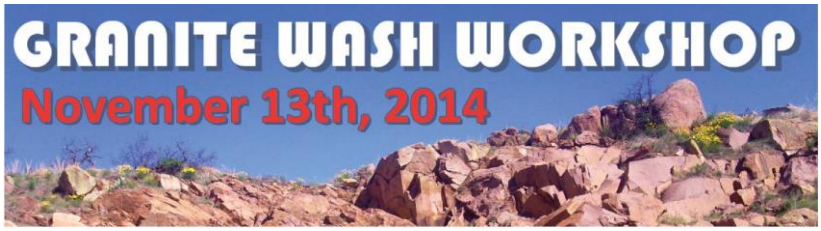


•Granite Wash:
•Where Engineering and Geology Collide.
•An Unstoppable Force Meets An Immovable Object

Bill Grieser Carla Eichler
Nov 13th 2014

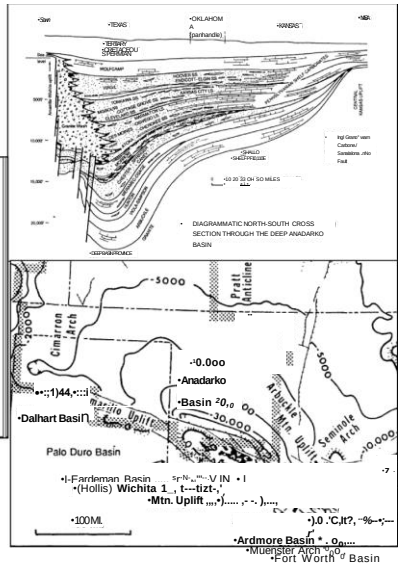
Sponsored by the
Oklahoma Geological Survey
University of Oklahoma
Norman, Oklahoma

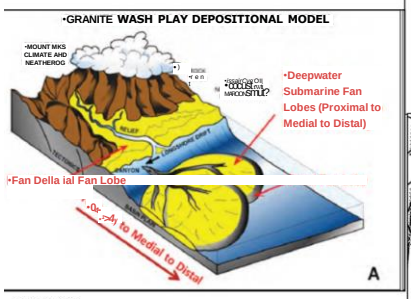
•Outline

- Granite Wash Deposition
- Subsurface visualization
- Granite Wash Stack Play Completions Overview
- Completion averages 2005-2014
- Fracture geometry
- Questions

•Geologic History

•Ball et al, 1991.

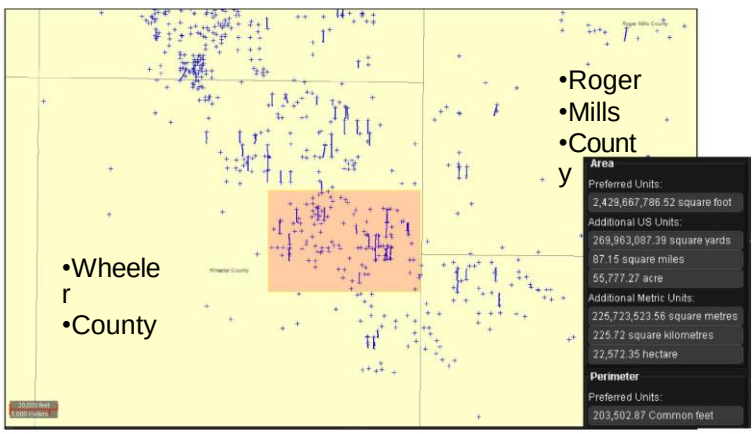




•Mitchell, 2011.

 Ball et al, 1991. HALLIBURTON

•Area of Interest



 4

HALLIBURTON

•Stratigraphic Correlation

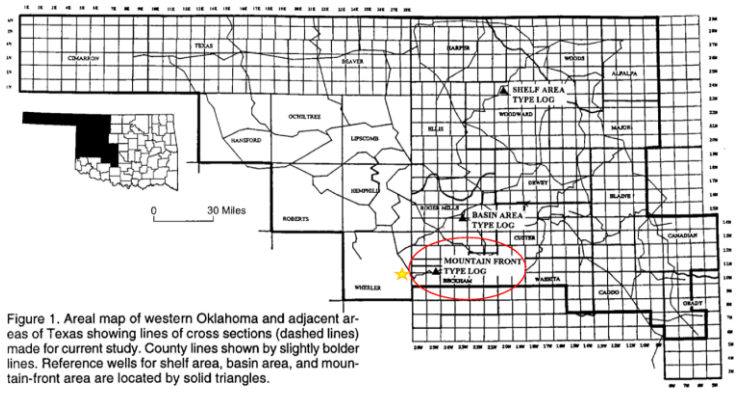
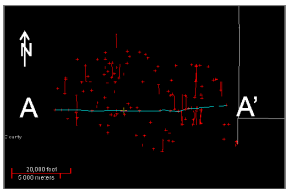


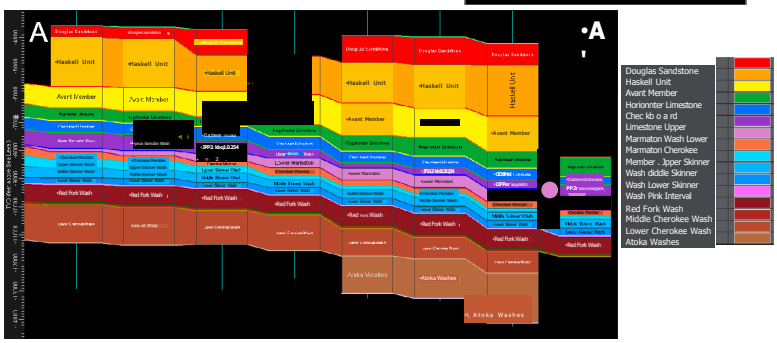
Figure 1. Areal map of western Oklahoma and adjacent areas of Texas showing lines of cross sections (dashed lines) made for current study. County lines shown by slightly bolder lines. Reference wells for shelf area, basin area, and mountain-front area are located by solid triangles.

•Hendrickson et al., 2001

HALLIBURTON

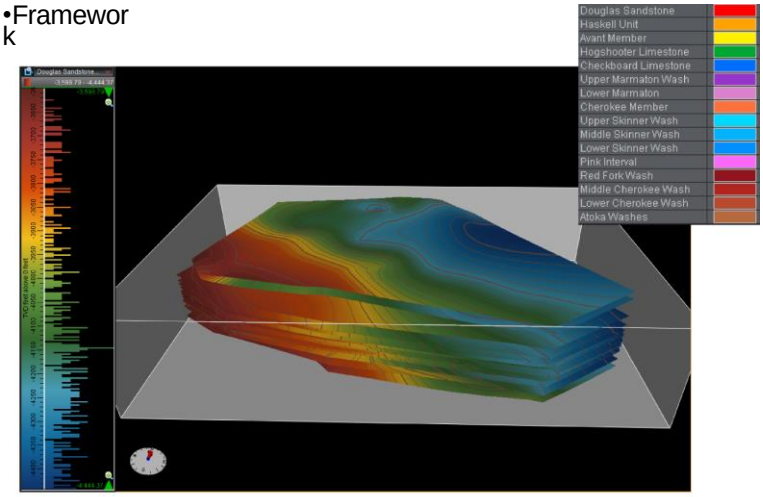
Stratigraphy and Structure





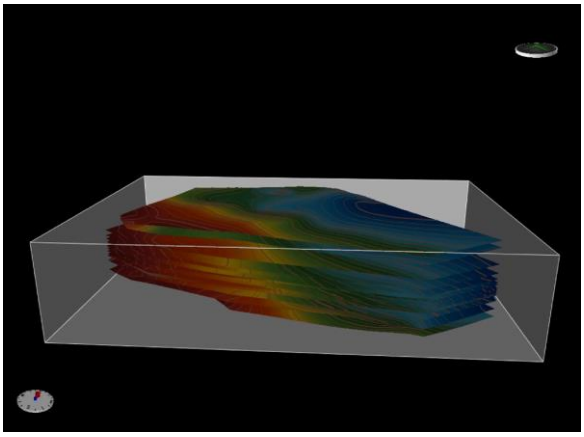
 HALLIBURTON

•Framework

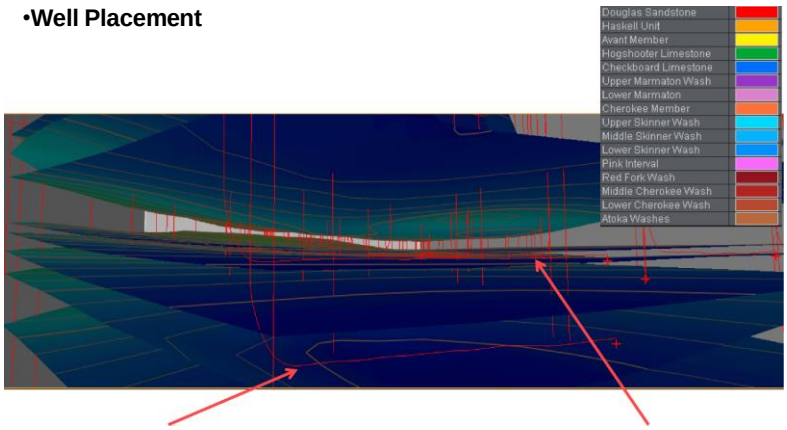


HALLIBURTON

•3D View of Granite Wash Framework



•**Well Placement**



•**Lateral Well in Lateral Well in**
•**Lower Skinner Upper Skinner**
•**Wash Wash**

•References

- Ball, M. M., Henry, M. E., Frezon, S. E., 1991, Petroleum Geology of •the Anadarko Basin Region, Province (115), Kansas, Oklahoma, and •Texas: USGS Open-File Report 88-450W, 38 p.
- Mitchell, J., 2011, Horizontal Drilling of Deep Granite Wash •Reservoirs, Anadarko Basin, Oklahoma and Texas: Shale Shaker, v. •62, p. 118 – 167.
- Hendrickson, W. J., Smith, P. J., Woods, R. J., 2001, Regional •Correlation of Mountain-Front "Washes" and Relationship to Marine •Sediments of Anadarko Basin and Shelf: Oklahoma Geological •Survey Circular 104, p. 71 - 80.

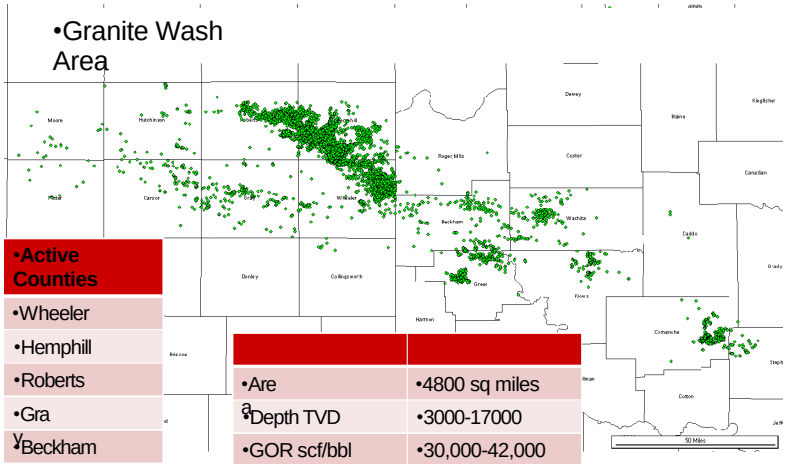
•Granite Wash Names

What is the Granite Wash Play? Granite Wash by definition is material eroded from granites and redeposited, forming a rock with the same major mineral constituents as the original rock. That in simpler terms, means that Granite Wash got its name from the weathering process that granite underwent over time.

Cleveland Wash
Hogshooter
Marmaton A-F
Alvin GW
ClearFork
Caldwell
Des Moines Wash
Colony Wash
Strawn Wash
Cherokee Wash
Granite Wash A-H
RedFork A-D
Atoka A-E

HALLIBURTON

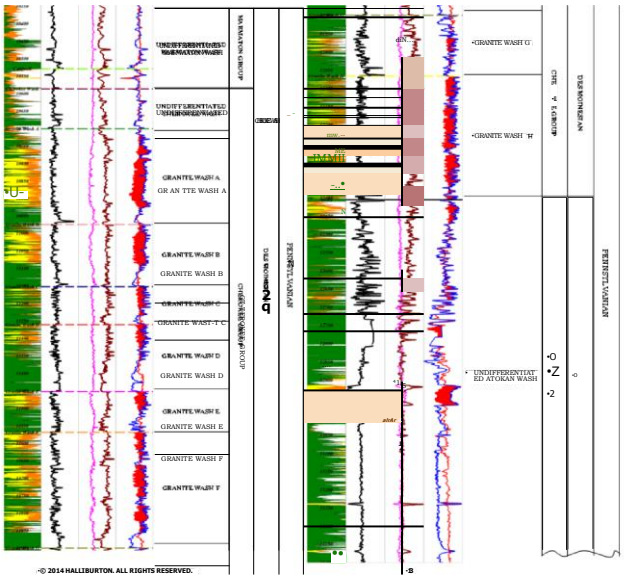
•Granite Wash Area



•Active Counties
•Wheeler
•Hemphill
•Roberts
•Gray
•Beckham
•Roger Mills
•Custer
•Washita
•Greer

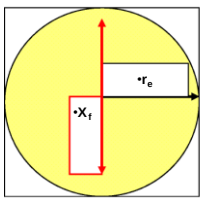
•Area	•4800 sq miles
•Depth TVD	•3000-17000
•GOR scf/bbl	•30,000-42,000
•Yield bbl/MMCF	•23-32
•API	•54
•Cost Horz	•$4-7 MM
•Dual Lateral	•$8-10 MM

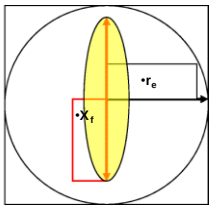
HALLIBURTON



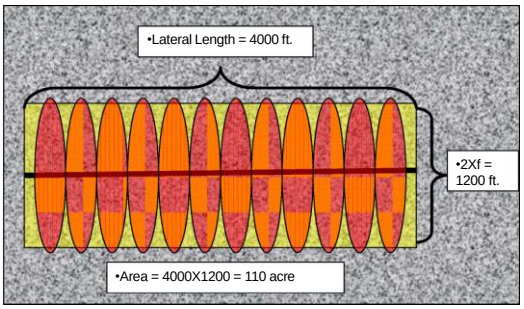
•Stacked Play

•HALLIBURTON





•Drainage Moderate Perm Drainage Low Perm

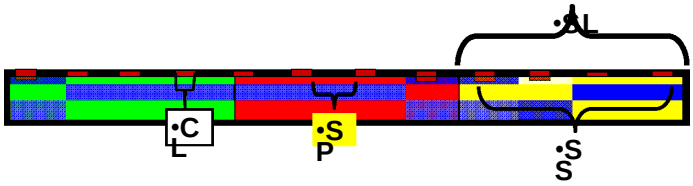


•Well EUR •Depends •On (kh) •Not (□h)

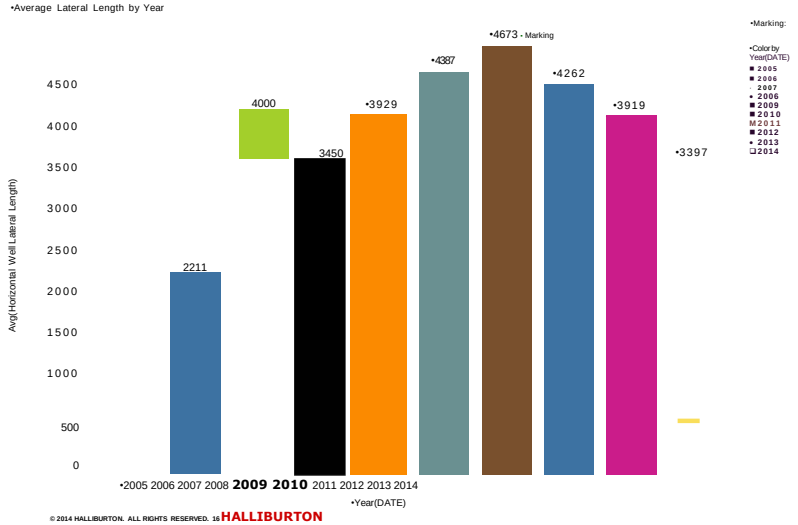
•Horizontal drainage = (lateral length)* (2Xf)

•1
•5

•**Spacing (S_P) = $\frac{(SL) - (NC)(CL)}{(NC-1)}$**
•**Overall Stage Length (SL)**
•**Number of Clusters (NC)**
•**Cluster Length (CL)**
•**Stimulation Span (SS) = stage bottom perf – stage top perf**

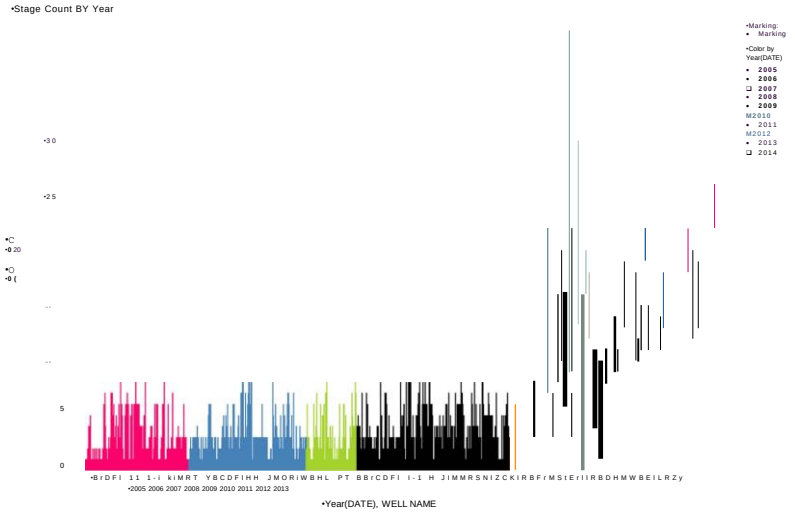


•Average Lateral Length VS YEAR



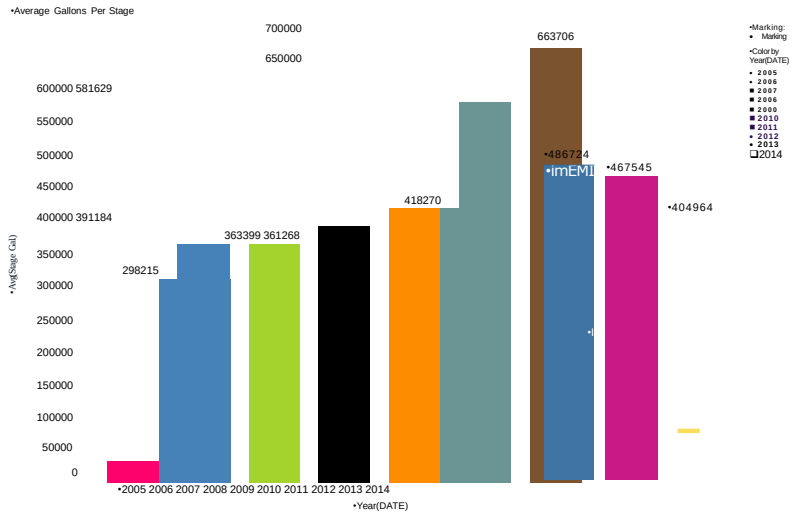
 HALLIBURTON

•Number of Frac Stages VS Year



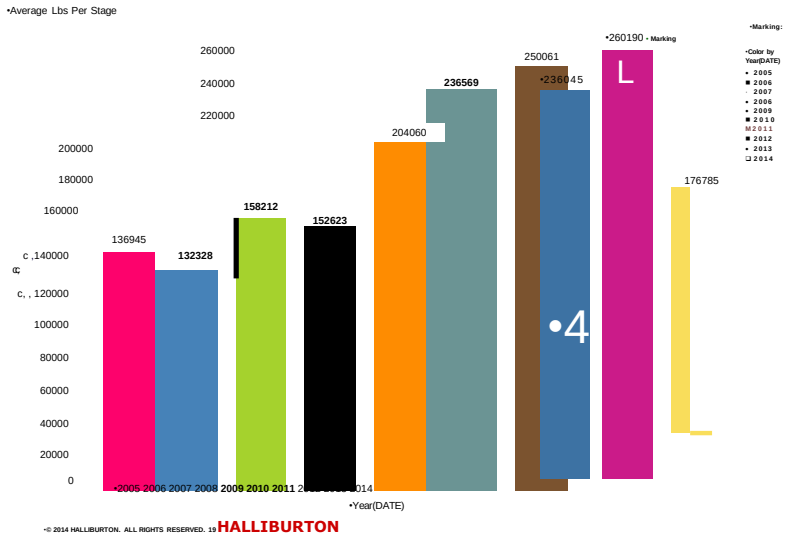
 HALLIBURTON

•Gallons/stage VS Year



 HALLIBURTON

•Lbs prop/stage VS Year



HALLIBURTON

Rate-Liq+Prop	Clean Vol.	Proppant	Proppant Conc.	Prop. Mass
80	20000		0	0
80	40000		0	0
80	22000	40/70	0.1	2200
80	15000	sweep	0	0
80	22000	40/70	0.1	2200
80	15000	sweep	0	0
80	22000	40/70	0.25	5500
80	15000	sweep	0	0
80	22000	40/70	0.25	5500
80	15000	sweep	0	0
80	22000	40/70	0.5	11000
80	15000	sweep	0	0
80	22000	40/70	0.5	11000
80	15000	sweep	0	0
80	22000	40/70	0.5	11000
80	15000	sweep	0	0
80	22000	40/70	0.6	13200
80	15000	sweep	0	0
80	22000	40/70	0.6	13200
80	15000	sweep	0	0
80	22000	40/70	0.6	13200
80	15000	sweep	0	0
80	22000	40/70	0.7	15400
80	15000	sweep	0	0
80	22000	40/70	0.7	15400
80	15000	sweep	0	0
80	22000	40/70	0.7	15400
80	15000	sweep	0	0
80	22000	40/70	0.9	19800
80	15000	sweep	0	0
80	26000	40/70	1	26000
80	15000	sweep	0	0
80	25000	40/70	1	25000
80	15000	sweep	0	0
80	25000	40/70	1	25000
80	16317.3	flush	0	0
	700197.3			230000

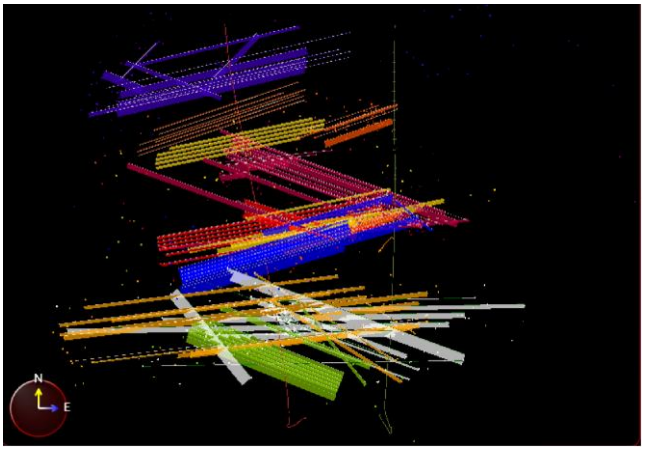
•GW Completions

•Lateral stim length (SL) =4000-4300 ft.
•Number of stages 8-21
•Stim Span Ft/stage (SS) 200-525 ft.

•Lateral stim length (SL) =9600-9800 ft.
•Number of stages 25-30
•Stim Span Ft/stage (SS) 325 – 388 ft.

•Perforations:
•3 clusters 3 ft. 6spf 54 holes 127 ft spacing
•4 clusters 3 ft. 4spf 48 holes 107 ft. spacing
•1.5 to 1.7 BPM/perf

•Granite Wash Horizontal Frac Planes From MSM



•132 planes (7 families 77°, 111°, 82°,110°, 118°,254°)
9.99e7 ft^2 Fracture Face Area

•Questions

EXPLORER
'Discovery Thinking' unveils Granite Wash
Assumed 'Simplicities' Masked Hidden Potential
By David Brown

EXPLORER
Horizontal drilling taps tight, old reservoir
Granite Wash a Wild Mix of Geology
By David Brown

•SPE 104546
•Granite Wash Field Study-Buffalo Wallow Field, Texas Panhandle

•SPE 106531
•Enhancing and Sustaining Well Production - Granite Wash, TX Panhandle

•SPE 88530
•Holistic Field Evaluations Improve Prospect Opportunities

•SPE 39814
•Granite Wash Completion Optimization with the Aid of Artificial Neural Networks

•SPE 67198
•Zone Selection and Production Prediction Using Advanced Logging Technology

•SPE 125732
•What Can Injection Falloff Tell About Job Placement and Production in Tight Gas Sand