[PS]Rift Shoulder Erosion and Basin Deformation Associated with the Wichita Uplift (Mountain Front): Anadarko Basin, Oklahoma and Texas, U.S.A*

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Search and Discovery Article #30523 (2017)**
Posted October 30, 2017

*Adapted from poster presentation given at AAPG Annual Convention and Exhibition, Houston, Texas, April 2-5, 2017. Please refer to companion article by the BP group (Search and Discovery Article #11005 (2017)) .

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Abstract

The ancestral Wichita uplift (Mountain Front) forms the southern margin of the Anadarko Basin in the Panhandle of Texas and Oklahoma. We used well logs and regional 2D and 3D seismic datasets to evaluate the structural history of the Mountain Front deformation and to assess its impacts on trap formation, reservoir characteristics, and hydrocarbon accumulation, particularly within the Pennsylvanian age Granite Wash play.

The southern boundary of the Anadarko Basin in Texas is the Amarillo Uplift, a buried mountain range (Wichita Mountains) bounded by the Mountain View fault zone with a left lateral transpression sense of movement. Clastic detritus of the Granite Wash interval was derived from erosion of Paleozoic strata and Proterozoic basement of the Amarillo uplift to the south, carried northward across the trace of the Mountain View fault by fluvial systems, and deposited in fan-deltas within the basin axis.

The Granite Wash was deposited during mid-Atokan to mid-Desmoinesian time, which coincides with the early stages of the Arbuckle orogeny. It is speculated that headward erosion and integration of drainages likely occurred during the early Atokan “tectonic lull”, leading to flushing of impounded sediments (stored terraces, piggyback basins, etc.) from the Amarillo uplift to feed the Granite Wash fan-delta system.

Locally some structures were active within the basin during Granite Wash deposition, most notable within the Old Mountain Front zone and within a broad zone of detached transpressional structures that lay to the north.

This study highlights how integrating tectonic history and seismic stratigraphy can improve the understanding of: (1) source to sink sedimentology and reservoir quality prediction; (2) variations in deformation timing that impact trap formation; and (3) and how

uplift/subsidence impact reservoir deposition. In Texas, for example, the Arbuckle orogeny involved a southward shift in the locus of deformation and uplift, whereas in Oklahoma the Arbuckle deformation front migrated basinward, uplifting and destroying the older Wichita deformation belt. Our findings suggest that oil-prone traps were in place during early charge in Texas, whereas gas-prone Mountain Front traps in Oklahoma were formed later. This methodology is applicable to other foreland basins where erosion of older rift shoulder sediments provides the provenance for later deposits and where episodic deformation along a broad tectonic front produces variations in trap timing.

Reference Cited

Gradstein, F.M., J.G. Ogg, M. Schmitz, and G. Ogg, editors, 2012, A Geologic Time Scale: ElsevierPublishing,1176p.

RIFT SHOULDER EROSION AND BASIN DEFORMATION ASSOCIATED WITH THE WICHITA UPLIFT (MOUNTAIN FRONT): ANADARKO BASIN, OKLAHOMA AND TEXAS, U.S.A.

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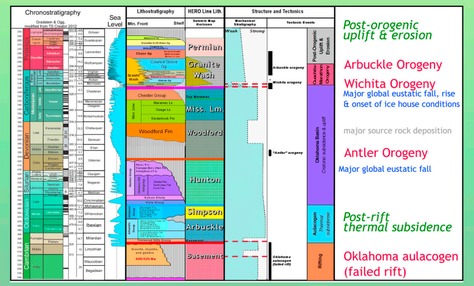


LEFT: Stratigraphic Chart for the Anadarko Basin. Time scale based on Gradstein et al. 2012. Nomenclature after Oklahoma Geologic Survey

Structural Framework

Texas

The leading edge of Early Pennsylvanian deformation is preserved in the Texas Panhandle suggesting a stepping back of the 'Mountain Front' in mid-Pennsylvanian time. As a result, deformation and uplift in the basin waned during Early Pennsylvanian time and basin subsidence led to burial of Mountain Front structures.

The illustration to the right is a HERO line (seismic line converted to depth and annotated with relevant tectonic and stratigraphic information in order to provide an overview of the basin history).

The Early Pennsylvanian Mountain Front is preserved in Texas (whereas it is eroded in Oklahoma)

- -Early Pennsylvanian structures are truncated by the Base Pennsylvanian (seismic Top Mississippian) angular unconformity.
- -Inversion of the southern rift basin shoulder caused uplift above a "blind" basement-involved thrust wedge
- -The old Mountain Front subsided when the deep master thrust cut through the basement wedge to the south of the leading edge of deformation

Two pulses of deformation can be seen in Texas

1. Early Pennsylvanian (Morrowan) Wichita orogeny
2. Mid-Pennsylvanian-Permian (Desmoinesian-Wolfcampian) Arbuckle orogeny

-Proximal Springer Fm. (Morrowan) sediments were deposited during the Early Pennsylvanian pulse

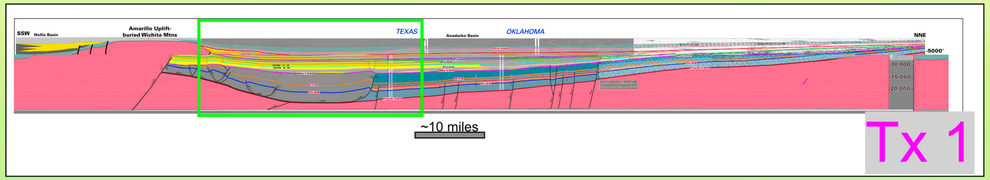
-Granite Wash sediments were deposited during the "tectonic lull" between the two pulses of deformation

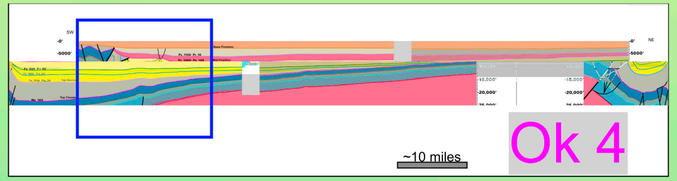
-Middle Pennsylvanian deformation affected local Granite Wash accommodation

Oklahoma

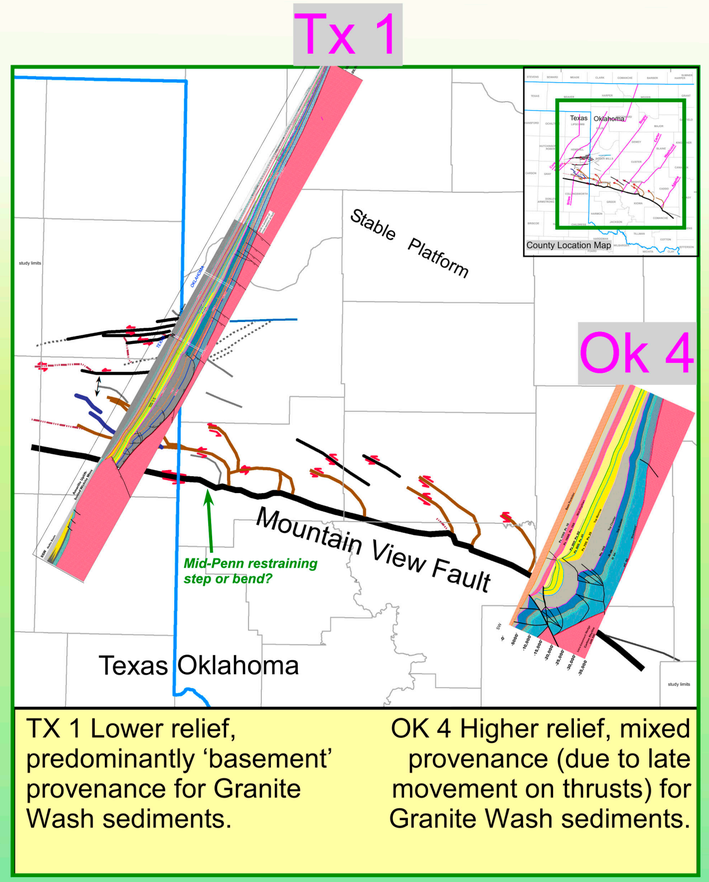
Continued thrusting along the old Mountain Front in Oklahoma resulted in uplift and erosion along the leading edge of deformation', bringing Lower Paleozoic strata to the surface. Here deformation in the basin continued through the Desmoinesian-Wolfcampian.

The illustration to the right is a HERO line. Deformation along the Mountain View Fault (MVF) system uplifted Lower Pennsylvanian and older strata that were the provenance for Granite Wash sediments. Outboard of the MVF system the intra-basinal Desmoinesian-Wolfcampian deformation formed anticlines which were eroded to source local sediments.





Seismic data removed



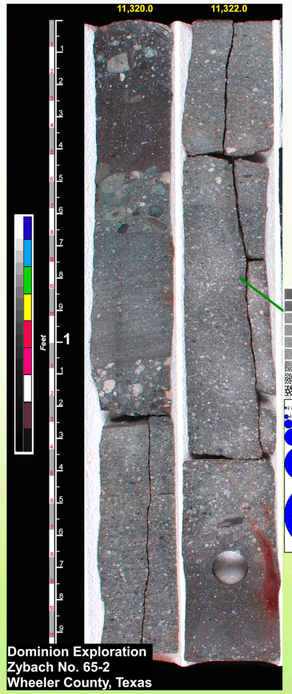
TX 1 Lower relief, predominantly 'basement' provenance for Granite Wash sediments.

OK 4 Higher relief, mixed provenance (due to late movement on thrusts) for Granite Wash sediments.

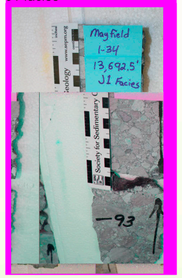
Texas

The coarsest material seen in cores from the Granite Wash sediments located in the Texas Panhandle region (Wheeler & Hemphill Counties) is generally very coarse sand to gravel within a muddy matrix.

Matrix-supported conglomerates are characterized by predominantly igneous (plutonic) and/or limestone rock fragments (sub-angular to sub-rounded), coarse sand to pebble grain sizes, and very muddy matrix that supports “floating” clasts. Units are distinguished by the presence of fining upward sequences, and the lower contact is often a scour surface within these amalgamated sheet sands. Dish and Pillar structures can be seen in many places. The lithology is classified as Arkose to Lithic Arkose.



Union Oil Co.
Mayfield 1-34
Beckham County, Oklahoma
J1 facies



Valero
Brauchi #1-36
Beckham County, Oklahoma
F2 facies

Gulf
Goeringer #1
Washita County, Oklahoma
J1 facies

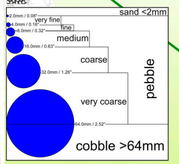
Oklahoma

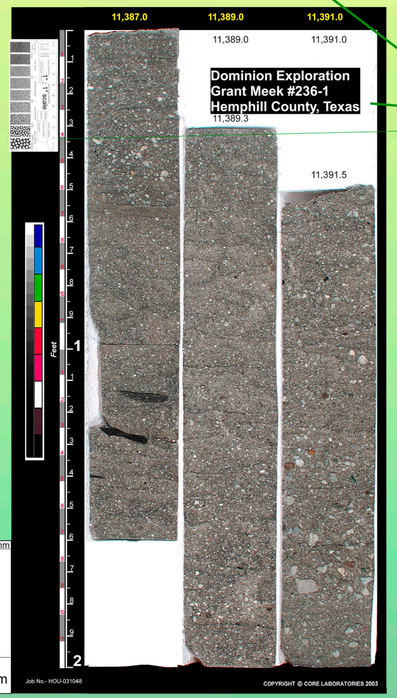
The coarsest material seen in cores from the Granite Wash sediments located in the Western Oklahoma region (Beckham to Washita counties) was generally very coarse sand to cobble size.

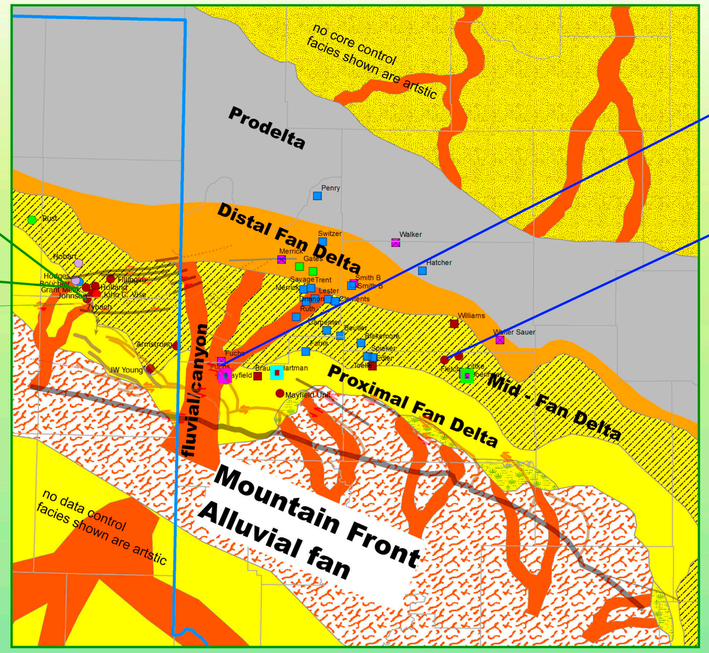
At least two kinds of coarse-grained deposits are seen:

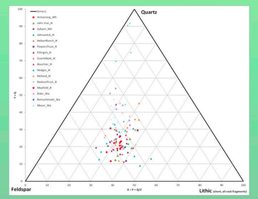
Clast-supported conglomerate with predominantly igneous and/or limestone rock fragments (sub-angular to sub-rounded), coarse sand to cobble grain sizes, very little mud, matrix is fine to coarse sandstone, lower contact is often a scour surface.

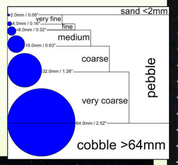
Matrix-supported conglomerate with predominantly igneous and/or limestone rock fragments (sub-rounded to rounded), coarse sand to cobble grain sizes, no mud, matrix is fine to coarse sandstone that supports large “floating” clasts; lower contact is often a scour surface.











70mm long axis = cobble
32mm short axis = pebble

Special thanks to CoreLab for permission to show cores photographs

Special thanks to the Oklahoma Geological Survey for allowing us access to the cores

Log X-sections and HERO lines

Hypotheses

1. Continued uplift of the Mountain Front in Oklahoma resulted in greater topographic relief and higher gradient fluvial systems
   a. sediments derived from unroofing of Pennsylvanian and Mississippian lithologies (followed by Lower Paleozoic and 'basement').
   b. grain size of the coarsest fraction is cobble size
   c. coarsest material was deposited by fluvial or mass-wasting processes

2. Stepback of the Mountain Front in Texas resulted in generally lower relief and lower gradient fluvial systems
   a. sediments derived from unroofing of older (than on Oklahoma side) sediments, Lower Paleozoic and 'basement'-dominated lithologies
   b. grain size of the coarsest fraction is gravel sized, generally sub-rounded to rounded suggesting longer transport

3. The change in the orientation of the Mountain Front from Oklahoma to Texas formed a zone of tectonic weakness in the very western portion of Oklahoma (between Mayfield and the Texas border).
   a. this structural zone localized a fluvial discharge point and/or canyon system that allowed texturally immature, cobble-sized sediments to enter the basin
   b. in Oklahoma the reactivation of thrusts caused "recycling" of syn-orogenic sediments and local sediment sourcing.
   c. in Texas the basin had low subsidence (and gentle slope). This allowed sediments to prograde further into the basin.

Conclusions

This study highlights how integration of structural history and seismic stratigraphy can improve understanding of how uplift and subsidence impact the size and lithology of the coarsest sediments. In Texas, the Arbuckle orogeny involved a southward retreat of the leading edge of deformation and locus of uplift. In Oklahoma, by contrast, the Arbuckle deformation front migrated northward into the basin, uplifting and eroding the older Wichita frontal deformation belt. Our observations suggest that the difference in style in Texas and Oklahoma is recorded in cores of the largest grain-sized sediment in the Granite Wash showing the coarsest material was derived from the Oklahoma Mountain Front in the western portion of Beckham County. The structural accommodation zone between these two deformation styles focused Granite Wash sediment dispersal systems in the Texas-Oklahoma border region.

Acknowledgments

We would like to thank the following:

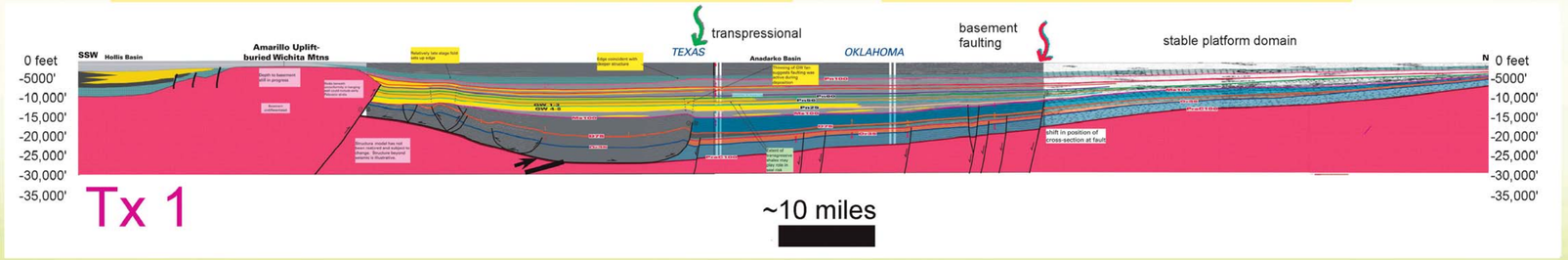
BP and particularly the Granite Wash Atlas Team and Mid Con BU teams for allowing us to share this work.

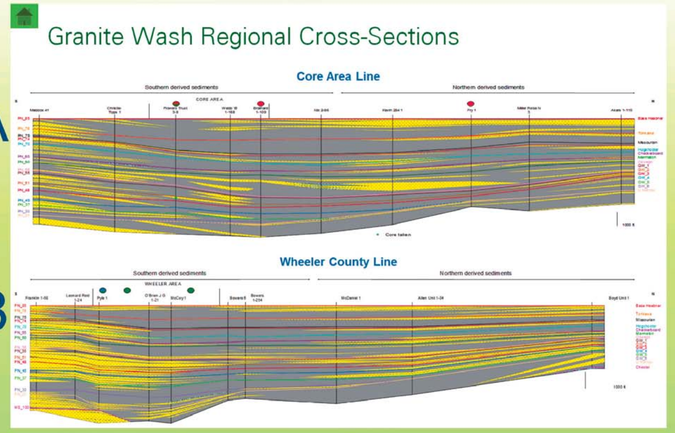
CoreLab for permission to show the core photos and mineralogy data

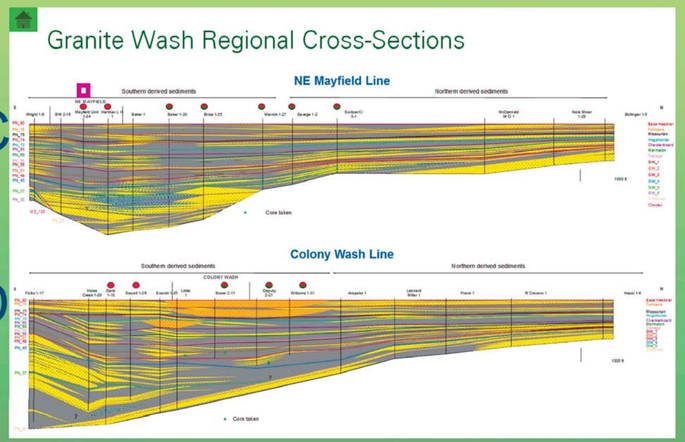
Oklahoma Geological Society for laying out all the cores

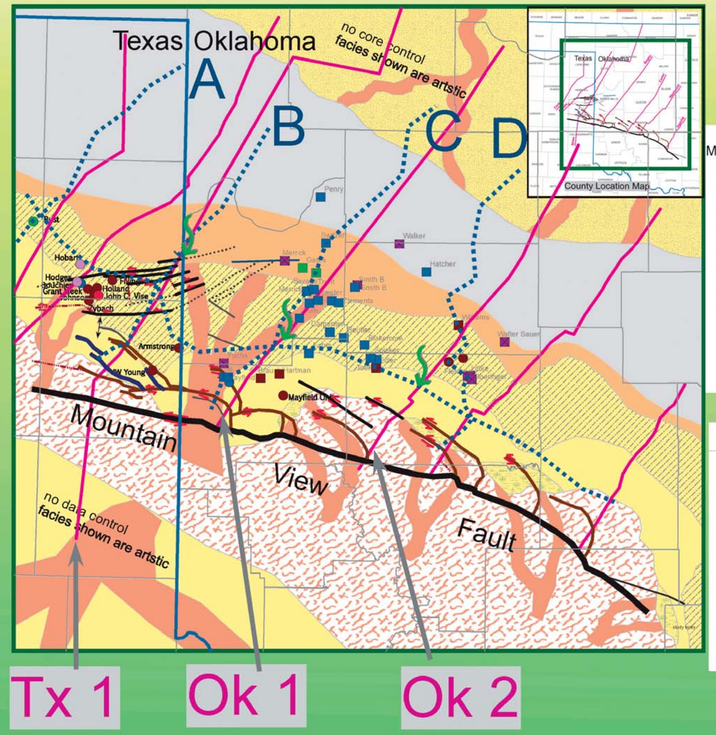
SEI for permission to publish the seismic.

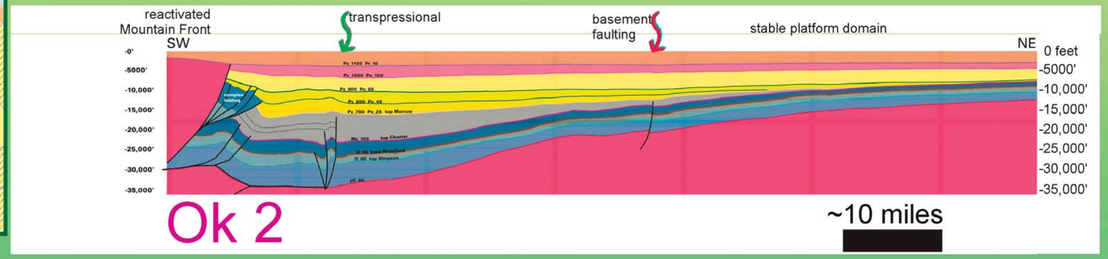
bp











SEI SEISMIC EXCHANGE

Seismic data owned or controlled by Seismic Exchange, Inc.; interpretation is that of BP

Reference Cited

Gradstein, F.M., Ogg, J.G., Schmitz, M., and Ogg, G. eds. (2012) A Geologic Time Scale 2012, Elsevier Publishing , 1176p.