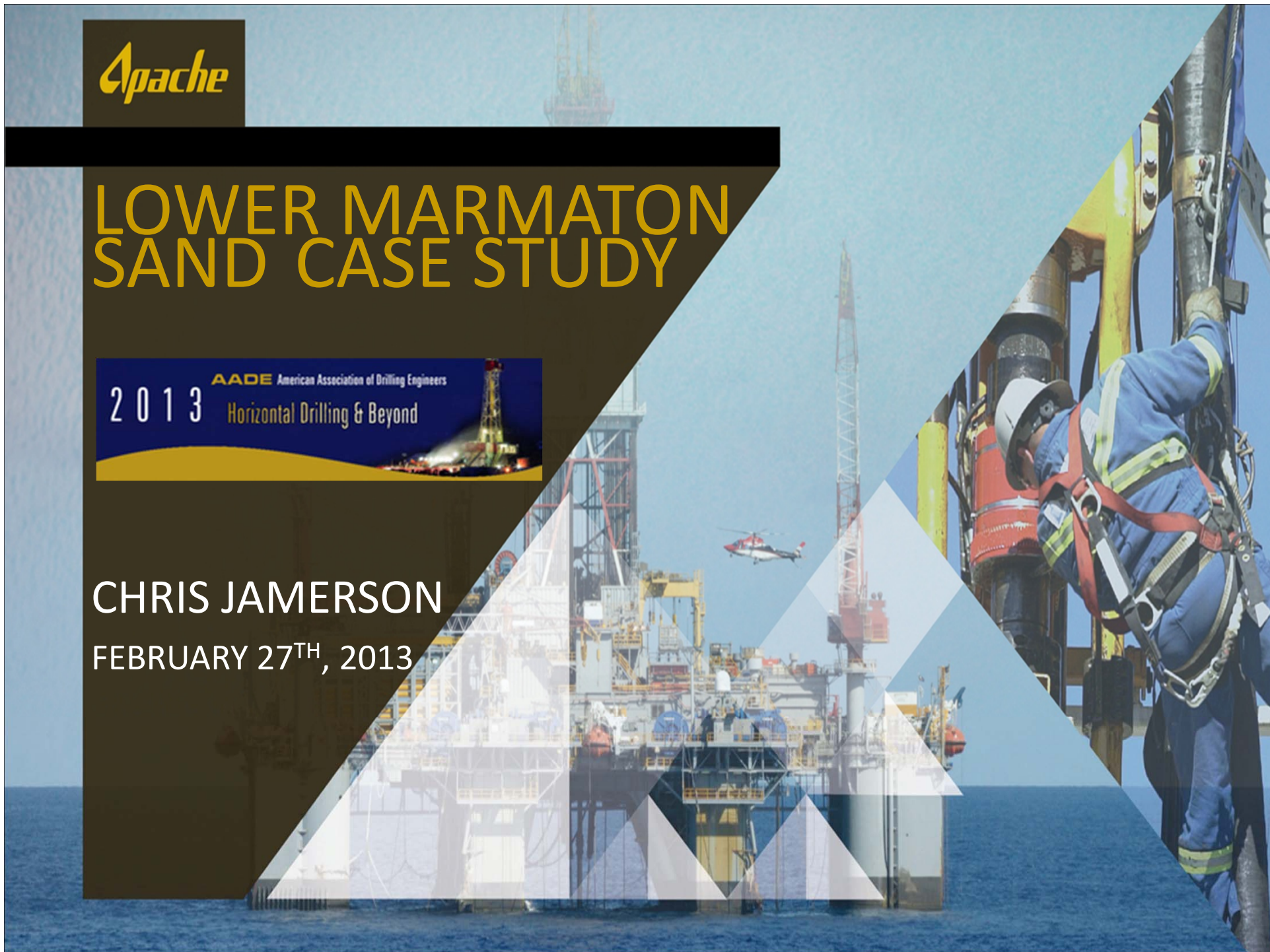




LOWER MARMATON SAND CASE STUDY

2013 **AADE** American Association of Drilling Engineers
Horizontal Drilling & Beyond

CHRIS JAMERSON
FEBRUARY 27TH, 2013



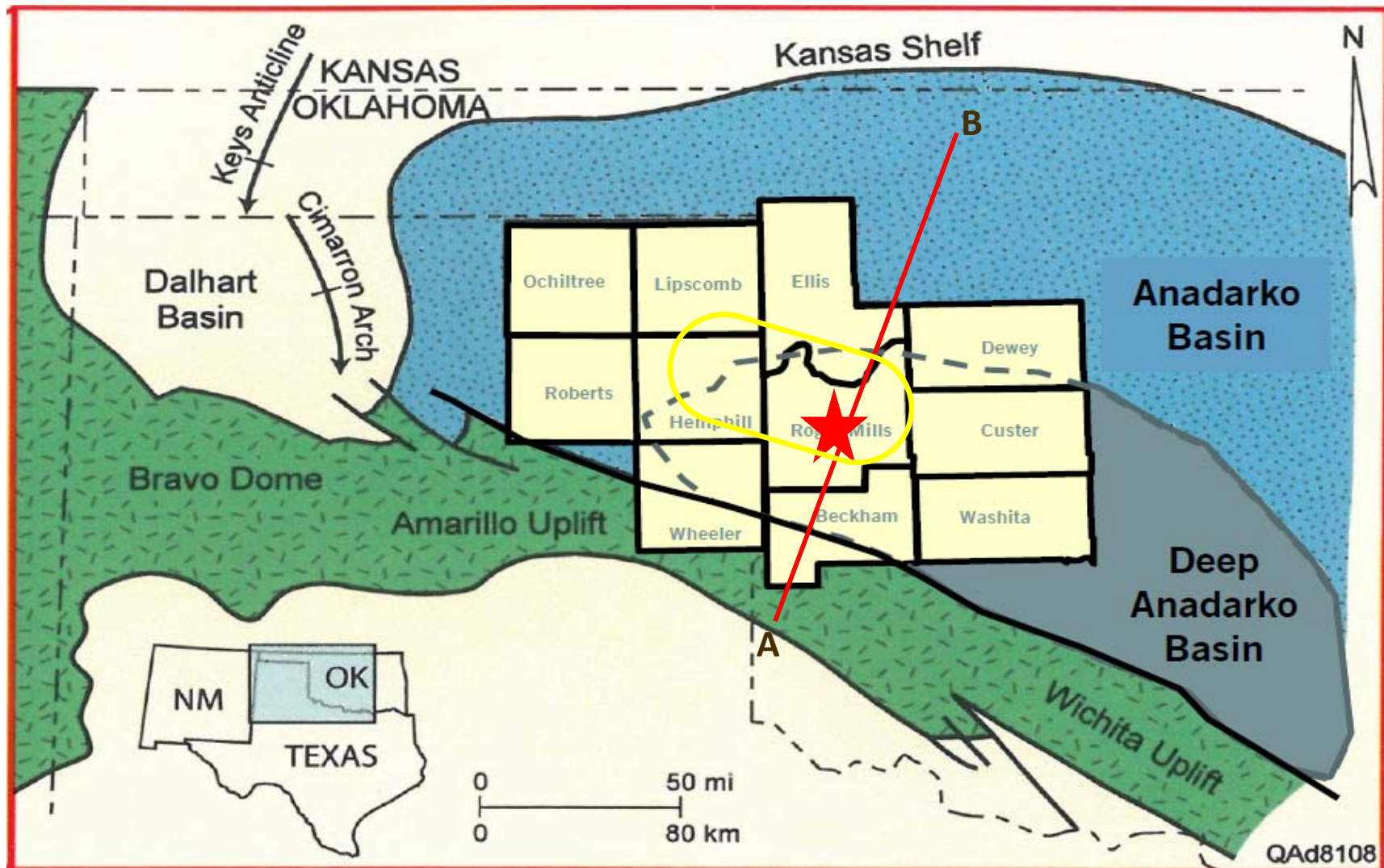
LOWER MARMATON AGENDA

- What is it?
- Where is it?
- What makes it different?
- What was done before?
- What have we done?
 - ▲ Round 1,2, and 3/4 results
- What is next?
- Questions

CORDILLERA ACQUISITION (CEPIII)

- Apache purchase – close May 1st, 2012
 - ▲ 254,000 net mineral acres
 - ▲ Acreage position filled in our Anadarko Gaps
 - ▲ Roger Mills, OK
 - ▲ Ellis, OK
 - ▲ Hemphill, OK
- 12 rigs w/ 1 month over-lap
- Picked up mostly:
 - ▲ Tonkawa
 - ▲ Cleveland
 - ★ Lower Marmaton ★
 - ▲ Upper Marmaton

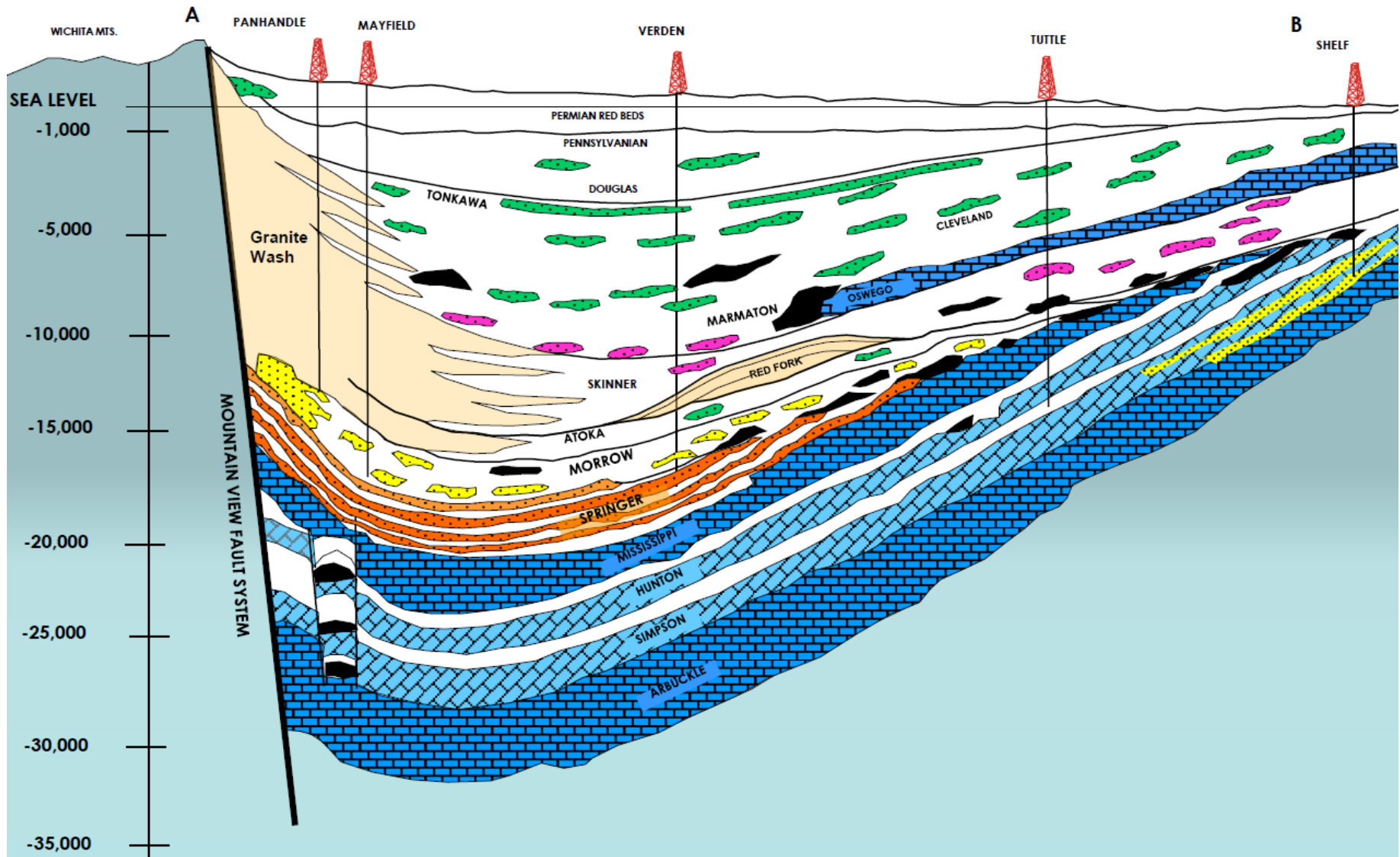
BASIN MAP AND TECTONIC SETTING



Modified from Blakey (2005) and Ambrose & Hentz (2011)

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BASIN CROSS-SECTION



TYPE LOG

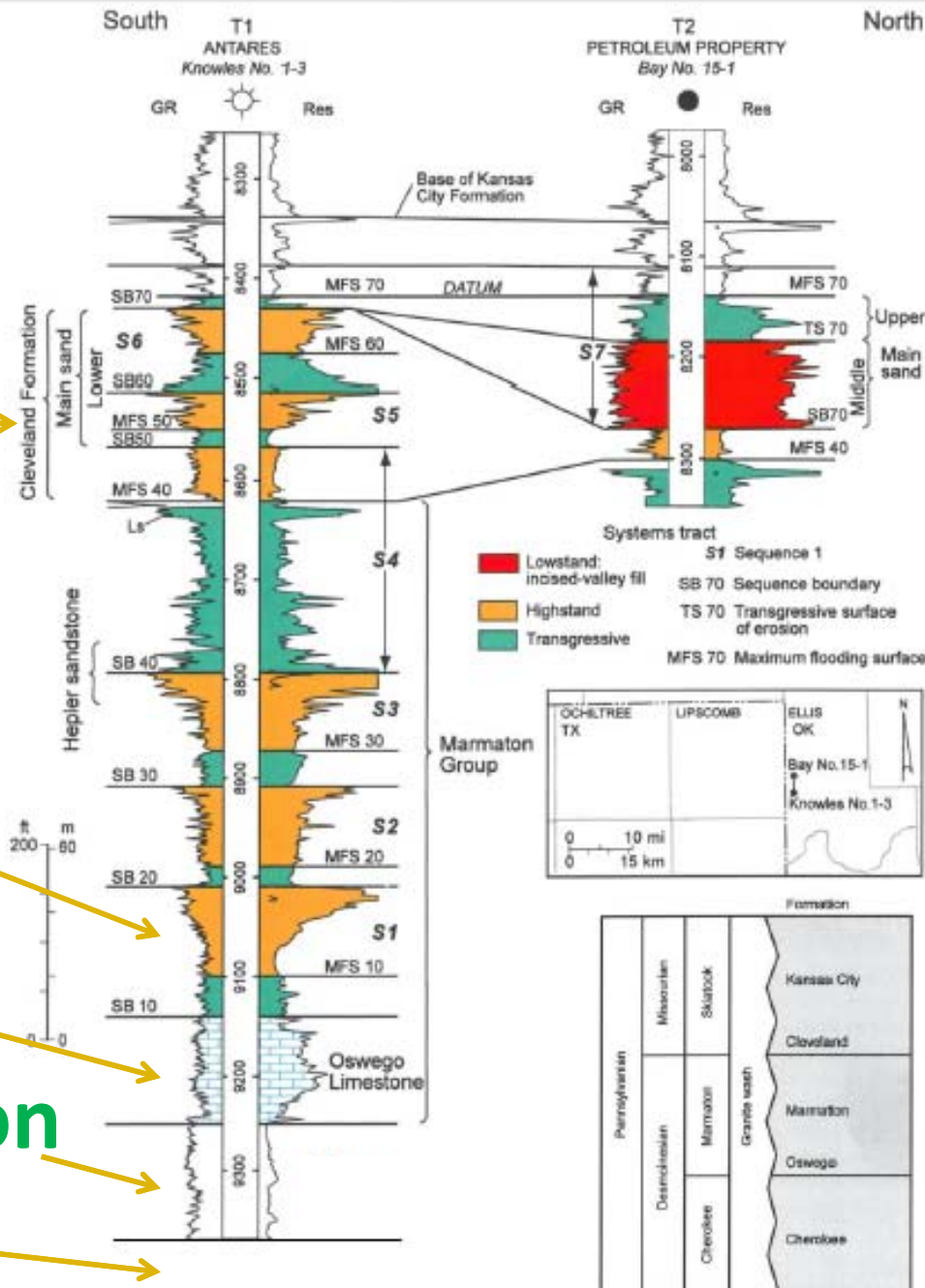
Cleveland Sand →

Deese Shale →

Oswego? →

Lower Marmaton →

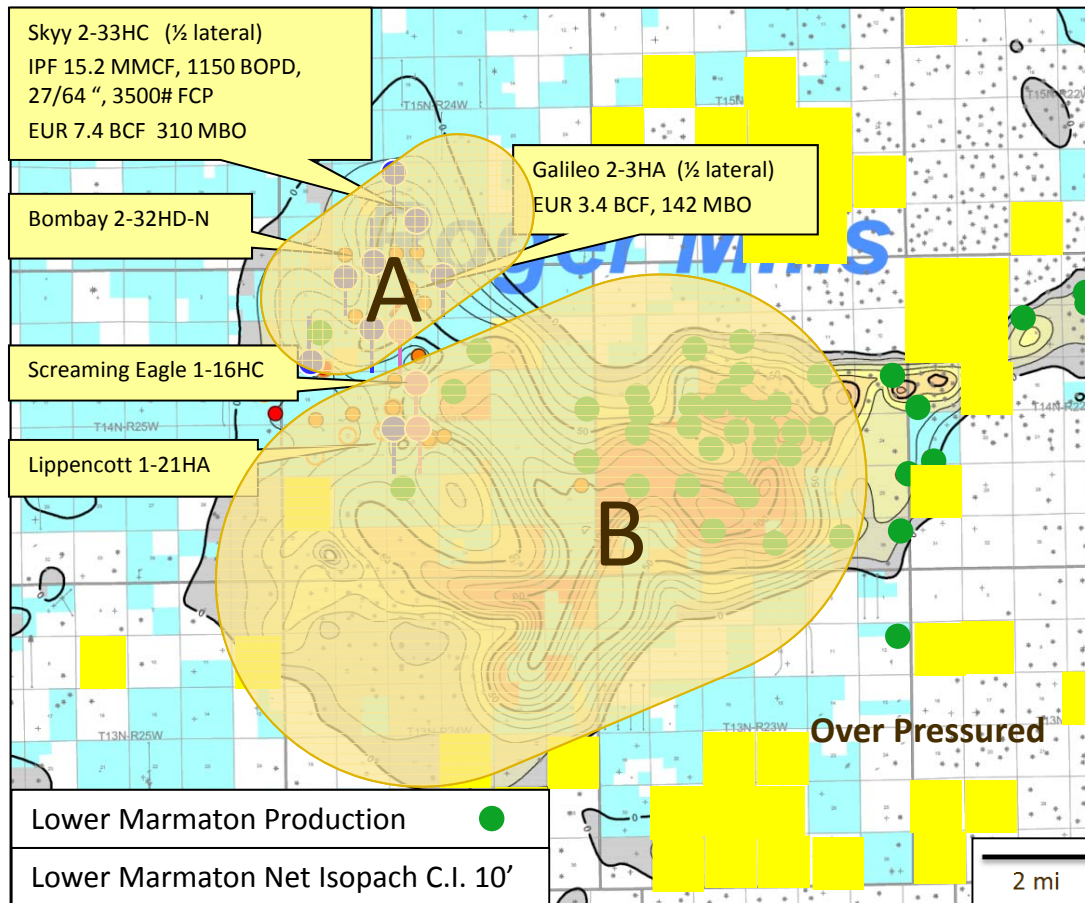
Granite Wash →



Modified from Hentz & Ambrose, 2011

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LOWER MARMATON



SINGLE WELL DATA:

Formation:	Lower Marmaton
Vertical Depth:	11,200-500'
Lateral Length:	4,800'
Completed Cost (MM\$):	
Reserves (BCF/MBO/MNGL):	
30 day IP(MCFD/BOPD):	
WI / NRI	

DRILLING ECONOMICS

ROR (%):

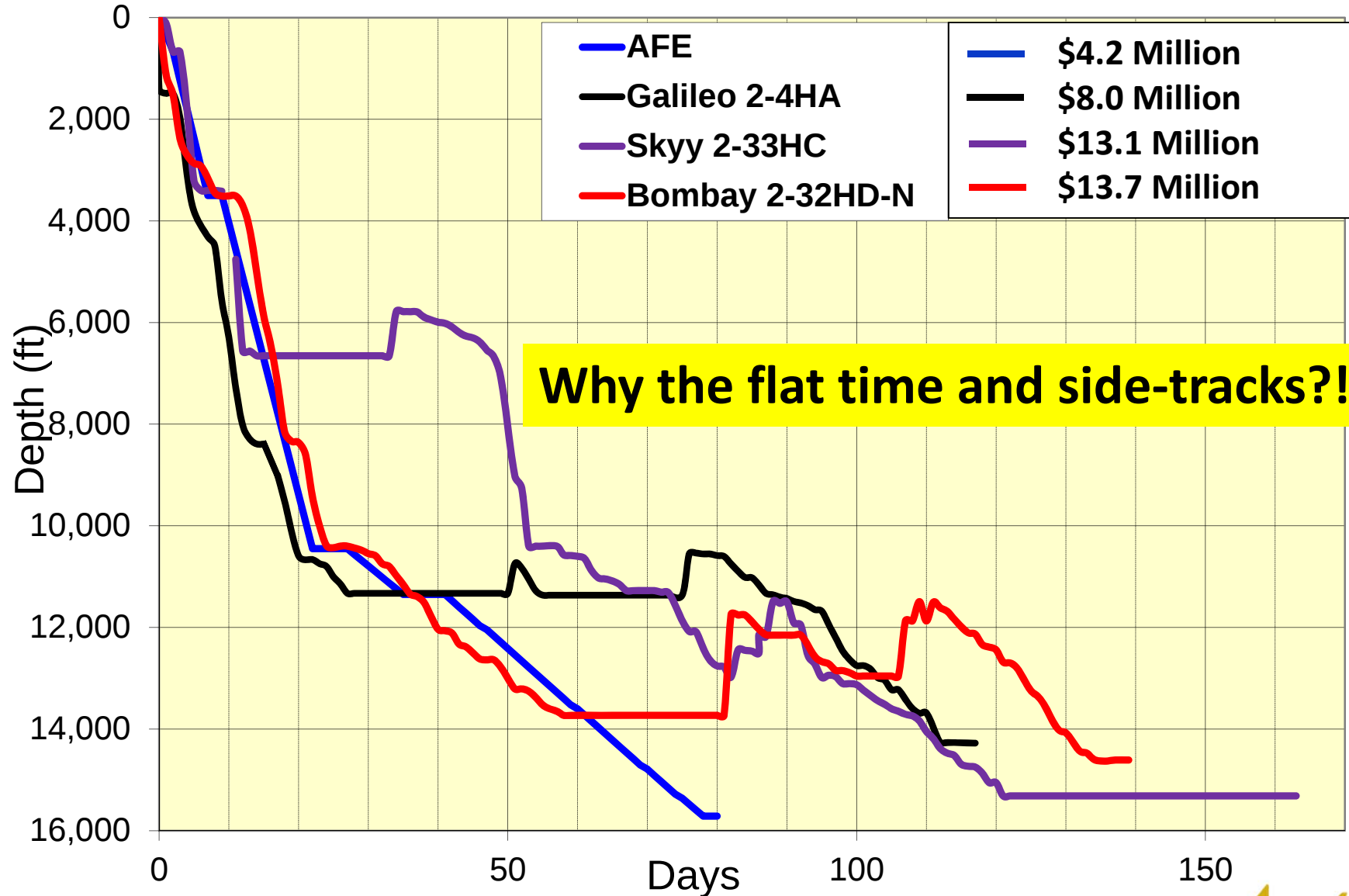
FC (\$/NEMCF):

PV12 (M\$):

INITIAL WELLBORE DIAGRAM

- ▶ Water-depth: 26" w/ 20" casing
- ▶ Intermediate: 17½" w/ 13-3/8" casing @ Anhydrites
- ▶ KOP: 12¼" Intermediate / 9-5/8" @ 10,450'
- ▶ Production: 8¾" Curve & lateral / 5.5" @ TD
 - ▲ Contingency 7" Liner / 5.5" by 4.5"

INITIAL DAYS VERSUS DEPTH



INVESTIGATION

Galileo 2-4H

OIL/SYNTHETIC BASED DRILLING FLUIDS

Time Samp Taken	SMALL FLAT, SHARP SHARDS OF SHALE																			
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Date

04.30	11177	11134	12.16	69	30	17	12 / 16	23	0	5.4	11		68	21	86/14	1580	4.2	5.436	30000	299,140
13.30	11230	11134	12.40	70	33	19	12 / 19	26	0	5.4	10		67	23	87/13	1490	4.4	5.698	29000	312,171

Remarks RAISED WT. TO 12.1#/GAL , CIRCULATE AND REAM TIGHT HOLE. RECOVERING SMALL FLAT, SHARP SHARDS OF SHALE ACROSS SHAKER, MINOR TO MODERATE IN VOLUME, DO NOT APPEAR TO BE DRILLED CUTTINGS.

Skyy 2-33HC

OIL/SYNTHETIC BASED DRILLING FLUIDS

Time Sample Taken	Depth (ft)	TVD (ft)	Mud Weight (ppg)	Funnel Vis (sec/qt)	Plastic Vis (cp)	Yield Point (lb/100ft²)	Gels (lb/100ft²)		API (mL)	HPHT 250F (mL)	Water % (V)	Other Fluid % (V)	Non Aqueous % (V)	Solids % (V)	Oil/Water Ratio	Electrical Stability (Volts)	POM (VSA)	Excess Lime (lb/bbl)	CIOM (mg/L)	Water Phase Salinity (ppm)
							10s/10m	30m												

Date

Fluid Type Oil-based

04.00	stuck			73	40	13	12 / 16	19	0	6	11		65	24	86/14	1153	3.6	4.662	34000	326,022
14.00																				

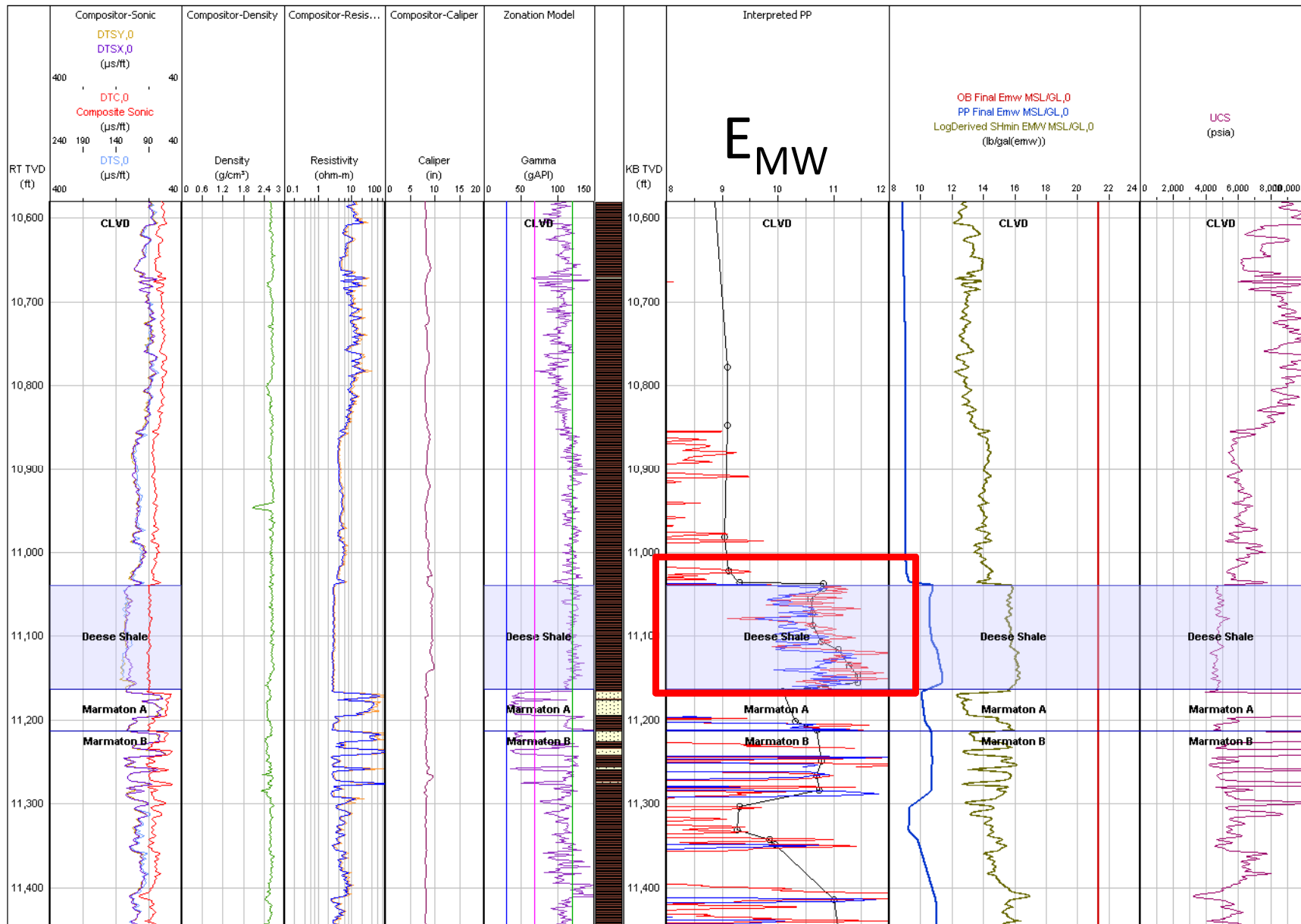
Remarks stuck@ 13,833, work free,

Date 12/29/2011

04.00	13635	11143	13.20																	
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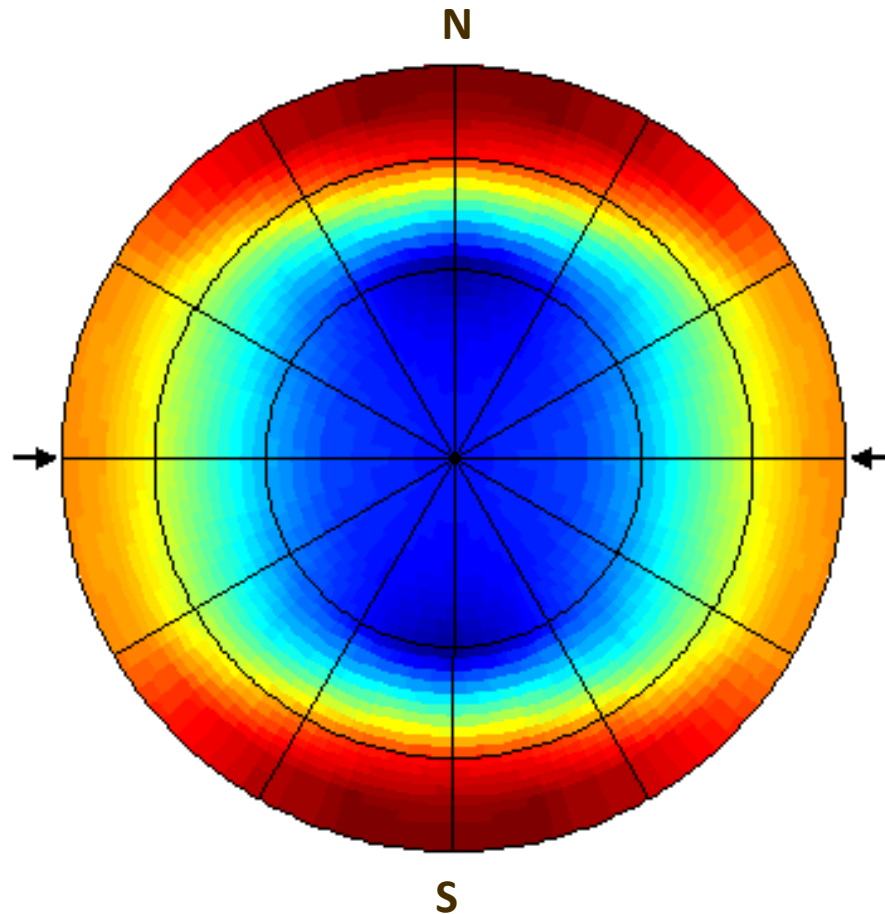
Remarks Lost 200 bbl washing casing in hole. Delivered 630 bbl to location. rig up C.R.T. equipment, casing stopped at 13,609 . rig up to lay down casing

PORE PRESSURE PREDICTION –MERCURY 1-5



REQUIRED MUD WEIGHT ASSUMING FISSILE ROCK BEHAVIOR

Wellbore Stability



12 12.5 13 13.5

Mud Weight, PPG

$S_v = 21.337$ PPG
 $SH_{max} = 18.745$ PPG
 $SH_{min} = 15.9$ PPG
Azimuth of $SH_{max} = 90$ degree
Pore Pressure = 10.91 PPG
Biot Coefficient = 1
Poissons' Ratio = 0.3168
Dip = 0 degree
Dip Azimuth = 0 degree
Cohesion = 386 PSI
Sliding Friction = 0.6516
Failure Criterion = Lade modified
Internal Friction = 0.6516
UCS = 4743 PSI
Failure Width = 0 degree
True Vertical Depth = 11100 feet

GEO-MECHANICS RECOMMENDATIONS

- Deese Shale is over-pressured. Likely fissile shale.
- Minimum of 13.7 ppg ESD beyond 75° in curve.
- >13.95 ppg is preferred to suppress the roof collapse.
- Losses higher in the borehole is seen as a potentially increased risk with higher mud weight. A losses prevention strategy may also be required.
- Large differences between ECD and ESD are also a cause for instability. Increases in ESD to combat instability have reduced efficacy if the pumps-on/pumps-off pressure differential ($ECD - ESD$) is increased too.

END OF THEORY – TIME TO DRILL

- Same basic casing plan as before.
- Run 7" liner – no contingency about it.
- Weight up in curve.
- Study shale shakers for the warning signs

ROUND 1: MERRITT #1-28HA

- Issues running 20" casing
 - ▲ Parted, fished, weight-up, ran to bottom.
- Remainder of vertical went quite well.
 - ▲ One-stage cement job achieved 7,000' of lift.
- Landed curve on depth & 7" liner successfully run.
 - ▲ Weight-up schedule established. It worked.
- Lateral was slow, painfully at times.
 - ▲ Found shale streak. Difficult to get out of streak.
 - ▲ Mud weight in lateral needed for shale stability – Zero bbl lost
- No good options to rotate production casing.
- End result: 74 days, 4,023' lateral, \$7.0 million

ROUND 2 CHANGES

► Vertical

- ▲ Higher MW on 20" casing.
- ▲ Two-stage cement job on 9-5/8"

► Run 7-5/8" liner through curve

- ▲ Allows for 6-3/4" hole & 5" long string.
- ▲ Try rotating near-bit stab to help hole geometry

► Reduce likelihood of encountering shales

- ▲ Azimuthal Resistivity

ROUND 2: FRANK #1-34HA

- Issues running 20" casing
 - ▲ Higher MW, stopped short, pulled casing, cleaned-up, re-ran
 - ▲ Remainder of vertical went quite well.
 - ▲ Two-stage 9-5/8" cement went well.
- Landed curve on depth & 7-5/8" liner successfully run.
 - ▲ Weight-up schedule worked again.
- Azimuthal resistivity helped, but eventually found shale
 - ▲ First 1,000' of lateral were great – feet on desk.
 - ▲ Losses started.
 - ▲ Some Mud weight in lateral needed for shale stability.
- End result: 87 days, 3,450' lateral, \$8.0 million
 - ▲ TD 400' early and casing stopped 700' short.



ROUND 3/4 CHANGES

► Vertical

- ▲ Even Higher MW on 20" casing.

► Well set-up out of section.

- ▲ Significant tangent in vertical.
- ▲ Casing wear issues?
- ▲ Continue 7-5/8" liner; 6-3/4" hole & 5" long string.
- ▲ Try Hybrid bit in curve.

► Continue Azimuthal Resistivity

- ▲ Frac in shales has been ok.
- ▲ May back off from well placement fight.

► Steer around well in lateral.

ROUND 3/4: MAMIE #5-4H & HAWKINS #1-6H

- Issues running 20" casing
 - ▲ Higher MW, few hang-ups. Casing run to 20' of bottom.
 - ▲ Remainder of vertical went quite well.
- Landed curve on depth & 7-5/8" liner successfully run.
 - ▲ Weight-up schedule worked again.
- Azimuthal resistivity helped, but eventually found shale
 - ▲ Some losses encountered.
 - ▲ Some Mud weight in lateral needed for shale stability.
- End result: ?
 - ▲ 1,500' to TD on Mamie 5-4H
 - ▲ 3,000' to TD Hawkins 1-6H

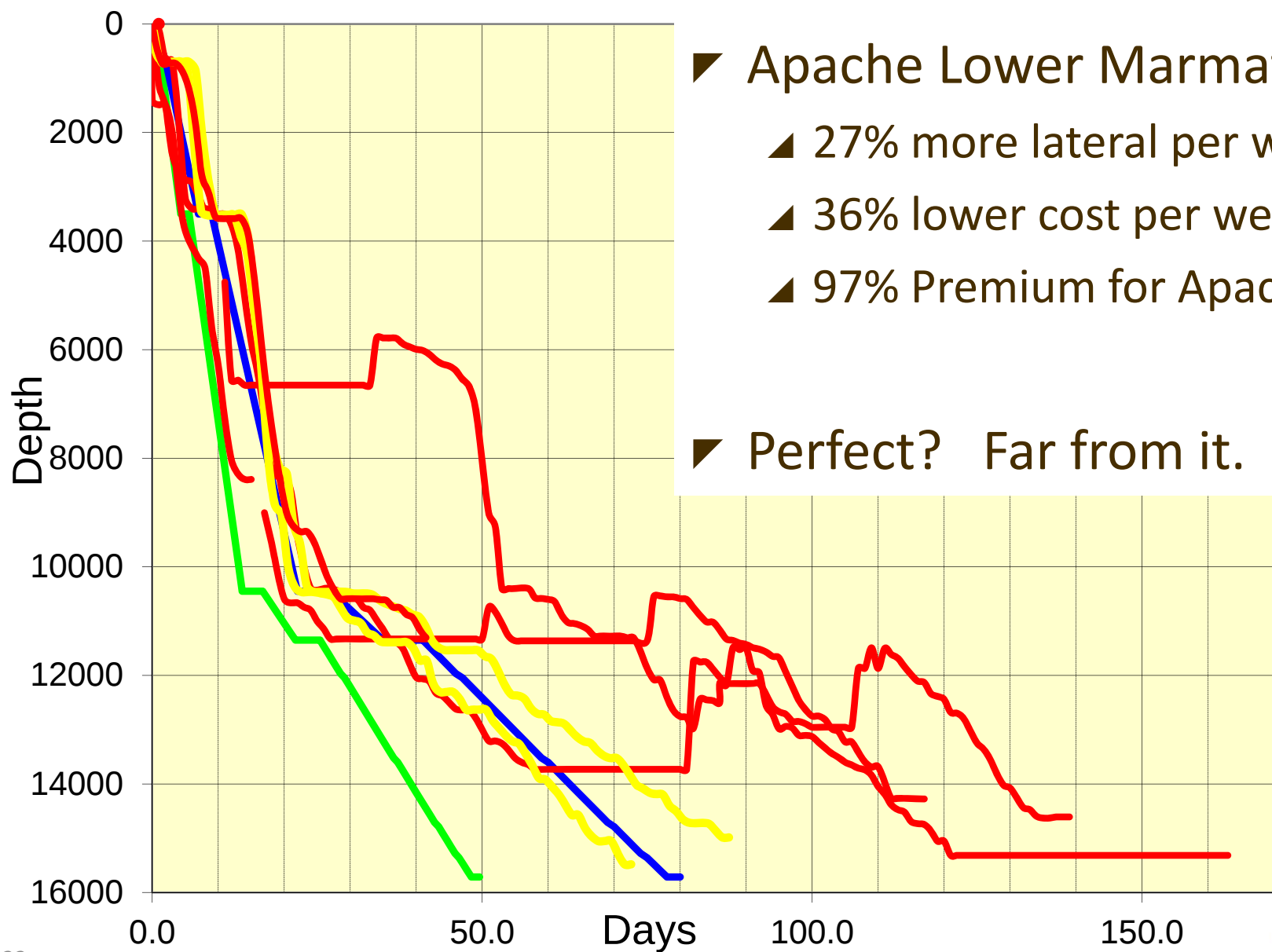
CONCLUSIONS

- We started with a good plan from Cordillera
- Geo-Mechanics review reduced issues
 - ▲ Over-pressure in Deese Shale
 - ▲ Pressure + trajectory are very bad
 - ▲ Must maintain MW to have stability
- 7-5/8" Liner simplifies completion with 5" long string
- Azimuthal Resistivity has helped geo-steer reservoir

NEXT CHALLENGES

- Move onto BLM Land
 - ▲ Permitting lead times
- Improve 6¾" lateral bits
- Attempt 6-1/8" lateral again
 - ▲ Engineered 5.5" by 4.5" casing cross-over
- Can I remove a string of casing?
- Review need for Azimuthal Resistivity
- Two Apache data points is not enough
 - ▲ Holistic review of 4 completed wells

RESULTS THUS FAR



Apache

THANK YOU.

QUESTIONS.

