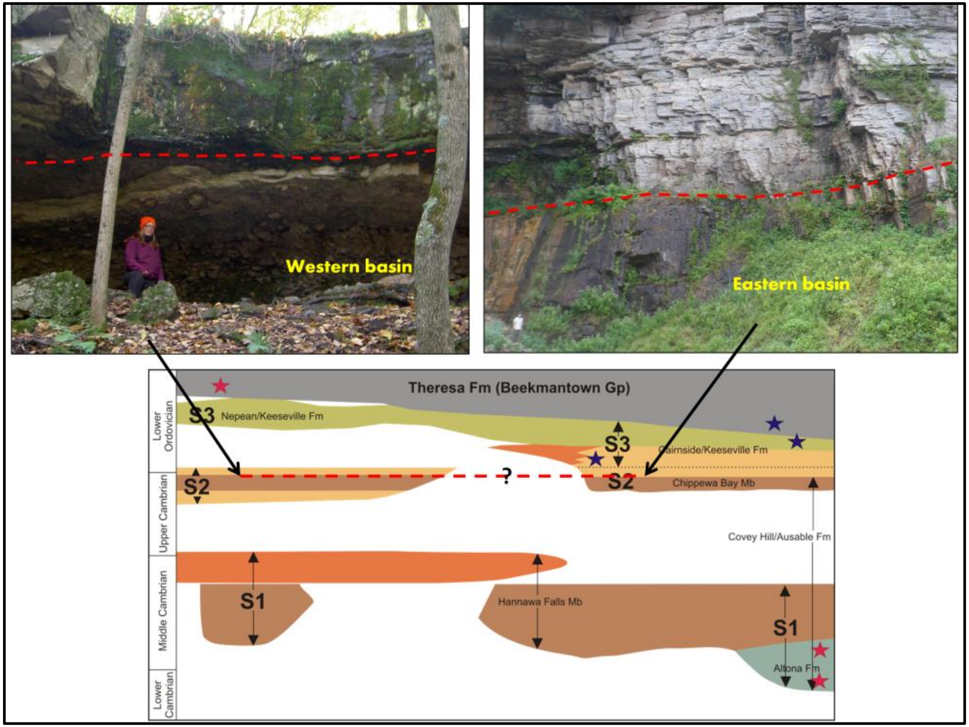
- Climate change is regional and happens at the same time everywhere; therefore ephemeral – perennial contacts approximate an isochronous surface and are potentially useful for regional correlations.







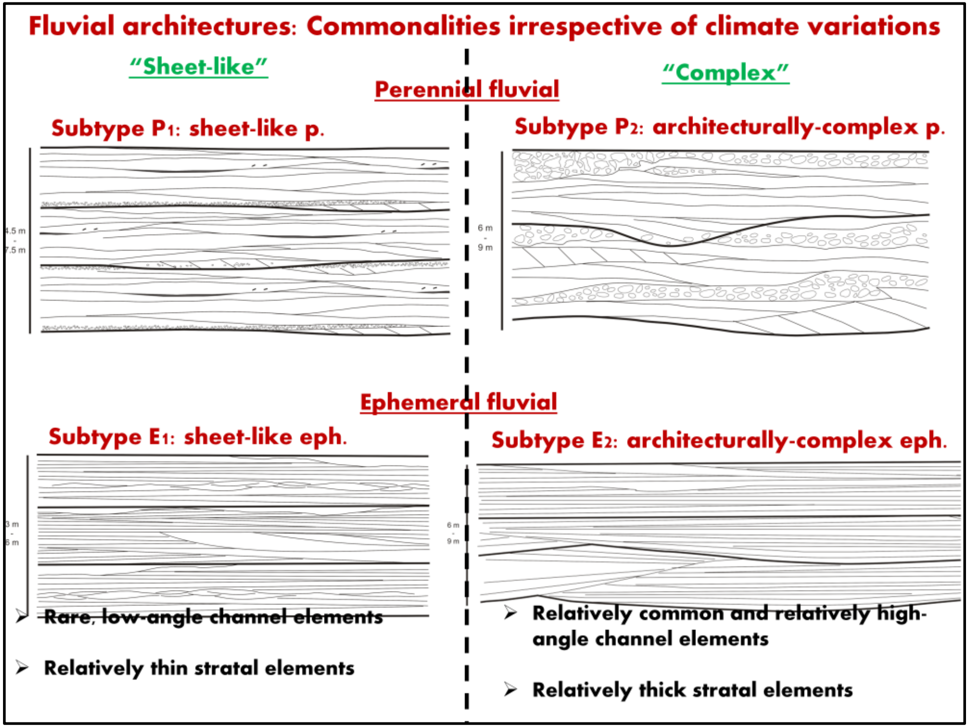




Presenter's notes: Use of eph-Perr contacts as regional isochrons.

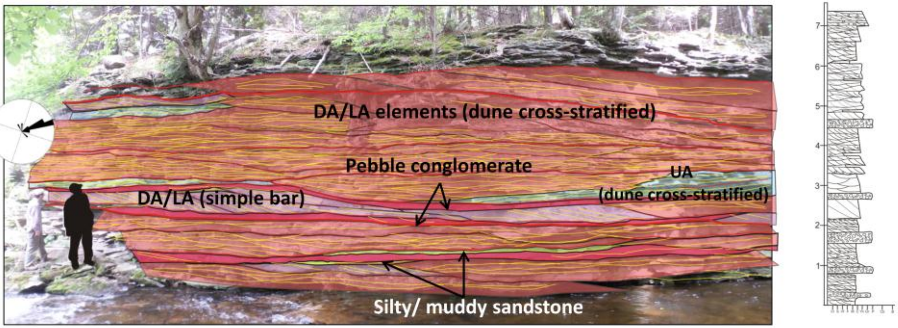
Part II: Controls imposed by bedrock topography :

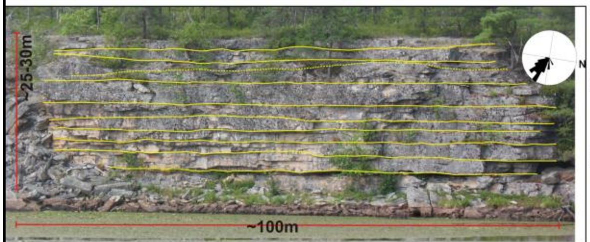
Floodplain width, slope and clast size and their effects on stratal architectures of perennial and ephemeral fluvial architectures.



Presenter's notes: Subtypes- based on differences in stratal architecture.

Subtype P1: "sheet-like" perennial fluvial

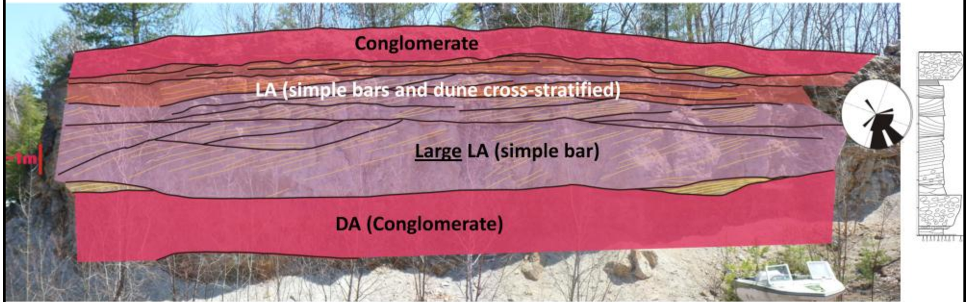


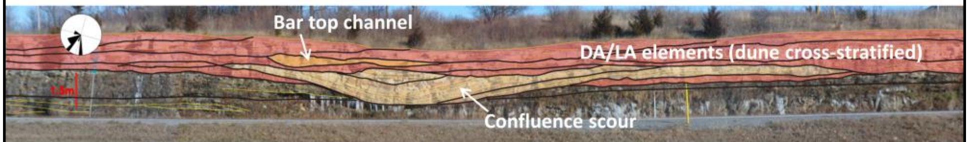


- Dune cross-stratification is the major component.
- Dune cross-beds form DA, LA and UA elements –essentially bar deposits.
- High-angle, thick stratification, formed by simple bars; conglomerates and fine-grained layers.
- Large-scale exposures reveal monotonous vertical stacking and "sheet-like" nature.

Presenter's notes: Type A: Unit bars 20–80 cm; dune strata typically 2D or broad 3D and 5–10 cm (15 cm max.). Thickness of dune bedform and unit bar deposits reflect channel depth (which, was pretty shallow). Unit bars compose compound bar deposits; these are on the order of 2.5–5 m thick. These consist of (from bottom to top) common bedload sheet conglomerates and AOR unit bars at the base, overlain (in some cases) by compound UA unit bars and everywhere DA/LA (oblique commonly) compound unit bars. Overbank/bar top fines may pre present locally. Compound bar sequences are erosionally based, but Incisional channel elements or confluence scours are rare, in general (although some incisional channel bases of compound bars occur [they are quite low angle]). This suggests that channel margins are uncommon and confluences are either uncommon or at a low angle. Compound bar sequences stack vertically in a very continuous and "sheet-like" manner--suggesting a large deal of lateral continuity in these deposits and in the channels in which they formed. Altogether, the architecture is suggestive of relatively shallow (X??), wide (??) and low-sinuosity braided rivers.

Subtype P2: Architecturally-complex perennial fluvial





- Dune cross-stratification is also common as in P1, but in general cross-beds here are twice as thick.
- Large-scale simple bars are more common, and individual elements thicker in general than those in P1.
- Scours- both big and small- are more abundant.

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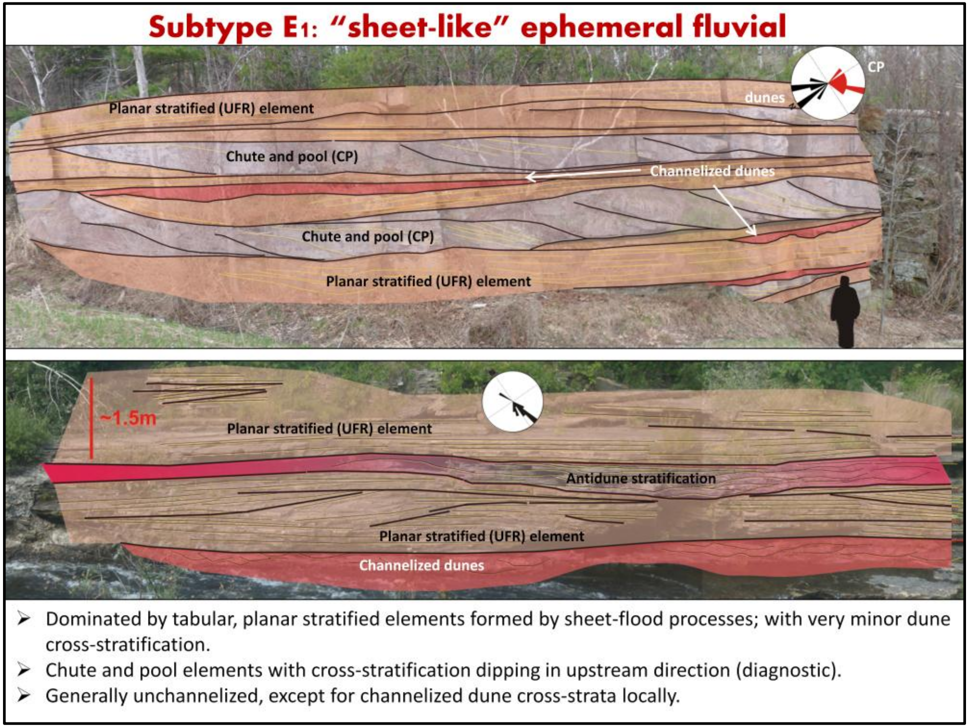

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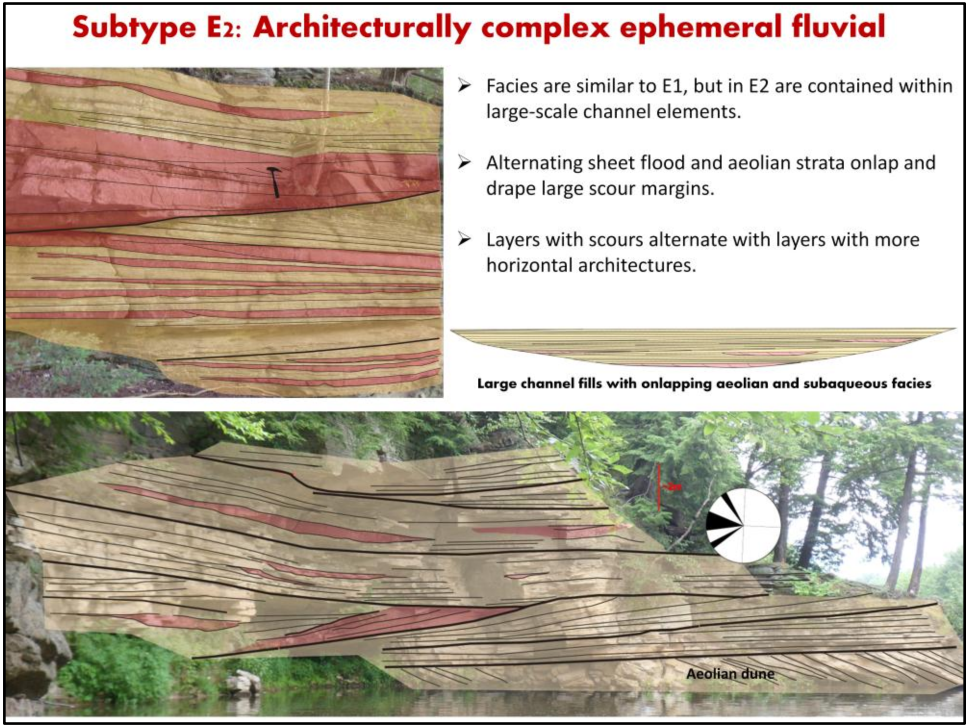

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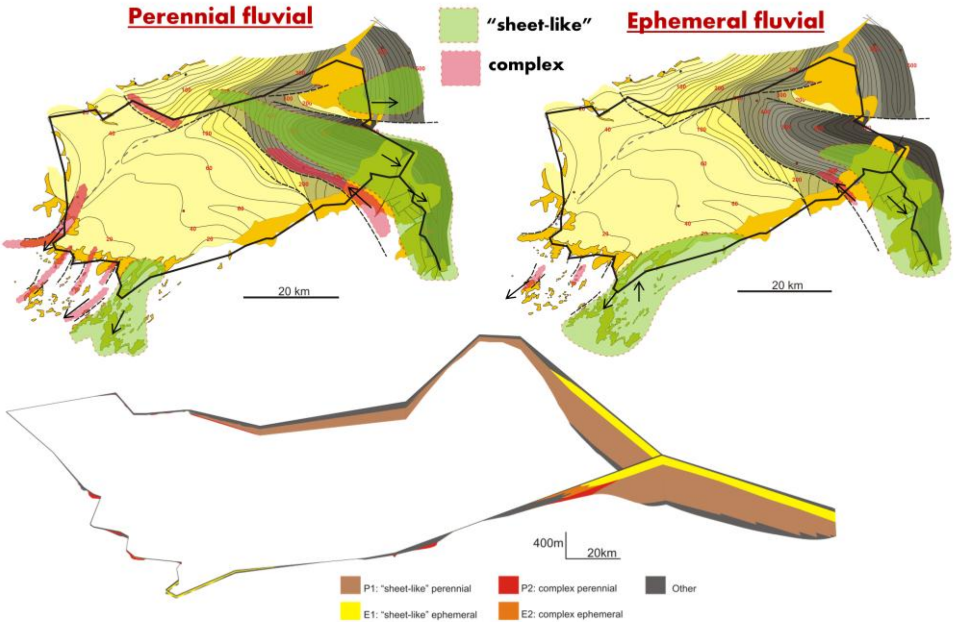
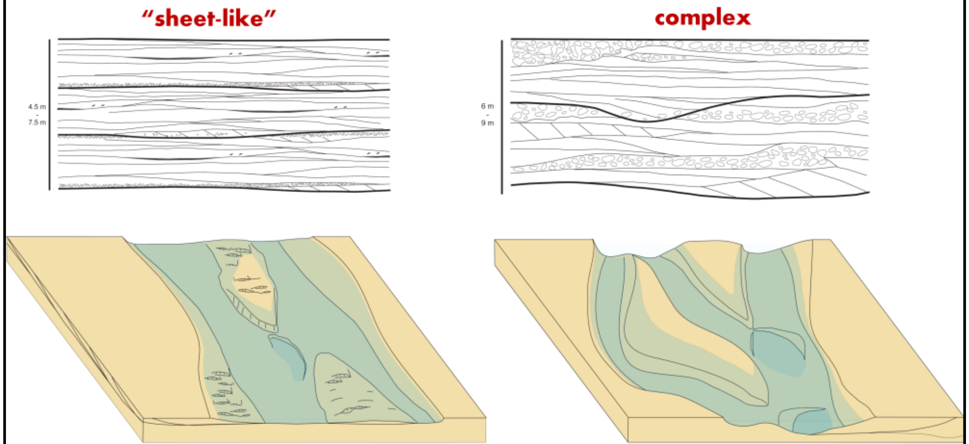
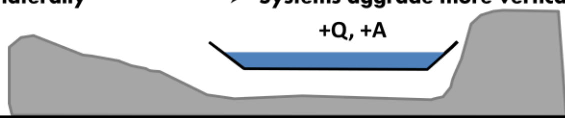
Regional distribution of fluvial types: Links between architectural styles and basin paleogeography



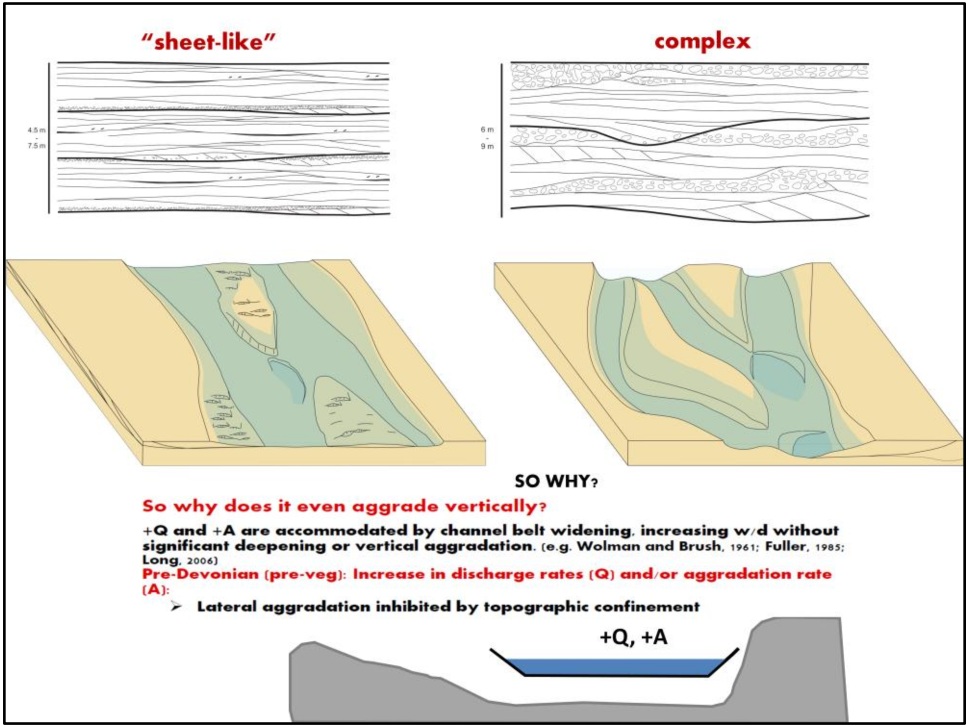


SO WHY?

- Thinner elements and dune cross-beds: shallower flows, thin bars.
- Systems aggrade more laterally
- Thicker elements and dune cross-beds: deeper flows, larger and thicker bars.
- Systems aggrade more vertically



Presenter's notes: Second controlling factor on stratal architecture: defining difference is channel depth, width, and sinuosity- W/ types B and D showing more channel depths and confluences (sinuosity). Related tor types A and C: studies show that without stabilization of floodplain banks (for example, by vegetation), increases in discharge would be taken up by channel widening, without significant increases in depth. Very consistent with types A and C So why are types B and D showing depth and sinuosity? We have good evidence to think that it is due to the presence of basement topography.



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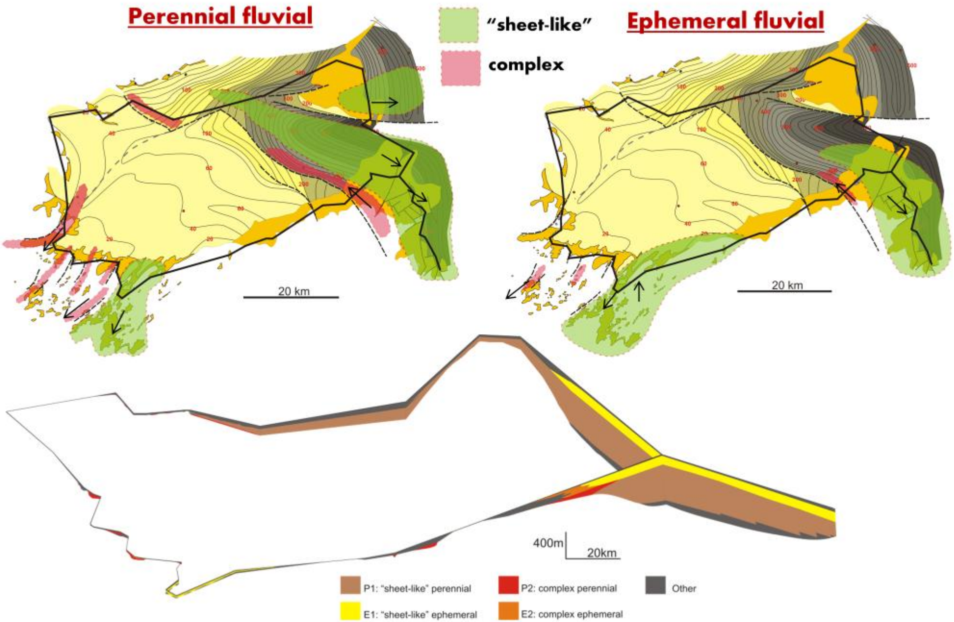

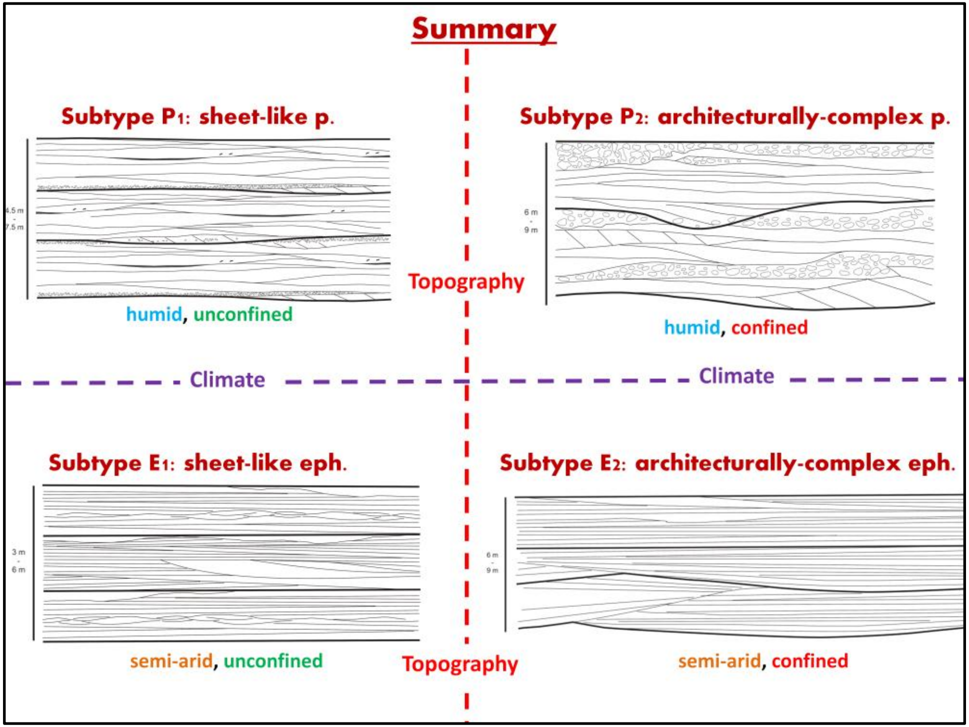

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Conclusions: Both ephemeral and perennial fluvial types occur in the Potsdam; The occurrence of one vs the other is controlled by climate. Contacts between them reflect broad climate changes and can be used for regional chornostratigraphic correlations. A second control on these systems that occurs irrespective of climate is topographic confinement of the floodplain--revealed by recognition of differences in stratal architectures and by stratigraphic relationships observed between fluvial strata and basement.