

The Effects of Early Eocene Climate Change on the Composition of Fluvial Sandstones, Uinta Basin, Utah*

Evan Jones¹ and Piret Plink-Björklund²

Search and Discovery Article #50880 (2013)**

Posted October 29, 2013

*Adapted from an oral presentation given at AAPG Rocky Mountain Section Meeting, Salt Lake City, Utah, September 22-24, 2013

**AAPG©2013 Serial rights given by author. For all other rights contact author directly.

¹Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401 (evjones@mines.edu)

²Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401

Abstract

The Wasatch and Green River Formations in the Uinta Basin contain fluvial sandstones that record terrestrial sedimentation coincident with Paleocene-Eocene Thermal Maximum (PETM) and six post-PETM hyperthermal climate change events. The Uinta Basin was one of a series of lacustrine basins isolated by Laramide uplifts in the Rocky Mountain region during the Early Eocene, and this project will better constrain the relative influence of both tectonic and climatic forcing on fluvial systems that fed sediment and water to these endorheic basins. This dataset combines quantitative petrographic analysis with carbon isotope analysis taken along measured stratigraphic sections in the southern margin of the Uinta Basin. This work shows that peak negative isotope excursions, related to pulses of greenhouse climate, correlate to regional flushing of sediment from catchment areas and progradation of fluvial systems into the lacustrine basin. This correlates to deeper channel incision, lateral and vertical amalgamation of channels, and delivery of relatively compositionally and texturally immature sediment to the basin. Understanding the compositional and textural maturity of these fluvial sandstones will provide insights into the response of chemical weathering rates, physical erosion rates, and the seasonality of sediment and water discharge to a series of global warming events. Climate change during the PETM was initiated by a release of over 2,000 gigatonnes of CO₂ into the atmosphere, comparable in magnitude to that which could occur in the coming centuries from anthropogenic sources, and understanding the terrestrial response to extreme climatic forcing is important for predictive climate change modeling. Further, if terrestrial records of chemical weathering rates differ substantially from proxies developed from marine sediments, carbon-cycle dynamics during the Early Eocene Climatic Optimum must be reconsidered.

References Cited

Amos, K.J., J. Alexander, A. Horn, G.D. Pocock, and C.R. Fielding, 2004, Supply limited sediment transport in a high-discharge event of the tropical Burdekin River, North Queensland, Australia: *Sedimentology*, v. 51/1, p. 145-162.

Castle, J.W., 1990, Sedimentation in Eocene Lake Uinta (lower Green River Formation), northeastern Uinta Basin, Utah, *in* B.J. Katz, (ed.), *Lacustrine basin exploration; case studies and modern analogs: AAPG Memoir 50*, p. 243-263.

Dickinson, W.R., and C.A. Suczek, 1979, Plate tectonics and sandstone compositions: AAPG Bulletin, v. 63/12, p. 2164-2182.

Dickinson, W.R., T.F. Lawton, M. Pecha, S.J. Davis, G.E. Gehrels, and R.A. Young, 2012, Provenance of the Paleogene Colton Formation (Uinta Basin) and Cretaceous-Paleogene provenance evolution in the Utah foreland; evidence from U-Pb ages of detrital zircons, paleocurrent trends, and sandstone petrofacies: Geosphere, v. 8/4, p. 854-880.

Fielding, C.R., J.D. Trueman, and J. Alexander, 2006, Holocene depositional history of the Burdekin River delta of northeastern Australia; a model for a low-accommodation, highstand delta: JSR, v. 76/3-4, p. 411-428.

Foreman, B.Z., P.L. Heller, and M.T. Clementz, 2012, Fluvial response to abrupt global warming at the Palaeocene/Eocene boundary: Nature London, v. 491/7422, p. 92-95.

Fricke, H.C., B.Z. Foreman, and J.O. Sewall, 2010, Integrated climate model-oxygen isotope evidence for a North American monsoon during the late Cretaceous: Earth and Planetary Science Letters, v. 289/1-2, p. 11-21.

Magioncalda, R., C. Dupuis, T. Smith, E. Steurbaut, and P.D. Ginerich, 2004, Paleocene-Eocene carbon isotope excursion in organic carbon and pedogenic carbonate; direct comparison in a continental stratigraphic section: Geology, v. 32/7, p. 553-556.

Taylor, A.W., 2002, Sedimentology, facies architecture, and reservoir characterization of lacustrine rocks, Eocene Green River and Colton Formations, Uinta Basin, Utah: Utah State University M.S. Thesis, 137 p.

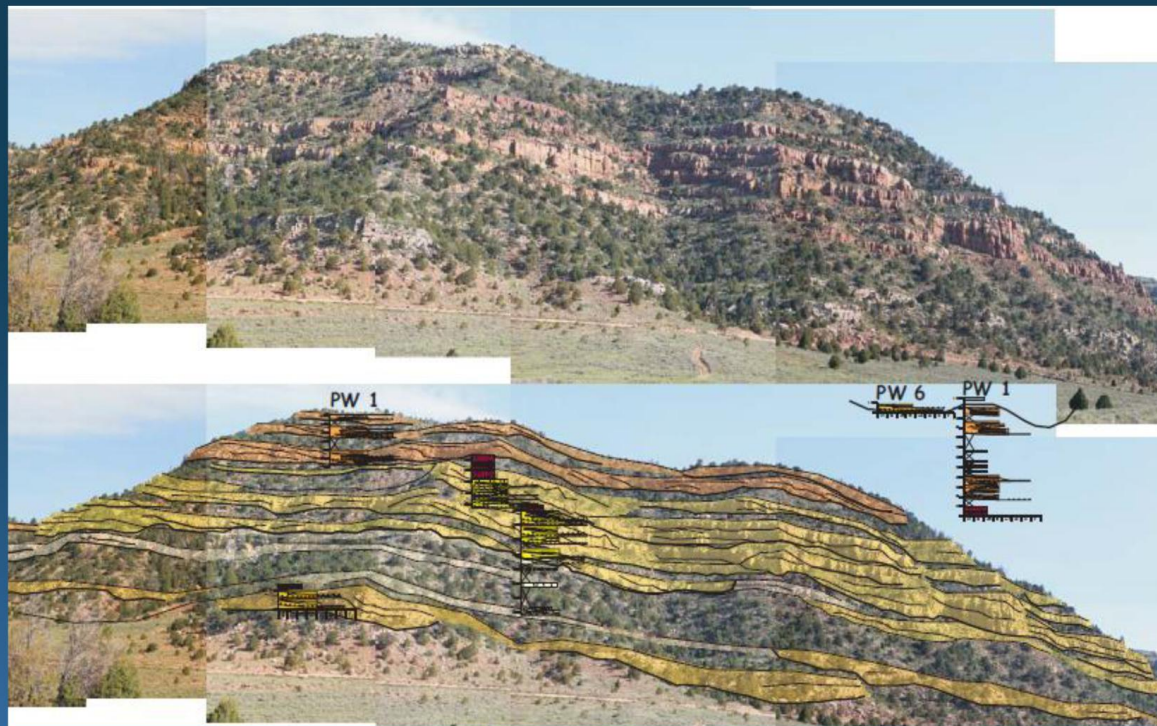
Wing, S.L., G.J. Harrington, F.A. Smith, J.I. Bloch, D.M. Boyer, and K.H. Freeman, 2005, Transient floral change and rapid global warming at the Paleocene-Eocene boundary: Science, v. 310/5750, p. 993-996.

Website Cited

Image of North America: Geographic Guide Globe Images. Web accessed October 21, 2013. <http://www.geographicguide.com/north-america-image.htm>

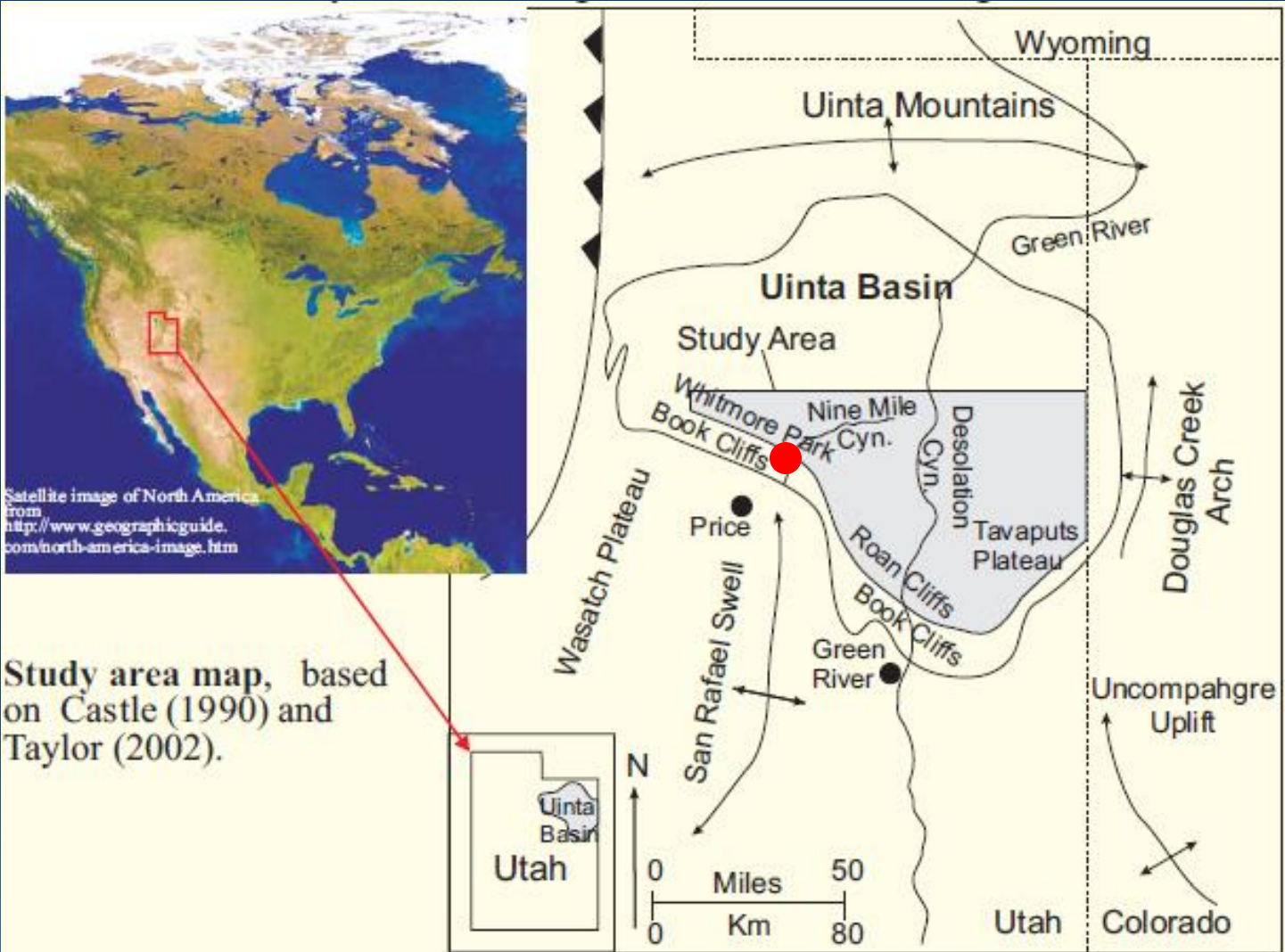
The Effects of Early Eocene Climate Change on the Composition of Fluvial Sandstones, Uinta Basin, Utah

Evan Jones and Piret Plink-Björklund



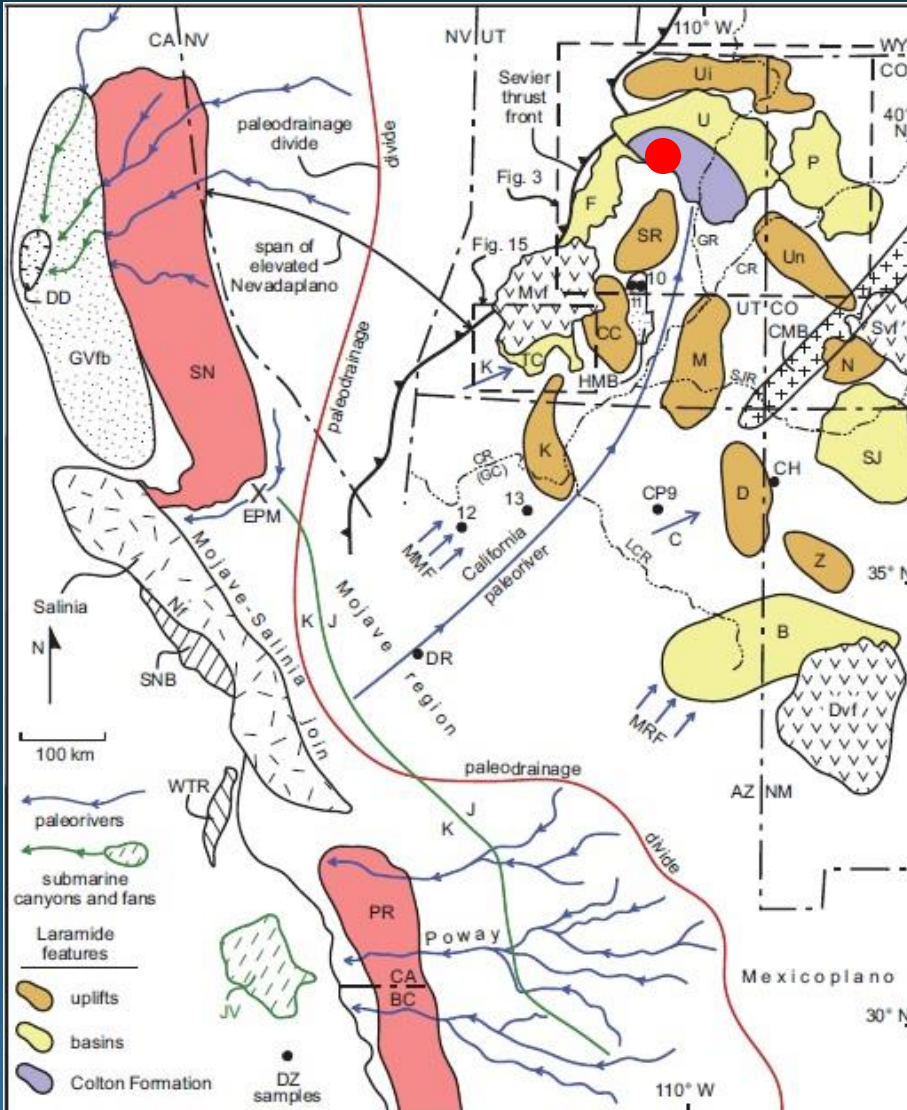


Study Area





Paleoreconstruction

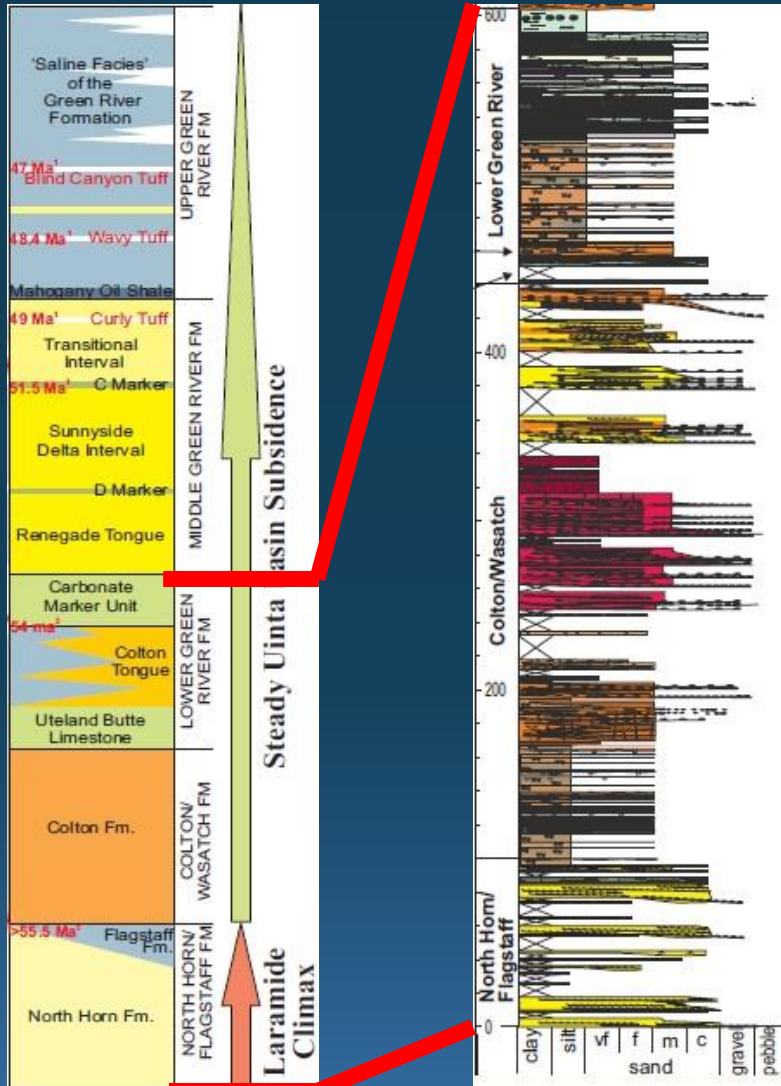


- Detrital zircon geochronology from Dickinson et al. (2012)
 - Multiple point sources into endorheic basin
 - 1) Sevier thrustbelt
 - 2) Laramide uplifts
 - 3) Cordilleran magmatic arc
 - Axial river system along the eastern flank of the Sevier Orogen

Figure 1 from Dickinson et al. (2012)



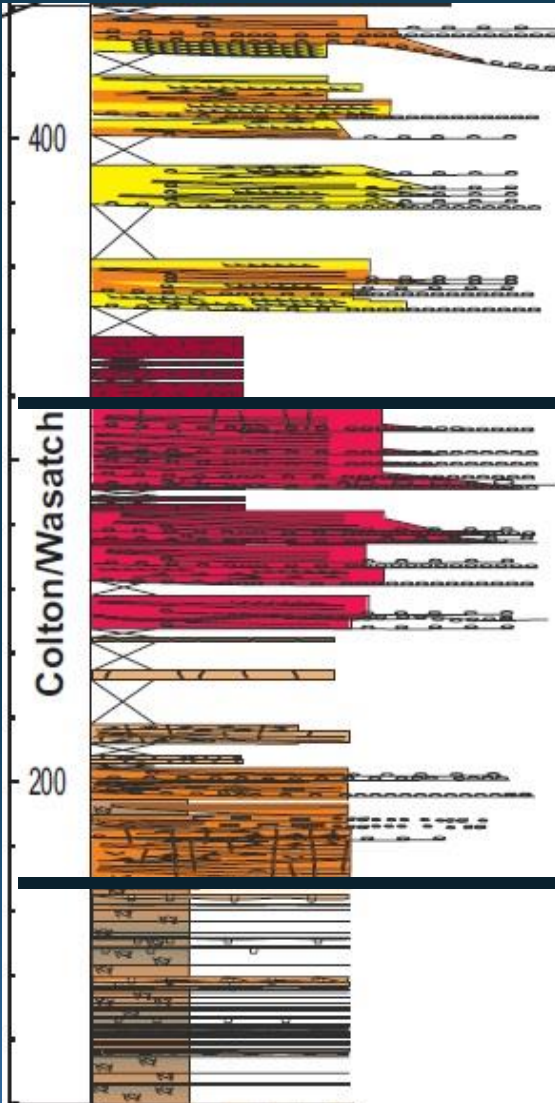
Stratigraphy – Uinta Basin



- North Horn Fm.
 - Syn-tectonic unconformities and conglomerates
- Wasatch Fm.
 - Fluvial sandstones prograding into paleolake Uinta
- Green River Fm.
 - Interfingering lacustrine carbonates and alluvial sandstones



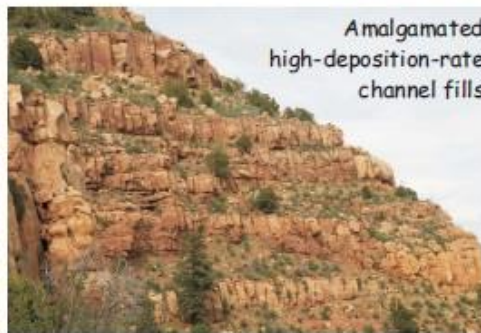
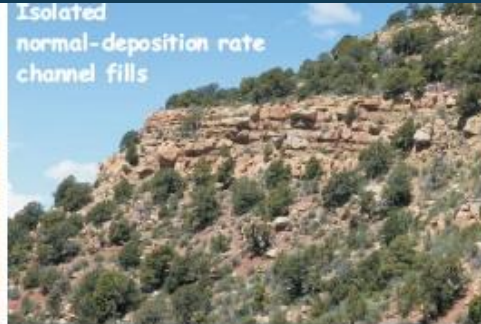
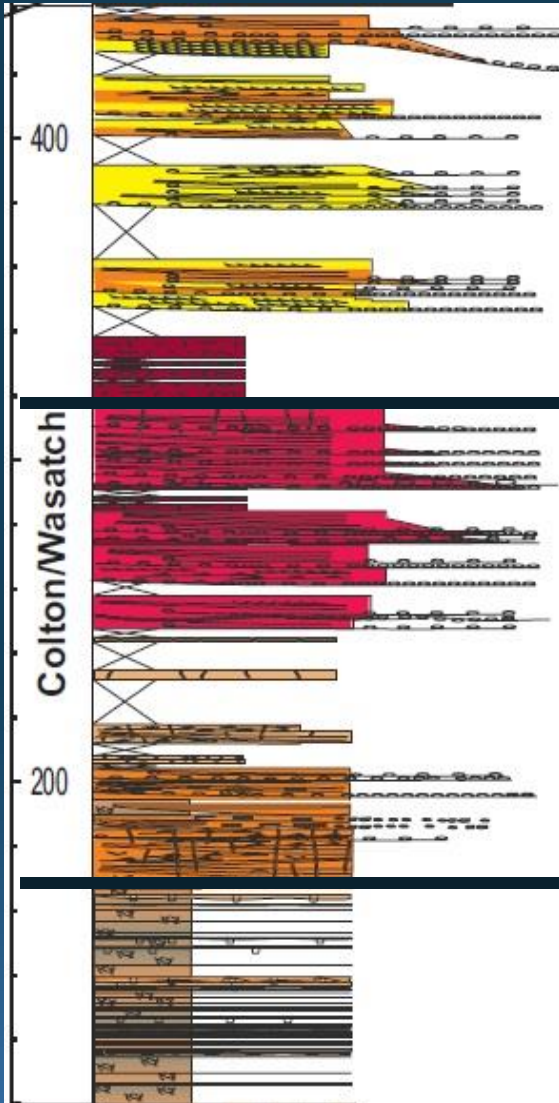
Stratigraphy – Wasatch Fm.



- Upper Wasatch
 - Dominated by trough cross stratified channel fills
 - Maximum channel depths – 16 meters
- Middle Wasatch
 - Channel fills dominated by gradational planar laminations and climbing ripples
 - Maximum channel depths 30 meters
 - Many second and third order erosion surfaces
- Lower Wasatch
 - Channel fills dominated b trough cross stratification and climbing ripples
 - Maximum channel depths 10 meters

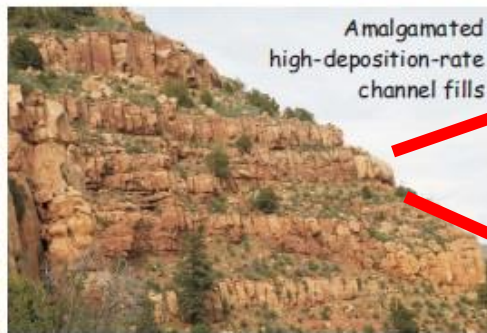
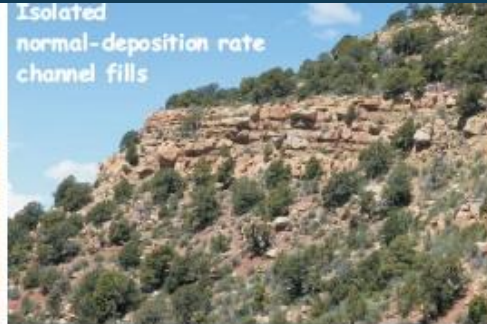
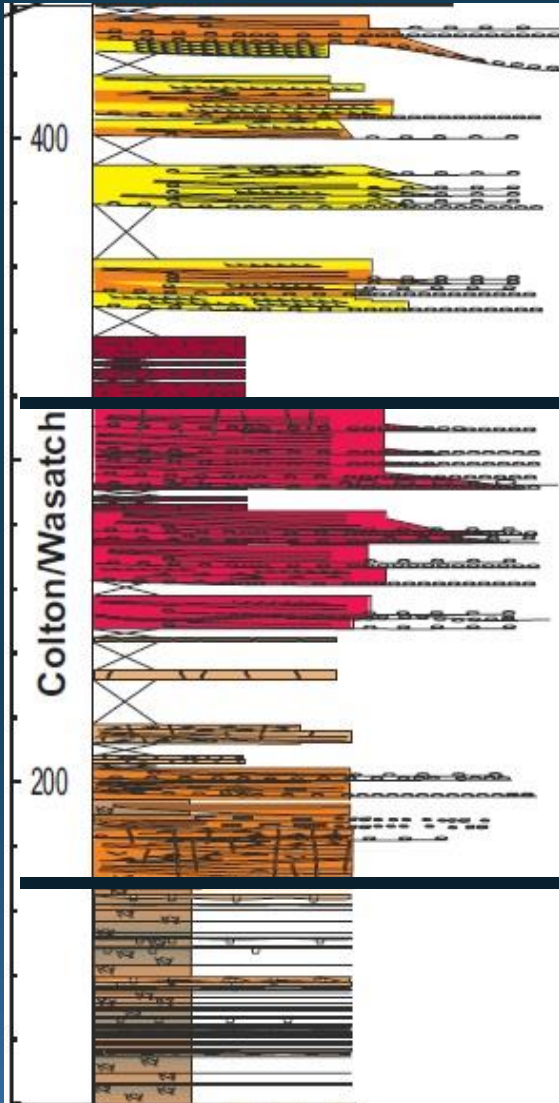


Stratigraphy – Wasatch Fm.



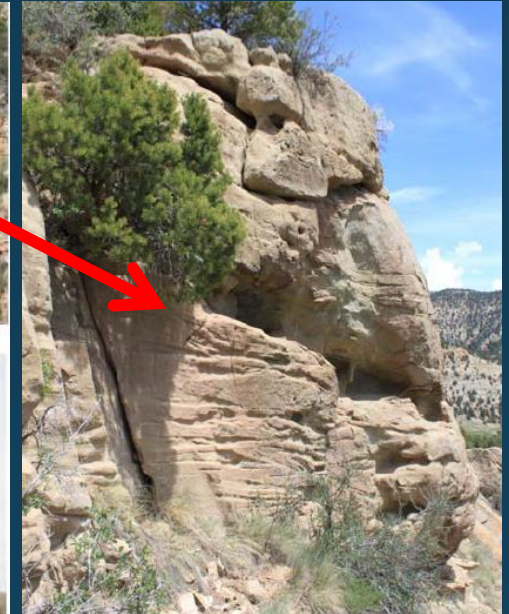
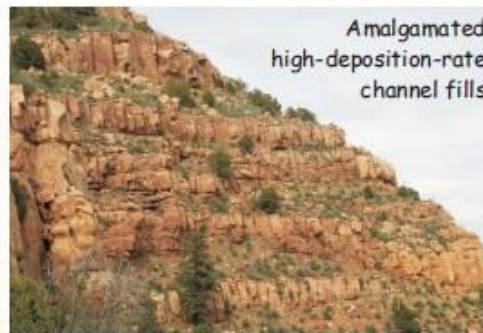
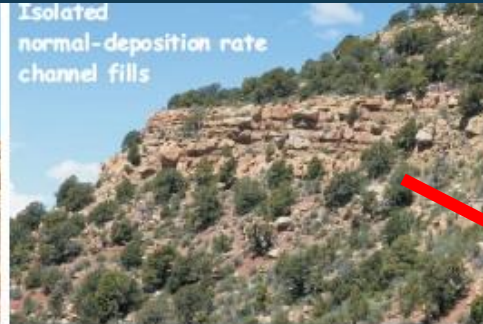
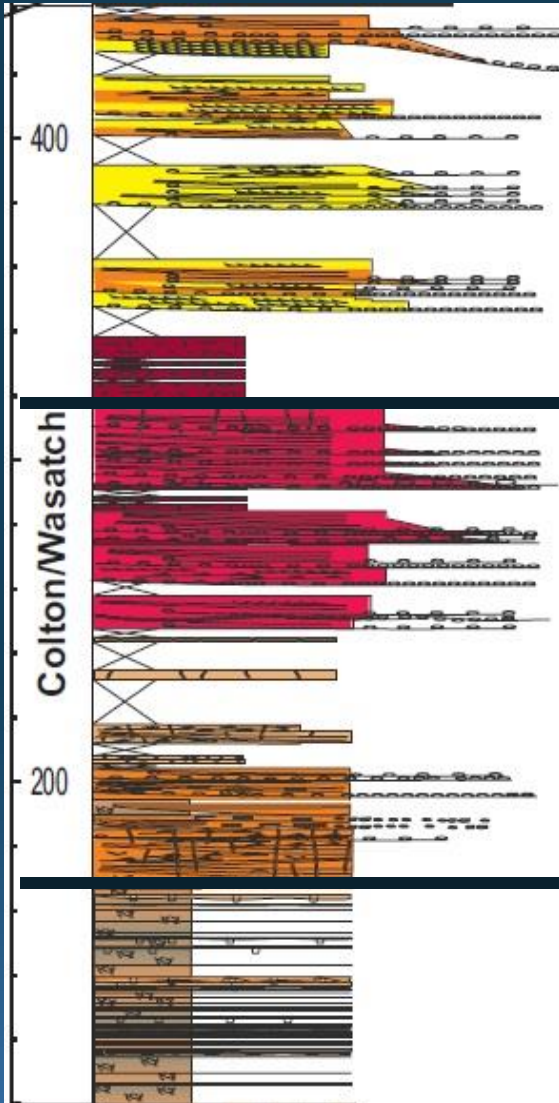


Stratigraphy – Wasatch Fm.



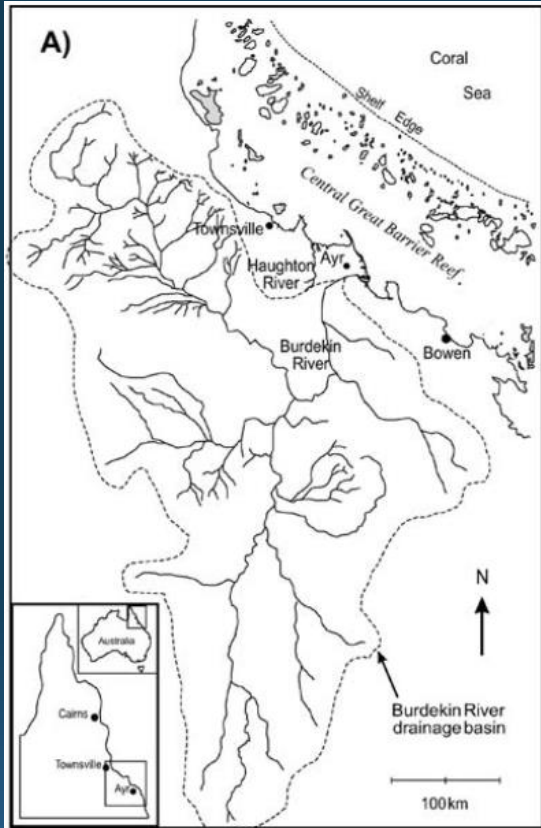


Stratigraphy – Wasatch Fm.





The Burdekin River System



- Predominantly semi-arid climate with average of 15 inches of rain per year (similar to Los Angeles)
- Large tropical cyclones have a recurrence interval of 3-10 years and can drop over 60 inches of rain in 90 days (similar to Seattle's annual total)
- For reference the recent Boulder floods dropped 17 inches of rain in eight days

From Amos et al., 2004



The Burdekin River System



- Description of bar deposits in the Burdekin River from Fielding et al.(2006):
 - High deposition rate sedimentary structures including gradational planar laminations
 - Simple downstream accreting barforms
 - Second and third order erosional surfaces



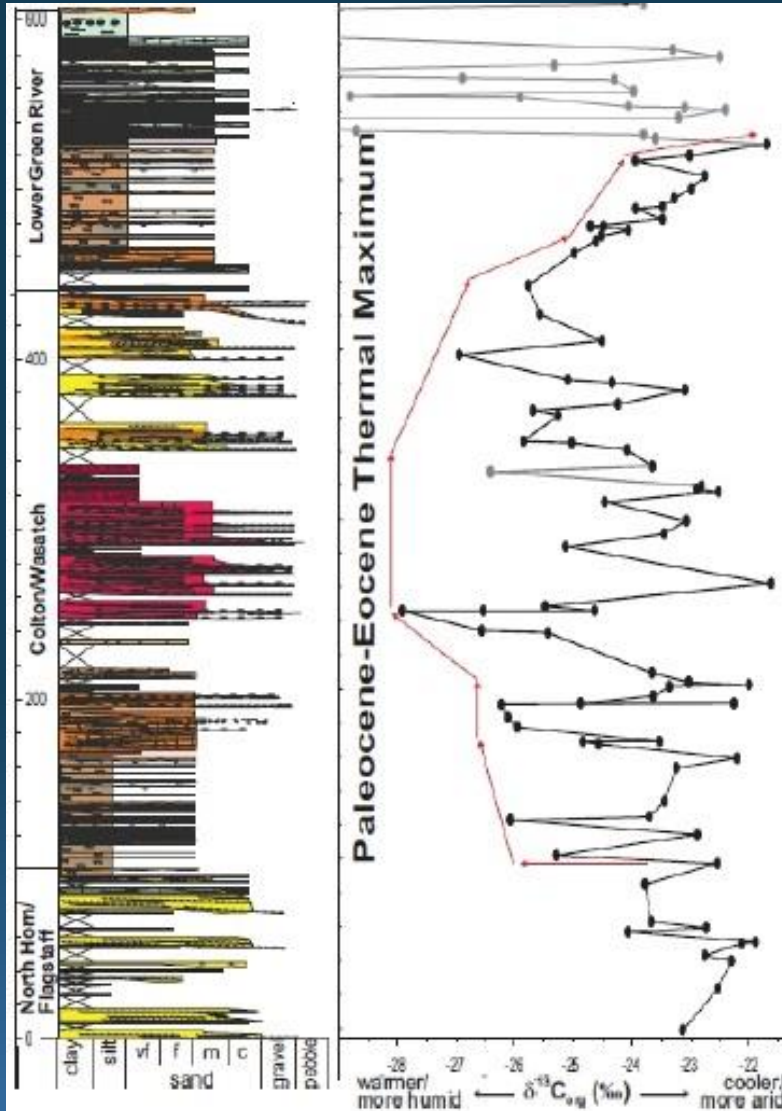
The Burdekin River System



From Alexander and Fielding, 1997



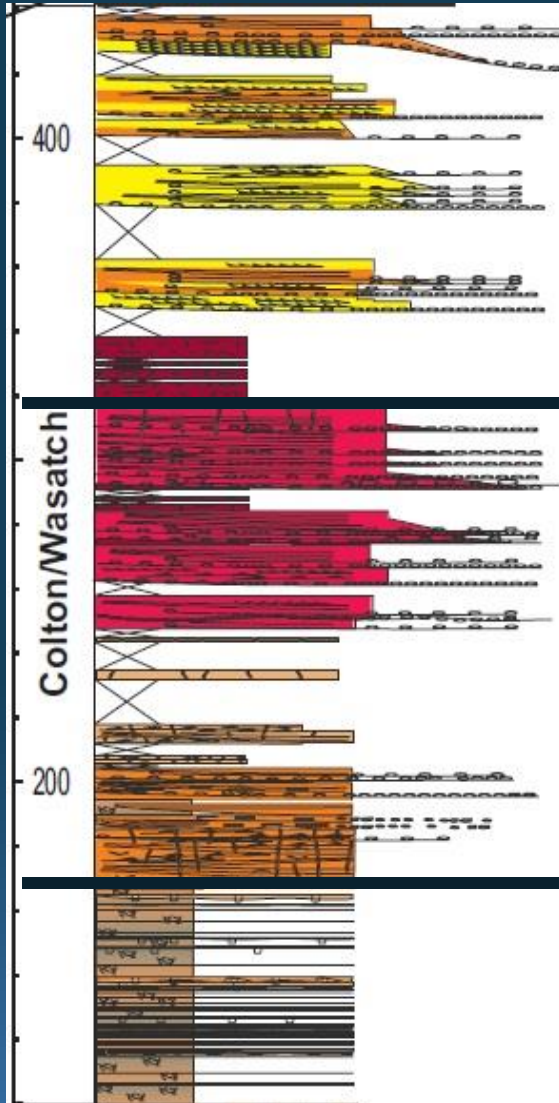
Climate – Early Eocene



- PETM – Global increase in temperatures of 5°-10° C (Wing et al., 2005) and precipitation
- Monsoonal precipitation in Piceance Basin (Foreman et al., 2012) and along Sevier Thrustbelt (Fricke et al., 2010)
- Major negative carbon isotope excursion in deep sea and terrestrial sediments (Magioncalda et al., 2004)



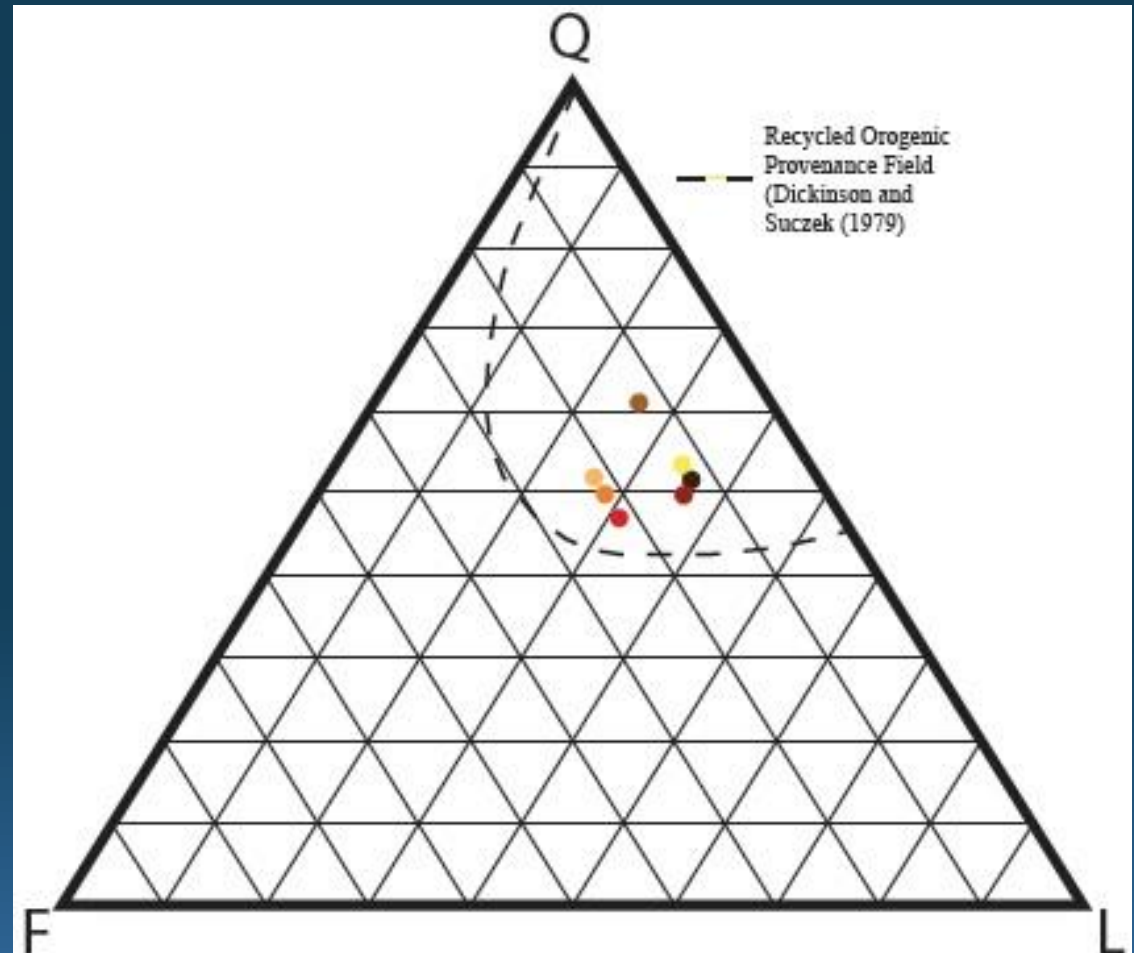
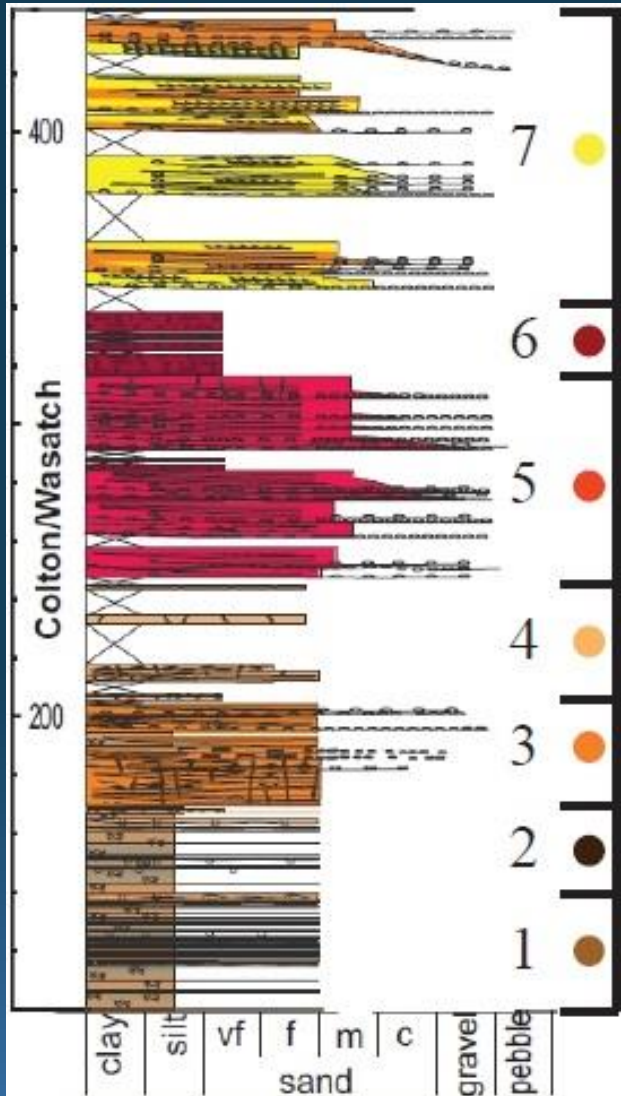
Stratigraphy – Wasatch Fm.



- Upper Wasatch
 - More perennial rainfall during offset of PETM
- Middle Wasatch
 - Extremely seasonal fluvial deposits in an overall arid climate at the peak of the PETM
- Lower Wasatch
 - Seasonal fluvial deposits in the more humid onset of the PETM

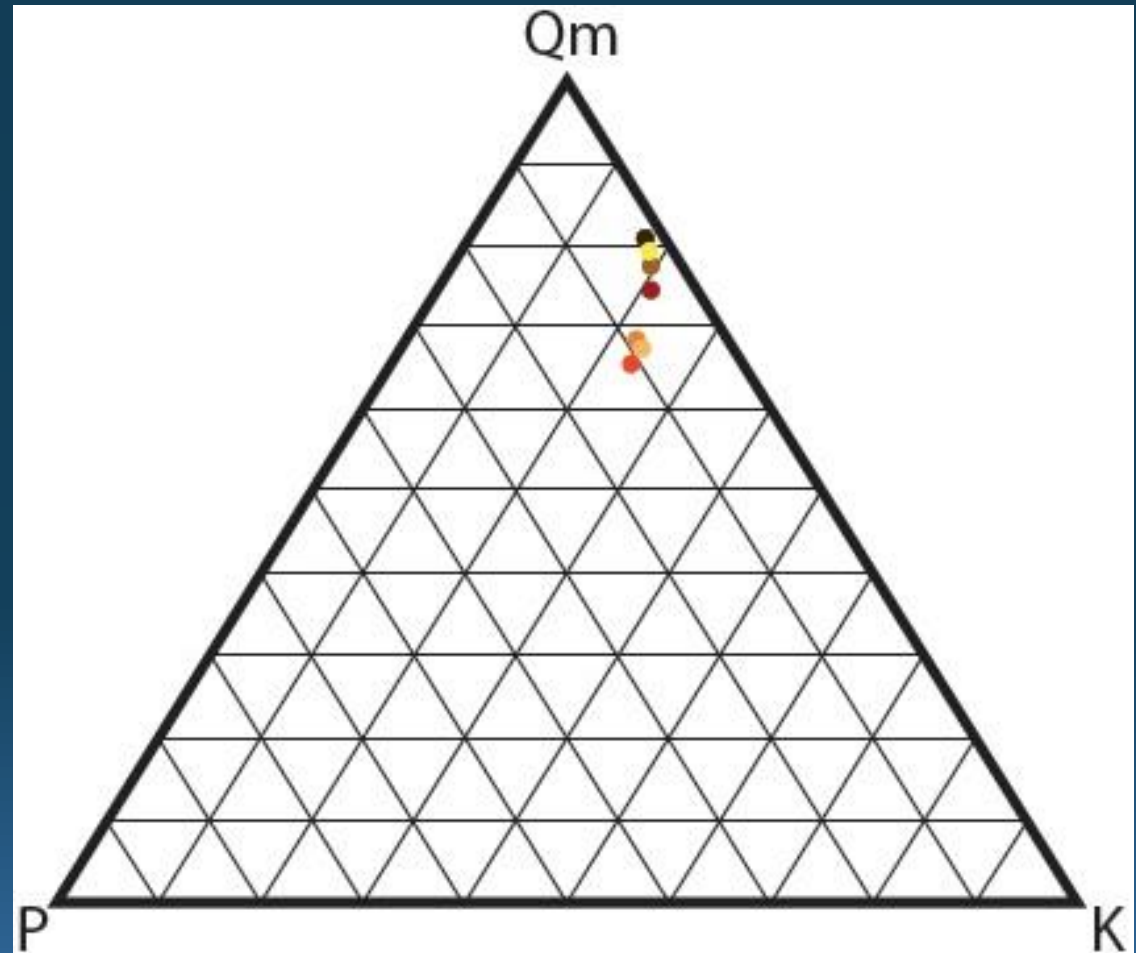
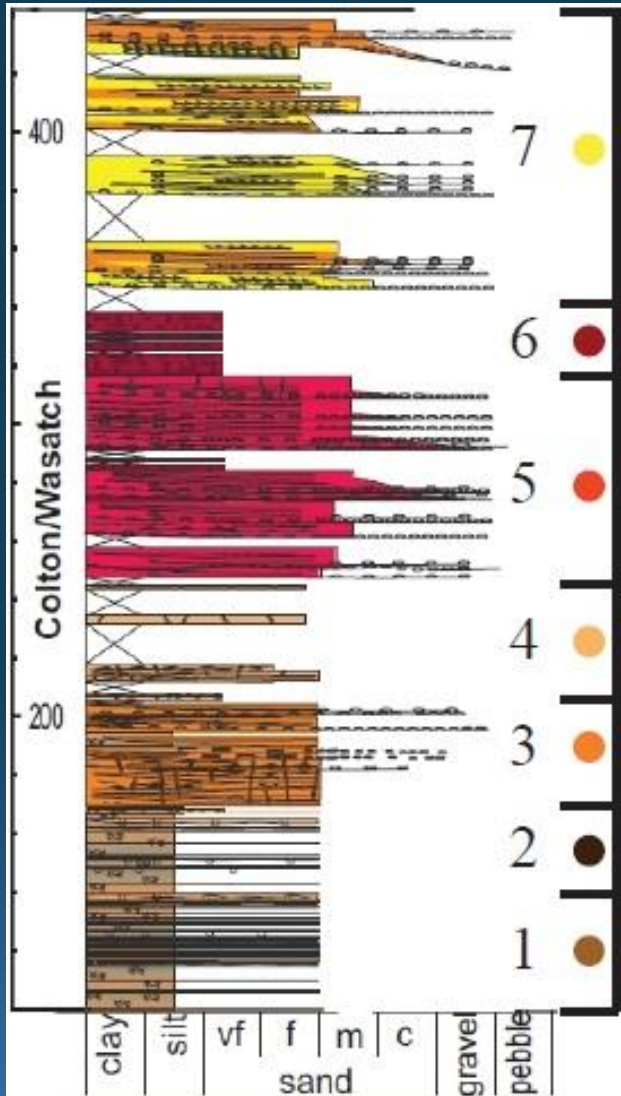


Composition of Wasatch Fm.



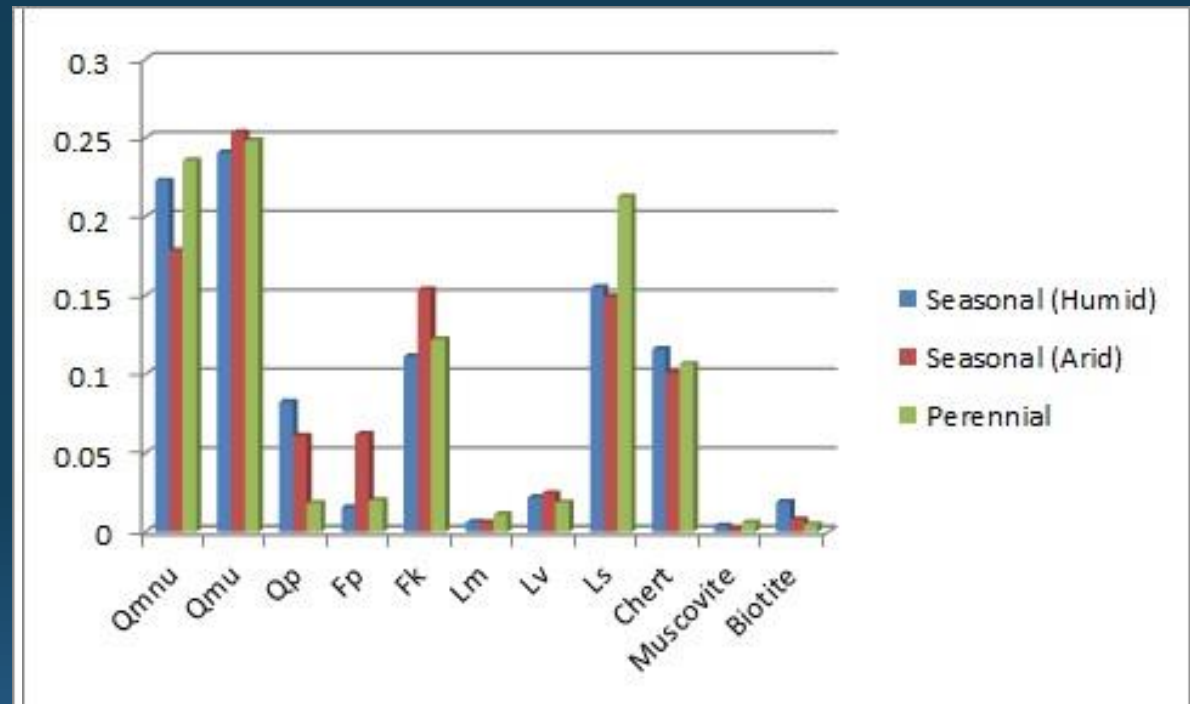
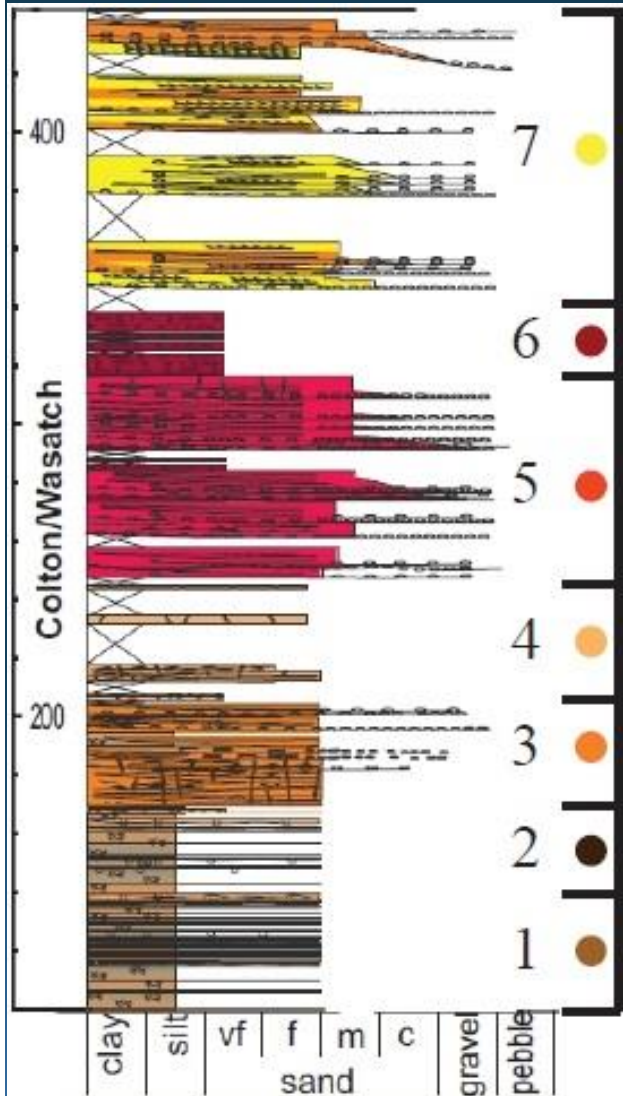


Composition of Wasatch Fm.



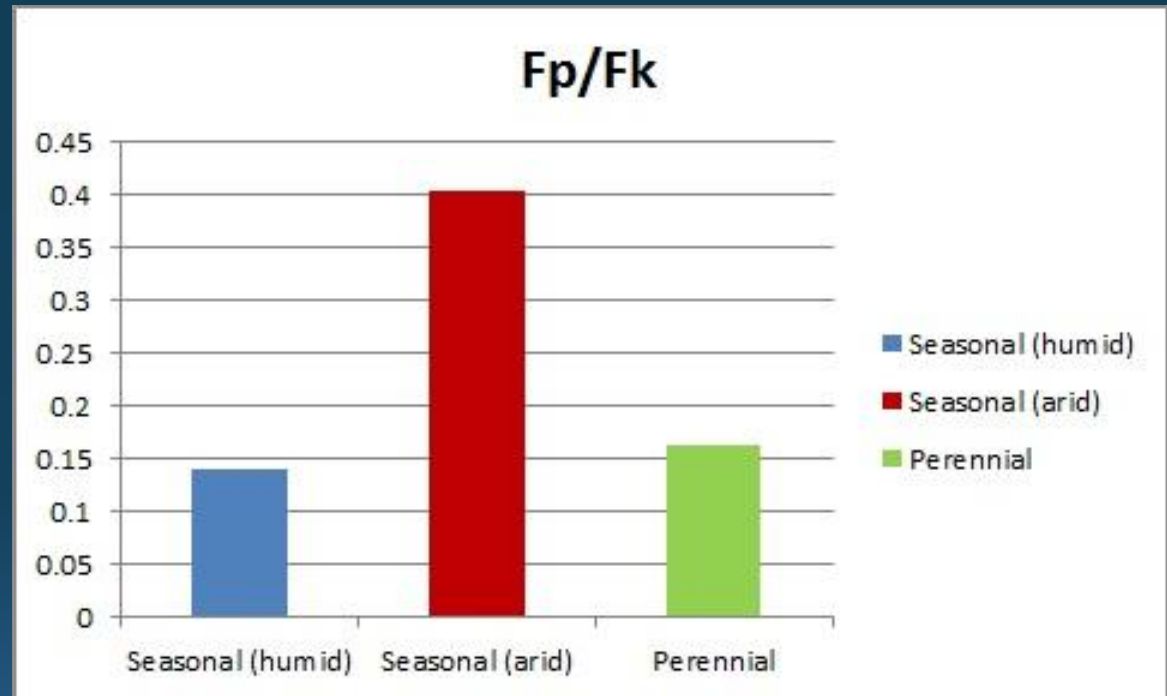
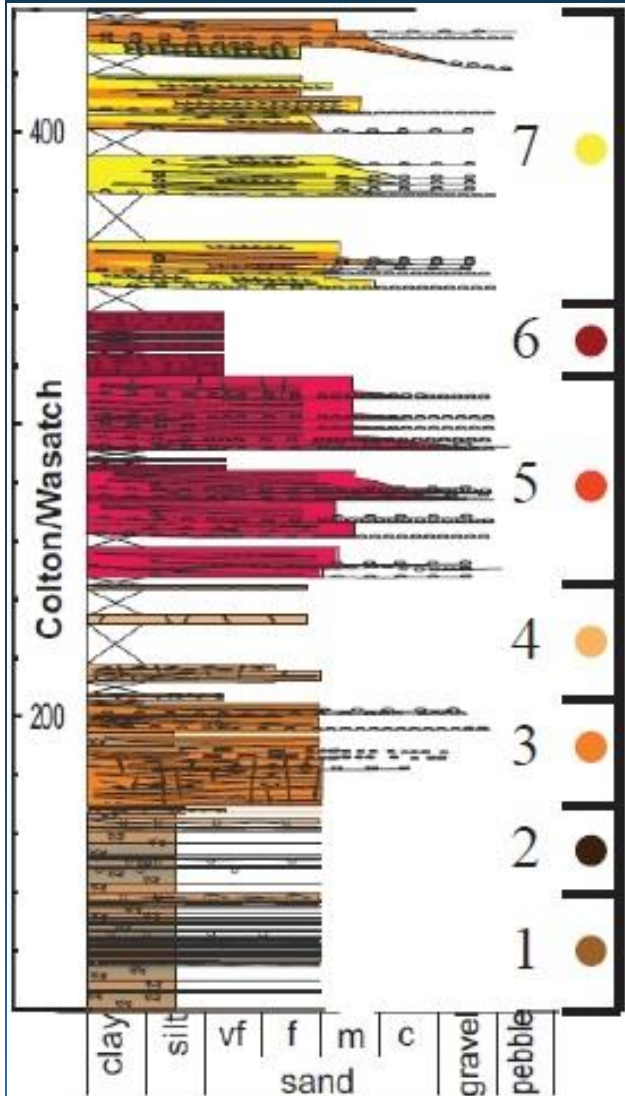


Composition of Wasatch Fm.



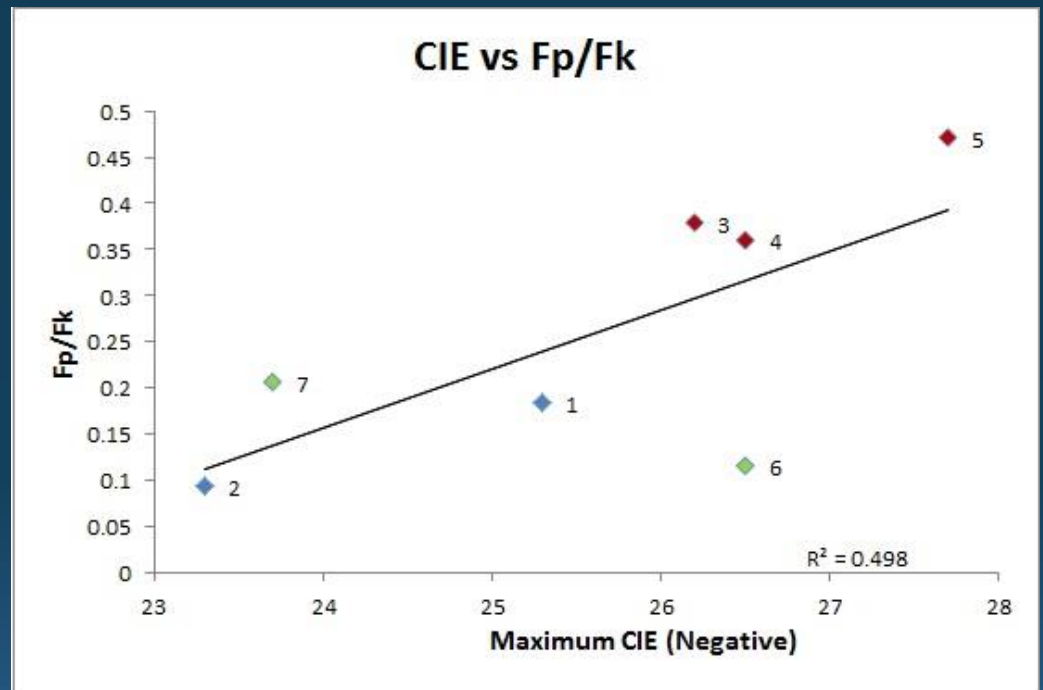
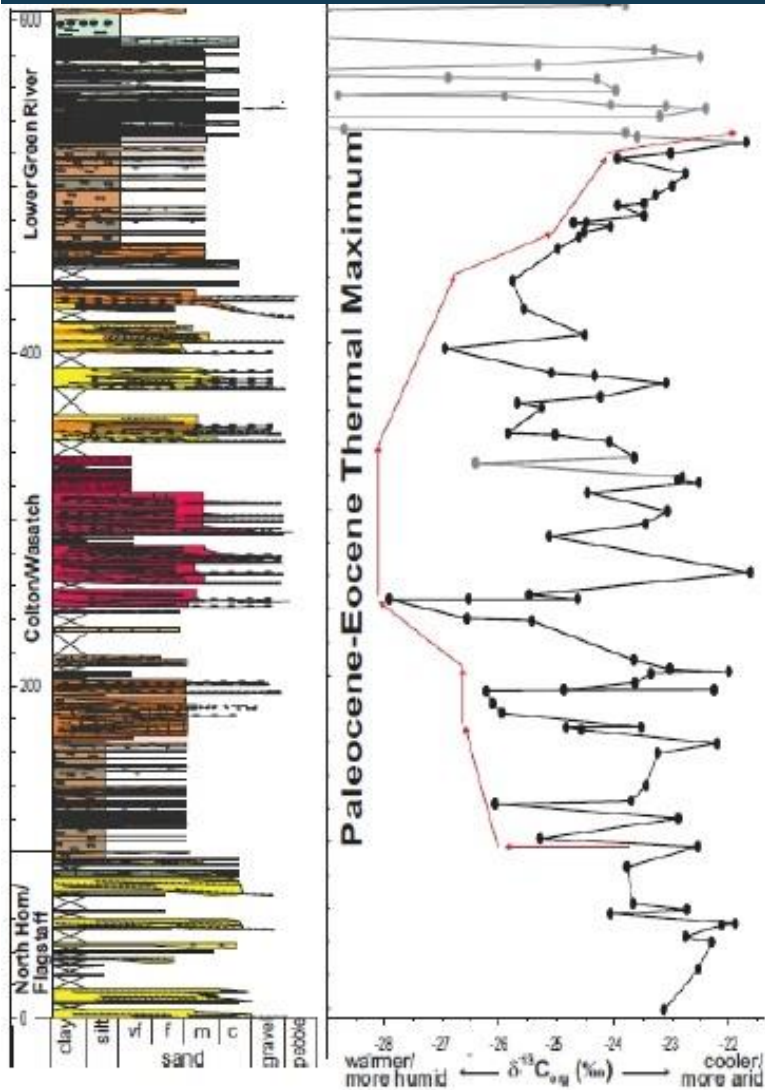


Composition of Wasatch Fm.





Composition of Wasatch Fm.





Conclusions

- Preservation potential of feldspar increases with increasing fluvial seasonality
 - Plagioclase particularly sensitive
 - Seasonal flooding events decrease duration of transport from source to sink
 - High erosion rates and short duration of transport outpace globally increased chemical weathering rates associated with PETM

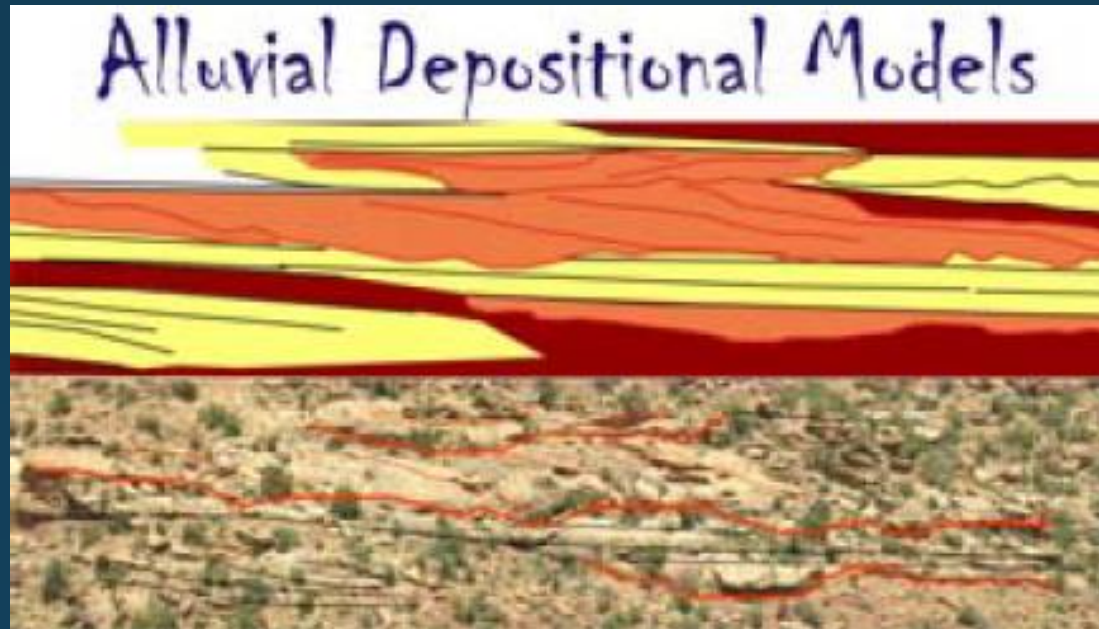


Potential Implications

- Tradeoff between reservoir connectivity and quality
 - Seasonal river systems are more vertically and laterally amalgamated
 - Short transport durations and high erosion rates can preserve more chemically unstable grain types
 - Highest net to gross fluvial systems may also be most compositionally immature
- Increase in K-feldspar abundance at PETM may improve correlations across the basin



Questions



NEWFIELD

