ePS Facies Architecture of a Compound Incised Valley System in the Ferron Notom Delta, Southern Utah*

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Abstract

Extensive outcrop exposures of a compound incised valley system in the Turonian Ferron Notom Delta in southern Utah allow a detailed bed-scale facies architectural study within a recently developed high-resolution sequence stratigraphic framework. This allows us to link internal facies variability to relative sea level change, as well as evaluating the diachroneity of the basal composite erosional discontinuity.

The incised valley system can be correlated for 30 km in both depositional strike and dip directions. The erosional base of the valley is interpreted as a regional composite sequence boundary. Erosional relief ranges from a few up to 25 meters. Across the erosional surface, there is an abrupt basinward shift in depositional facies from lower shoreface below to pure fluvial or locally tidal estuarine deposits above. The incised valley fill records three episodes of cutting and filling. Estuarine tidal sand ridges characterize the oldest valley fill 1, with concave-up lens-shaped sand bodies containing bar-scale centimeter to decimeter thick mud drapes and abundant tidal bundles. The tidal sand ridges, immediately above the valley 1 floor, suggest that deposition occurred close to the shoreline, possibly during a subsequent short-lived transgression. The second overlying valley erodes these estuarine terrace deposits and cuts into the lower shoreface. Valley 2 contains purely fluvial channel deposits at the base that are overlain by tidally-influenced fluvial channel storeys. Valley 2 shows a multistory fill and represents a renewed fall followed by a transgression. The fluvial lower storeys in Valley 2 were deposited farther inland than the tidal facies in valley 1, and may indicate a less vigorous transgression. The third valley erodes into the two older valleys, and is composed of multistory fluvial channel deposits which lack tidal influence. The composite valley-fill thus shows a complex cutting and filling history. Older terraces are more marine-influenced, whereas younger valley fills record increasingly proximal fluvial facies. The successively more fluvial-dominated nature of each successive valley fill may correlate with a longer-term, prolonged relative sea level fall, punctuated by decreasingly vigorous transgressions. The

main composite erosional discontinuity was not formed instantaneously but is highly diachronous and records a complex history of stepped falls punctuated by decreasingly effective transgressions.

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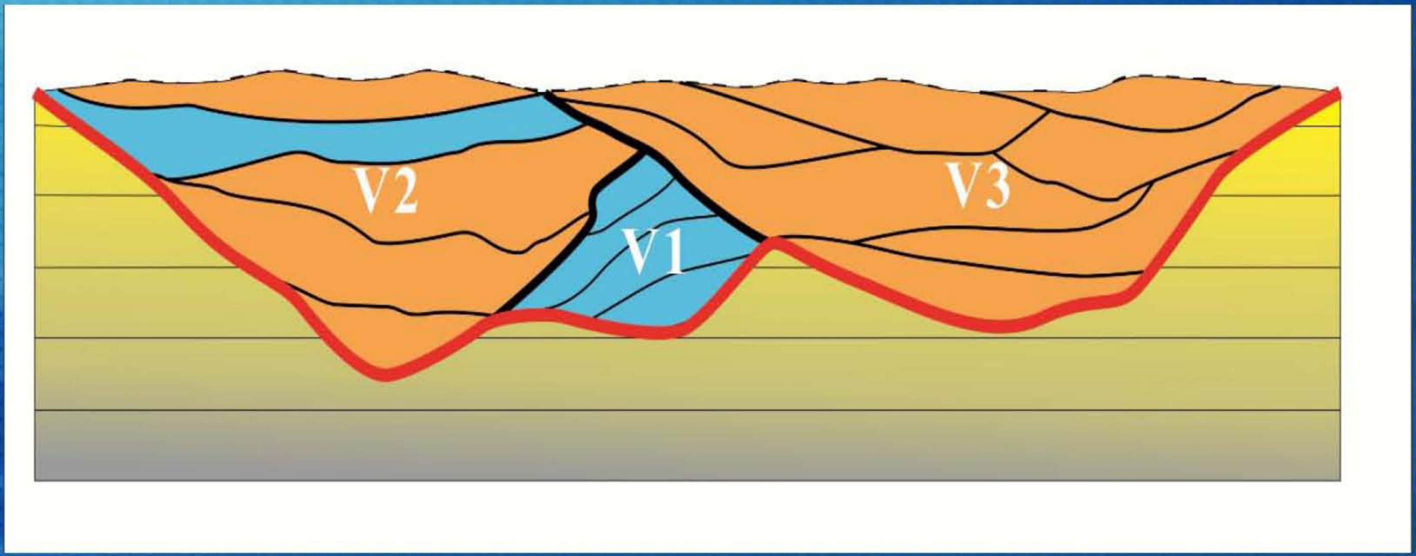
Facies Architectural Study of a Compound Incised Valley System in the Ferron Notom Delta, Southern Utah



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Introduction and Background

- **Definition**
  - Erosional features characterized by an elongate paleotopographic low and larger than a single channel (*Zaitlin et al. 1994*).
- **Economic Meaning**
  - Significant hydrocarbons are produced from reservoirs hosted by incised valleys systems (*Van Wagoner et al. 1991*).
- **Scientific Meaning**
  - A lot of important geological information (climate, tectonic movement, eustatic sea level change) of an area were recorded in incised valley deposits (*Dalrymple et al. 1994; Blum and Tornqvist 2000; Yoshida 2000*).

Presenter's Notes: Incised valleys are erosional features characterized by an elongate paleotopographic low and larger than a single channel. Significant hydrocarbons are produced from incised valley related reservoirs. And a lot of important geological information such as climate change, tectonic movement and eustatic sea level were recorded in valley deposits. In this study, questions about the origin of the incised valleys in the Ferron Notom Delta and factors controlling their internal facies organization are addressed.

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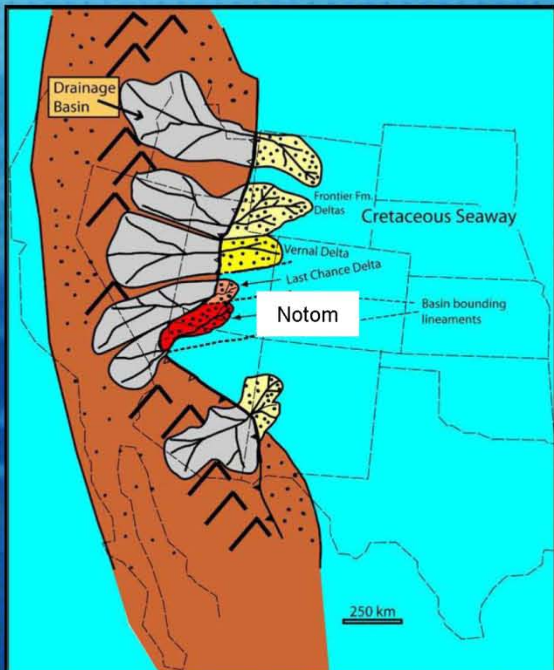
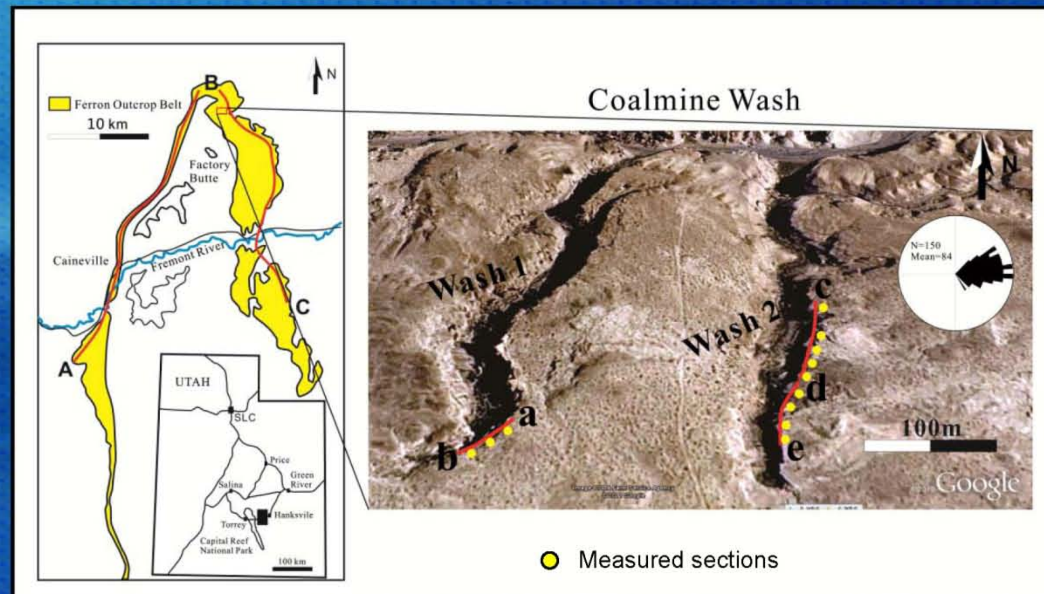
Geological Settings and Study Area

Paleogeographic Reconstruction



From Bhattacharya and Tye, 2004

Study Area



Presenter's Notes: The Notom Delta in Ferron Sandstone member Mancos Shale formation was deposited in the Cretaceous Western Interior Seaway along with the thrusting of the Sevier Orogenic belt and the subsidence of the Cordillera foreland basin. My study area is located in the Coalmine Wash area close to city Hanksville as is shown in the right figure.

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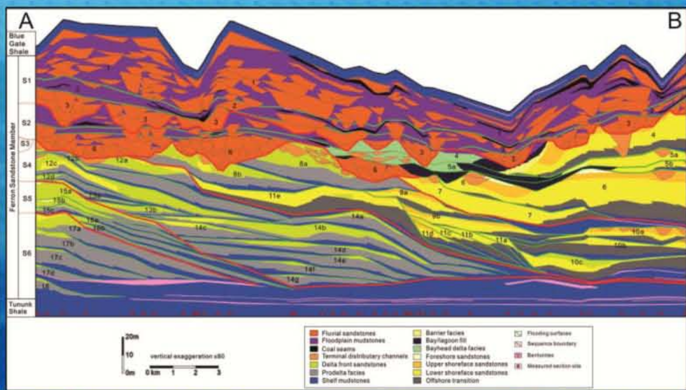
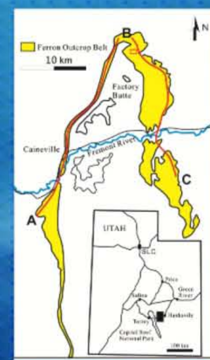
Regional Sequence Stratigraphy

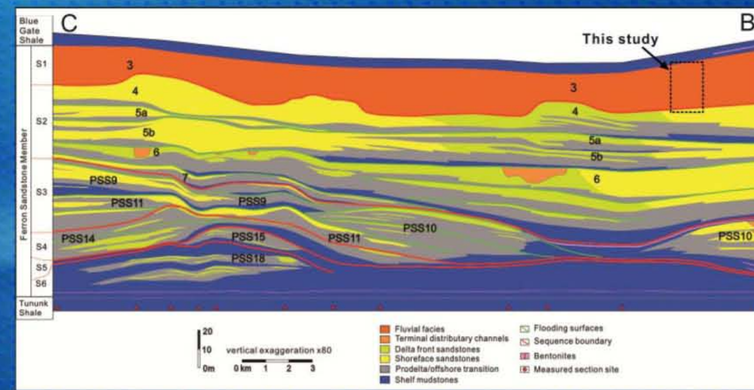
Depositional dip cross section



From Zhu, 2010



Depositional strike cross section



From Li, 2009

- Six sequences, 42 parasequences are recognized in the previous study;
- Parasequence 3 which is bounded below by SB 1 is the focus of this study.

Presenter's Notes: In the previous regional sequence stratigraphic study of the Notom delta by Zhu and Li Six sequences, 42 parasequences are recognized. Parasequence 3 which is bounded below by SB 1 is the focus of this study.

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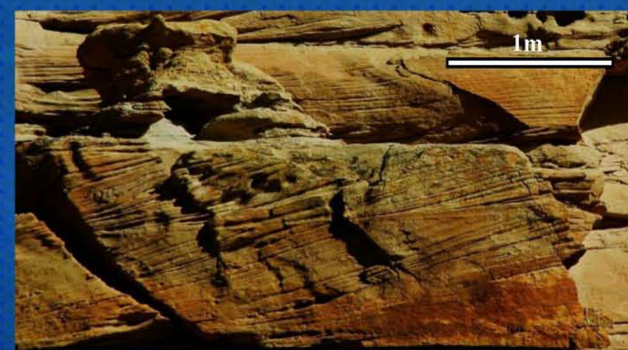
Facies Analysis

Fluvial Facies:

Valley Lag

Trough Cross Bedding (Migration of 3D Dunes)

Tabular Cross Bedding (Migration of 2D Dunes)



Solitary Meter-scale Cross Bedding (Unit Bars)

Presenter's Notes: This slide shows some of the fluvial facies in the incised valley. Upper left picture shows a coaly, pebbly medium to coarse grained valley lag deposit. But the dominant fluvial lithofacies are cross bedded medium grained sandstone as shown in other pictures.

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Facies Analysis

Tidal Facies:

Dune-scale Cross Bedding with Double Mud Drapes

Meter-scale Cross Bedding with Double Mud Drapes

Flaser Bedding

Tidal Bundles

Presenter’s Notes: Tidal facies are also identified in the incised valley system, including dune-scale cross bedded sandstone with double mud drapes, meter-scale cross bedded sandstone with double mud drapes and falser bedded sandstone.

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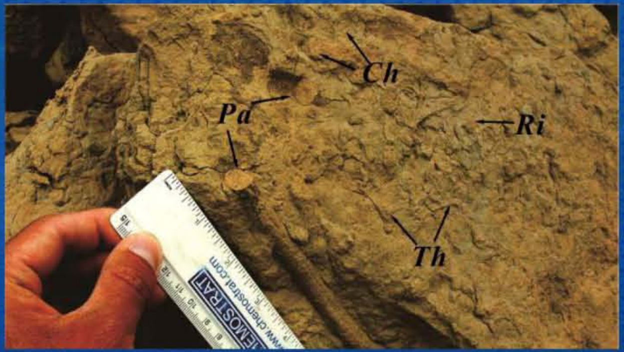
Facies Analysis

Lower Shoreface:

Interbedded HCS Sandstone with Mudstone

Amalgamated HCS Sandstone

Wave Ripple Cross Laminated Sandstone



Highly Bioturbated Sandstone

Presenter's Notes: The compound incised valley cuts below into lower shoreface deposits in parasequence 4, which is characterized by abundant HCS and a Cruziana ichnofacies.

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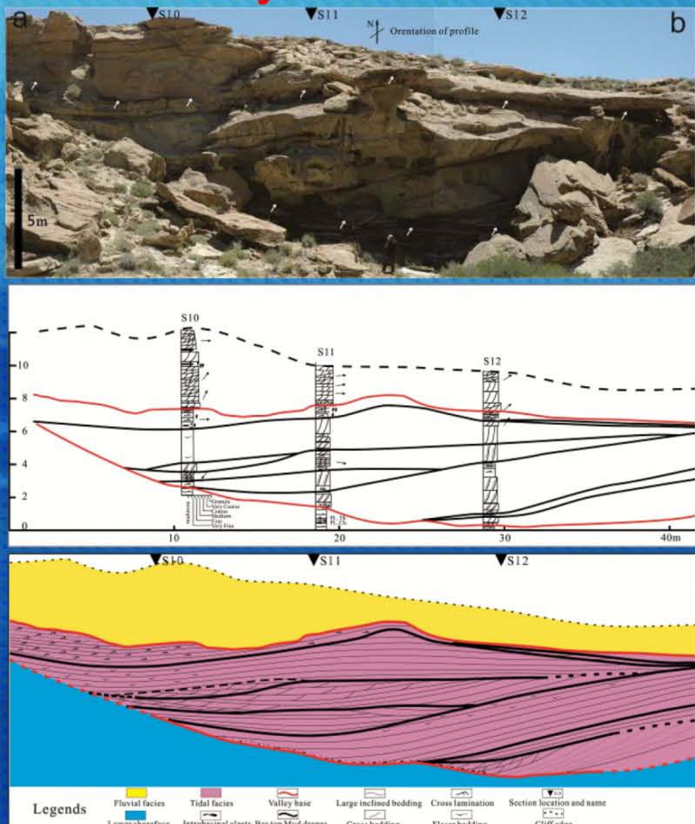
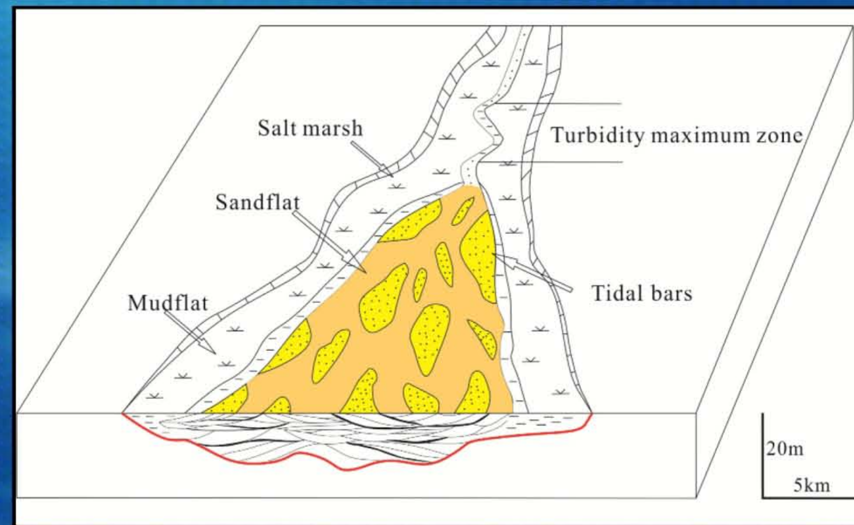
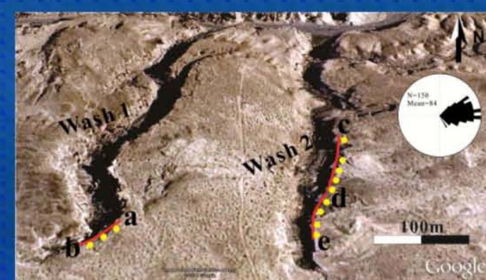
Facies Architecture Analysis

Incised Valley 1:







Presenter's Notes: Three simple incised valley systems are identified in the compound valley system. Incised valley 1 is exposed at Wash 1 at transect a-b. It is bounded above and below by two major erosional surfaces as marked by white arrows in the photomosaic. Correlation of measured sections shows that incised valley 1 cuts into lower shoreface deposits below. The upper erosional surface correlates with the base of valley 2 and 3, which indicates that incised valley 1 is the oldest of the three valleys. Internally, incised valley 1 is separated by a few centimeter- to decimeter- thick mud drapes into lens-shaped sand bodies, which are composed of mainly tidal influenced deposits. These Lens-shaped sand bodies are interpreted to be sandy tidal bars deposited in a tidal estuary environment as shown in the blocking diagram and the mudstone layers draping the sandy tidal bars are interpreted to be produced by seaward shifting of turbidity maximum zone during a flood event.

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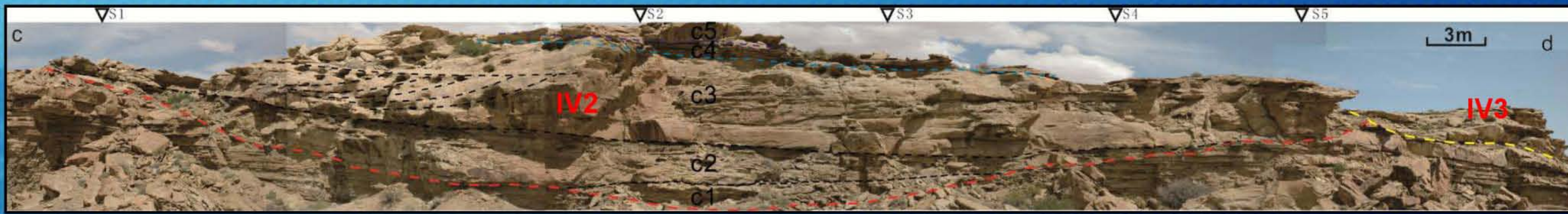
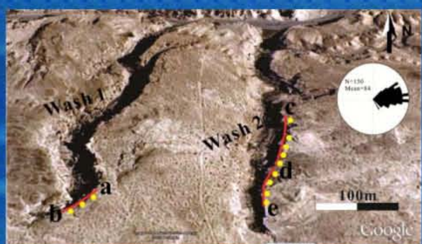
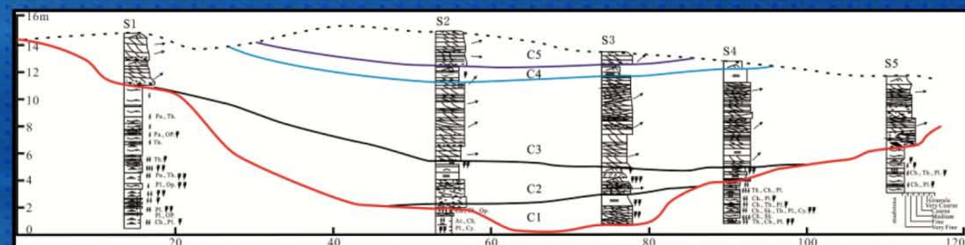
Facies Architecture Analysis

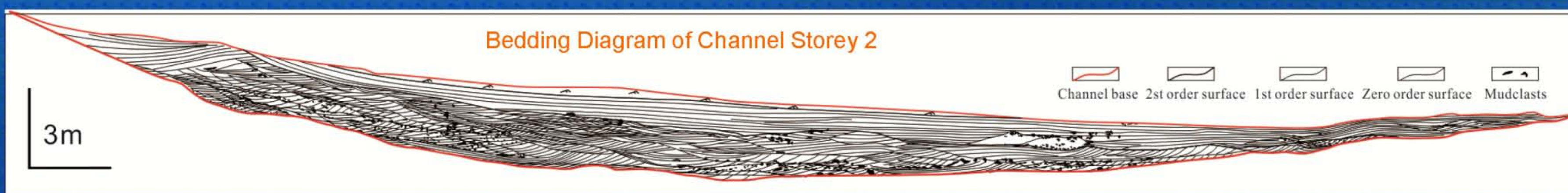
Incised Valley 2:



Photomosaic of Incised Valley 2 showing a multistorey fill







Bedding Diagram of Channel Storey 2

Presenter’s Notes: Incised Valley 2 is well exposed at Wash 2 of the study area at transect c-d. It cuts into the lower shoreface deposits below. Internally, it shows a multistorey fill and five storeys (c1-c5) are recognized. The lower channel storeys 1, 2 and 3 are pure fluvial deposits. Channel storey 2 for example, show a regular change in lithofacies from mud clast rich cross bedded medium grained sandstone upward to planar and current ripple cross laminated fine grained sandstone. Channel storey 4 is tidal influenced deposits and channel 5 back to fluvial. Consequently, channel storey 4 is interpreted to be bounded below and above respectively by a transgressive surface and a maximums flooding surface.

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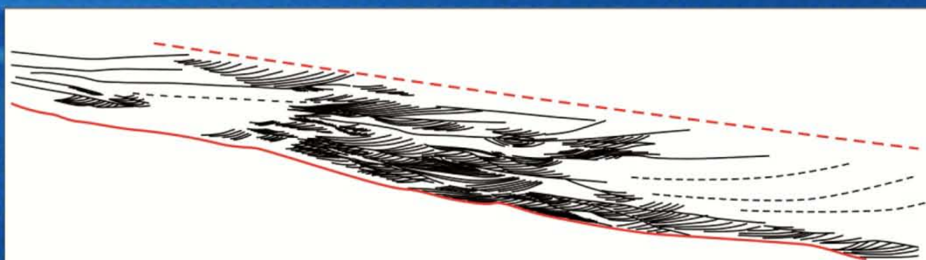
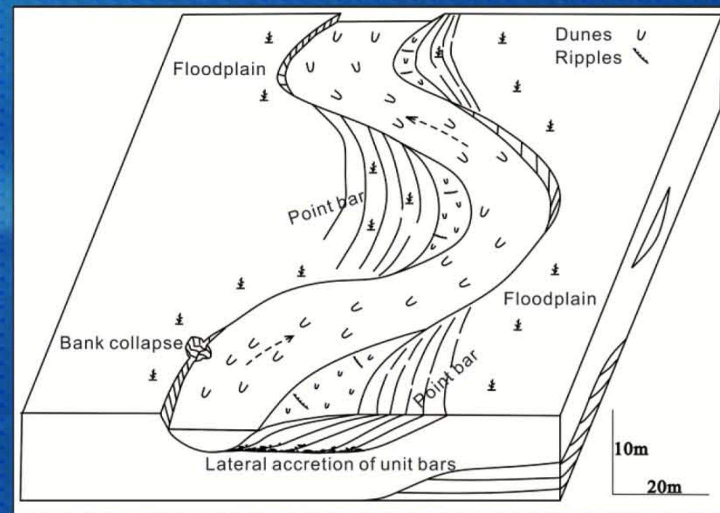
Facies Architecture Analysis

Channel Storey 3 in Incised Valley 2:

Photomosaic of the lower left part of channel storey 3 in incised valley 2.



Bedding Diagram



Paleogeographic reconstruction of channel storey 3 (after Miall, 1985).

Presenter's Notes: The large scale inclined beds in channel storey 3 are interpreted to be lateral accreting unit bars. They are composed of dune-scale cross bedded medium grained sandstone and meter-scale cross bedded sandstone. The large inclined beds are dipping to the left which is generally toward north, while the internal dune-scale cross beds mainly dip into the outcrop which is east, indicating that the unit bars are accreting perpendicular to the paleoflow direction. Consequently, a classic sandy meandering fluvial style is suggested. Bankfull channel depth is estimated to be about 4.4m from both the thickness of lateral accreting unit bars and the average thickness dune-scale cross sets.

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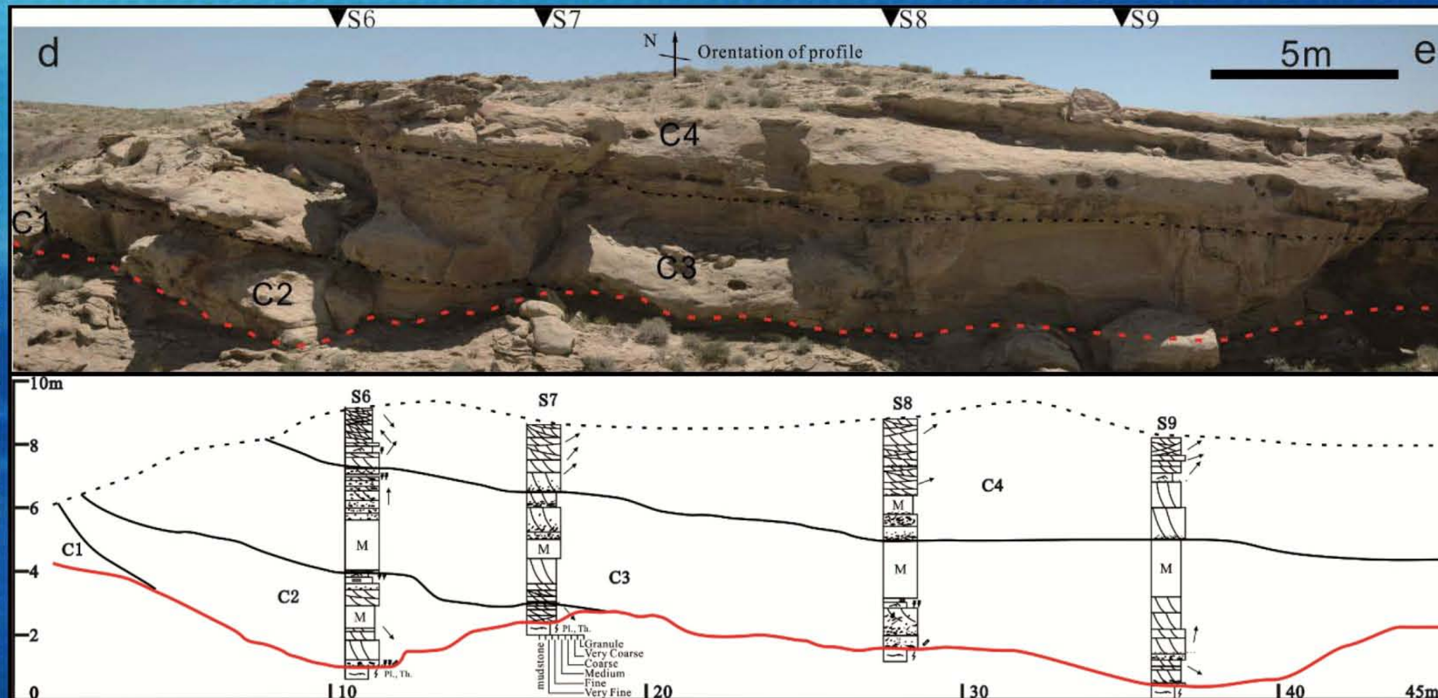
Facies Architecture Analysis

Incised Valley 3:



Presenter's Notes: Incised valley 3 which is exposed at the end of Wash 2 at d-e truncates incised valley 2, indicating that incised valley 3 is the youngest of the three incised valleys. Internally it shows a multistorey fill. Four channel storeys which are pure fluvial deposits are recognized and are separated by major erosional surfaces. A lateral and upward amalgamated stacking pattern of these four channel storeys can be seen.

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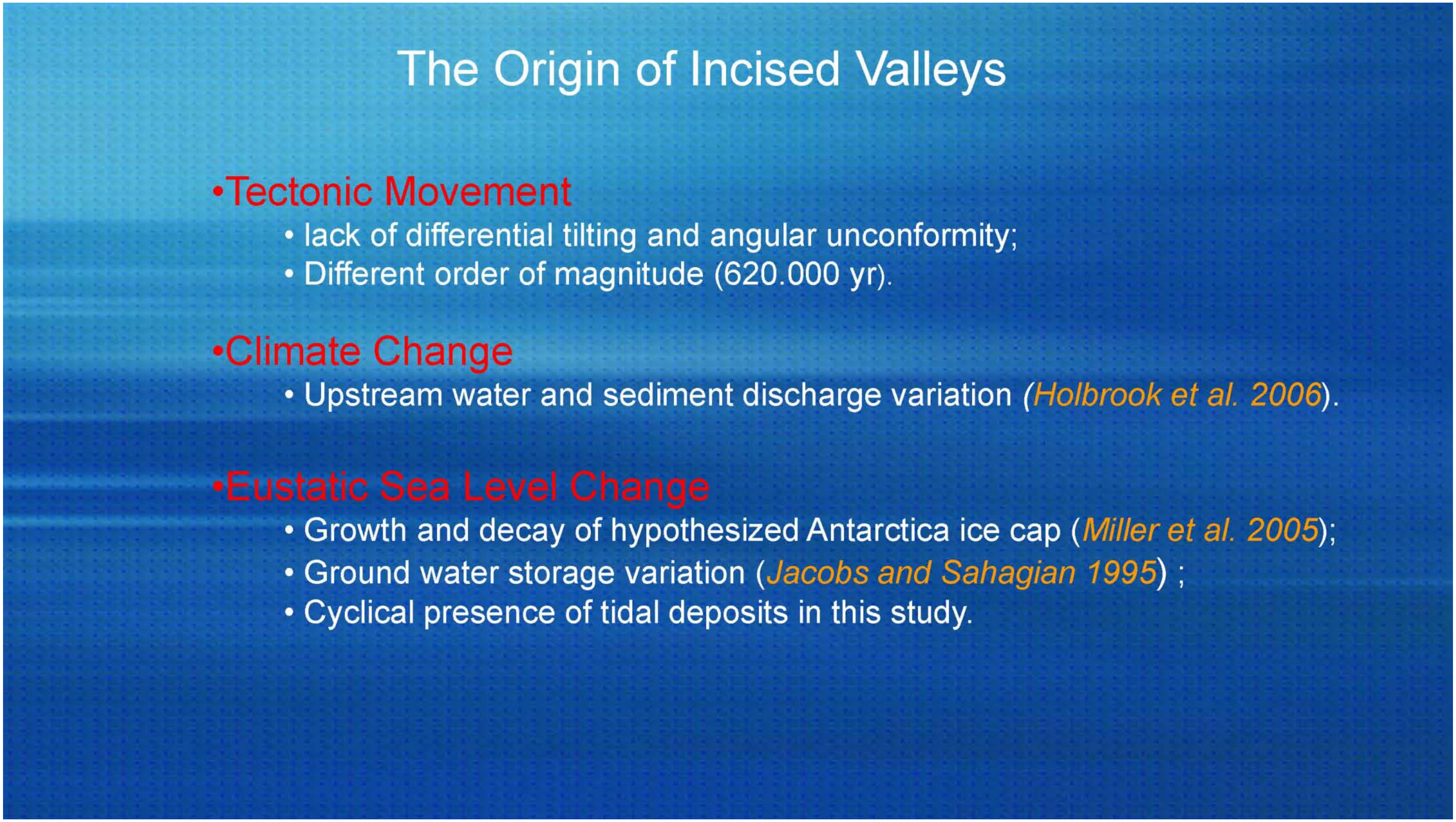
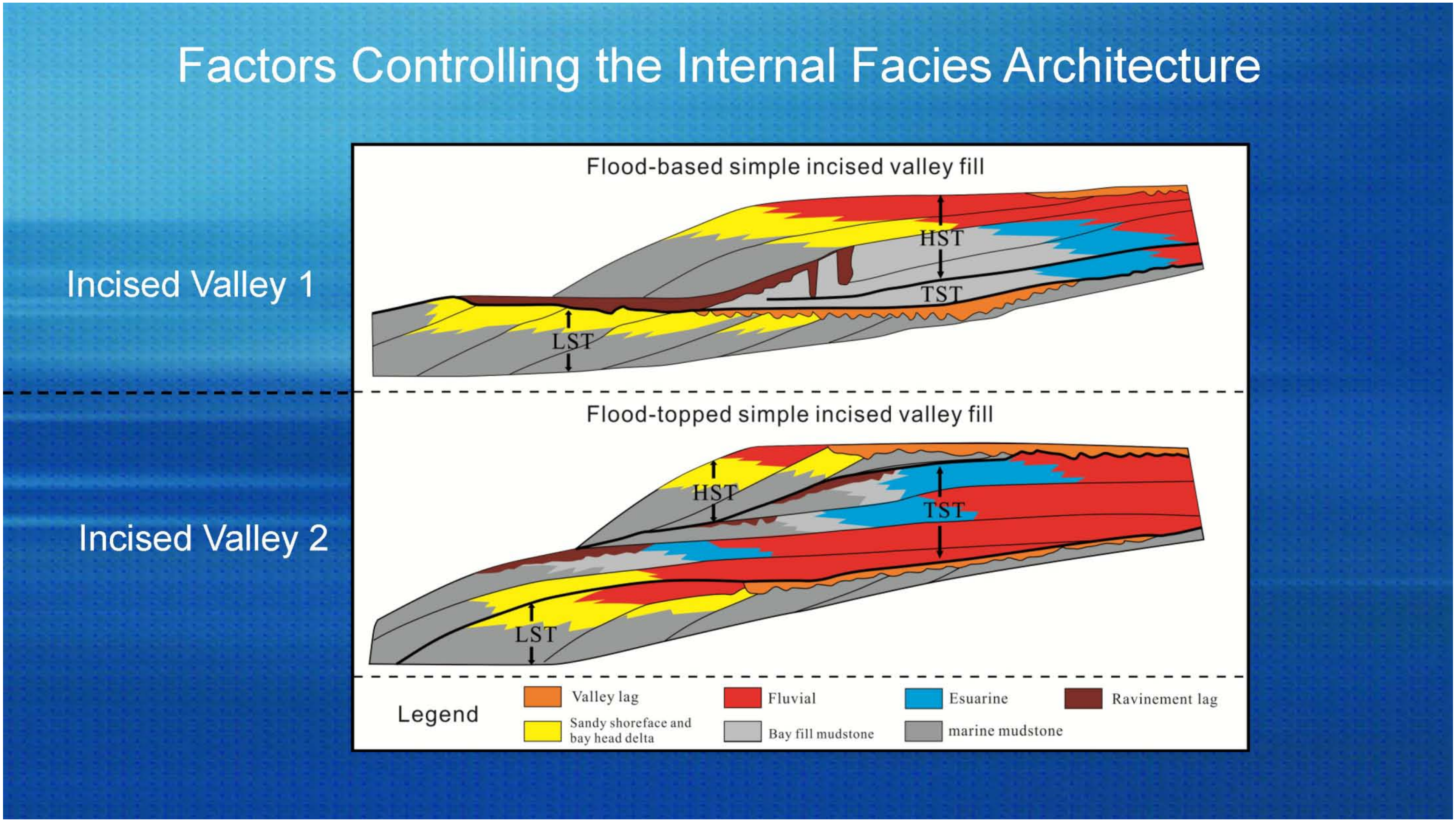


Presenter’s Notes: Ok, what are the possible origins of the compound incised valley system. Bentonite dating indicates that the Notom Delta was emplaced during 91.25 ~90.63 Ma, a total of 600, 000 yrs. Thus, each sequence has an average of 100,000 yrs. Consequently, the formation of each simple incised valley system in this study is probably on the order of 10,000 yrs. Tectonic movements are commonly on the order of Ma yrs or longer and are excluded due to the lack of differential tilting and the absence of angular unconformities. Climate change induced water and sediment discharge variation and eustatic sea level change due to growth and decay of a hypothesized Antarctic ice cap or variation of ground water storage (Miller et al., 2005) are interpreted to be major driving forces.



Presenter's Notes: The internal facies organization and abundance in the valleys are interpreted to be controlled by the ratio of sediment supply to accommodation creation. Incised valley 1 was rapidly flooded by the rising sea, and the rate of relative sea level rise greatly exceeded rate of sediment supply. In this scenario, the bulk of the valley was filled with estuarine deposits and the flooding surface is positioned at the base of the valley fill, forming a flood-based valley-fill pattern. In contrast, the rate of sediment supply initially kept pace with the rate of relative sea level rise when incised valley 2 was filled. In this case, the bulk of the valley was filled with fluvial deposits and the flooding surface is positioned at upper part of the valley fill because the valley was largely filled before the major flooding, forming a flood-topped valley-fill pattern. Lateral and upward aggradation of fluvial deposits in incised valley 3 indicates rising of relative sea level, but absence of marine influenced deposits suggests that it was never flooded before the complete fill of the valley.

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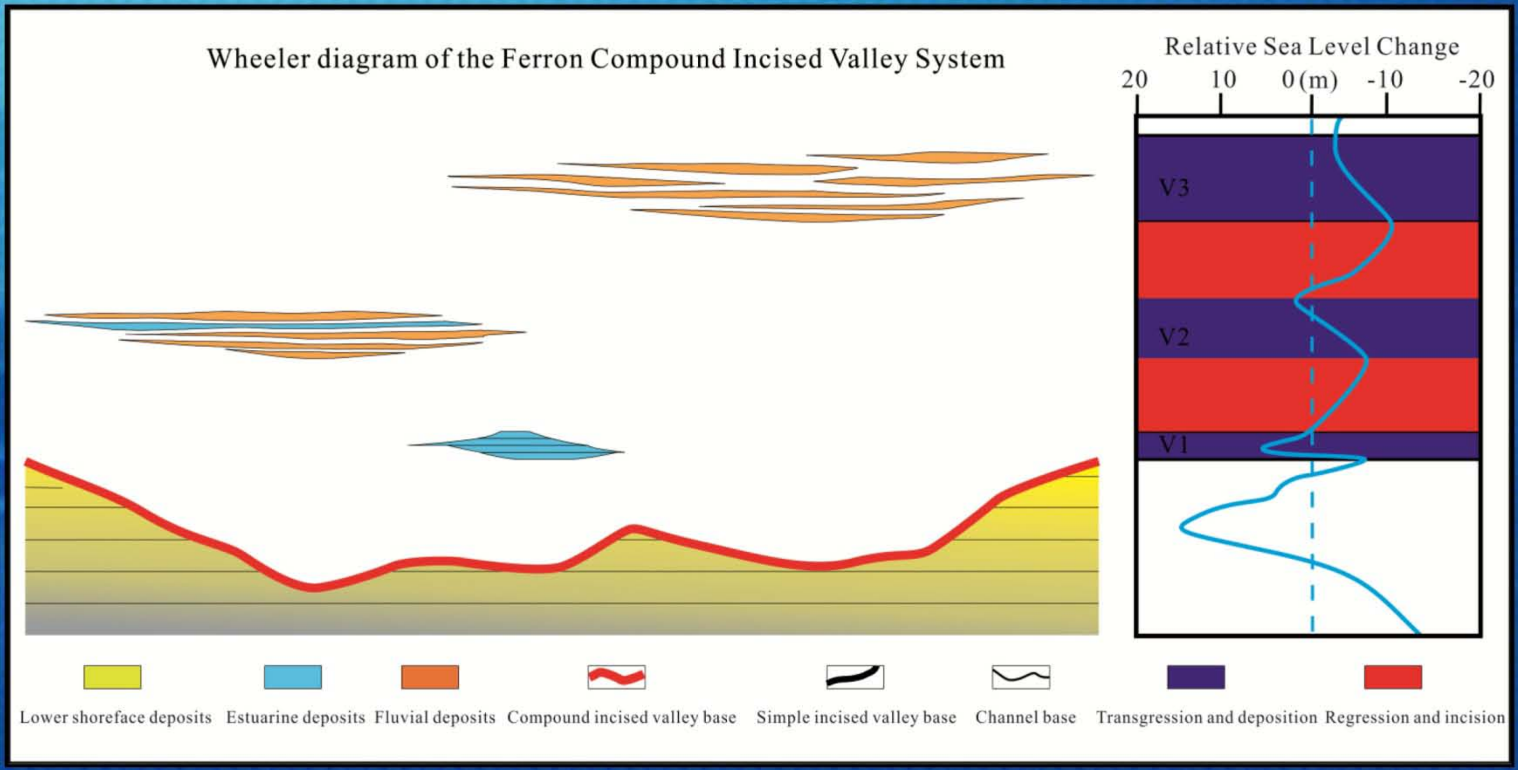
Conclusions



Presenter's Notes: To summarize, a compound incised valley system is identified, with 3 simple incised valleys showing different fill patterns, which are controlled by ratio of sediment supply over accommodation creation. Climate and eustatic sea level change are major driving forces. The successively more fluvial-dominated nature of each successive valley fill may correlate with a longer-term, stepped relative sea level fall, punctuated by decreasingly vigorous transgressions.