“Integration of the recently drilled basement test at Cutter Field, Stevens County, Kansas into the evaluation of regional CO2 storage potential”

W. Lynn Watney and Jason Rush
Joint PIs, DE-FE0002056
Kansas Geological Survey

Dana Wreath
Berexco, LLC

Outline

- **Background of Project DE-FE0002056 (Characterization of CO2 Storage Capacity in Southern Kansas)**
  - Type wells
  - Regional characterization
  - Wellington Field
- **Selection of site for southwestern Kansas calibration site**
  - Satisfy statement of work and budget with industry participants bidding on the project
    - Sites with geology suited for evaluating carbon management
      - CO2-EOR potential in oil field
      - Geology is representative of the Arbuckle in the region
  - Site is western anchor for the regional carbon management characterization
    - Calibrate capacity and evaluate efficacy/risks of commercial scale CO2 injection into the Arbuckle
    - Utilization of CO2-EOR in the shallower oil fields
      - Fund the infrastructure
      - Revitalize the oil fields
- **Geology of Cutter Field and Vicinity**
- **Core and logging in Berexco Cutter KGS #1**
  - Drilling prognosis
  - Drilling statistics
  - Georeport and oil shows
  - Core recovery and first look
  - Core-log integration
  - Comparison with Wellington KGS #1-32
- **Future studies**
- **Key findings, significance**

Background

with preview of
Bob Slamal Type Logs Project
(4 slides)

Work is partially supported by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) under Grant Number DE-FE0002056.

The development of a digital well log standard LAS in the 1990's, digital acquisition by all Kansas logging companies in late 2000's, and accommodation and use of digital logs in surface mapping software has encouraged increasing use of digital well logs. This has been accompanied by the new technology driven developments in the oil and gas industry driven by price and importantly, ideas on where remaining petroleum resides, conventional and unconventional. The ideas are founded upon the currency of reliable stratigraphic formation tops to frame the subsurface analyses. Reference stratigraphic type well logs that are digital and linked with peer reviewed stratigraphic datums will serve as a starting point that will aid in further advancing our Geoscience for future. The existing Kansas Type Logs published in 1960s by the Kansas Geological Society have served the community extremely well, created by a committee of volunteers. A new digital version of the type logs, the Bob Slamal Digital Type Logs Project, builds on this heritage and is dedicated to an untiring stratigrapher and subsurface geologist who exemplified the enthusiasm of an oil finder and a scientist seeking answers to important stratigraphic problems up to the day he lost his life in a tragic car accident on a snowy Saturday morning on the way to the society library.

The Bob Slamal Digital Type Logs Project is first and foremost, an effort of an expert community of geologists who are dedicating their time and knowledge to establish a consistent, detailed subsurface stratigraphic framework across Kansas. No one geologist has detailed knowledge and extensive experience across the entire state. This is why we seek the assistance of Society members in the correlation of the stratigraphic framework, in a members area of expertise. To contribute to the project all you need is the desire to help and a computer with an internet connection. The online application is easy to use and contains "workflow" assistance and extensive help files.

The project is a joint effort between the Kansas Geological Society and the Kansas Geological Survey utilizing membership of the Society and the programming talents of John Victorine, of the Kansas Geological Survey, who has developed the online Java application to manage and display the digital logs and stratigraphic data. John Doveton has been instrumental in advancing knowledge and use of digital well logs from the efforts in the 1990's to develop a "Kansas Virtual Geology" and a more recently "Stratigraphic GIS", to make the Kansas subsurface visible through imaging of digital logs, facilitating ties between surface exposures and the subsurface.

Society member Paul Gerlach has worked with Larry Nicholson and Tom Hansen to development the initial "seed" correlations under DOE-NETL Contract DE-FE0002056, where digital type logs have been defined, digitized, and correlated to support mapping and petrophysical analysis in the evaluation of carbon storage potential of southern Kansas. Paul is managing this effort to deliver a compiled CD set of type wells for the Society and inclusion of logs among other type wells that will be accessible on the DOE-supported interactive oil and gas project mapper soon available through the Kansas Geological Survey.

This version of the Bob Slamal Digital Type Logs Project is constructed to facilitate future updates anticipating that new research and stratigraphic concepts will continue to evolve as science and technology advance. The collective stratigraphic information will enable elevation of informal stratigraphy to formal status following protocol established by the Kansas Geological Survey Stratigraphic Nomenclature Committee.

Lynn Watney, DOE project Joint PI with Jason Rush, Kansas Geological Survey, 14 December 2012

Bob Slamal Digital Type Logs Project Applet

Work is partially supported by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) under Grant Number DE-FE0002056.

Step 1: Login to Enable Image Map:

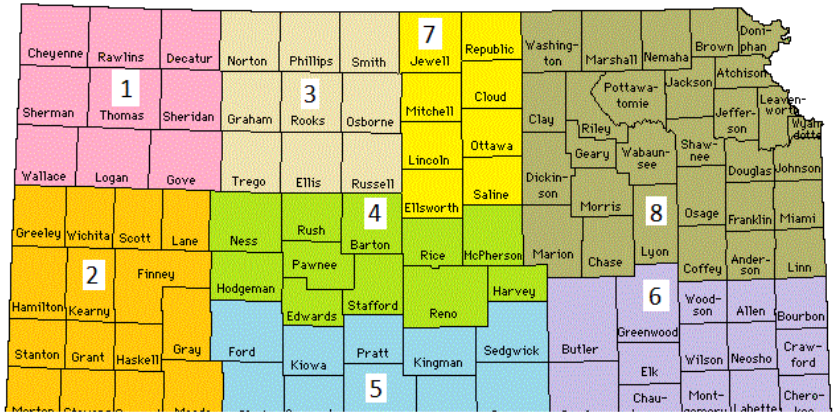
Enter your Email Address and then Select Login Button:

Login Clear

Step 2: Choose Button to Display Wells by County or by Area:

Display Wells in County Map | Display Wells in Area Map

Step 3: Click on Map Below to Plot Wells on a Township-Range-Section (TRS) Grid County Map or Ar

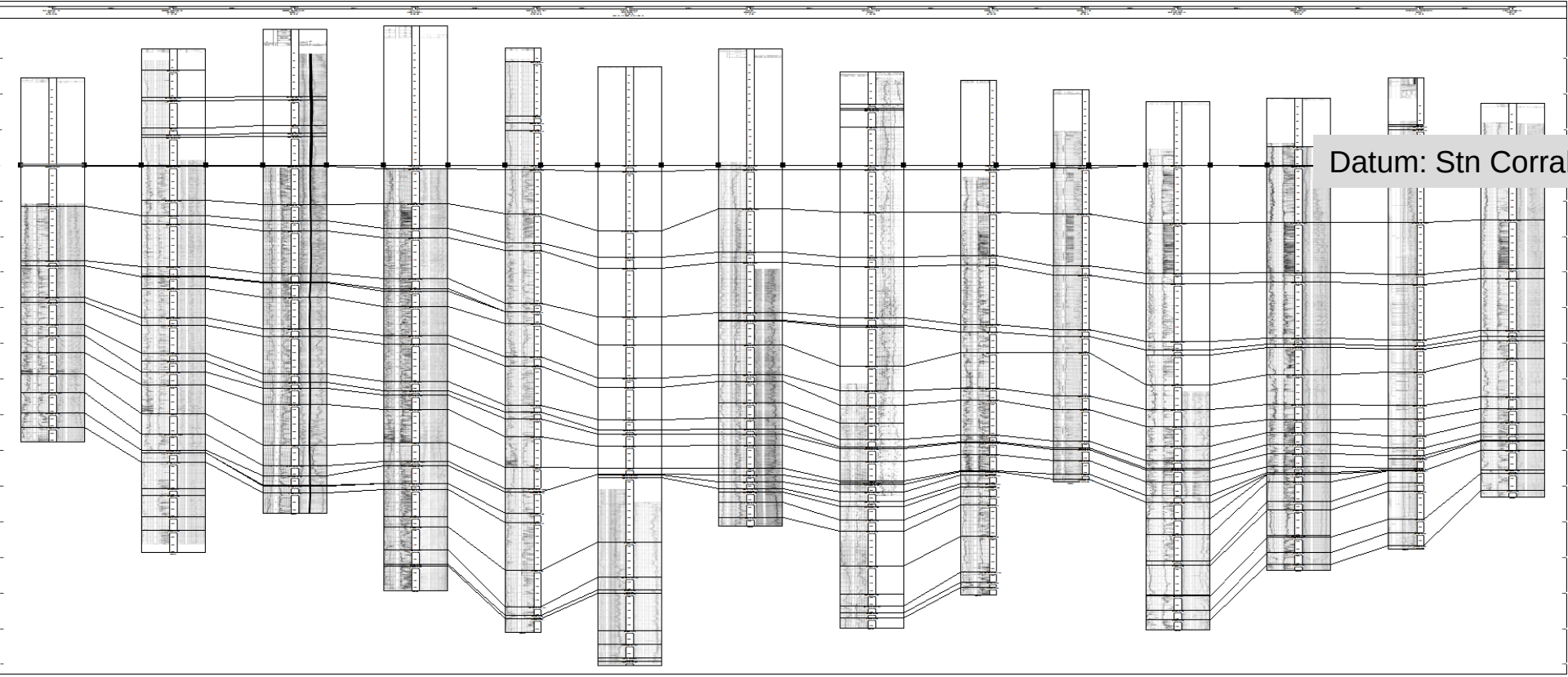


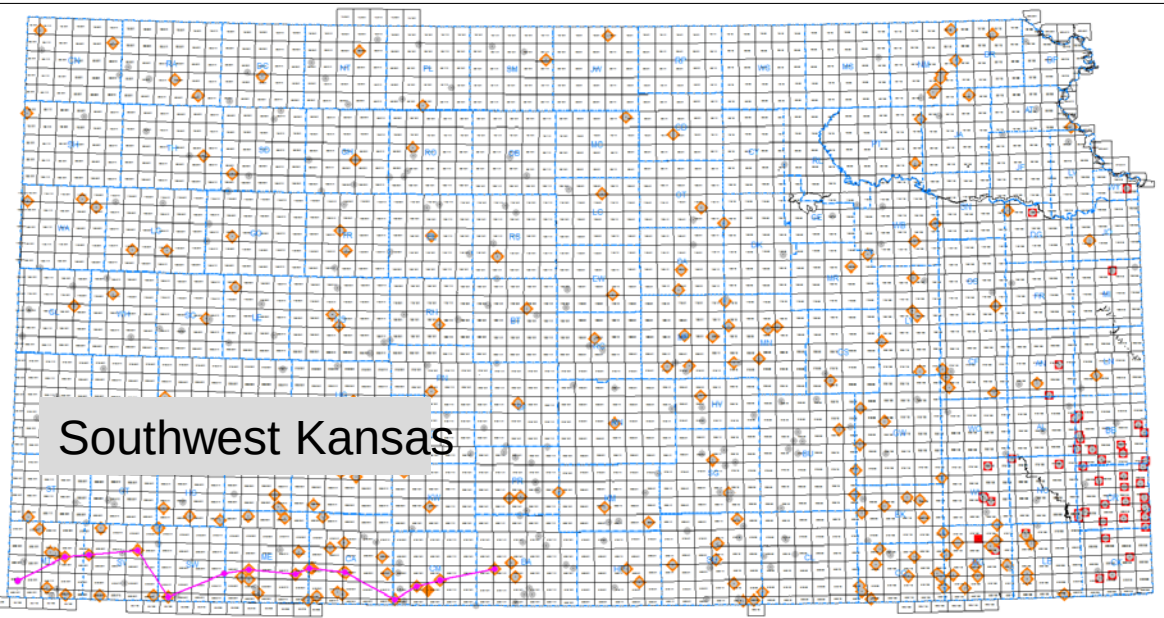
Areas of Log Commmittee

ID	Description
1	North West Kansas
2	South West Kansas
3	Northern CKU
4	Southern CKU and saddle area to east
5	South-Central Kansas
6	Southeast Kansas
7	Eastern Salina Basin
8	Northeast Kansas

Author: John R. Victorine **jvictor@kgs.ku.edu**

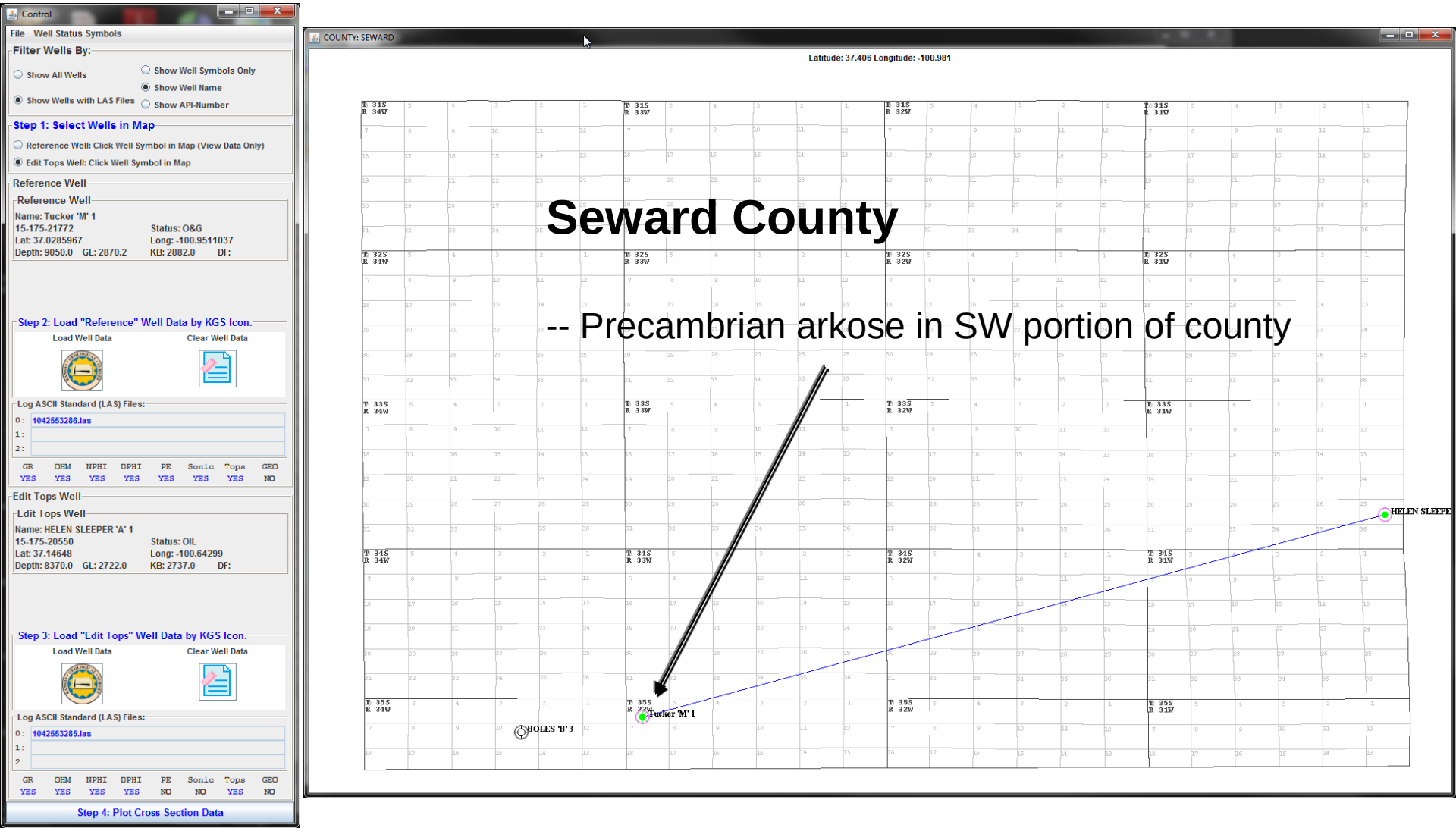
The URL for this page is http://www.kgs.ku.edu/PRS/Ozark/TYPE_LOG/applet.html

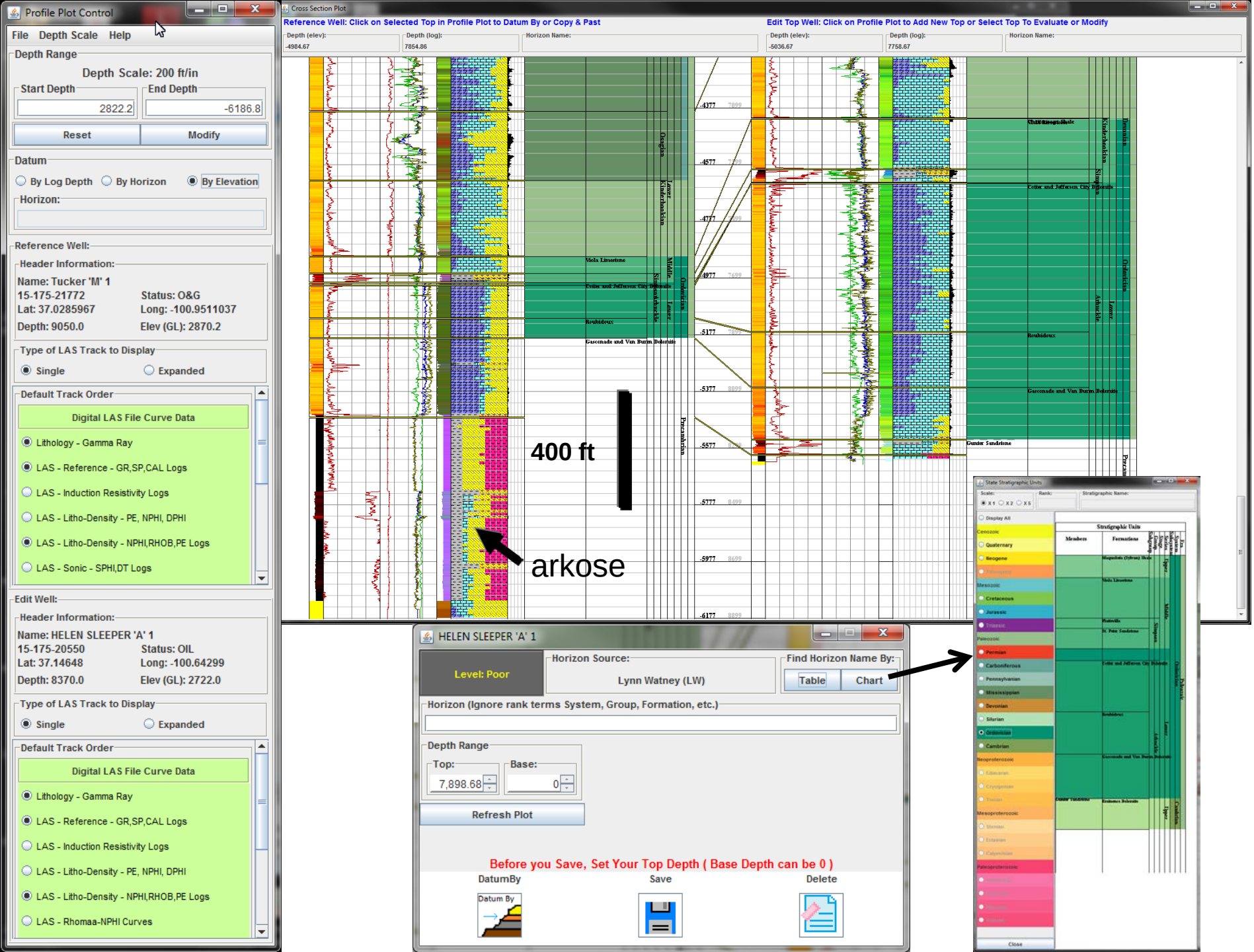




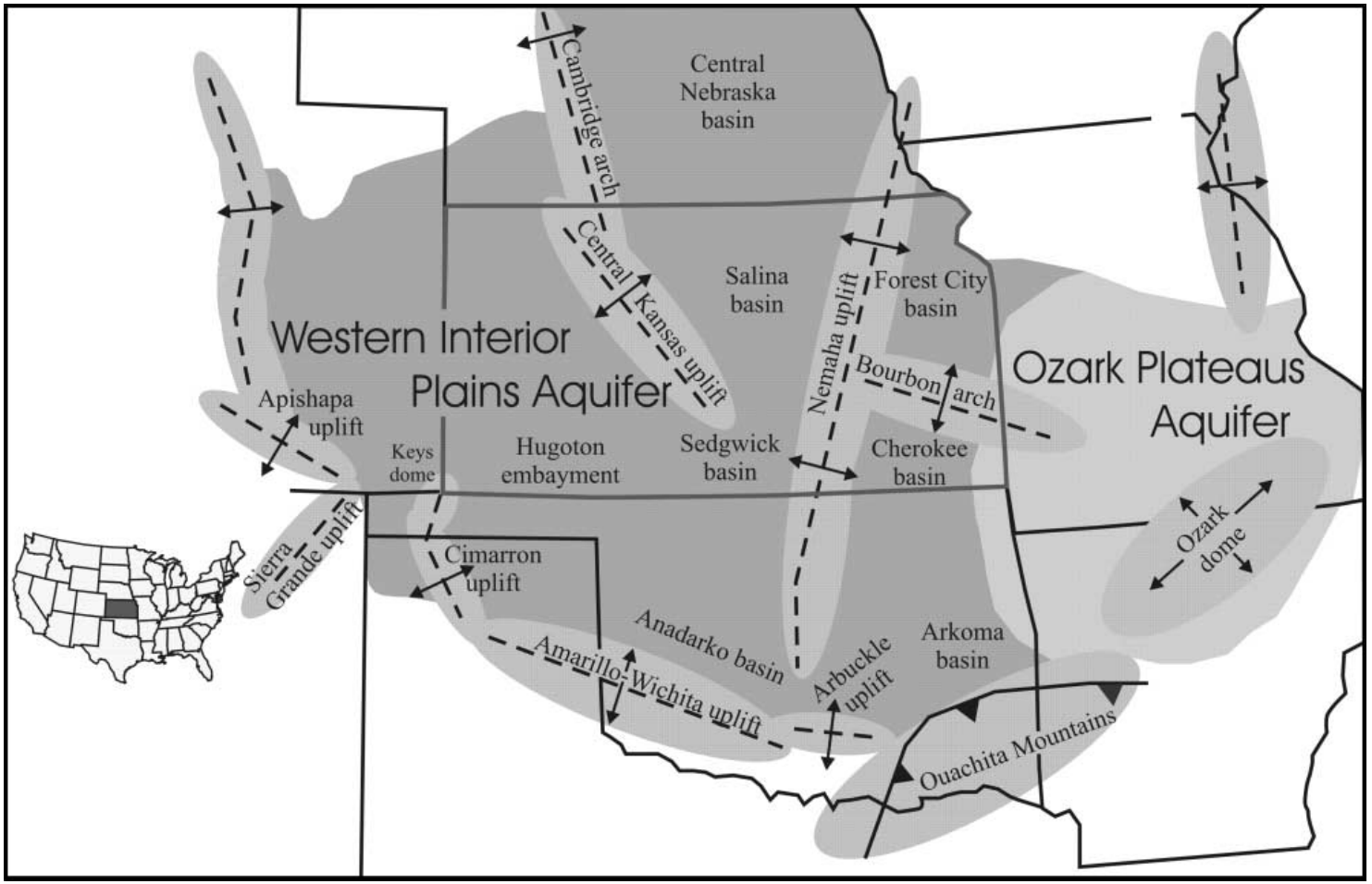
DOE-CO2 digitial type wells are “seeded” with regional tops from “near surface“ to Pre-Cambrian to serve as basis part of the **Kansas Type Log Project**

Interactive map to compare control well with well to be classified

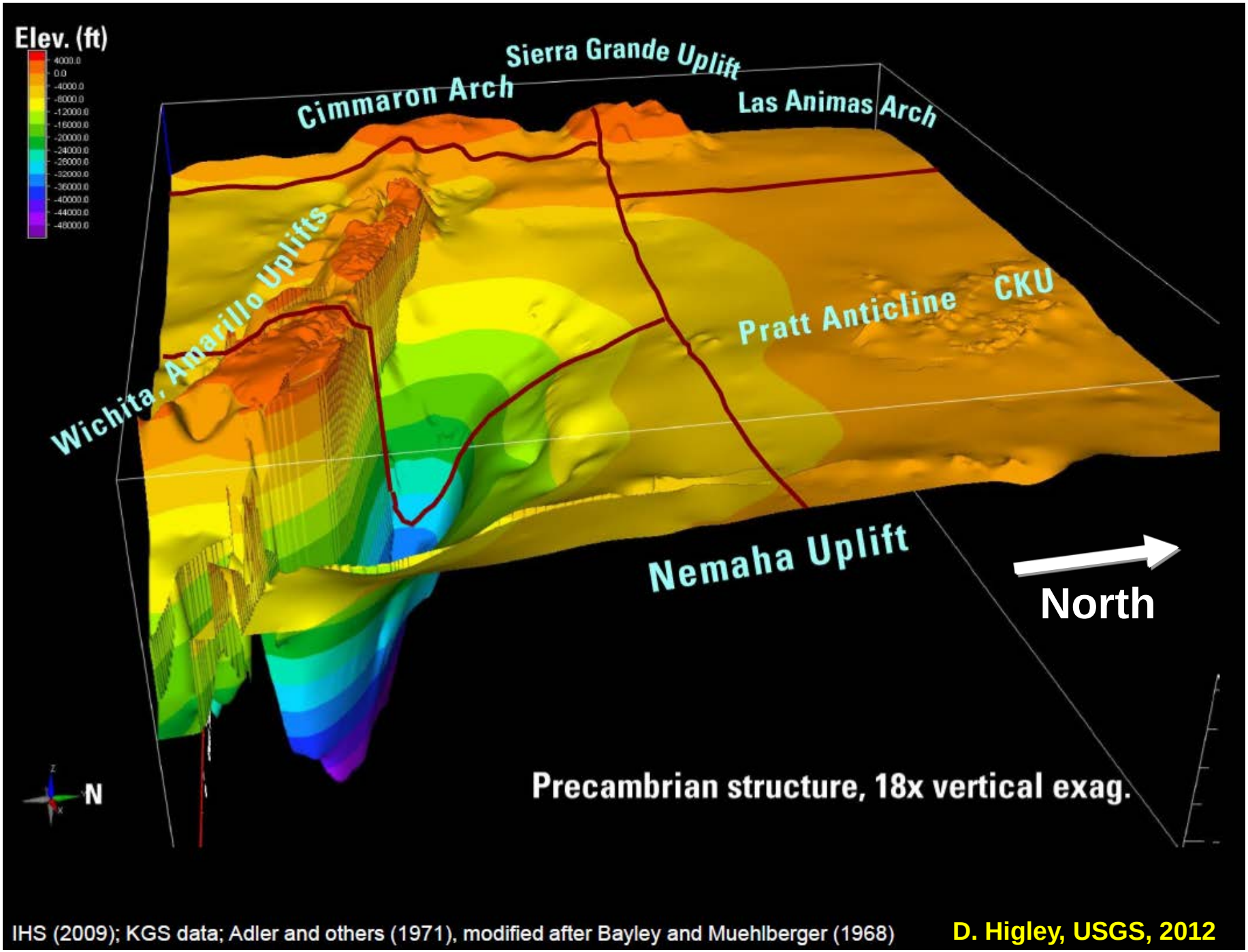



Profile Plot Control
File Depth Scale Help
Depth Range
Depth Scale: 200 ft/in
Start Depth
2822.2
End Depth
-6186.8
Reset
Modify
Datum
By Log Depth
By Horizon
By Elevation
Horizon:
Reference Well:
Header Information:
Name: Tucker 'M' 1
15-175-21772
Status: O&G
Lat: 37.0285967
Long: -100.9511037
Depth: 9050.0
Elev (GL): 2870.2
Type of LAS Track to Display
Single
Expanded
Default Track Order
Digital LAS File Curve Data
Lithology - Gamma Ray
LAS - Reference - GR,SP,CAL Logs
LAS - Induction Resistivity Logs
LAS - Litho-Density - PE, NPHI, DPHI
LAS - Litho-Density - NPHI,RHOB,PE Logs
LAS - Sonic - SPHI,DT Logs
Edit Well:
Header Information:
Name: HELEN SLEEPER 'A' 1
15-175-20550
Status: OIL
Lat: 37.14648
Long: -100.64299
Depth: 8370.0
Elev (GL): 2722.0
Type of LAS Track to Display
Single
Expanded
Default Track Order
Digital LAS File Curve Data
Lithology - Gamma Ray
LAS - Reference - GR,SP,CAL Logs
LAS - Induction Resistivity Logs
LAS - Litho-Density - PE, NPHI, DPHI
LAS - Litho-Density - NPHI,RHOB,PE Logs
LAS - Rhomaa-NPHI Curves
Cross Section Plot
Reference Well: Click on Selected Top in Profile Plot to Datum By or Copy & Past
Edit Top Well: Click on Profile Plot to Add New Top or Select Top To Evaluate or Modify
Depth (elev):
-4984.67
Depth (log):
7854.86
Horizon Name:
Depth (elev):
-5036.67
Depth (log):
7758.67
Horizon Name:
Viola Limestone
Cotter and Jefferson City Dolomite
Roubideux
Gasconade and Van Buren Dolomite
Gunter Sandstone
400 ft
arkose
HELEN SLEEPER 'A' 1
Level: Poor
Horizon Source:
Lynn Watney (LW)
Find Horizon Name By:
Table
Chart
Horizon (Ignore rank terms System, Group, Formation, etc.)
Depth Range
Top:
7,898.68
Base:
0
Refresh Plot
Before you Save, Set Your Top Depth (Base Depth can be 0)
DatumBy
Save
Delete
Datum By
State Stratigraphic Units
Stratigraphic Units
Members
Formations
Close

Structural features and of the Paleozoic aquifer systems of the mid-continent



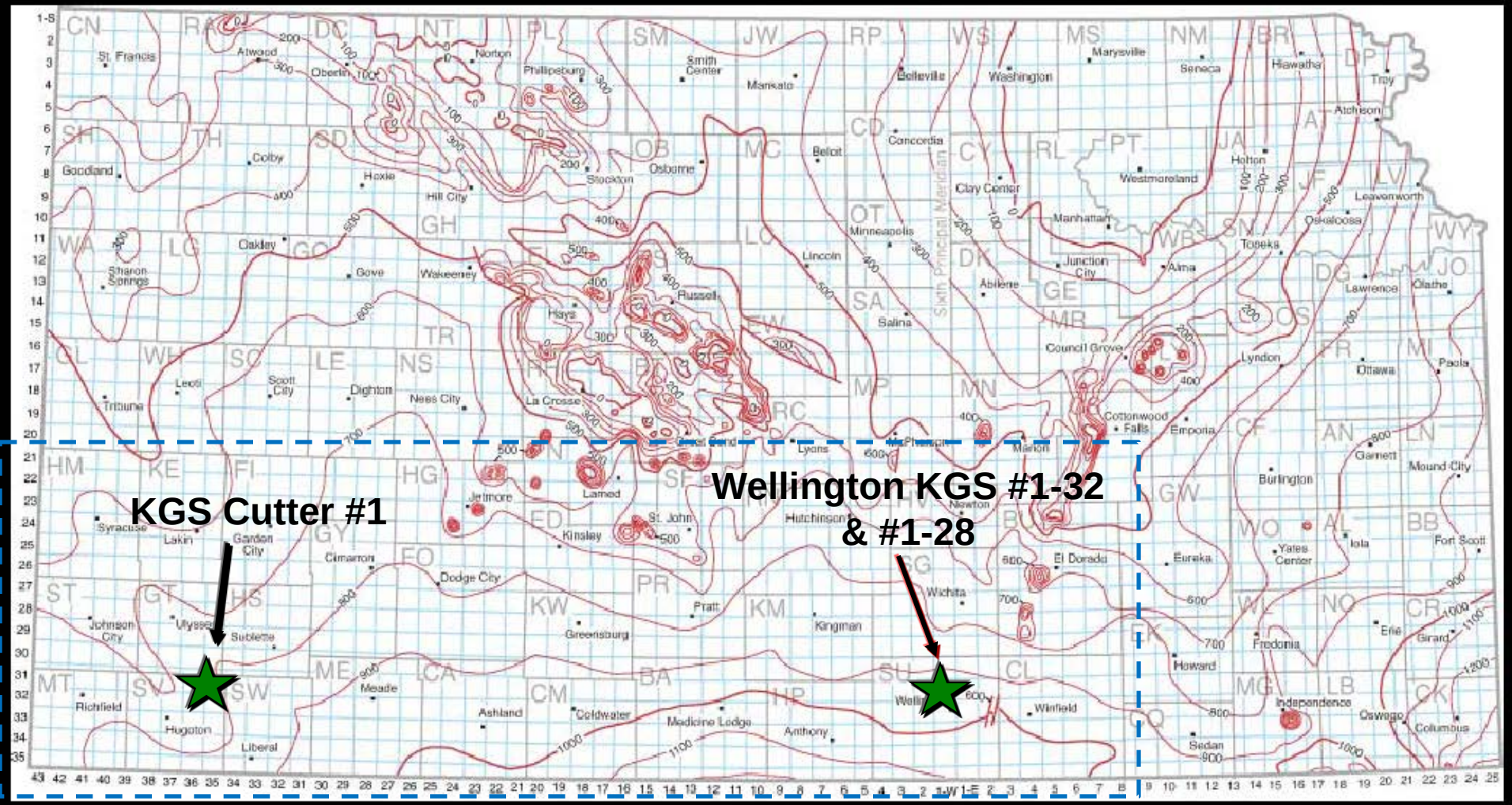
(modified from Merriam, 1963; from Jorgensen et al. (1993).
Carr et al., AAPG Bulletin, v. 89, no. 12 (December 2005), pp. 1607–1627



IHS (2009); KGS data; Adler and others (1971), modified after Bayley and Muehlberger (1968)

D. Higley, USGS, 2012

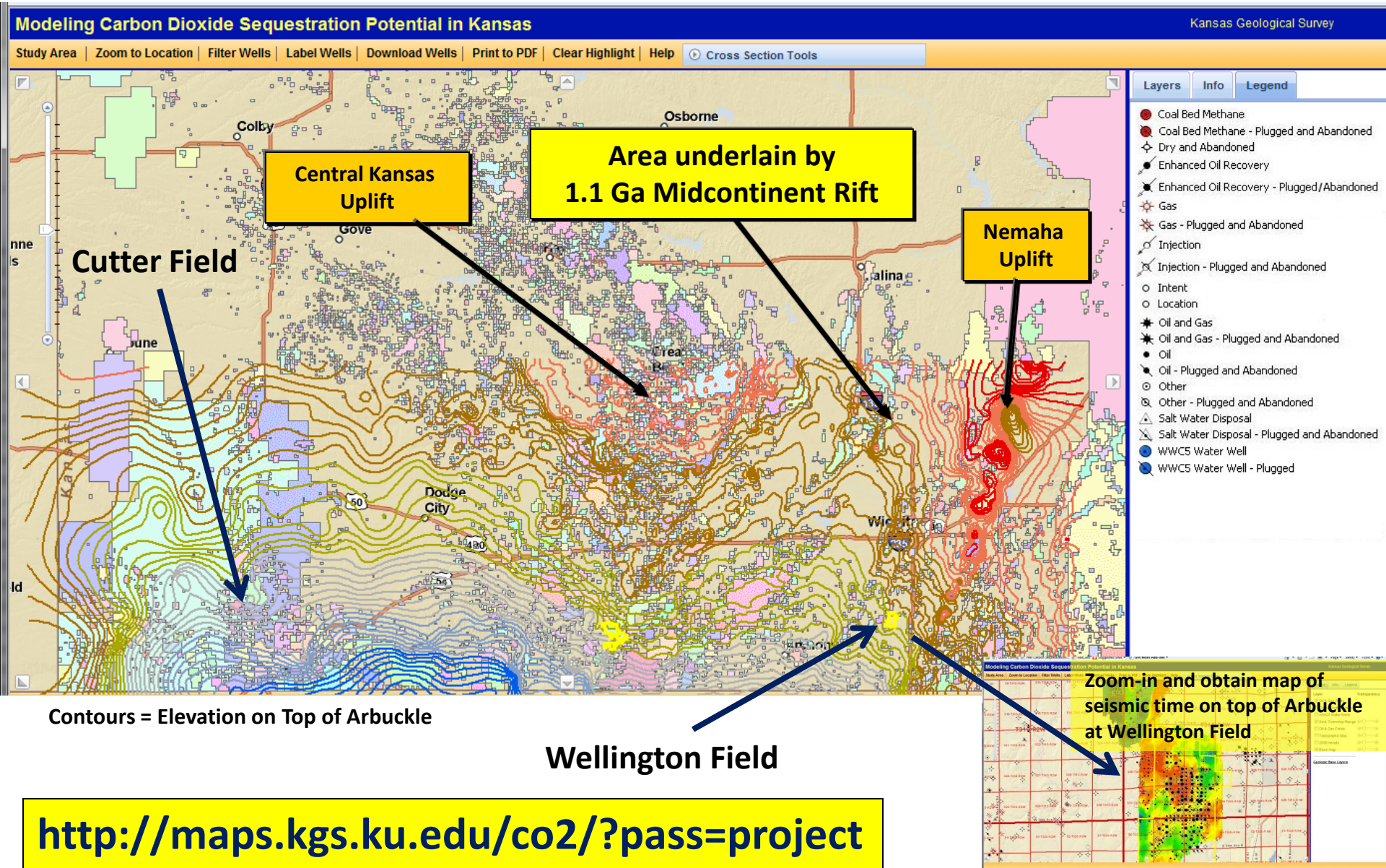
Arbuckle Isopach Map



KGS Website

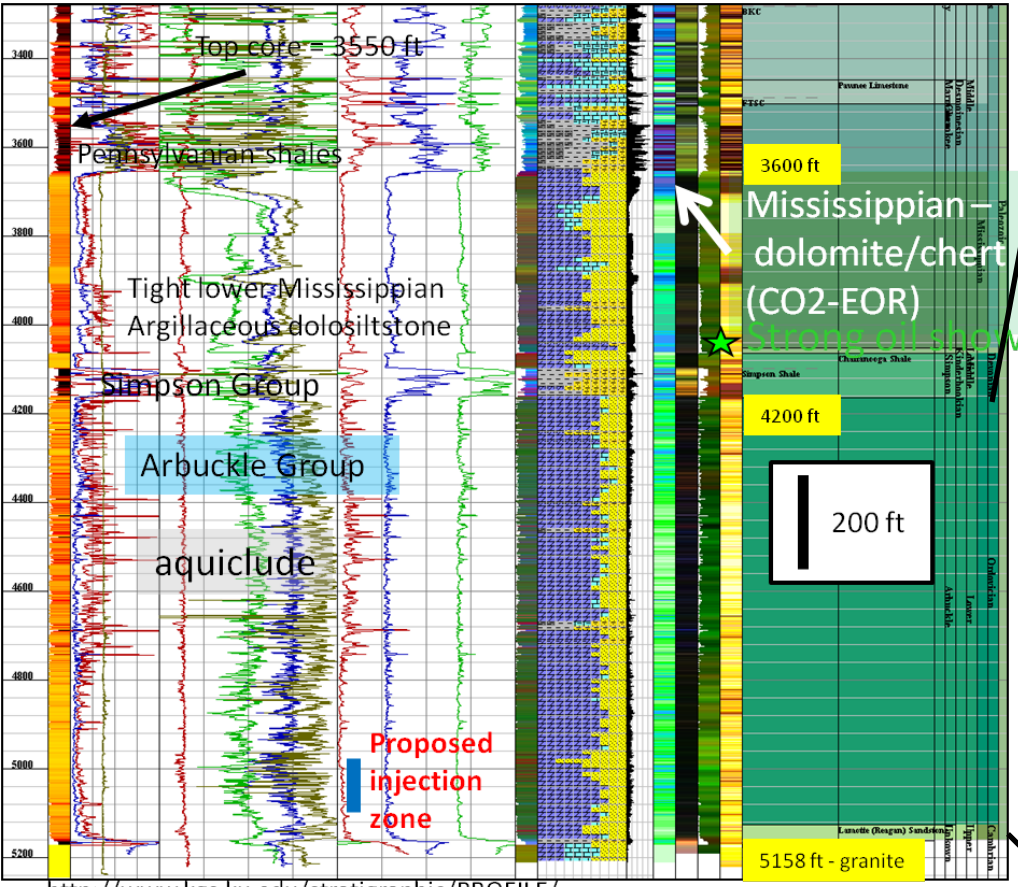
Web-based Interactive DOE-CO2 Project Mapper

Overlay of Oil and gas field outlines and Top Arbuckle Group in study area of southern Kansas



http://maps.kgs.ku.edu/co2/?pass=project

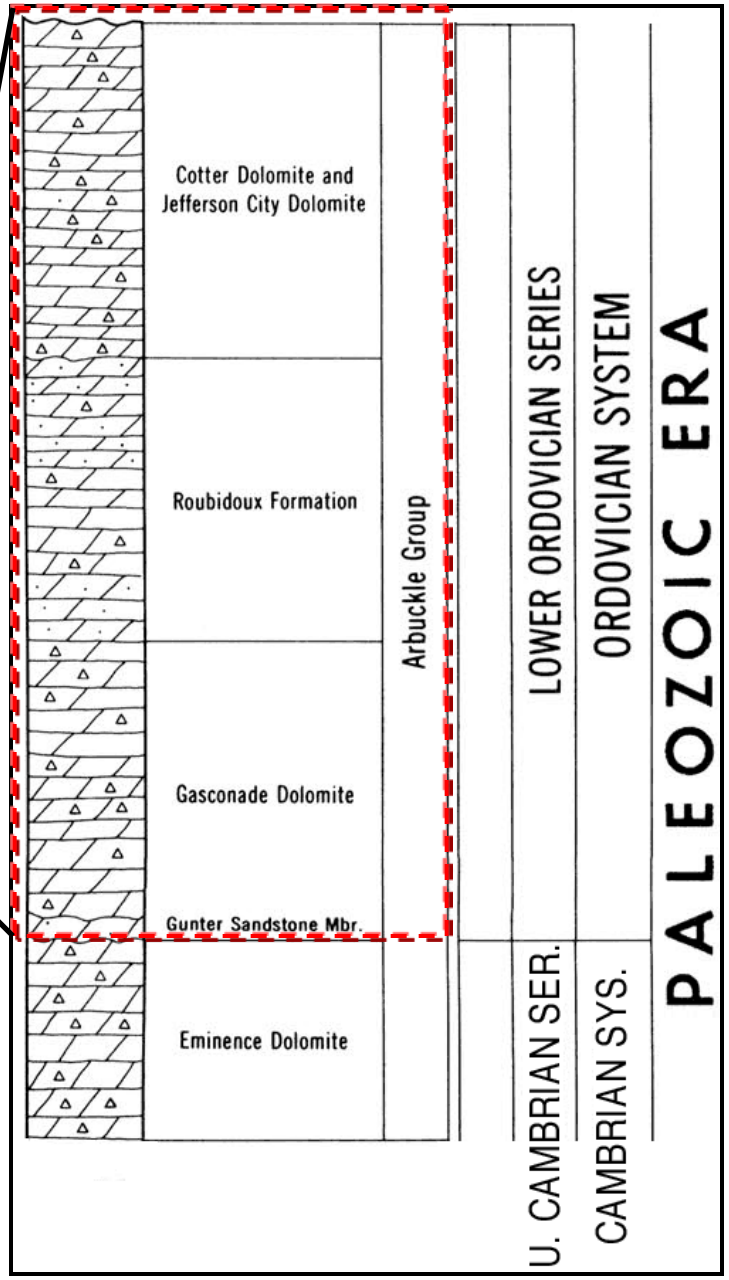
Western Interior Plains Aquifer & Ozark Plateau Aquifer System



http://www.kgs.ku.edu/stratigraphic/PROFILE/

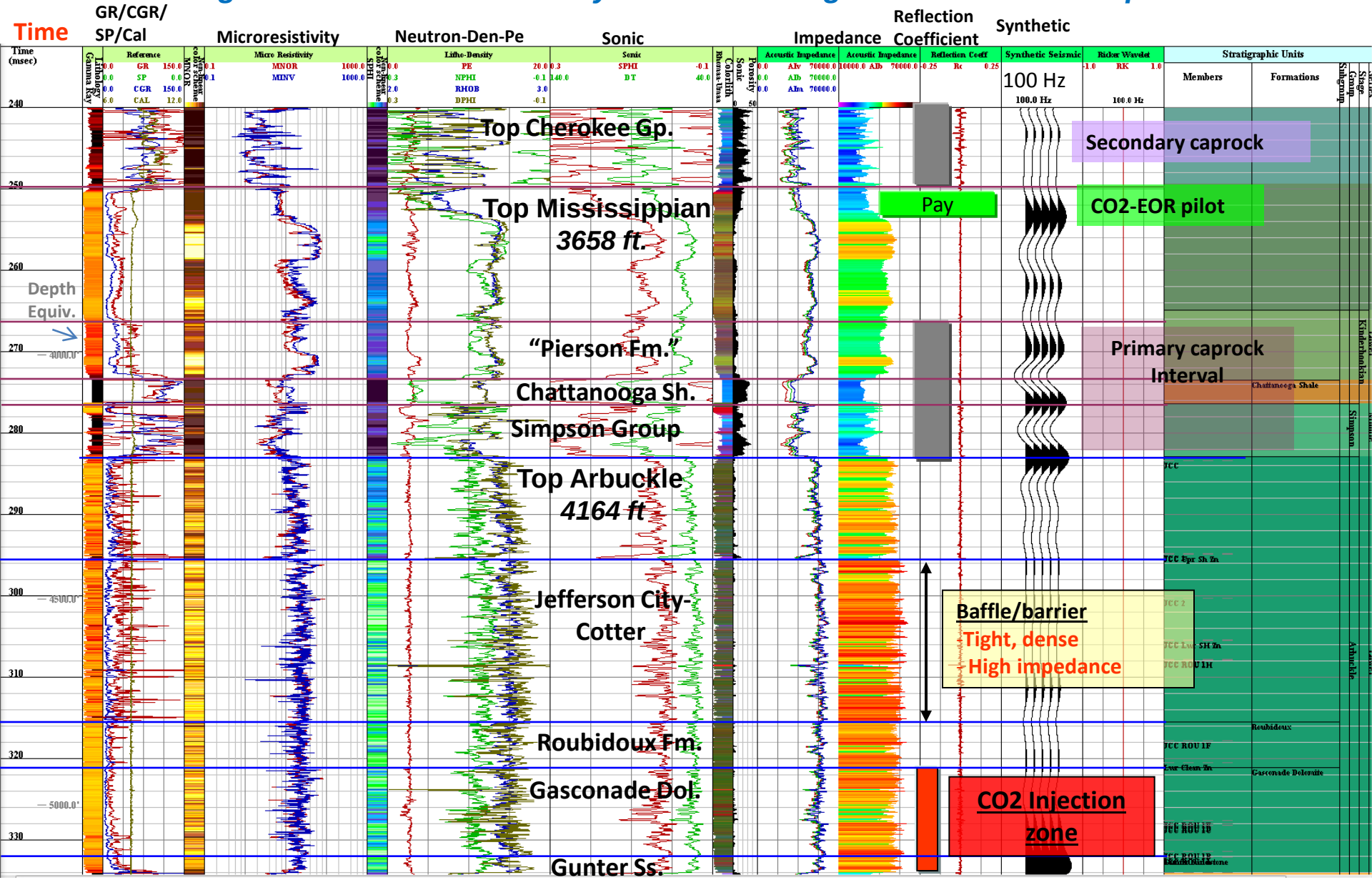
Cored well, Berexco Wellington KGS #1-32 at Wellington Field, Sumner County

Lower Ordovician Arbuckle Group



CO_2 injection zones in Arbuckle and Mississippian

Wellington Field KGS #1-28 --- Synthetic seismogram and seismic impedance

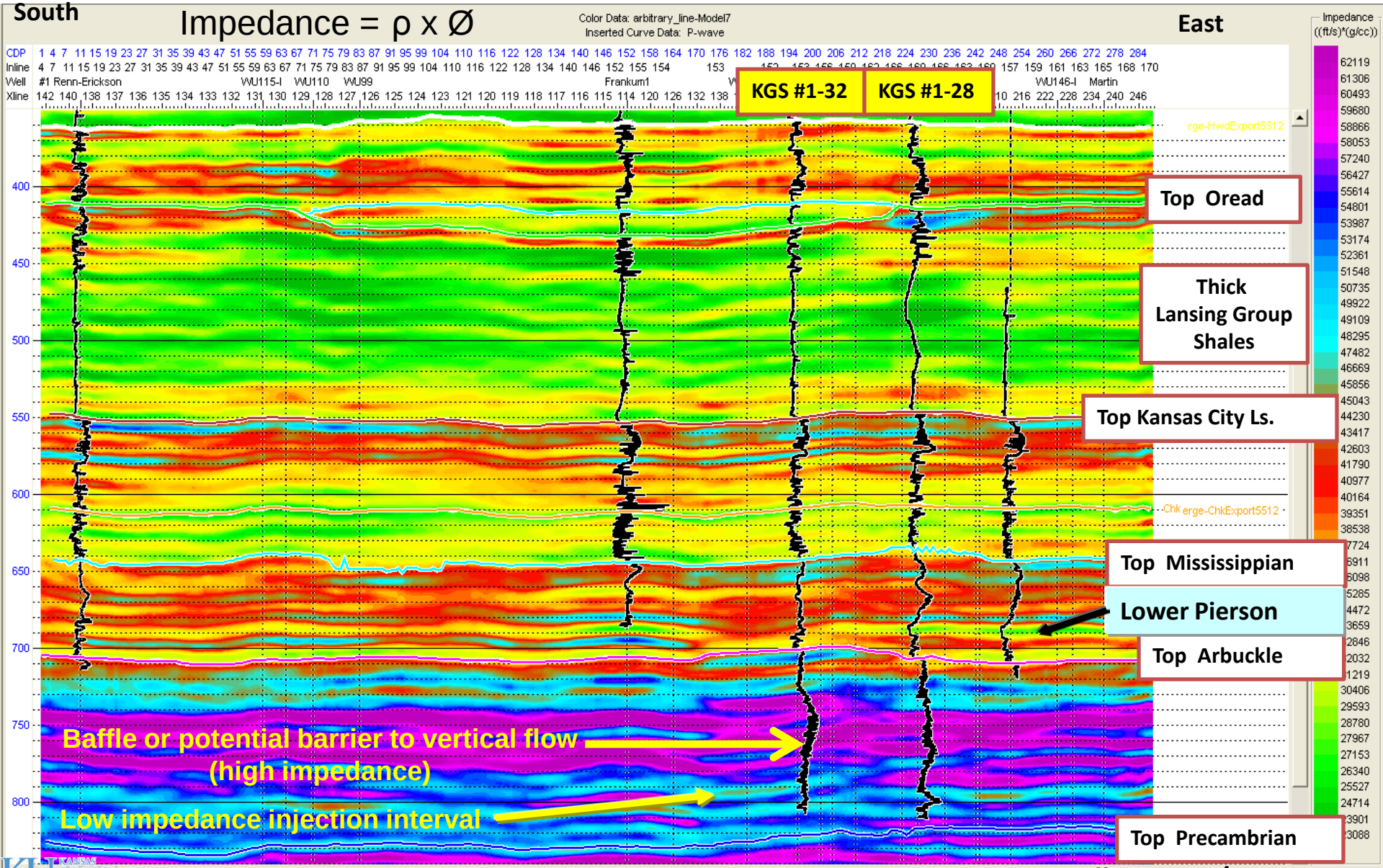


Precambrian granite – bottom of core = *5174 ft*

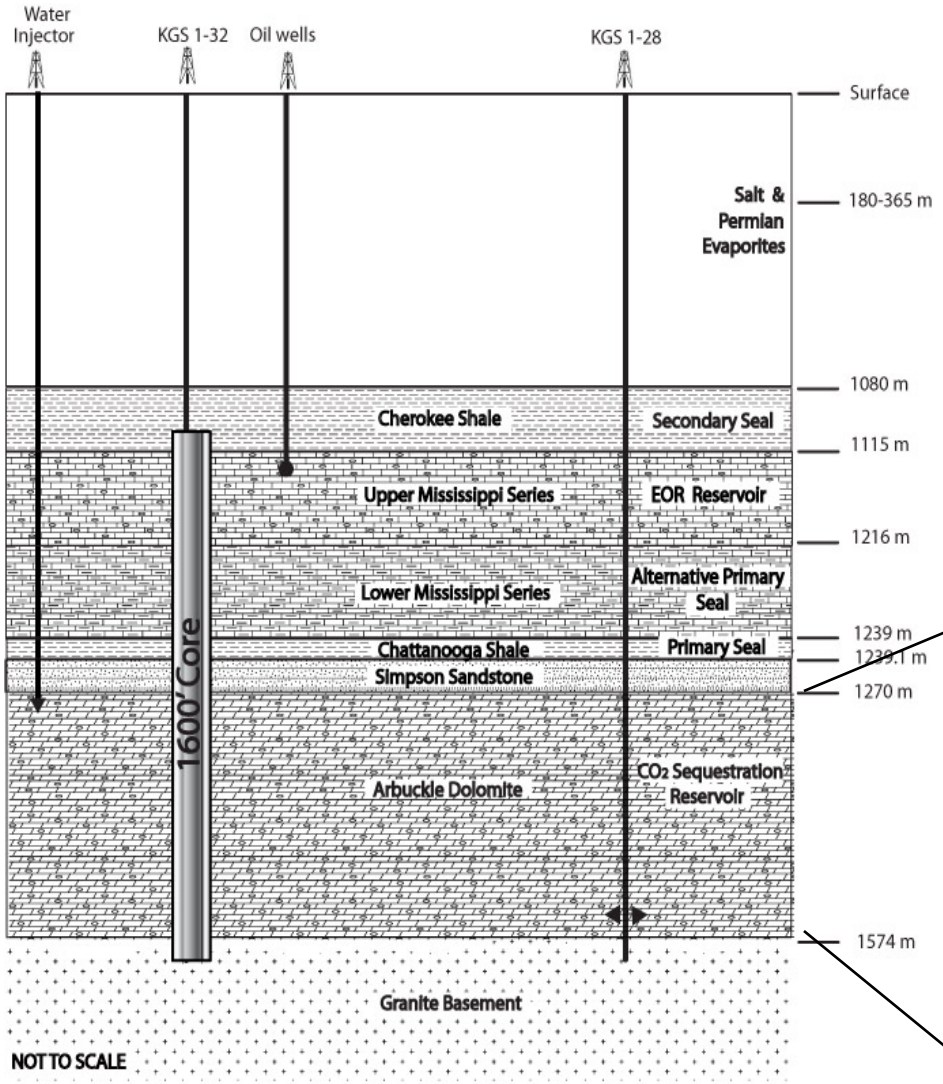
http://www.kgs.ku.edu/software/SS/

Arbitrary seismic impedance profile – Wellington Field

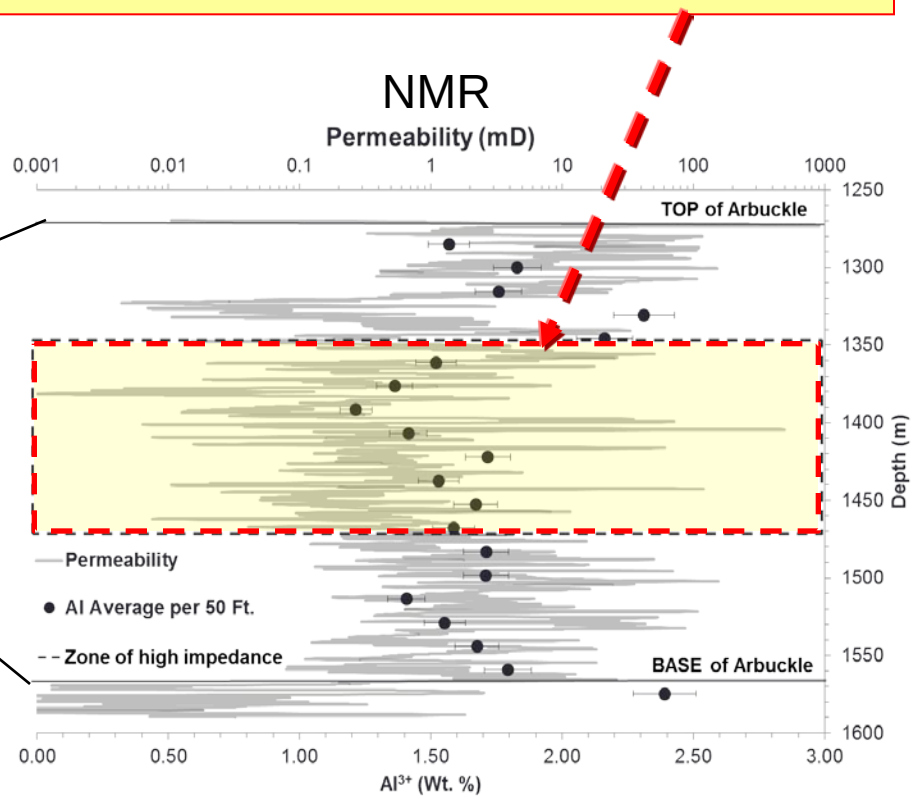
distinct caprock, mid-Arbuckle tight, lower Arbuckle injection zone



Mid-Arbuckle flow barrier KGS #1-32



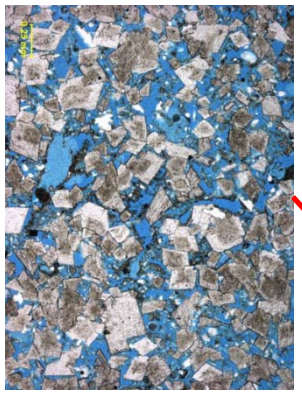
- 400 ft of tighter rock
- Widespread high seismic impedance

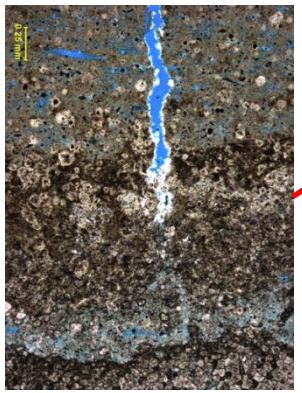


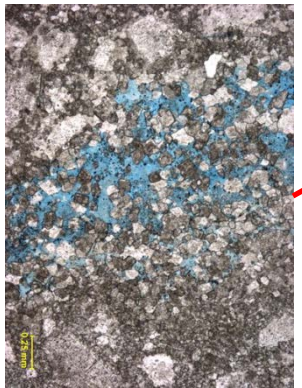
Scheffer, 2012

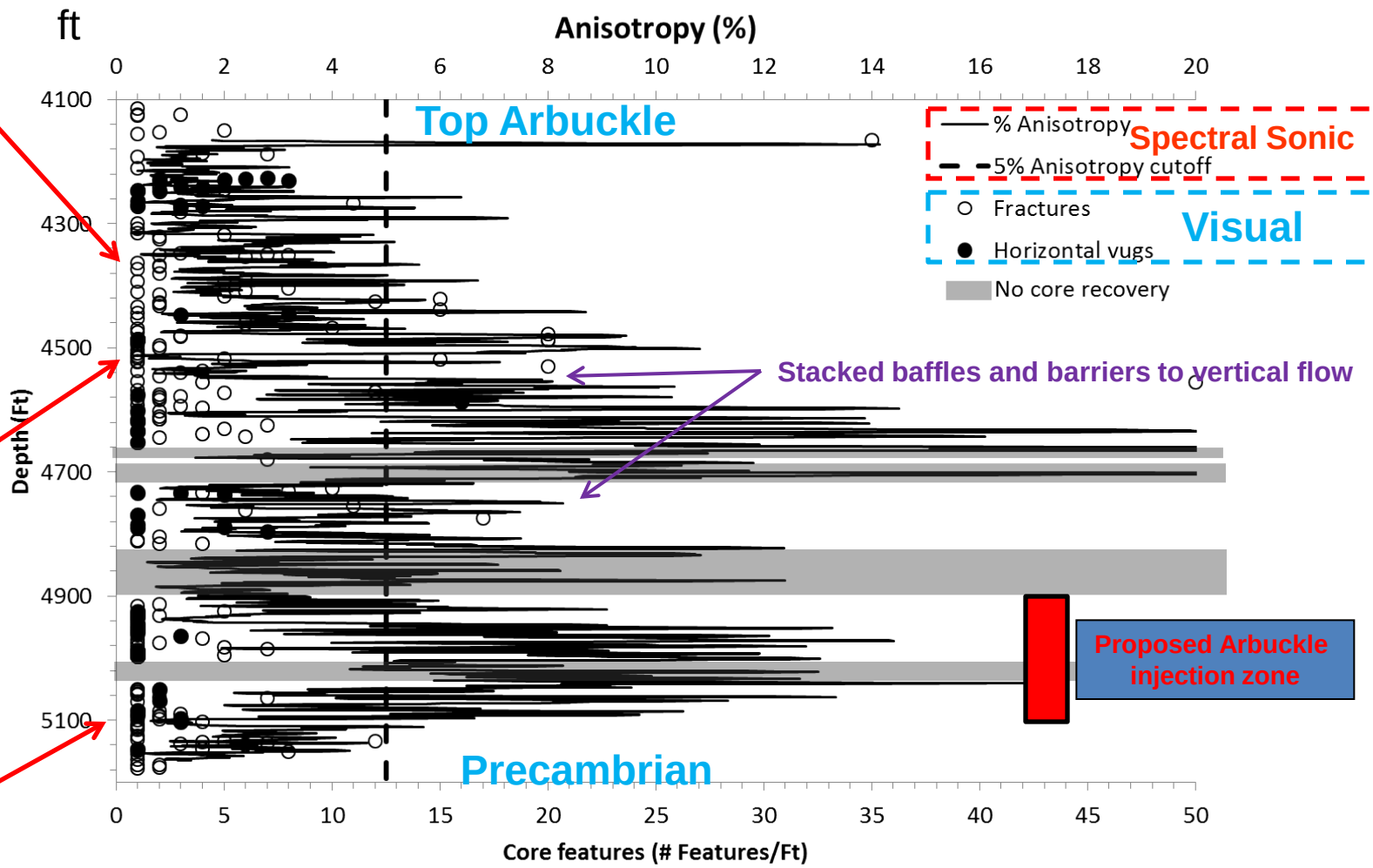
Zonal fracturing in Arbuckle, KGS #1-32

Spectral acoustic log, core, microresistivity imaging







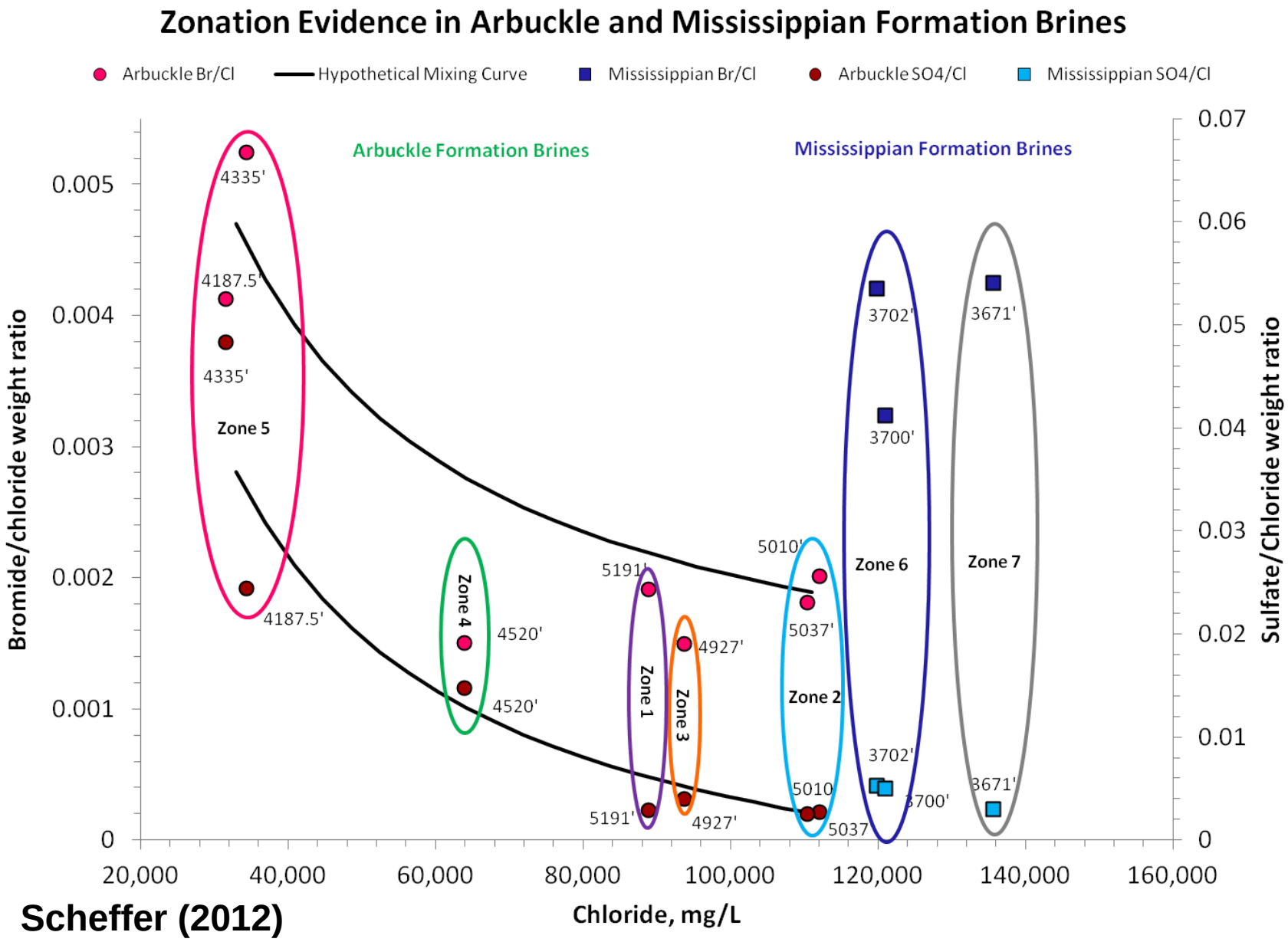


KANSAS GEOLOGICAL SURVEY
The University of Kansas

Scheffer, 2012; Lorenz and Cooper, 2011

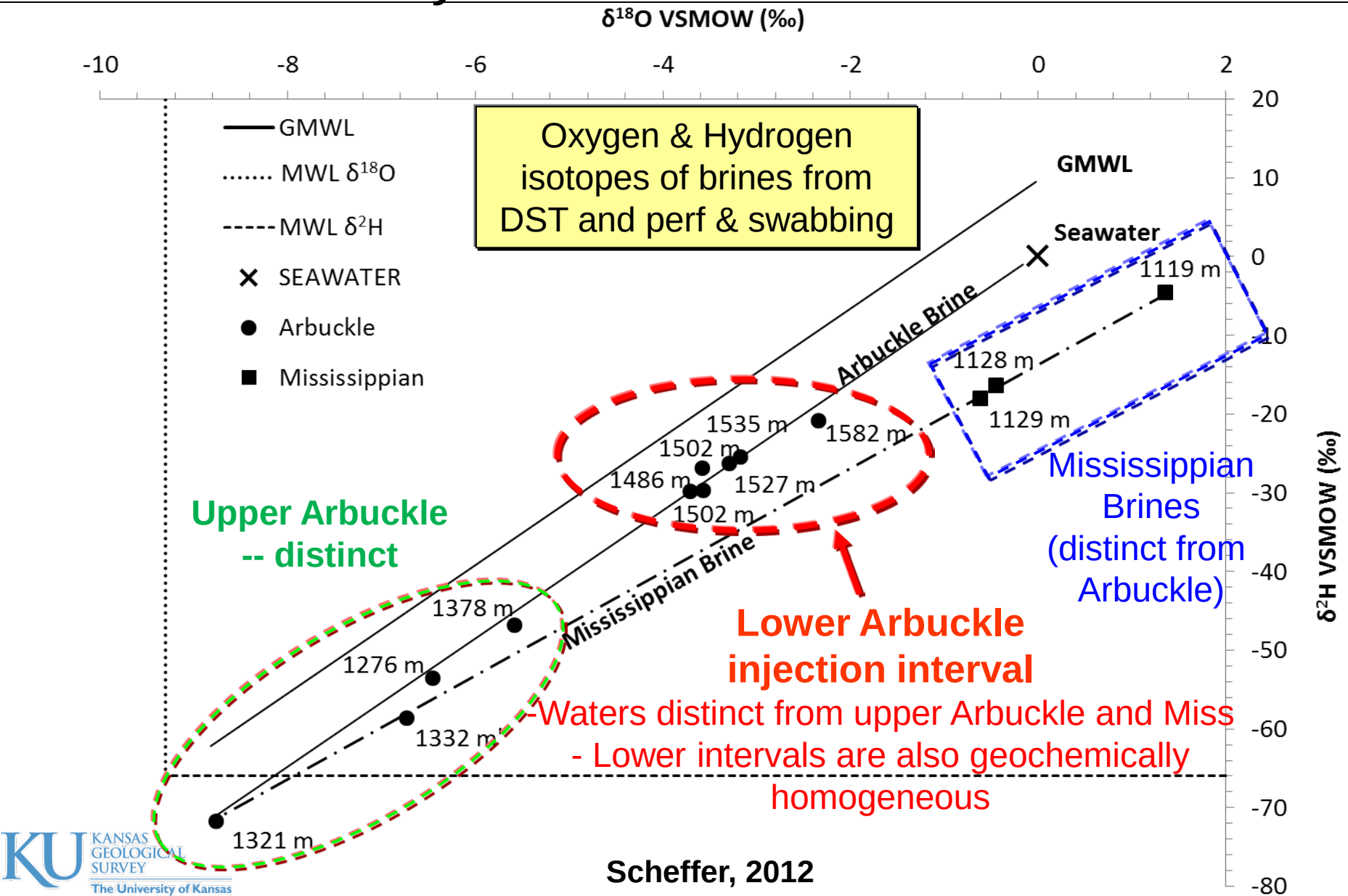
Arbuckle Hydrostratigraphy at Wellington Field

obtained from DST and perf & swab test



Scheffer (2012)

Lower and upper Arbuckle are not in hydraulic communication



KANSAS GEOLOGICAL SURVEY
The University of Kansas

Selected core from Lower Arbuckle

Proposed Injection Interval

5089-92 ft

Vug and interparticle Ø

5080-83

Crackle breccia w/ Ø

5053-56

Fracture Ø

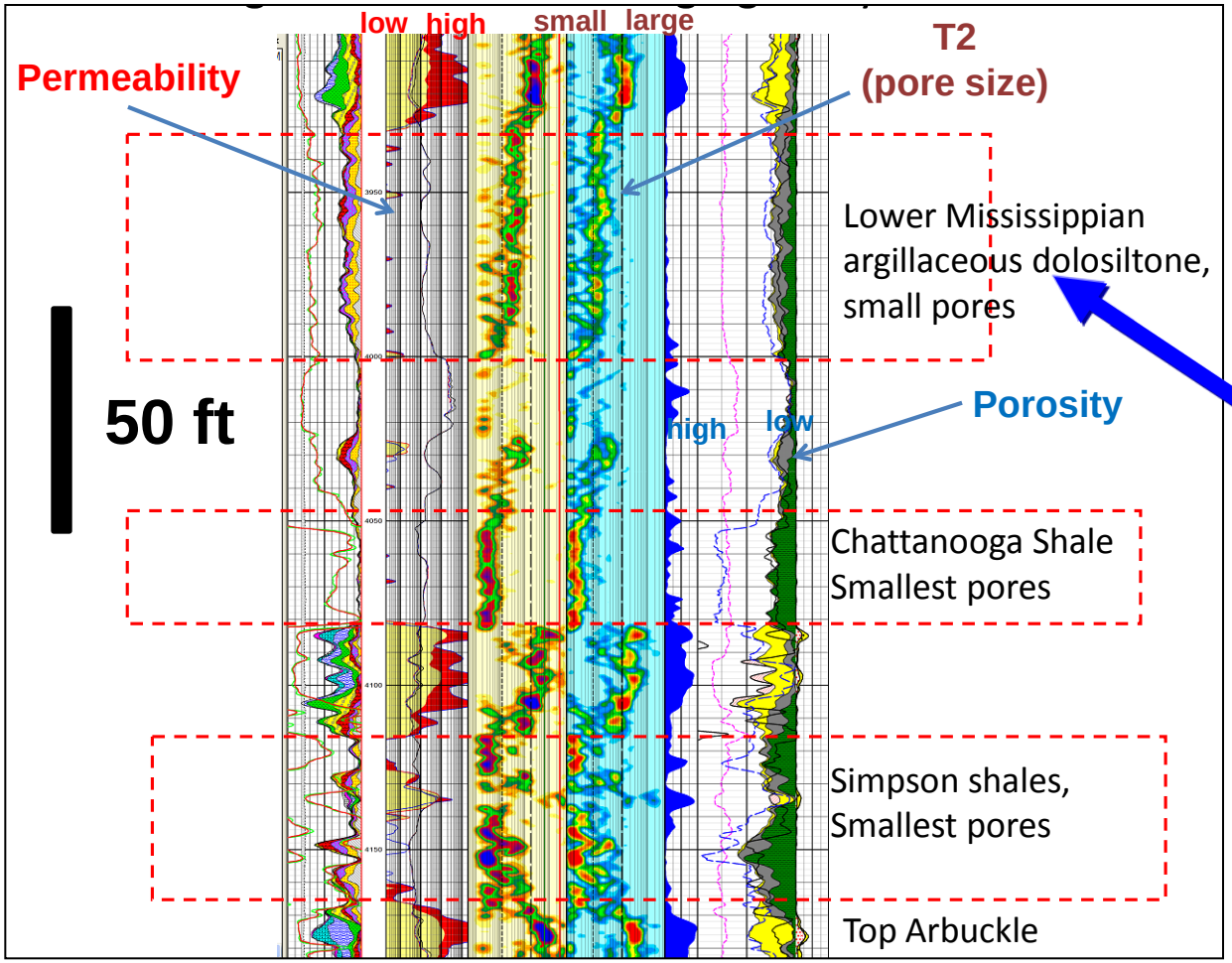
4995-97.7 ft

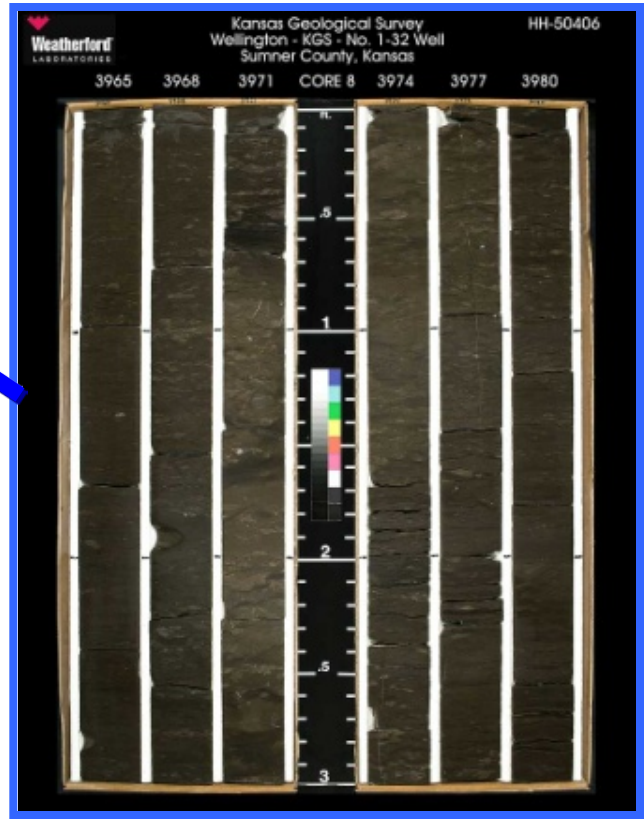
Vugs and interparticle Ø

Fine interparticle Ø

KU KANSAS GEOLOGICAL SURVEY
The University of Kansas

230 ft gross thickness interval of primary caprock in KGS #1-28 (injection well) – illustrated by nuclear magnetic resonance log



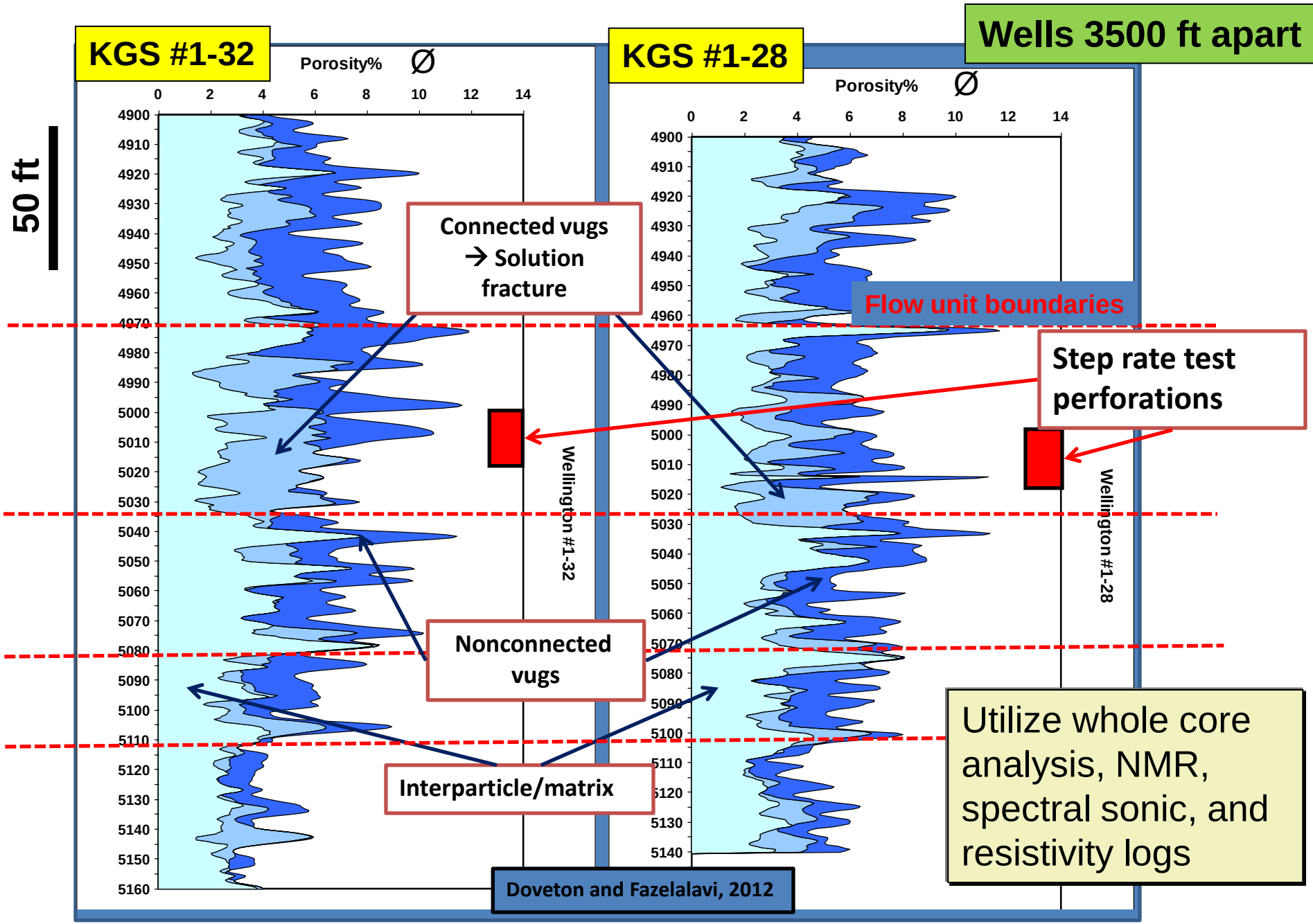


Caprock evidence:

- Micro-nano darcy perm
- Quiet fracture wise
- Organic matter 1%

KANSAS GEOLOGICAL SURVEY
The University of Kansas

Flow units in the lower Arbuckle **injection zone, ~4900-5160 ft**



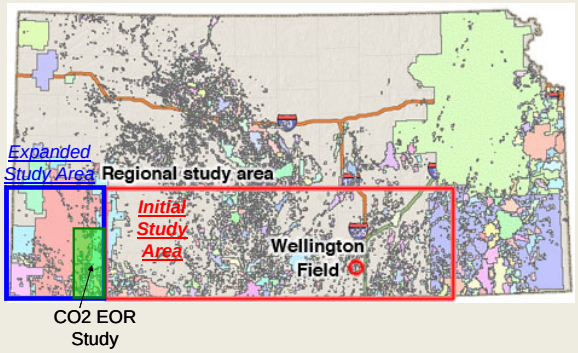
Selection of site for southwestern Kansas calibration site

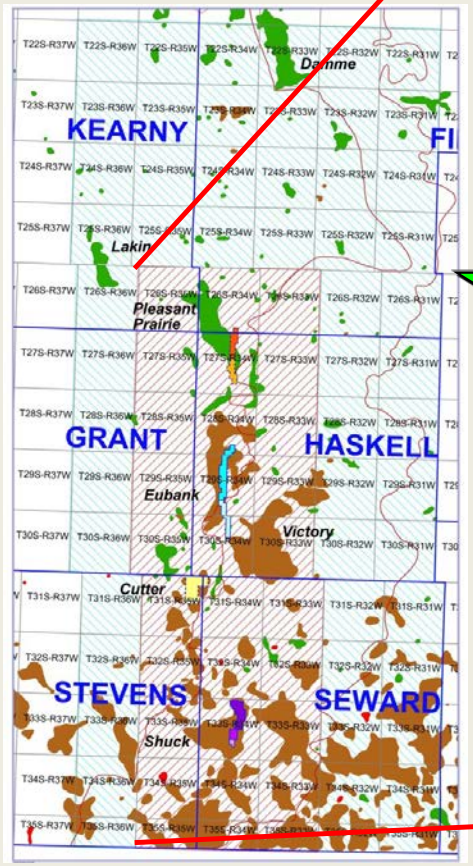
Technical Status

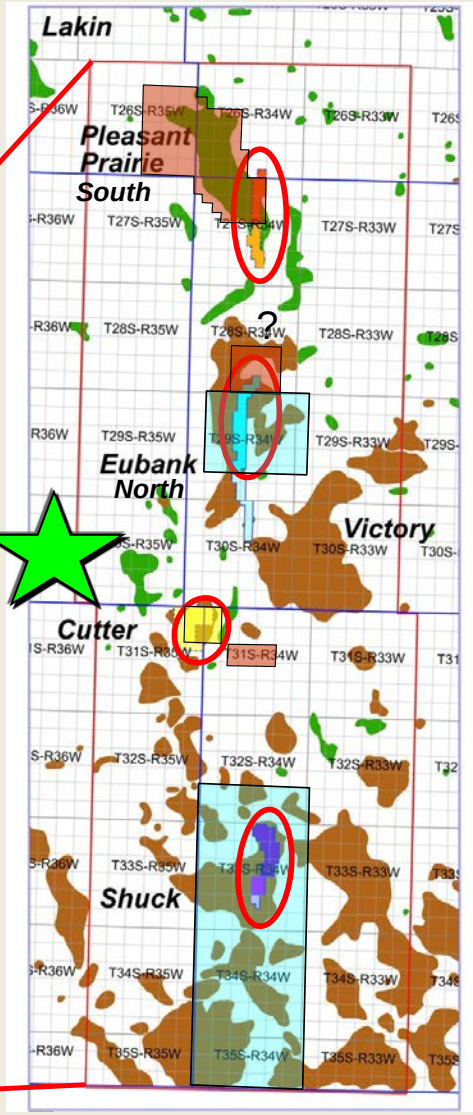
Evaluate CO_2 sequestration potential in Arbuckle Group saline aquifer and CO_2-EOR in four fields in southwestern Kansas

Southwest Kansas CO2 Consortium (*Western Annex*)

Seismic blocks are color coded by operator (~120 mi^2 of 3D seismic)







Chester/Morrow Sandstone (IVF) &

Deep saline Arbuckle aquifer

KU KANSAS GEOLOGICAL SURVEY The University of Kansas

Industry Partners

Southwest Kansas CO_2 Consortium

IHR
Improved Hydrocarbon Recovery LLC

HEDKE-SAENGER GEOSCIENCE, LTD

SUNFLOWER ENERGY LLC

+drilling and seismic contractors TBN

CIMAREX

GloriOil

BEREXCO

Anadarko
Petroleum Corporation

Dawson-Markwell Exploration Co.

CELEBRATING 20 YEARS
MERIT ENERGY COMPANY

Industrial and Electrical Power Sources of CO_2

Conestoga Energy Partners, LLC
fueling the new frontier

SUNFLOWER ELECTRIC POWER CORPORATION
A Touchstone Energy® Cooperative
. . . energy done right

Abengoa Bioenergy : The Global Ethanol Company

Successful bid to drill well by Berexco

Previous discussion:

Completed review of geology and seismic data at proposed drill sites using following criteria to evaluate the sites --

- 1) provide a useful location in the incised valley fill sandstones for operator,
- 2) avoid fault zones around drill site or within the 10 mi2 around the well so faults are at minimum outside of the multicomponent seismic survey, and
- 3) ideally, we'd have a drill site with a high potential for porous section of lower Arbuckle and shaly or tight layers above the porous interval.

To reduce AFE costs, reduce core from 2100 ft to 1200 ft

Met the project budget.

Basement Test Well Selection Made by Watney

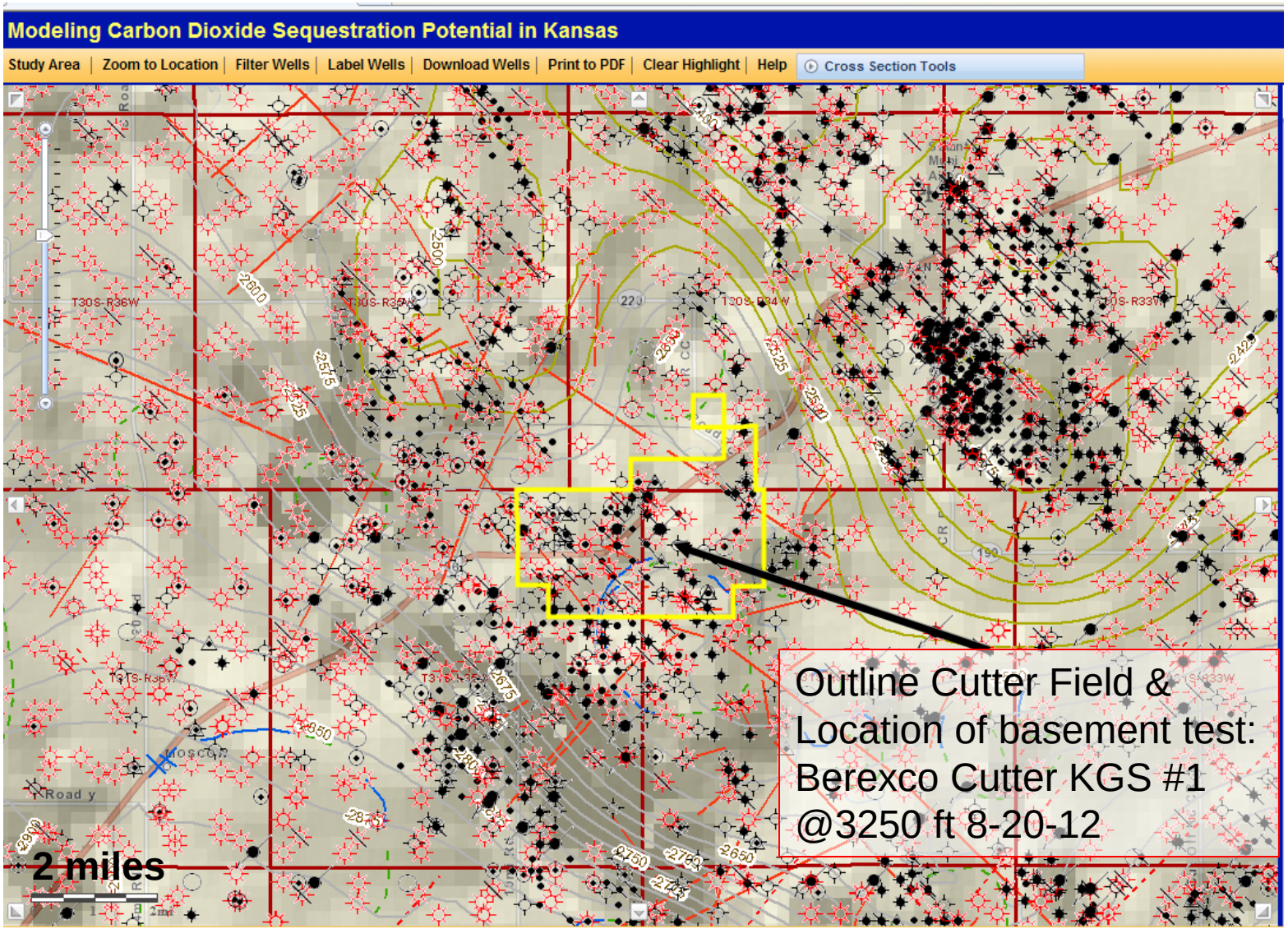
- Accepted quote from Berexco for well with 1180 ft of core
- Well location
  - Cutter Field, Stevens County
  - **Section 1-T31S–R35W**
  - **Spud date by early August 2012**
- 10 mi^2 multicomponent survey
  - design likely to include incised valley to east of proposed well location; acquisition as soon as possible to use initial p-wave data to assist in selecting location of new well

Coring Schedule Cutter KGS #1
Est KB 2935'

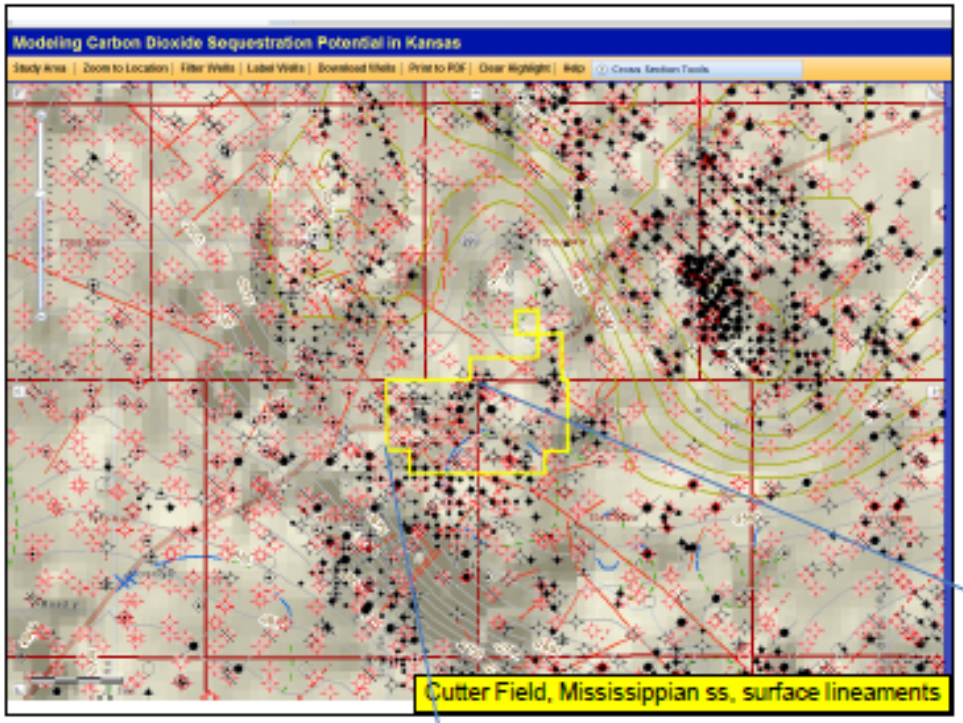
Depth Interval	Footage	Formation	Core storage
5210-5290	80	Morrow	Alum Bbl
5400-5600	200	Chester	Boxes
6400-6800	400	Kinderhook/Viola/Upper Arb	Alum Bbl
6900-7200	300	Arbuckle	Boxes
7350-7550	200	Lower Arb	Alum Bbl
	1180		

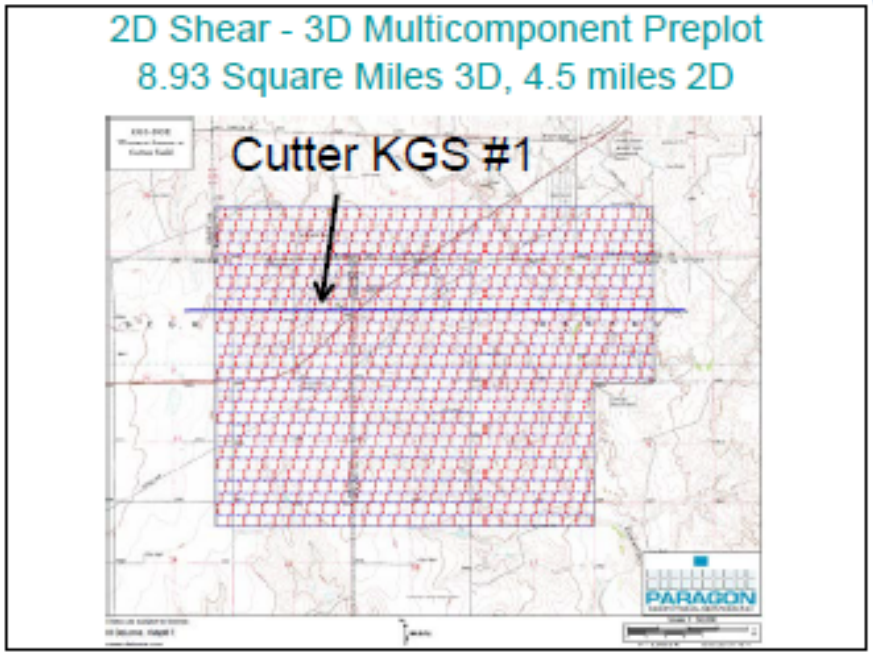
Cutter Field drill site, SW Kansas

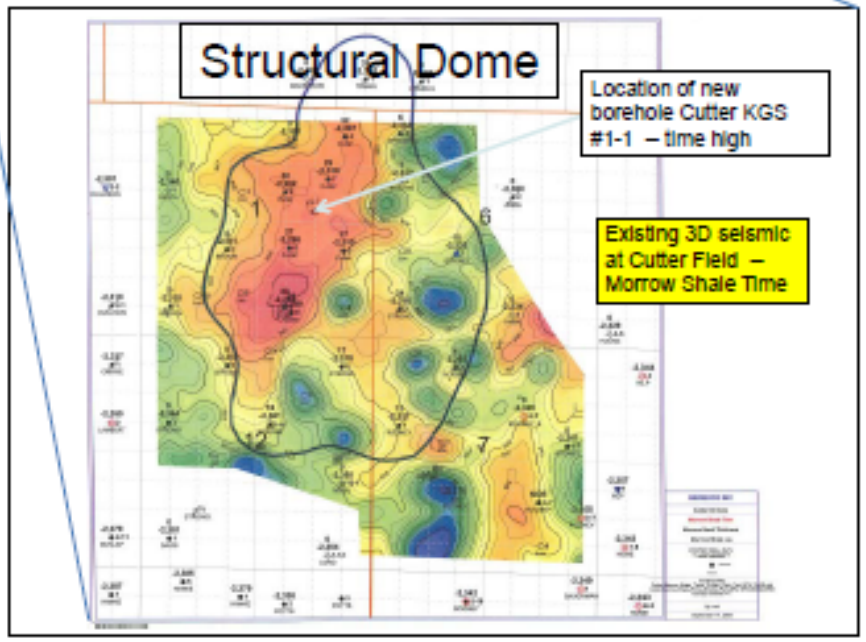
Top Mississippian (contours), surface lineaments (red lines), Lower Permian top Ft. Riley Ls. dip gradient (gray shading)



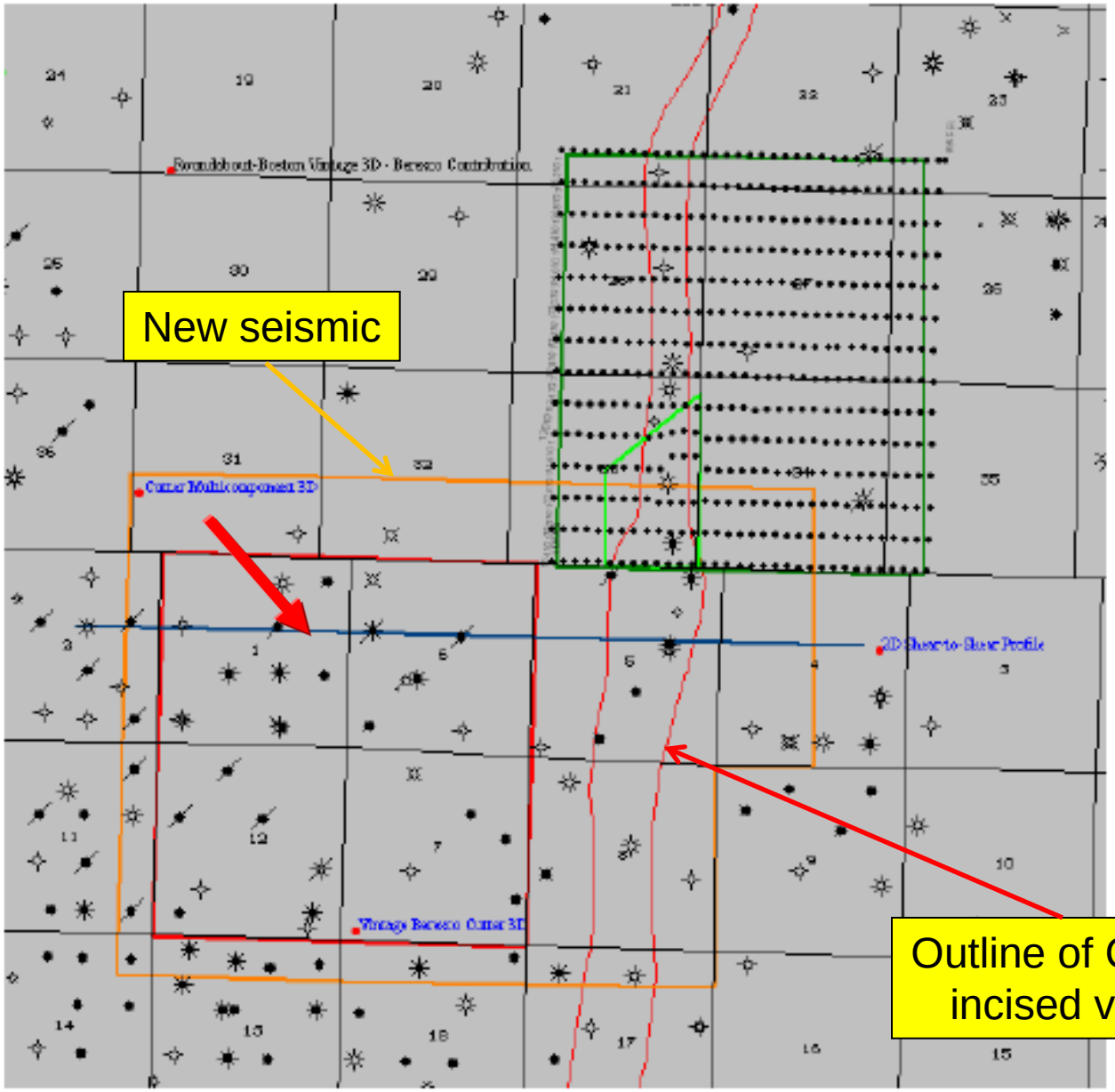
Top Mississippian (contours), surface lineaments (red lines), Lower Permian top Ft. Riley Ls. dip gradient (gray shading)



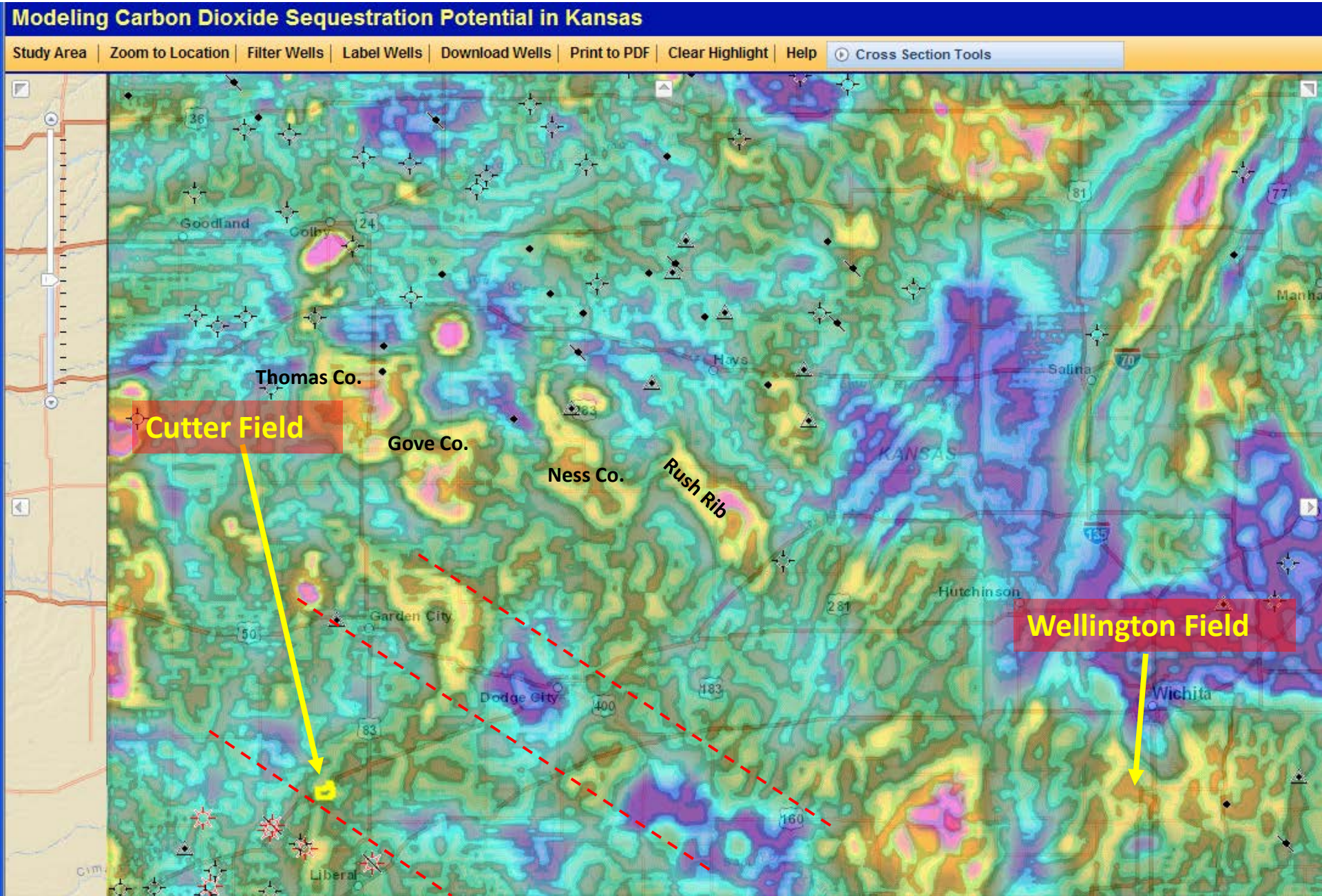




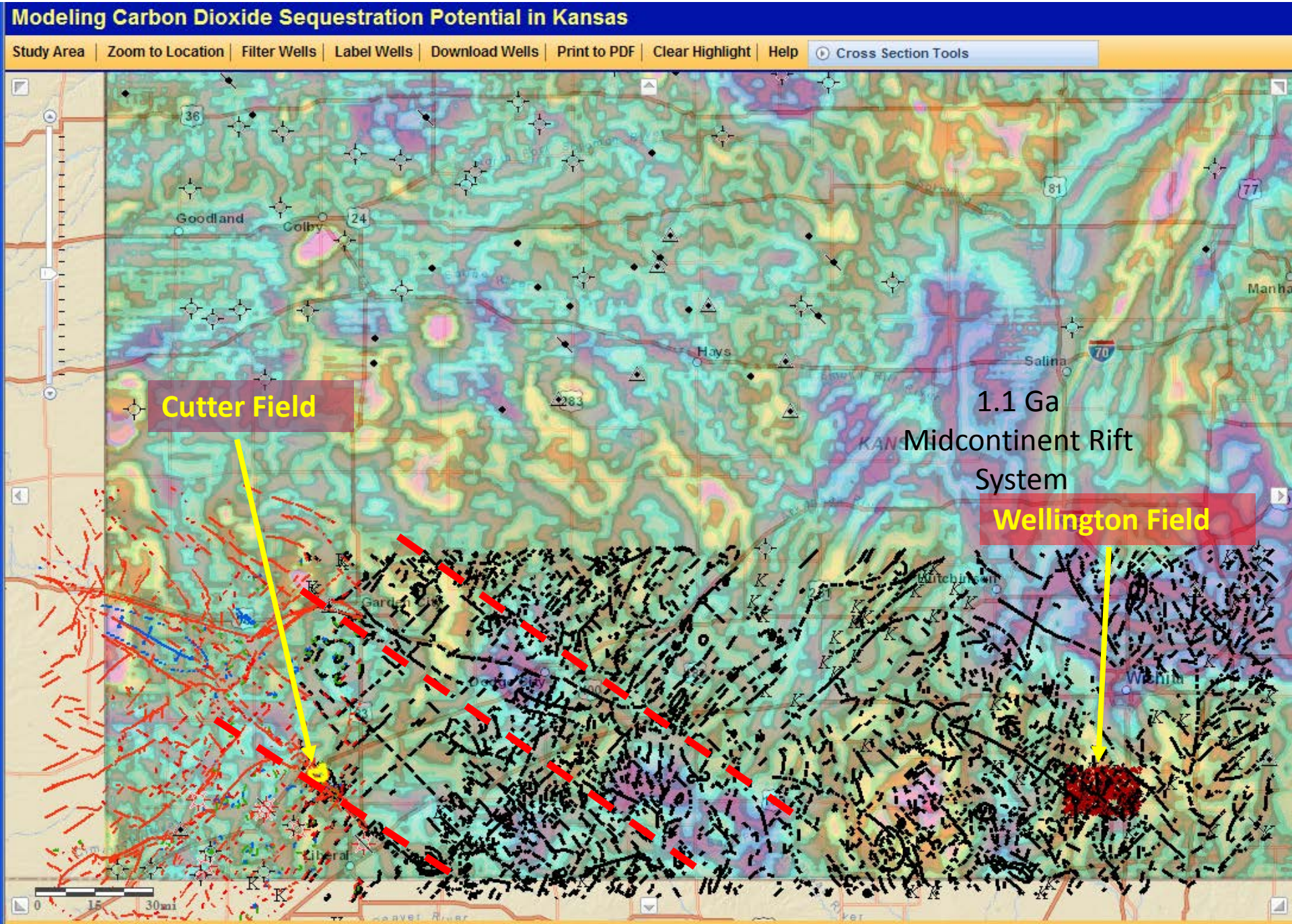
New Seismic Acquisition & Vintage Data at Cutter Field



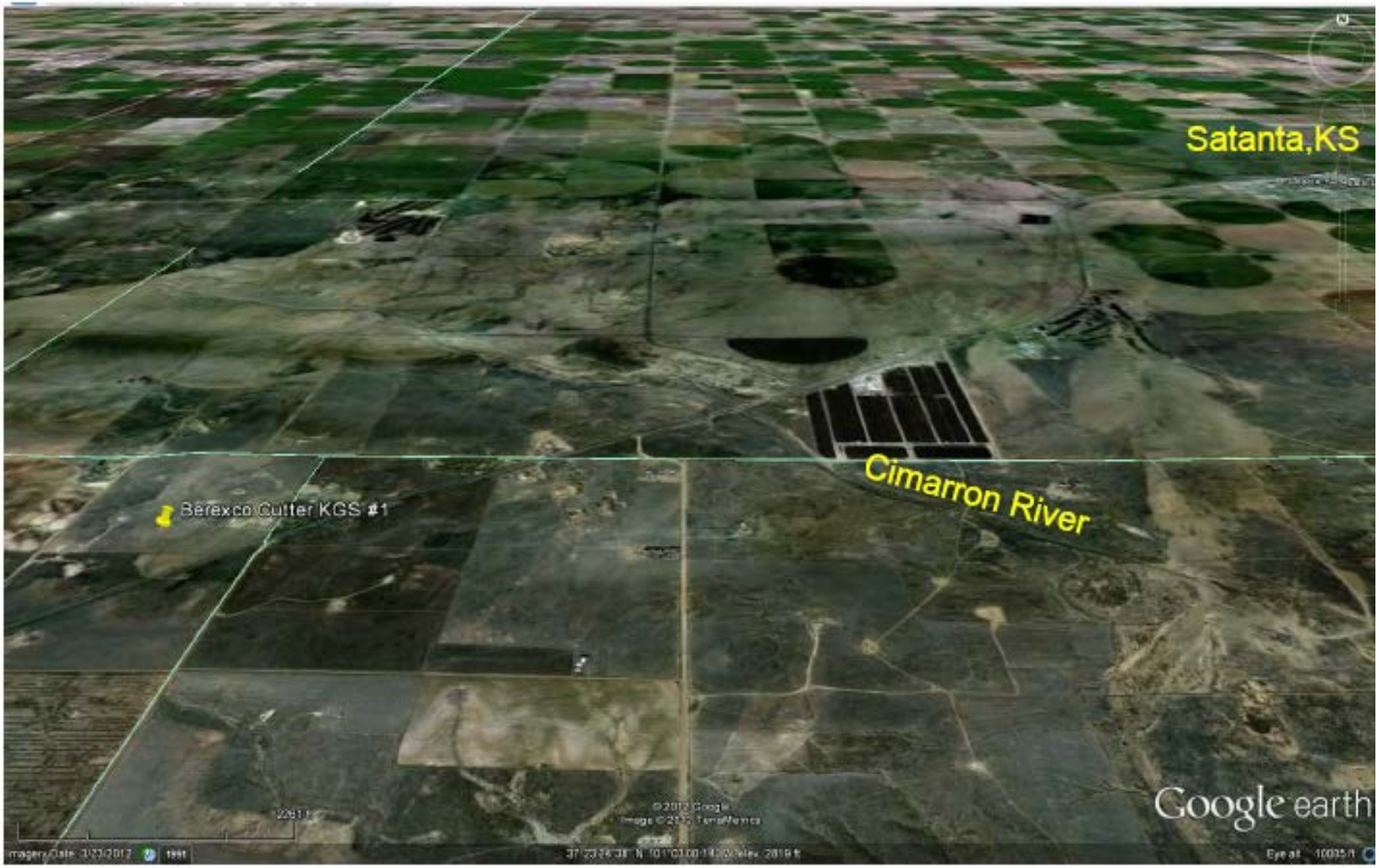
Reprocessed Kansas Magnetics -- Tilt Angle, Total Magnetic 2-10 mi + Total Magnetic Reduced to Pole (910m)

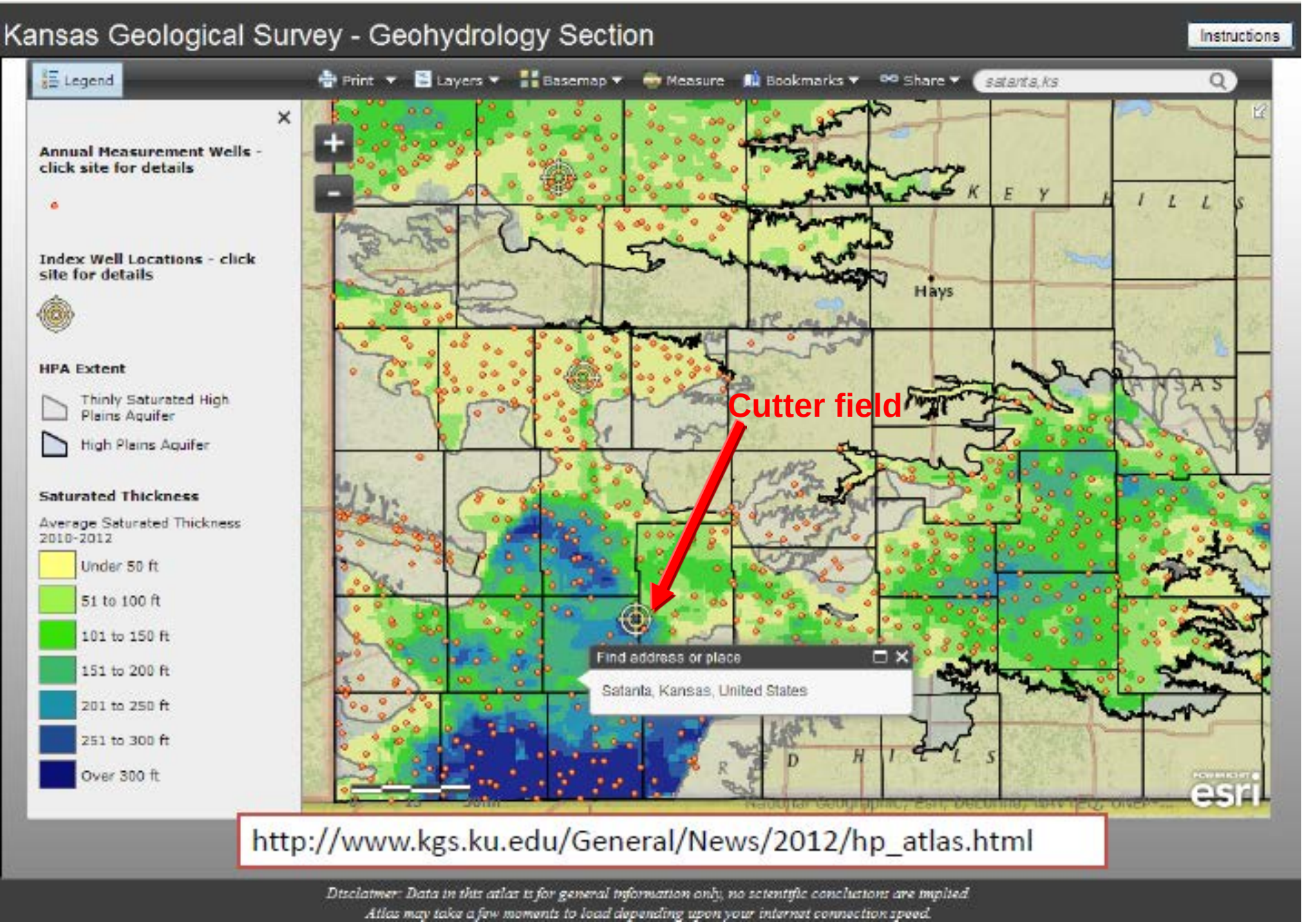


Tilt Angle, Total Magnetic 2-10 mi + Total Magnetic Reduced to Pole (910m)



Oblique view between Cutter drillsite (left) and Satanta, KS (right) with Cimarron River valley between (looking north)




Kansas Geological Survey - Geohydrology Section
Instructions
Legend
Print
Layers
Basemap
Measure
Bookmarks
Share
satanta,ks
Annual Measurement Wells - click site for details
Index Well Locations - click site for details
HPA Extent
Thinly Saturated High Plains Aquifer
High Plains Aquifer
Saturated Thickness
Average Saturated Thickness 2010-2012
Under 50 ft
51 to 100 ft
101 to 150 ft
151 to 200 ft
201 to 250 ft
251 to 300 ft
Over 300 ft
Hays
Cutter field
Find address or place
Satanta, Kansas, United States
esri
http://www.kgs.ku.edu/General/News/2012/hp_atlas.html
Disclaimer: Data in this atlas is for general information only, no scientific conclusions are implied
Atlas may take a few moments to load depending upon your internet connection speed.

Cutter KGS #1
S/2 S/2 S/2 NE, Sec. 1-31S-35W
Stevens County, Kansas
API Number: 15-189-22761

Elevation: 2926' GL 2939' KB

2440' from North line of Section
1320' from East line of Section
Regular Section ---- ☒
Irregular Section ---☐

Primary Objective: Core Morrow, Chester and Arbu

DAILY REPORTS FROM CONTRACTOR
Weekdays:
FAX reports **NO LATER THAN 9:00 a.m.**, to the BEREXCO offices in Wichita.
Weekends/Holidays:
Call Evan Mayhew at 316 215 1245.

SURFACE CASING
Size: 8 5/8", Depth: Est. 1750'
Surface cement: Basic 620 624 2277

DRILLING TIME
One foot drilling time over the following interval(s): 3500' to TD'

SAMPLES
One set of washed, clean, dried and bagged cuttings should be caught and saved as follows:
10' intervals: ..... 3500' to TD
Additional 5' samples may be caught per the geologist's instructions.

DRILL STEM TESTING
Probable zones: Arbuckle
Possible zones: Upper Morrow, Chester
Tester: Trilobite 800.728.5369, Colby

CORING: Devilbiss Coring (405) 808 3120
GAS DETECTOR: Yes
H2S Equipment: None
LOGGING: Halliburton
(620) 624 6123
email: TIF, PDF, LAS to lwalney@kgs.ku.edu, dweath@Berexco.com, rkoudele@berexco.com

Estimated Tops:

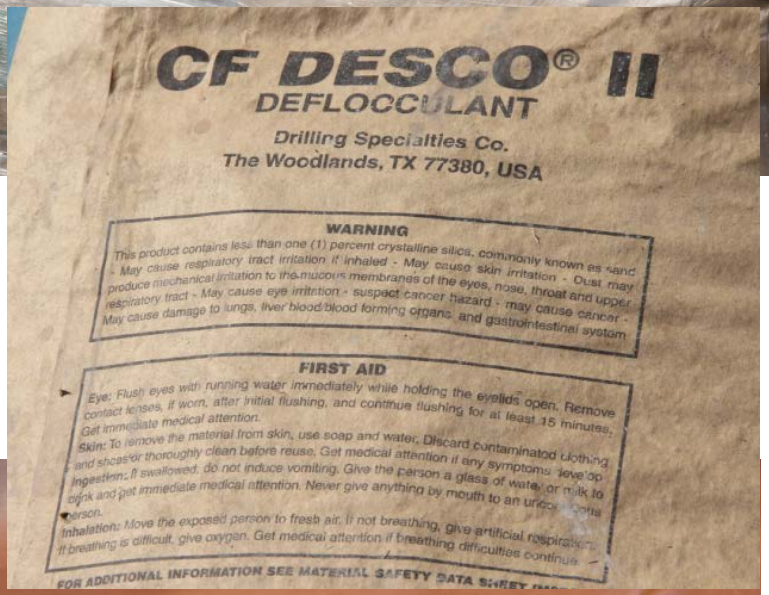
Heebner shale top	3960'
Lansing	4080'
Lansing G	4340'
Marmaton A	4704'
Pawnee	4838'
Cherokee Shale top	4908'
Upper Morrow Sand	5255'
Chester Form top	5420'
Viola	6480'
Simpson Shale top	6690'
Arbuckle	6725'
Total Depth	7550'

Mission Accomplished


United Rentals
1227860


CEDAR FIBER


MISSISSIPPI
LIME
The Standard of Excellence
STANDARD HYDRATED
CALCIUM HYDROXIDE


CF DESCO® II
DEFLOCCULANT
Drilling Specialties Co.
The Woodlands, TX 77380, USA
WARNING
FIRST AID


Pecan
NUT PLUG*


DRILLPAC®
HIGH VISCOSITY
POLYMER
• Controls water loss
• Reduces mud maintenance costs
• Allows lower solids mud
NET WT. 50 LBS. - 22.7 Kg

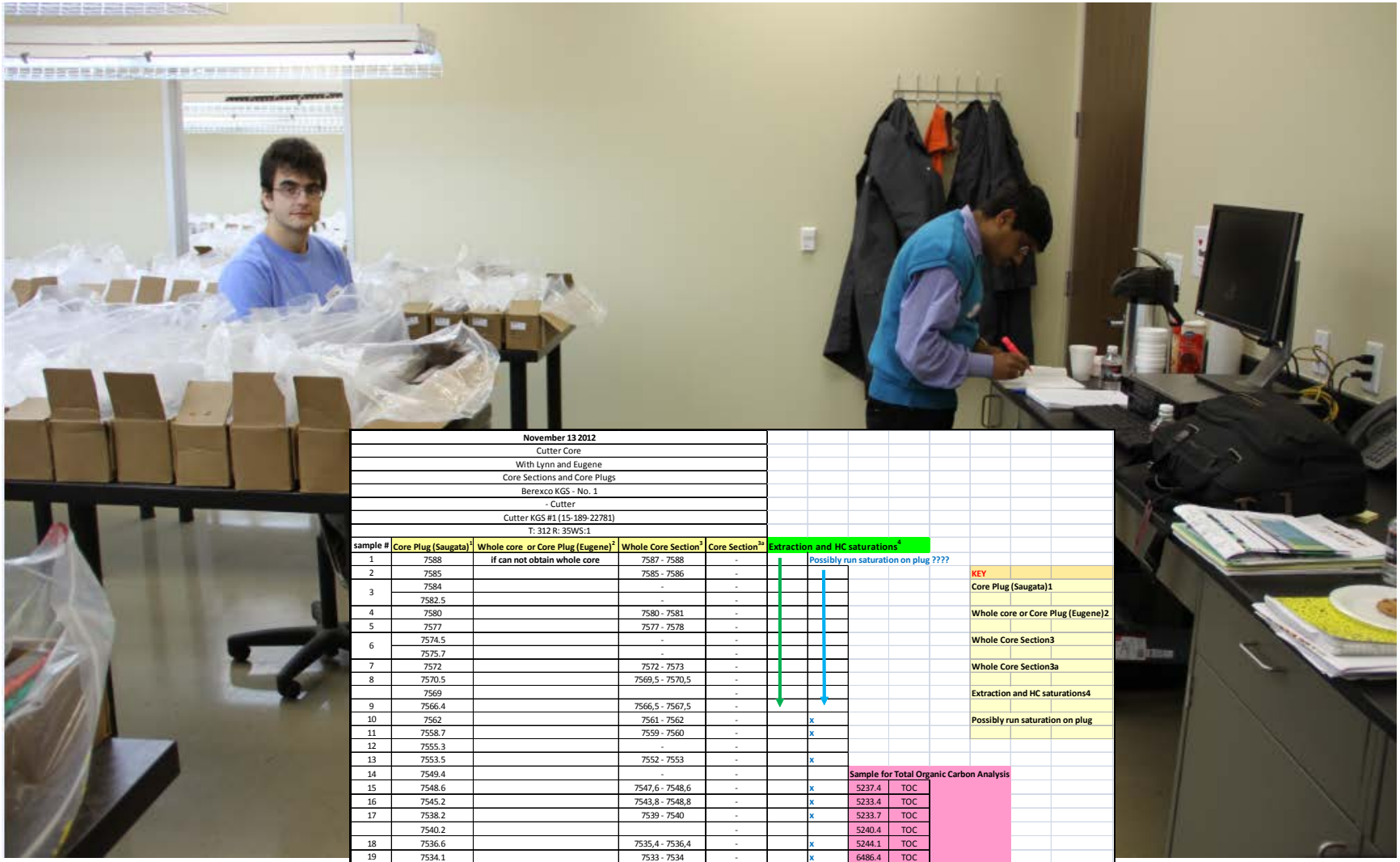
Wireline Logging

- Halliburton has provided excellent service at Wellington and an equivalent log suite is requested as listed below
- SERVICE CENTER: Liberal, Kansas
- SERVICE COORDINATOR: Steven White
- SERVICE MANAGER: Scott Carr

TOOL NAME (HALLIBURTON)	**ABBREVIATED NAME**
Gamma Ray	(GTET-I)
Array Compensated True Resistivity	(ACRT-I)
Dual Spaced Neutron	(DSNT-I)
Spectral Density	(SDLT-I)
Microlog	(ML)
Wave Sonic - (Dipole Sonic)	(WSTT-I)
Elemental Analysis Tool	(GEM)
Comp. Spectral Natural Gamma	(CSNG-I)
Magnetic Resonance Imaging Log	(MRIL)
Extended Reach Micro Imaging Tool	(XRMI)

Weatherford Labs, Houston

describe & ID sampling on 1042 ft of core, Nov. 11-13, 2012



November 13 2012
Cutter Core
With Lynn and Eugene
Core Sections and Core Plugs
Berexco KGS - No. 1
- Cutter
Cutter KGS #1 (15-189-22781)
T: 312 R: 35WS:1

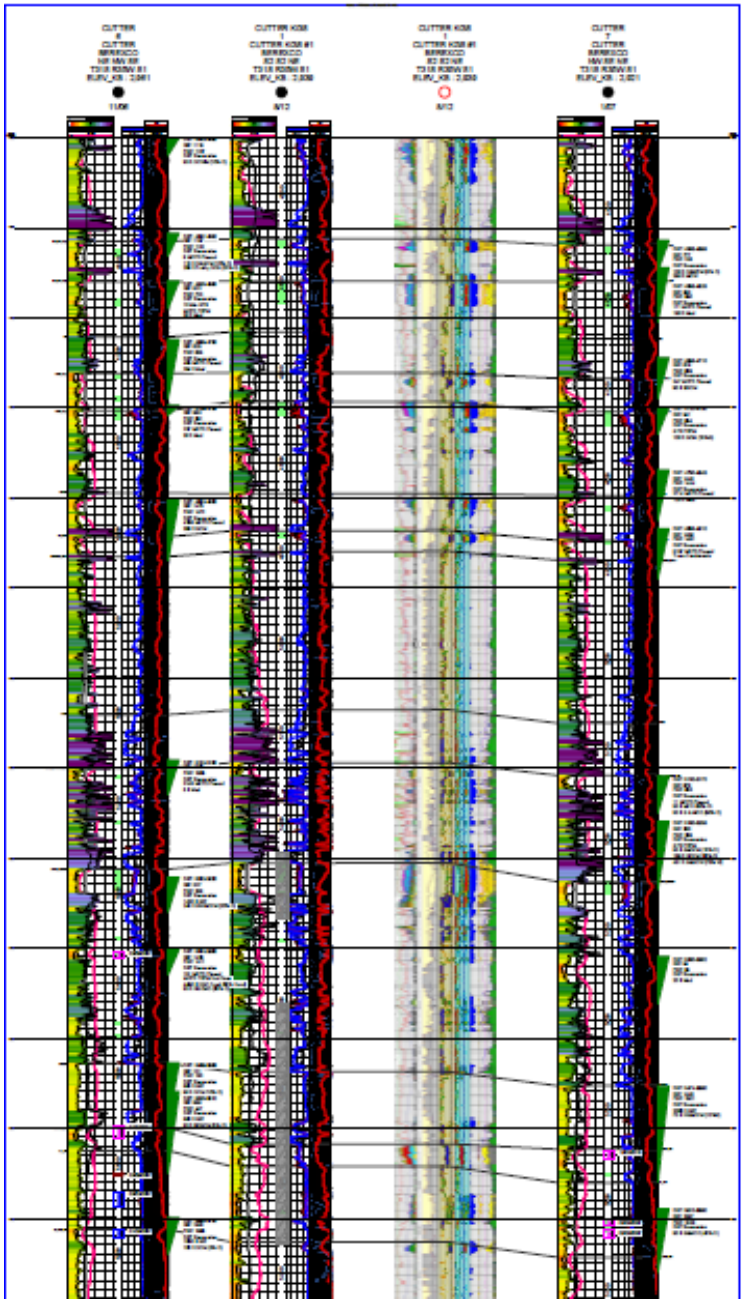
sample #	Core Plug (Saugata)[1]	Whole core or Core Plug (Eugene)[2]	Whole Core Section[3]	Core Section[3a]	Extraction and HC saturations[4]	Possibly run saturation on plug ????
1	7588	if can not obtain whole core	7587 - 7588	-		
2	7585		7585 - 7586	-		
3	7584		-	-		
	7582.5		-	-		
4	7580		7580 - 7581	-		
5	7577		7577 - 7578	-		
6	7574.5		-	-		
	7575.7		-	-		
7	7572		7572 - 7573	-		
8	7570.5		7569,5 - 7570,5	-		
	7569			-		
9	7566.4		7566,5 - 7567,5	-		
10	7562		7561 - 7562	-		x
11	7558.7		7559 - 7560	-		x
12	7555.3		-	-		
13	7553.5		7552 - 7553	-		x
14	7549.4		-	-		
15	7548.6		7547,6 - 7548,6	-		x
16	7545.2		7543,8 - 7548,8	-		x
17	7538.2		7539 - 7540	-		x
	7540.2			-		
18	7536.6		7535,4 - 7536,4	-		x
19	7534.1		7533 - 7534	-		x
20	7531.7		-	-		
21	7529.6		7528,5 - 7529,5	-		
22	7527.7		7526,6 - 7527,6	-		
23	7422.5		-	-		
24	7419		7418 - 7419	-		x

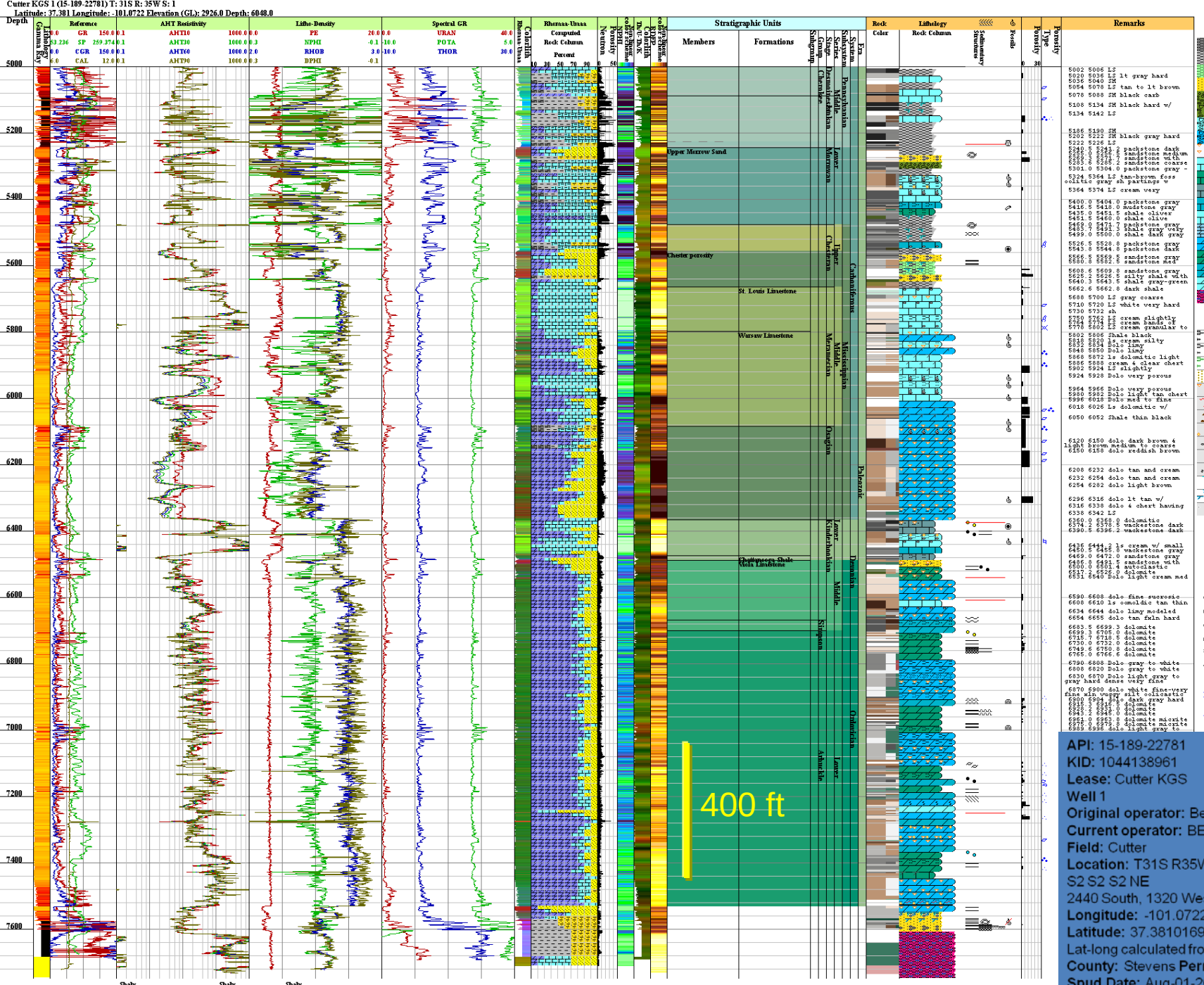
Sample for Total Organic Carbon Analysis	
5237.4	TOC
5233.4	TOC
5233.7	TOC
5240.4	TOC
5244.1	TOC
6486.4	TOC
6486.7	TOC
5535.5	TOC
5589.5	TOC
5414.4	TOC

KEY
Core Plug (Saugata)1
Whole core or Core Plug (Eugene)2
Whole Core Section3
Whole Core Section3a
Extraction and HC saturations4
Possibly run saturation on plug

UV Fluorescence Shows in Cutter KGS #1

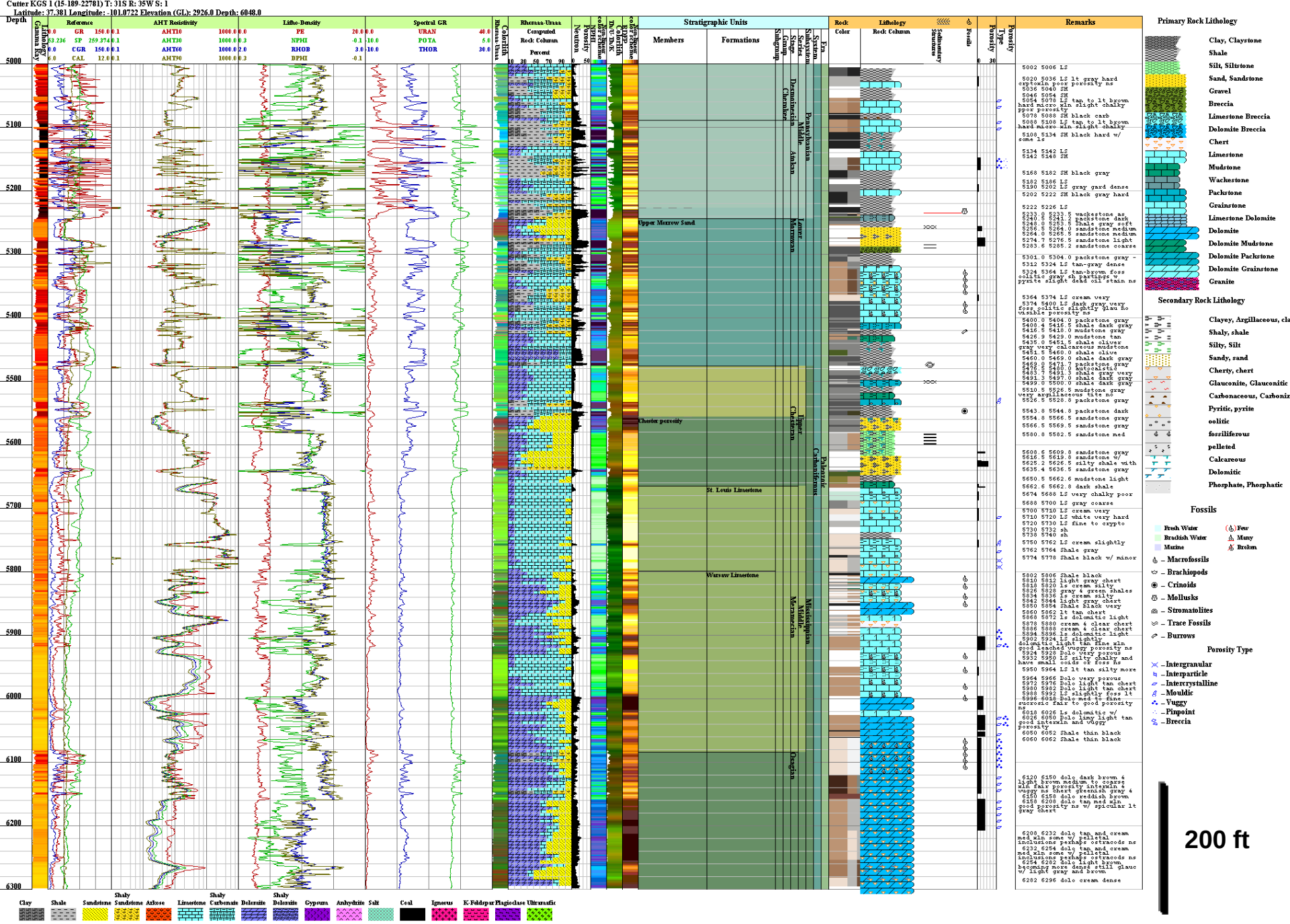
- 5401-5403 light show
- 5420-5424light show
- 5476-5480mid show
- 5530-5532heavy show
- 5533-5543heavy show
- 5557-5562light show
- 5592-5596light show
- 5600-5619heavy show
- 5611-5636heavy show
- 5638-5642light show
- 5664-5668light show
- 6515-6725light show
- 6515-6518light show
- 6524-6526light show
- 6690-6697light show
- 6708-6711light show
- 6741-6753light show
- 6907-6909very light show
- 6915-6921very light irregular show
- 6928-6932light show
- 6937-6940light show
- 6953-6959light show
- 6967-6971light show
- 6975-6977light show
- 6978-6982light show
- 7090-7095light show
- 7099-7101light show
- 7112-7106light show
- 7158-7160light show
- 7222-7224light show
- 7381-7388light show
- 7420-7420light show
- 7402-7412light show
- 7550-7589light show

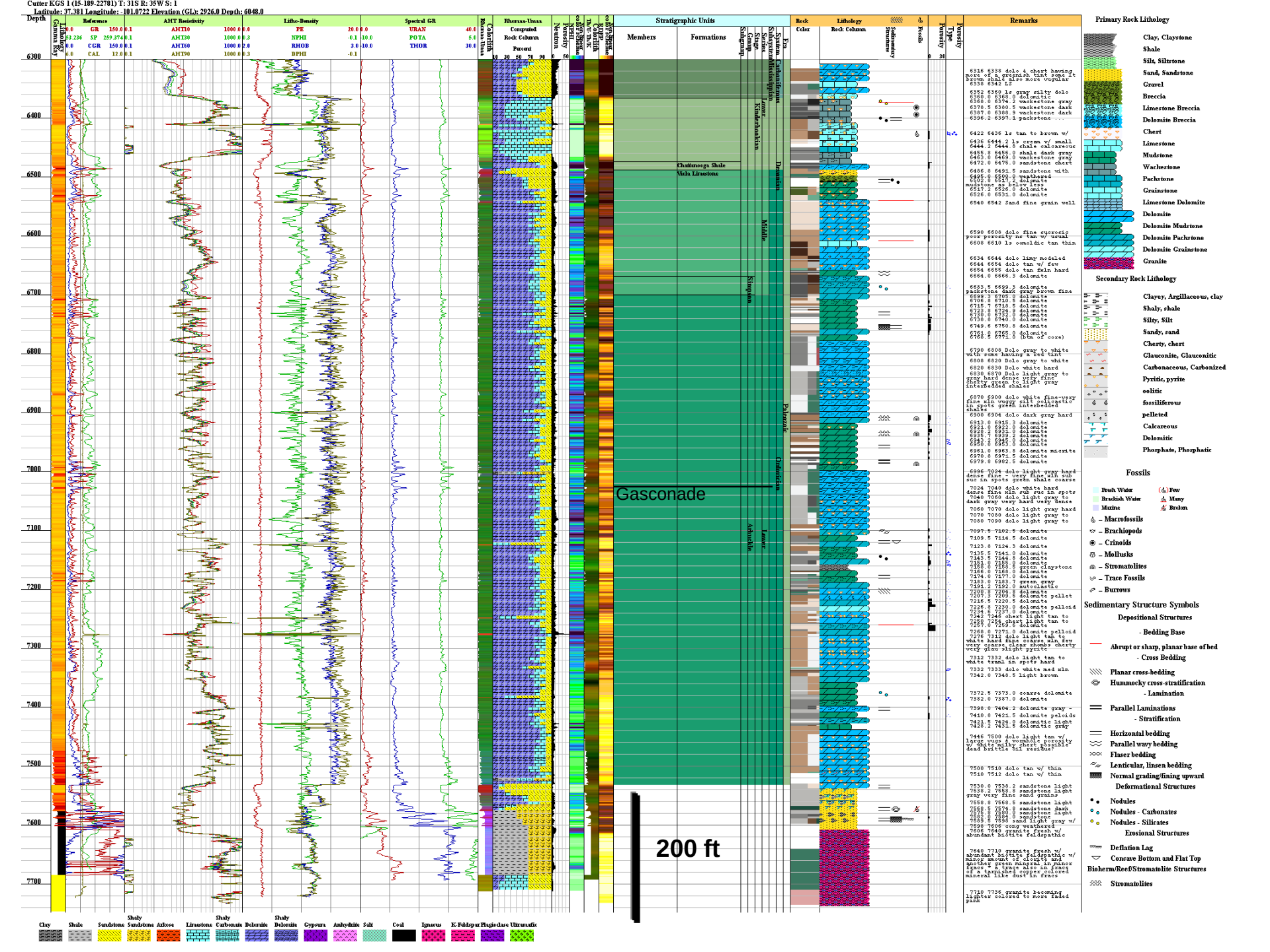


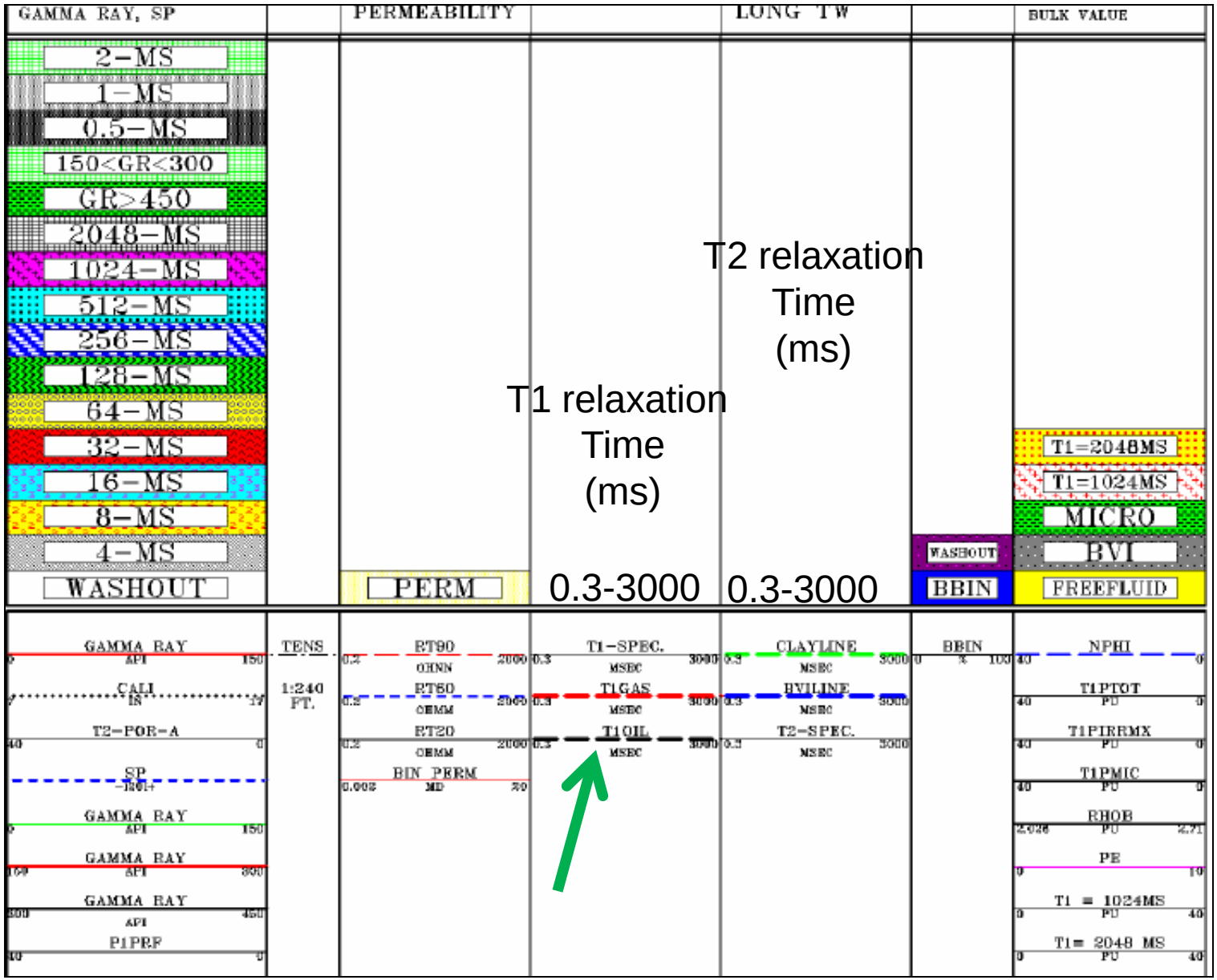


API: 15-189-22781
KID: 1044138961
Lease: Cutter KGS
Well 1
Original operator: Berexco, LLC
Current operator: BEREXCO LLC
Field: Cutter
Location: T31S R35W, Sec. 1
S2 S2 S2 NE
2440 South, 1320 West, from NE corner
Longitude: -101.0722814
Latitude: 37.3810169
Lat-long calculated from footages
County: Stevens Permit Date: Jul-18-2012
Spud Date: Aug-01-2012

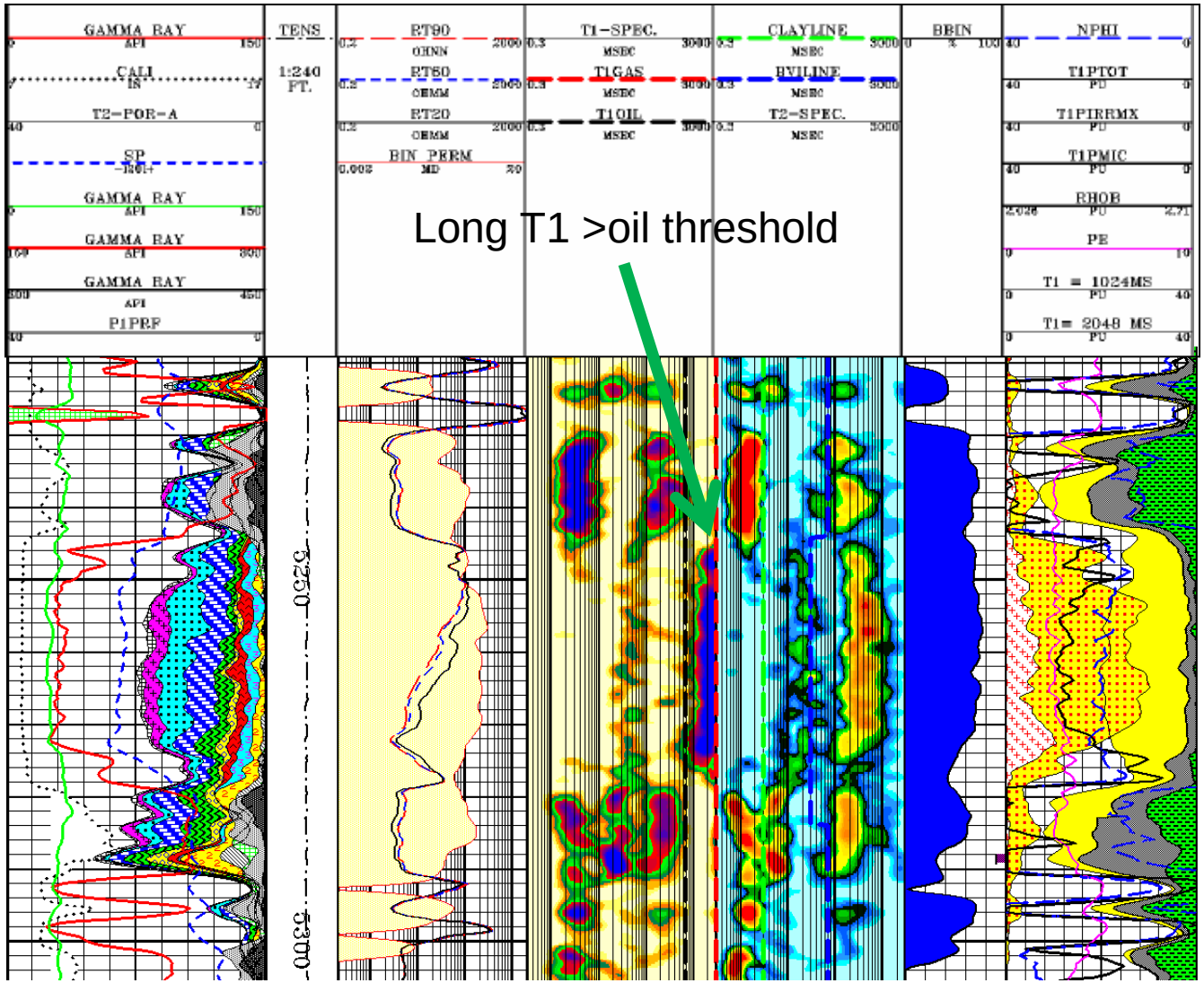
Cutter KGS 1 (15-189-22781) T: 31S R: 35W S: 1
Latitude: 37.381 Longitude: -101.0722 Elevation (GL): 2926.0 Depth: 6048.0




Cutter KGS 1 (15-189-22781) T: 31S R: 35W S: 1
Latitude: 37.381 Longitude: -101.0722 Elevation (GL): 2926.0 Depth: 6048.0
Depth
Lithology
Gamma Ray
Reference
GR 150.0
SP 259.374
CGR 150.0
CAL 12.0
AHT Resistivity
AHT10 1000.0
AHT20 1000.0
AHT60 1000.0
AHT90 1000.0
Litho-Density
PE 26.0
NPHI -0.1
RHOB 3.0
DPHI -0.1
Spectral GR
URAN 40.0
POTA 5.0
THOR 30.0
Rhomaa-Umaa
Computed
Rock Column
Percent
Neutron
Density
Stratigraphic Units
Members
Formations
Chattanooga Shale
Viola Limestone
Gasconade
Kinderhookian
Lower
Middle
Simpson
Arbuckle
Devonian
Ordovician
Paleozoic
Rock
Color
Lithology
Rock Column
Sedimentary Structures
Porosity
Type
Porosity
Remarks
6316 6338 dolo & chert having more of a greenish tint some lt brown shale also more vuggular
6338 6342 LS
6352 6360 ls gray silty dolo
6360.0 6368.0 dolomitic
6368.0 6394.2 wackestone gray
6378.5 6380.5 wackestone dark
6387.0 6388.9 wackestone dark
6396.2 6397.1 packstone
6422 6436 ls tan to brown w/
6436 6444.2 ls cream w/ small
6444.2 6444.8 shale calcareous
6455.8 6456.0 shale dark gray
6463.0 6469.0 wackestone gray
6472.0 6475.0 sandstone chert
6486.8 6491.5 sandstone with
6495.0 6500.0 weathered
6500.0 6517.2 dolomite
mudstone fair perm
6517.2 6526.0 dolomite
6526.0 6531.0 dolomite
6540 6542 Sand fine grain well
6590 6608 dolo fine sycrosic poor porosity no tan w/ usual
6608 6610 ls comolidic tan thin
6634 6644 dolo limy modeled
6644 6654 dolo tan w/ few
6654 6655 dolo tan fkln hard
6664.0 6666.3 dolomite
6683.5 6699.3 dolomite packstone dark gray brown fine
6699.3 6715.0 dolomite
6715.7 6716.5 dolomite
6723.0 6723.5 dolomite
6732.0 6738.0 dolomite
6738.8 6740.0 dolomite
6749.6 6750.8 dolomite
6763.0 6765.0 dolomite
6765.0 6771.0 (bbm of core)
6790 6808 Dolo gray to white with some having a red tint
6808 6820 Dolo gray to white
6820 6830 Dolo white hard
6830 6870 Dolo light gray to gray hard dense very fine cherty green to light gray interbedded shales
6870 6900 dolo white fine-very fine mln vuggy salt colitastic in spots green interbedded shales
6900 6904 dolo dark gray hard
6913.0 6915.3 dolomite
6922.0 6922.0 dolomite
6932.5 6933.0 dolomite
6937.7 6938.2 dolomite
6943.0 6945.0 dolomite
6950.0 6961.0 dolomite micrite
6961.0 6963.8 dolomite micrite
6970.8 6971.5 dolomite
6979.8 6982.5 dolomite
6996 7024 dolo light gray hard dense fine - very fine mln sub suc in spots green shale coarse
7024 7040 dolo white hard dense fine mln sub suc in spots
7040 7060 dolo light gray to dark gray very hard very dense
7060 7070 dolo light gray hard
7070 7080 dolo light gray to
7080 7090 dolo light gray to
7097.5 7102.5 dolomite
7109.5 7114.5 dolomite
7123.8 7124.3 dolomite
7135.5 7141.0 dolomite
7143.5 7144.8 dolomite
7153.0 7155.0 dolomite
7158.0 7158.8 green claystone
7166.0 7168.0 dolomite
7174.0 7177.0 dolomite
7183.0 7183.7 green, gray
7191.2 7192.0 autoclastic
7200.8 7204.8 dolomite
7209.3 7209.5 dolomite pellet
7216.5 7220.5 dolomite
7226.8 7230.0 dolomite pelloid
7234.6 7237.0 dolomite
7241 7245 chert light tan to
7250 7256 chert light tan to
7257.0 7259.6 dolomite
7260.0 7271.0 dolomite pelloid
7276 7312 dolo light tan to white hard fine coarse mln few very coarse clear rhombs cherty very glau slight pyrite
7312 7332 dolo light tan to white tan in spots hard
7332 7333 dolo white med mln
7342.0 7348.8 light brown
7372.5 7373.0 coarse dolomite
7382.0 7387.0 dolomite
7398.0 7404.2 dolomite gray -
7410.8 7421.5 dolomite peloids
7428.2 7434.0 dolomite light
7434.0 7441.0 dolomite gray
7446 7500 dolo light tan w/ large vugs - vuggy porosity w/ thin shaly chert possible dead brittle oil residue?
7500 7510 dolo tan w/ thin
7510 7512 dolo tan w/ thin
7530.0 7538.2 sandstone light
7538.2 7558.8 sandstone light gray very fine sand grains
7558.8 7568.5 sandstone light
7568.5 7574.8 sandstone dark
7574.8 7580.0 sandstone light
7580.0 7584.0 sandstone
7584.8 7589.8 sand light gray w/
7590 7606 cong weathered
7606 7640 granite fresh w/ abundant biotite feldspathic
7640 7710 granite fresh w/ abundant biotite feldspathic w/ minor amount of clorite and another green mineral in minor frac a trace also in fracs of a tarnished copper colored mineral like dust in fracs
7710 7736 granite becoming lighter colored to more faded pink
200 ft
Primary Rock Lithology
Clay, Claystone
Shale
Silt, Siltstone
Sand, Sandstone
Gravel
Breccia
Limestone Breccia
Dolomite Breccia
Chert
Limestone
Mudstone
Wackestone
Packstone
Grainstone
Limestone Dolomite
Dolomite
Dolomite Mudstone
Dolomite Packstone
Dolomite Grainstone
Granite
Secondary Rock Lithology
Clayey, Argillaceous, clay
Shaly, shale
Silty, Silt
Sandy, sand
Cherty, chert
Glauconite, Glauconitic
Carbonaceous, Carbonized
Pyritic, pyrite
oolitic
fossiliferous
pelleted
Calcareous
Dolomitic
Phosphate, Phosphatic
Fossils
Fresh Water
Brackish Water
Marine
Few
Many
Broken
– Macrofossils
– Brachiopods
– Crinoids
– Mollusks
– Stromatolites
– Trace Fossils
– Burrows
Sedimentary Structure Symbols
Depositional Structures
- Bedding Base
Abrupt or sharp, planar base of bed
- Cross Bedding
Planar cross-bedding
Hummocky cross-stratification
- Lamination
Parallel Laminations
- Stratification
Horizontal bedding
Parallel wavy bedding
Flaser bedding
Lenticular, linsen bedding
Normal grading/fining upward
Deformational Structures
Nodules
Nodules - Carbonates
Nodules - Silicates
Erosional Structures
Deflation Lag
Concave Bottom and Flat Top
Bioherm/Reef/Stromatolite Structures
Stromatolites
Clay
Shale
Sandstone
Shaly Sandstone
Arkose
Limestone
Shaly Carbonate
Dolomite
Shaly Dolomite
Gypsum
Anhydrite
Salt
Coal
Igneous
K-Feldspar
Plagioclase
Ultramafic

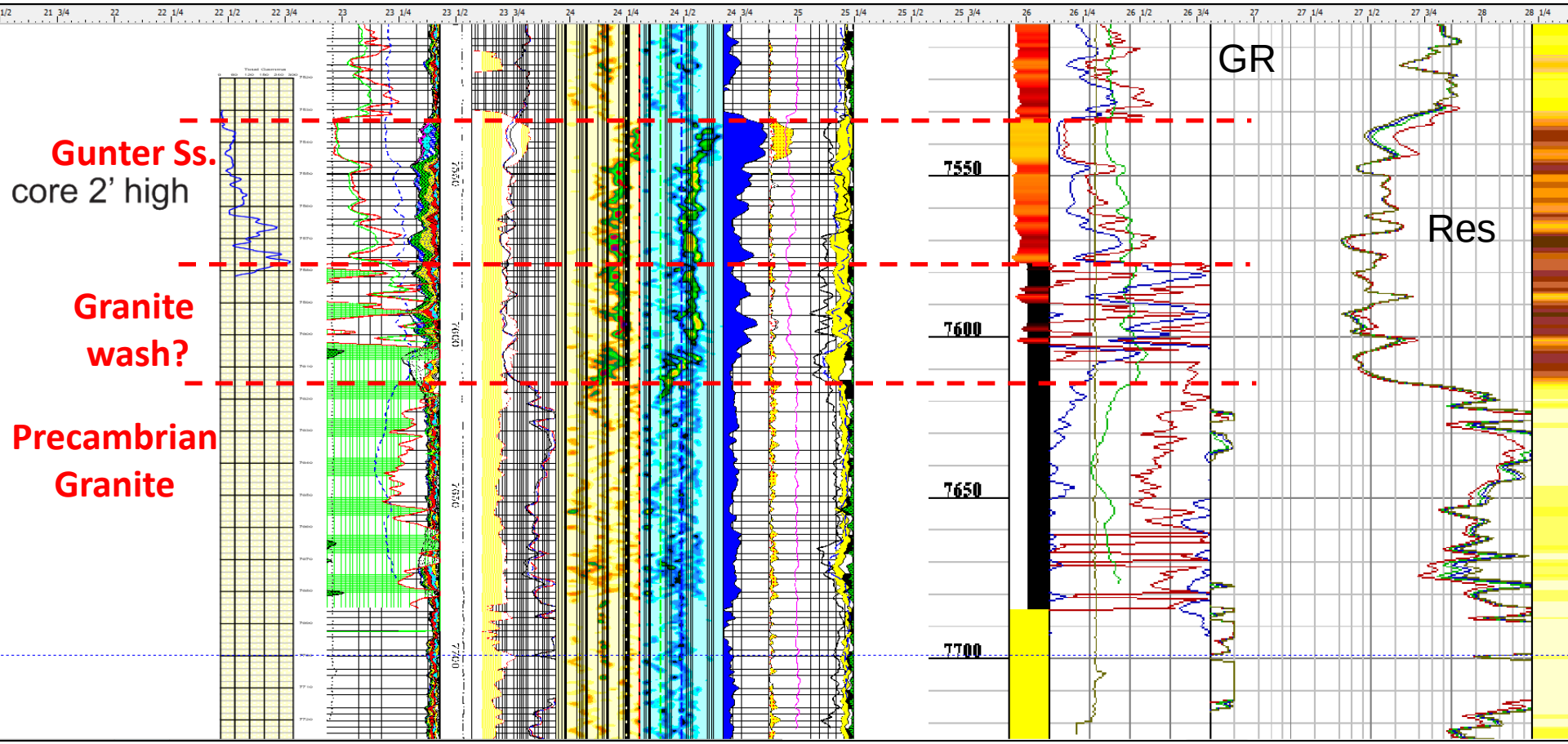

GAMMA RAY, SP
PERMEABILITY
LONG TW
BULK VALUE
2-MS
1-MS
0.5-MS
150<GR<300
GR>450
2048-MS
1024-MS
512-MS
256-MS
128-MS
64-MS
32-MS
16-MS
8-MS
4-MS
WASHOUT
PERM
T1 relaxation Time (ms)
T2 relaxation Time (ms)
0.3-3000
0.3-3000
WASHOUT
BBIN
T1=2048MS
T1=1024MS
MICRO
BVI
FREEFLUID
GAMMA RAY
API
CALI
IN
T2-POR-A
SP
GAMMA RAY
API
GAMMA RAY
API
GAMMA RAY
API
P1PRP
TENS
1:240 FT.
RT90
OHMM
RT60
OHMM
RT20
OHMM
BIN_PERM
MD
T1-SPEC.
MSEC
T1GAS
MSEC
T1OIL
MSEC
CLAYLINE
MSEC
BVILINE
MSEC
T2-SPEC.
MSEC
BBIN
%
NPHI
T1PTOT
PU
T1PIRRMX
PU
T1PMIC
PU
RHOB
PU
PE
T1 = 1024MS
PU
T1= 2048 MS
PU

MRIL log and Main pay of Field -- Upper Morrow Sandstone

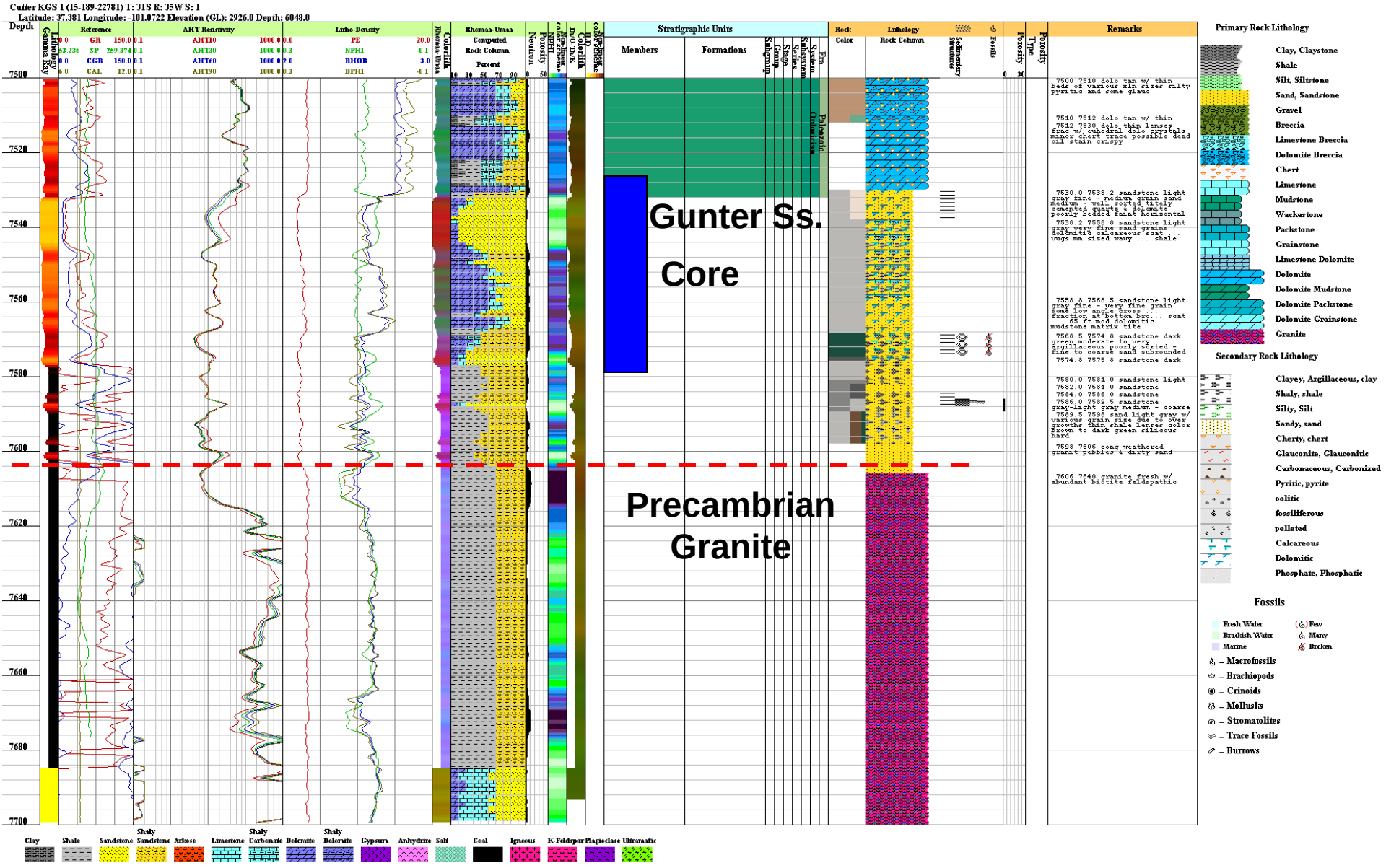


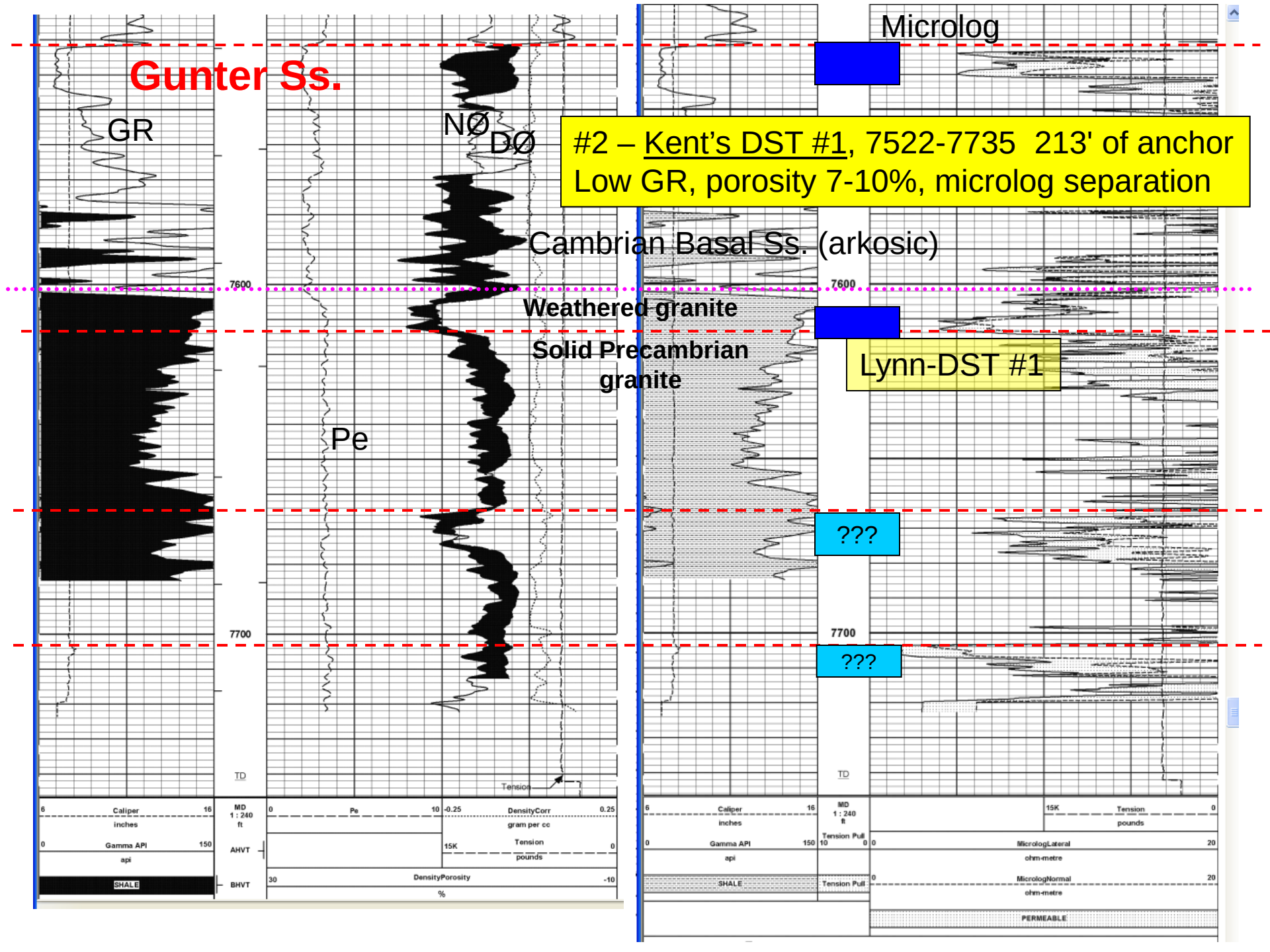
Base Gasconade Dolomite, Gunter Sandstone, granite wash, Precambrian granite

MRIL log

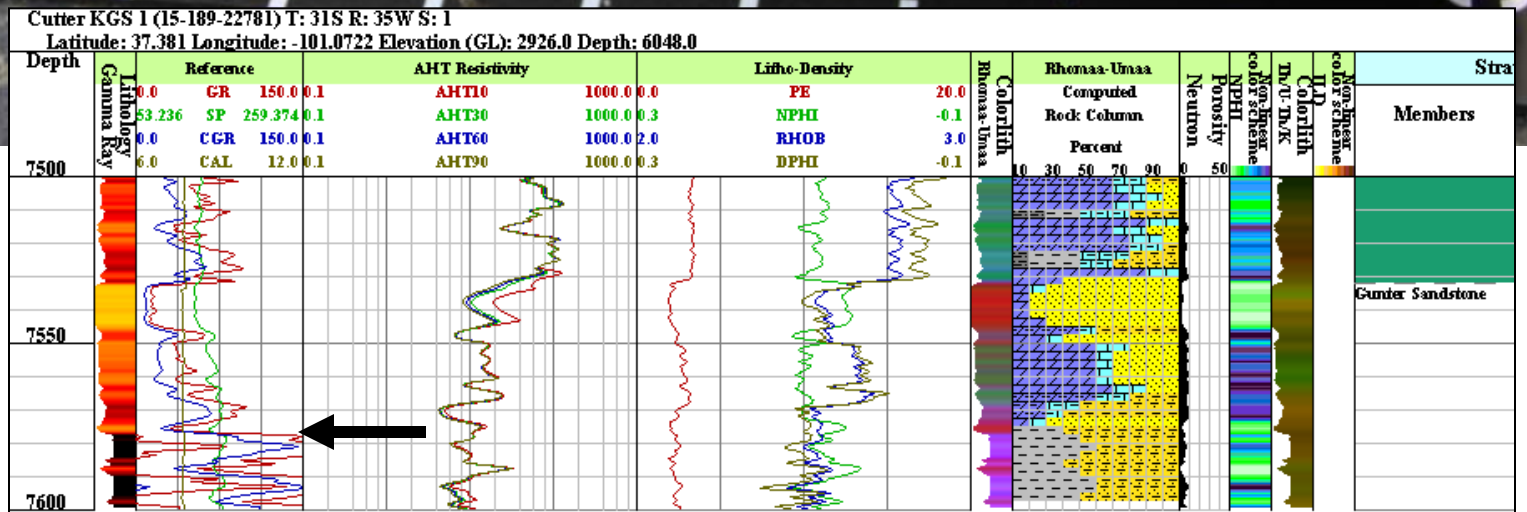


7550-7589 UV fluorescence, light show

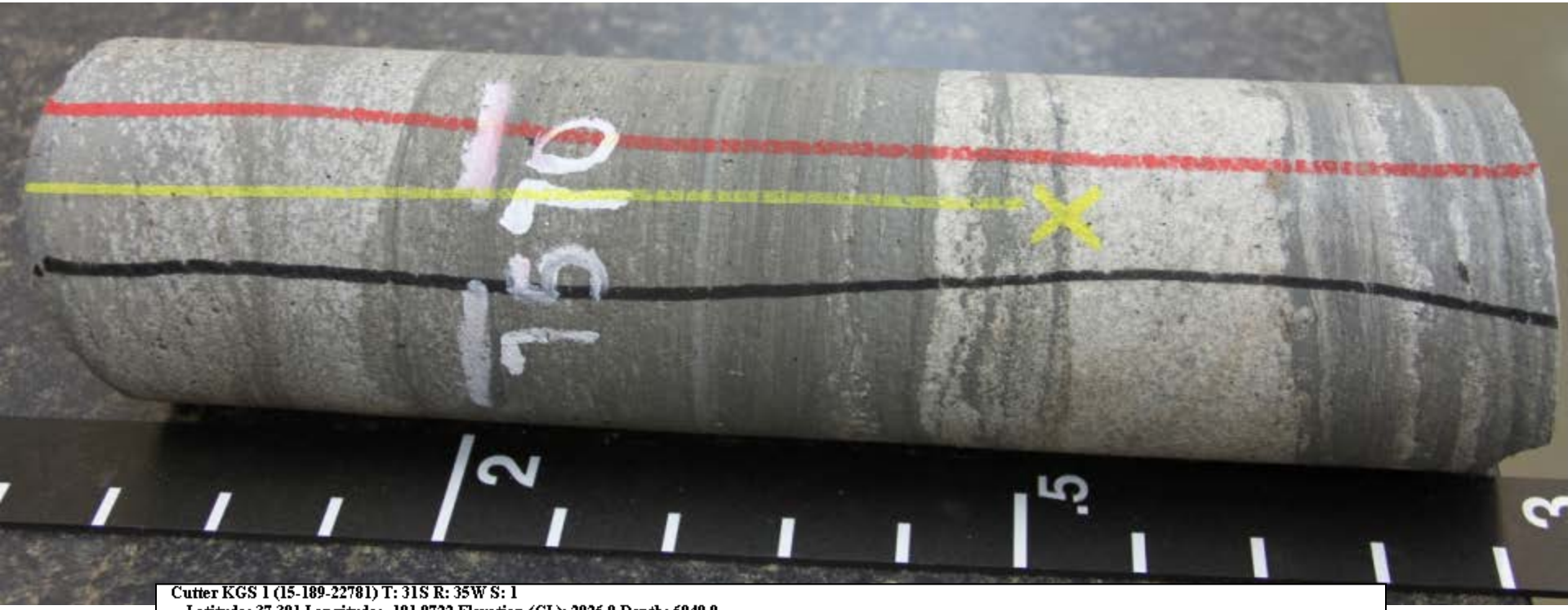

Cutter KGS 1 (15-189-22781) T: 31S R: 35W S: 1
Latitude: 37.381 Longitude: -101.0722 Elevation (GL): 2926.0 Depth: 6048.0
Depth
Reference
Lithology
Gamma Ray
0.0 GR 150.0
53.236 SP 259.374
0.0 CGR 150.0
6.0 CAL 12.0
AHT Resistivity
0.1 AHT10 1000.0
0.1 AHT30 1000.0
0.1 AHT60 1000.0
0.1 AHT90 1000.0
Lithe-Density
0.0 PE 20.0
0.3 NPHI -0.1
2.0 RHOB 3.0
0.3 DPHI -0.1
Rhomaa-Umaa
ColorHth
Computed
Rock Column
Percent
10 30 50 70 90
Neutron Porosity
NPHI
0 50
Th-U-Th-K
ColorHth
CLD
Stratigraphic Units
Members
Formations
Supergroup
Group
Stage
Series
System
Era
Paleozoic
Ordovician
Rock Color
Lithology
Rock Column
Sedimentary Structures
Fossils
Porosity Type
Porosity
0 30
Remarks
7500 7510 dolo tan w/ thin beds of various wkn zones silty pyritic and some glauc
7510 7512 dolo tan w/ thin
7512 7530 dolo thin lenses frac w/ euhedral dolo crystals minor chert trace possible dead oil stain crispy
7530.0 7538.2 sandstone light gray fine - medium grain sand medium - well sorted tightly cemented quartz & dolomite poorly bedded frant horizontal
7538.2 7558.8 sandstone light gray very fine sand grains dolomitic calcareous scat ... vugs mm sized wavy ... shale
7558.8 7568.5 sandstone light gray fine - very fine grain some low angle bross ... fraction at bottom bro ... scat ... 65 ft mod dolomitic mudstone matrix tite
7568.5 7574.8 sandstone dark green moderate to very argillaceous poorly sorted - fine to coarse sand subrounded
7574.8 7575.8 sandstone dark
7580.0 7581.0 sandstone light
7582.0 7584.0 sandstone
7584.0 7586.0 sandstone
7586.0 7589.5 sandstone gray-light gray medium - coarse
7589.5 7598 sand light gray w/ various grain size due to over growths thin shale lenses color brown to dark green silicous hard
7598 7606 cong weathered granit pebbles & dirty sand
7606 7640 granite fresh w/ abundant biotite feldspathic
Gunter Ss.
Core
Precambrian
Granite
7500
7520
7540
7560
7580
7600
7620
7640
7660
7680
7700
Clay
Shale
Sandstone
Shaly Sandstone
Arkose
Limestone
Shaly Carbonate
Dolomite
Shaly Dolomite
Gypsum
Anhydrite
Salt
Coal
Igneous
K-Feldspar
Plagioclase
Ultramafic
Primary Rock Lithology
Clay, Claystone
Shale
Silt, Siltstone
Sand, Sandstone
Gravel
Breccia
Limestone Breccia
Dolomite Breccia
Chert
Limestone
Mudstone
Wackestone
Packstone
Grainstone
Limestone Dolomite
Dolomite
Dolomite Mudstone
Dolomite Packstone
Dolomite Grainstone
Granite
Secondary Rock Lithology
Clayey, Argillaceous, clay
Shaly, shale
Silty, Silt
Sandy, sand
Cherty, chert
Glauconite, Glauconitic
Carbonaceous, Carbonized
Pyritic, pyrite
oolitic
fossiliferous
pelleted
Calcareous
Dolomitic
Phosphate, Phosphatic
Fossils
Fresh Water
Brackish Water
Marine
Few
Many
Broken
Macrofossils
Brachiopods
Crinoids
Mollusks
Stromatolites
Trace Fossils
Burrows

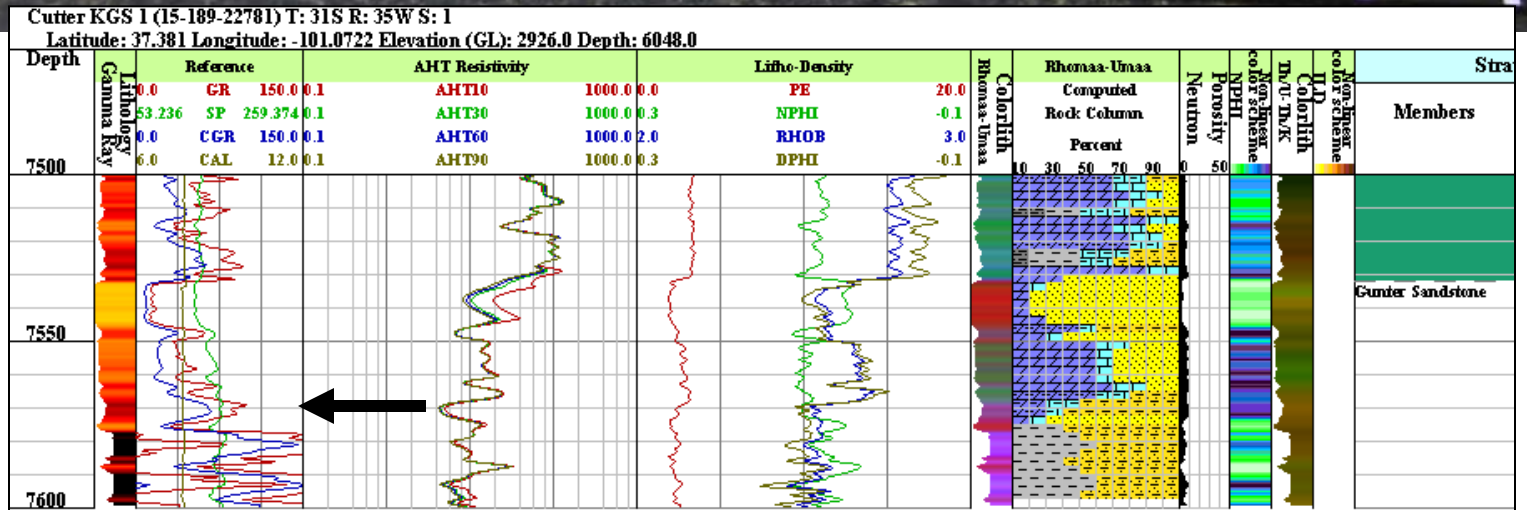

Gunter Ss.
GR
NØ
DØ
Pe
7600
7700
TD
Tension
Caliper
inches
Gamma API
api
SHALE
MD
1 : 240
ft
AHVT
BHVT
Pe
DensityCorr
gram per cc
Tension
pounds
DensityPorosity
%
Microlog
#2 – Kent's DST #1, 7522-7735 213' of anchor
Low GR, porosity 7-10%, microlog separation
Cambrian Basal Ss. (arkosic)
Weathered granite
Solid Precambrian granite
Lynn-DST #1
???
???
Tension Pull
MicrologLateral
MicrologNormal
ohm-metre
PERMEABLE

Gunter Sandstone,7579 ft
(core depth 2 ft high to logs)

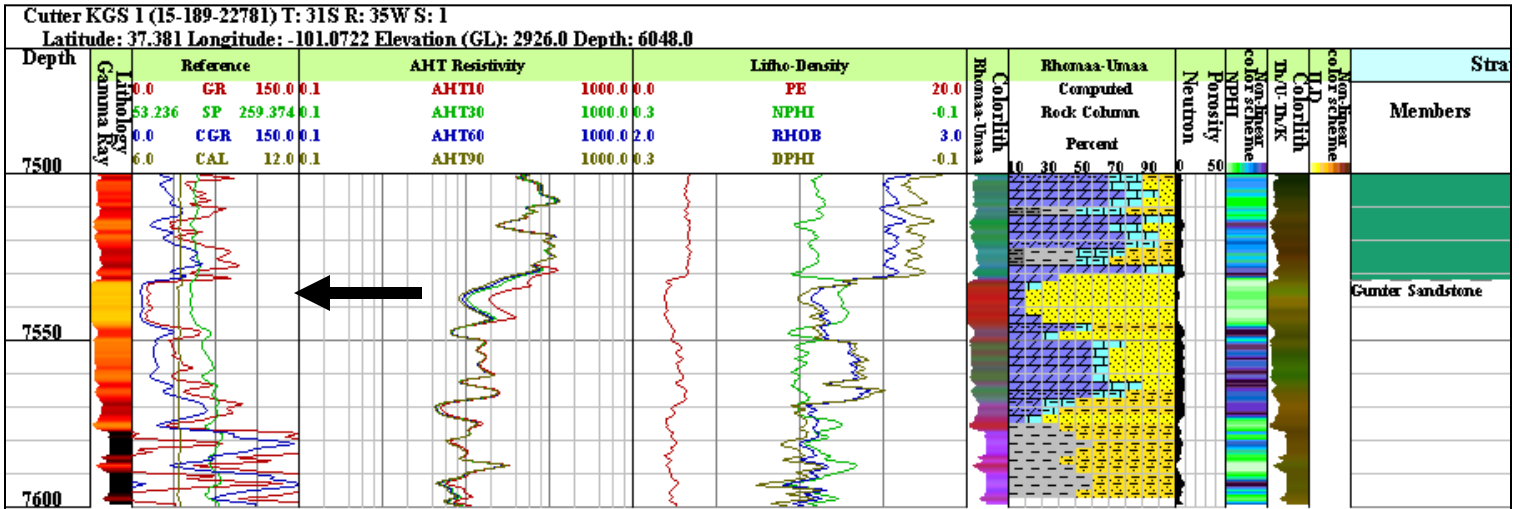


Gunter Sandstone
(core depth 2 ft high to logs)

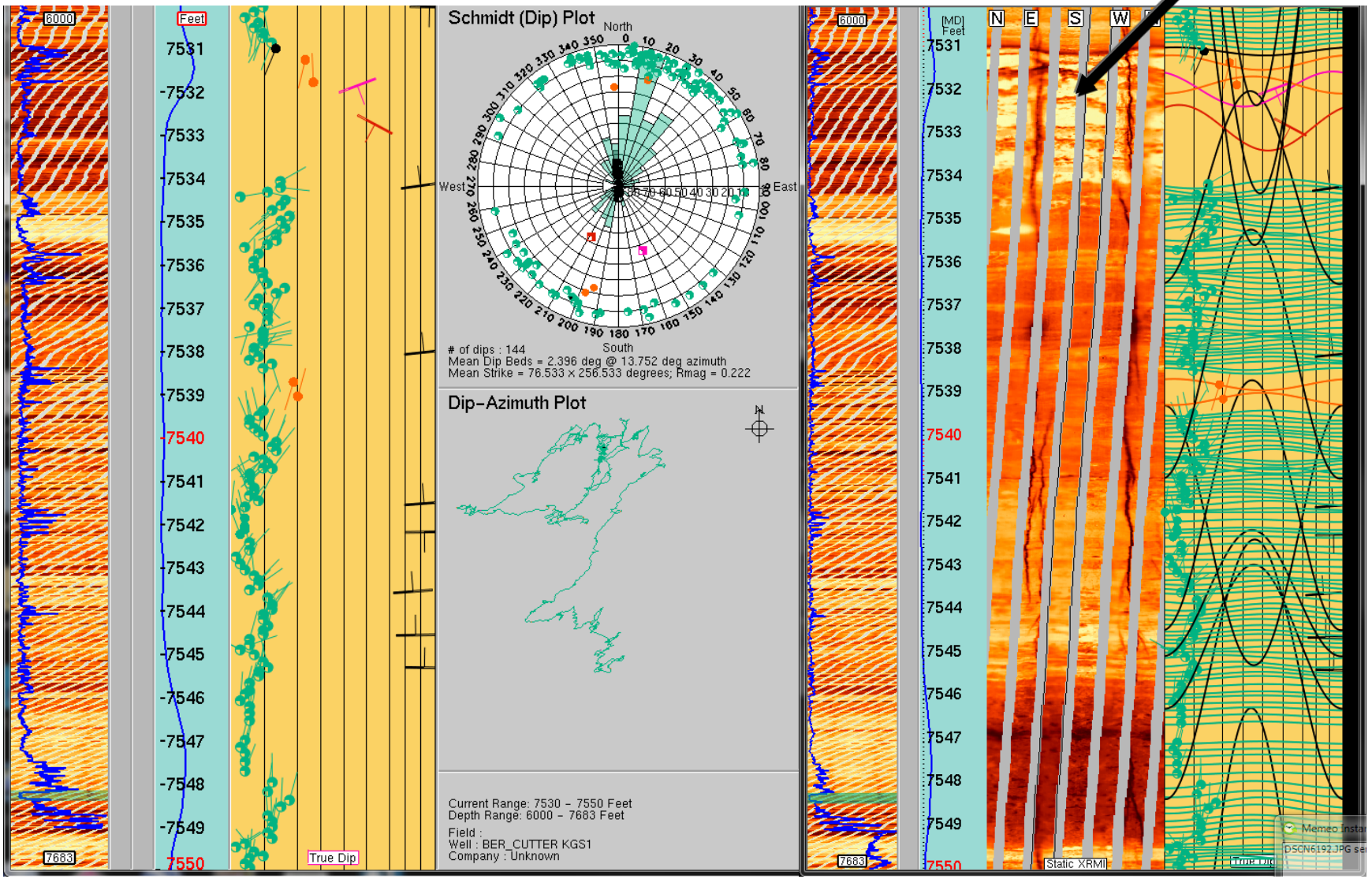




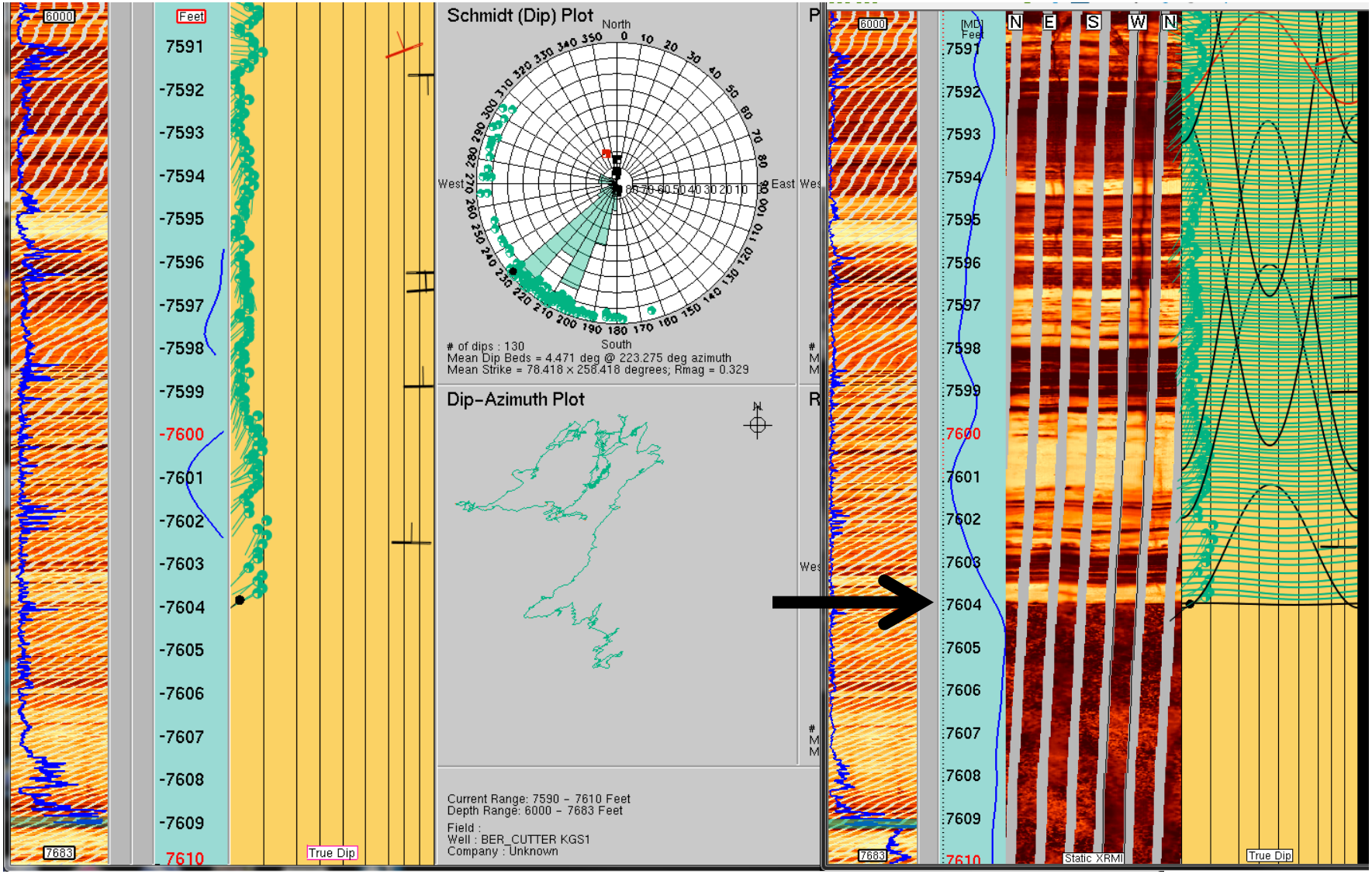
Gunter Sandstone, 7532 ft
(core depth 2 ft high to logs)



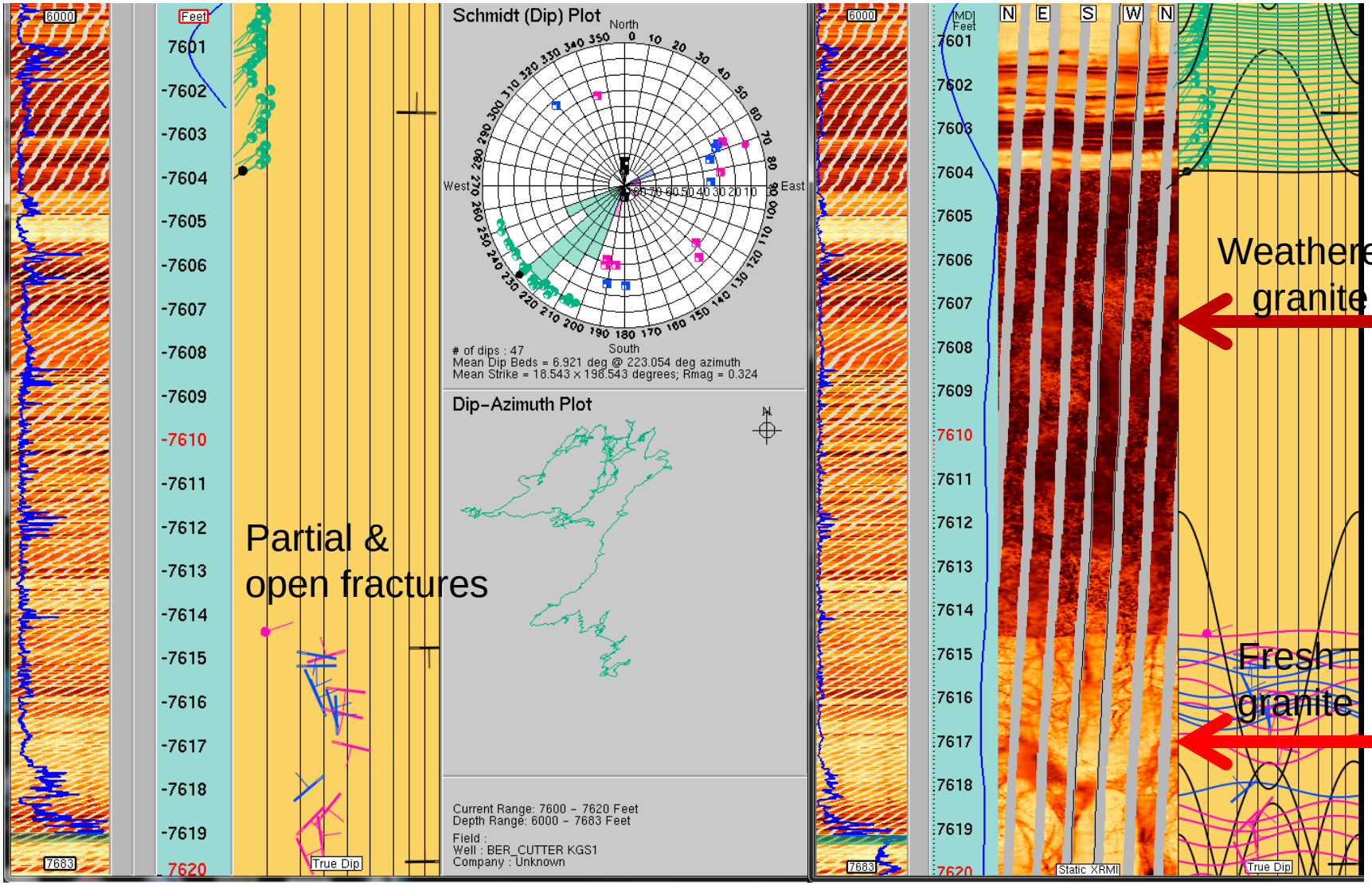
Gunter Sandstone, 7530-50 ft
Northeast dip

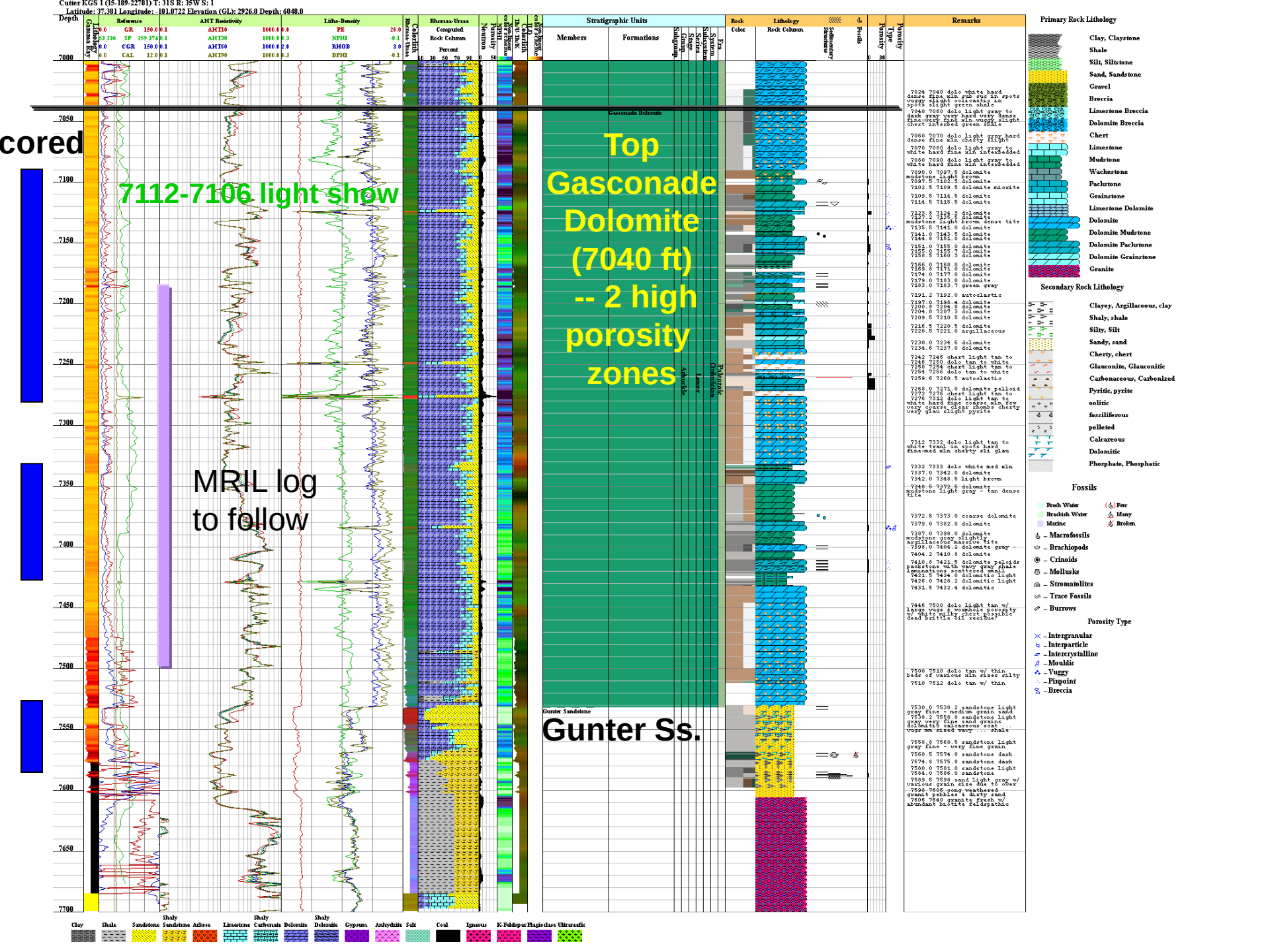


Gunter Sandstone-Granite contact, 7590-7610 ft SE dip, lower sandstone on weathered granite

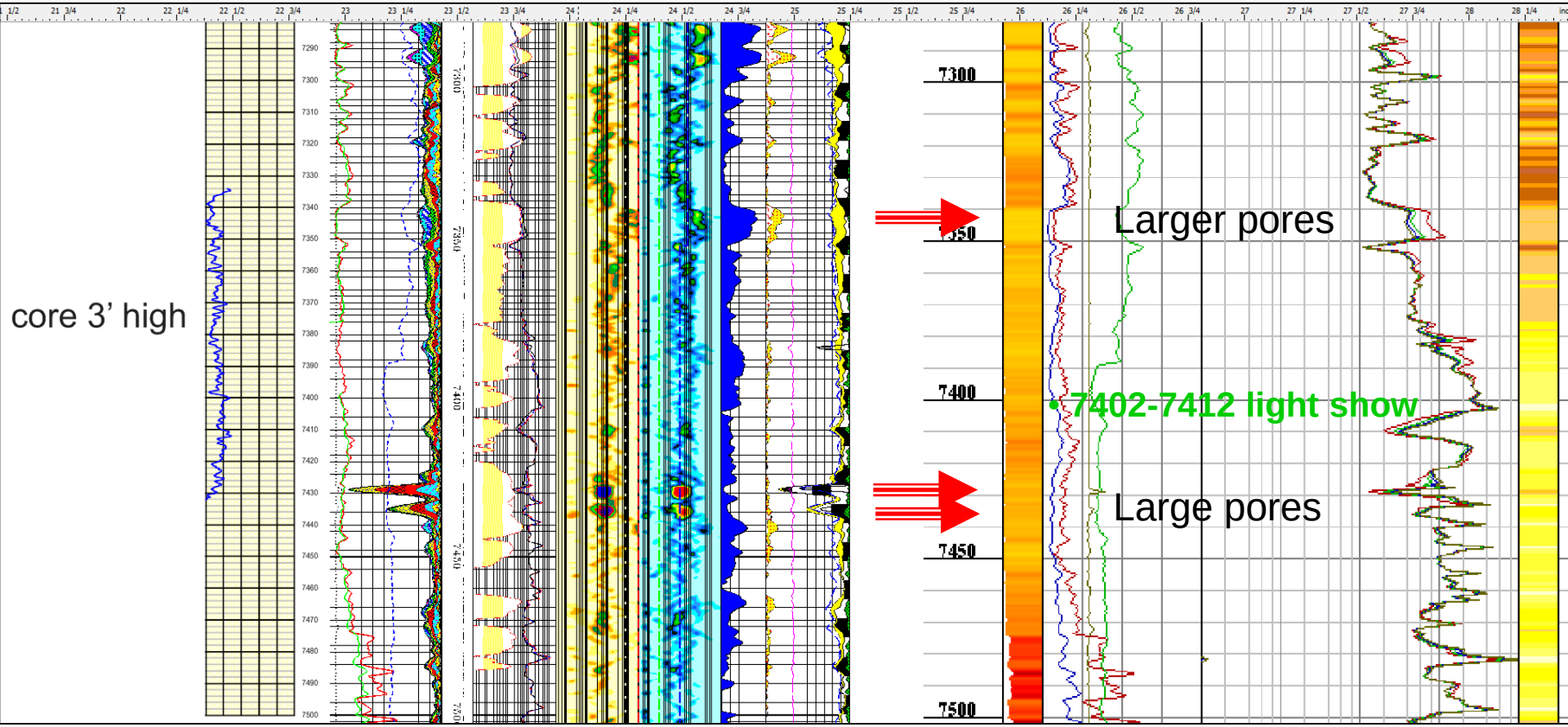


Weathered and Fresh Precambrian Granite

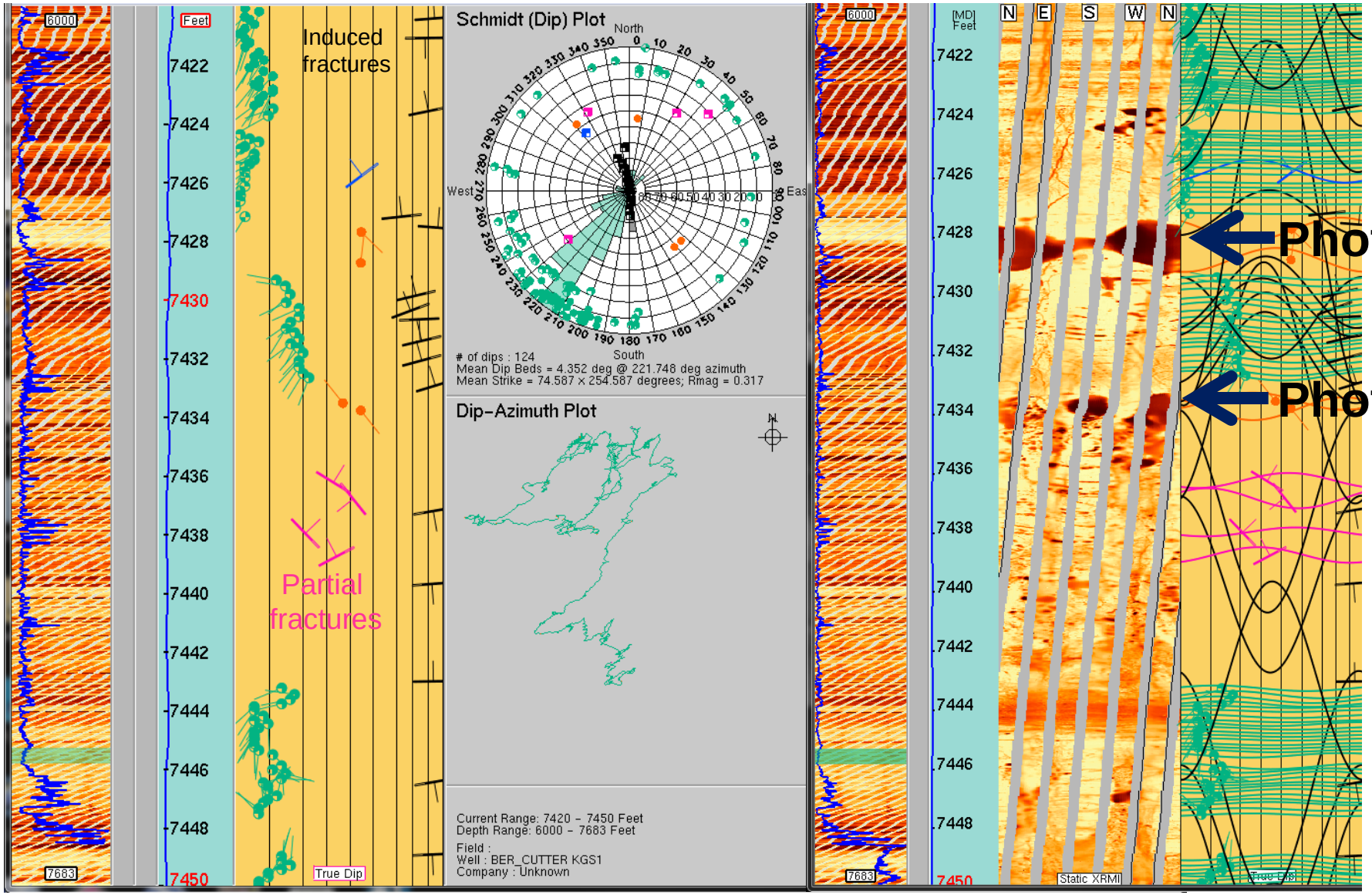



Cutter KGS 1 (15-189-22781) T: 31S R: 35W S: 1
Latitude: 37.381 Longitude: -101.0722 Elevation (GL): 2926.0 Depth: 6048.0
cored
7112-7106 light show
MRIL log to follow
Top Gasconade Dolomite (7040 ft) -- 2 high porosity zones
Gunter Ss.
Gasconade Dolomite
Gunter Sandstone
Stratigraphic Units
Members
Formations
Remarks
Primary Rock Lithology
Clay, Claystone
Shale
Silt, Siltstone
Sand, Sandstone
Gravel
Breccia
Limestone Breccia
Dolomite Breccia
Chert
Limestone
Mudstone
Wackestone
Packstone
Grainstone
Limestone Dolomite
Dolomite
Dolomite Mudstone
Dolomite Packstone
Dolomite Grainstone
Granite
Secondary Rock Lithology
Clayey, Argillaceous, clay
Shaly, shale
Silty, Silt
Sandy, sand
Cherty, chert
Glauconite, Glauconitic
Carbonaceous, Carbonized
Pyritic, pyrite
oolitic
fossiliferous
pelleted
Calcareous
Dolomitic
Phosphate, Phosphatic
Fossils
Fresh Water
Brackish Water
Marine
Few
Many
Broken
Macrofossils
Brachiopods
Crinoids
Mollusks
Stromatolites
Trace Fossils
Burrows
Porosity Type
Intergranular
Interparticle
Intercrystalline
Mouldic
Vuggy
Pinpoint
Breccia
Clay
Shale
Sandstone
Shaly Sandstone
Arkose
Limestone
Shaly Carbonate
Dolomite
Shaly Dolomite
Gypsum
Anhydrite
Salt
Coal
Igneous
K-Feldspar
Plagioclase
Ultramafic

Lower Gasconade Dolomite (7280-7500 ft)

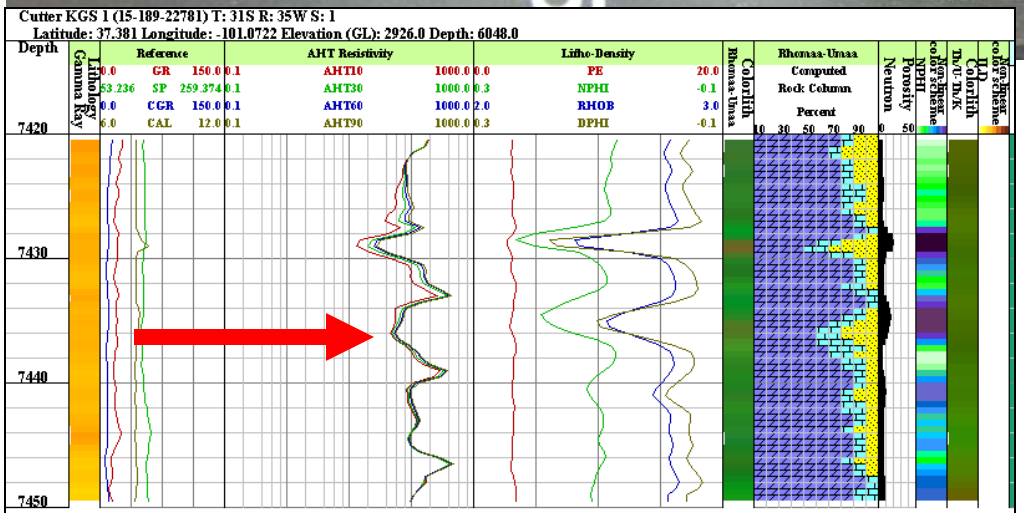


Lower Gasconade Dolomite, 7420-50 ft



Lower Gasconade, 7433 ft

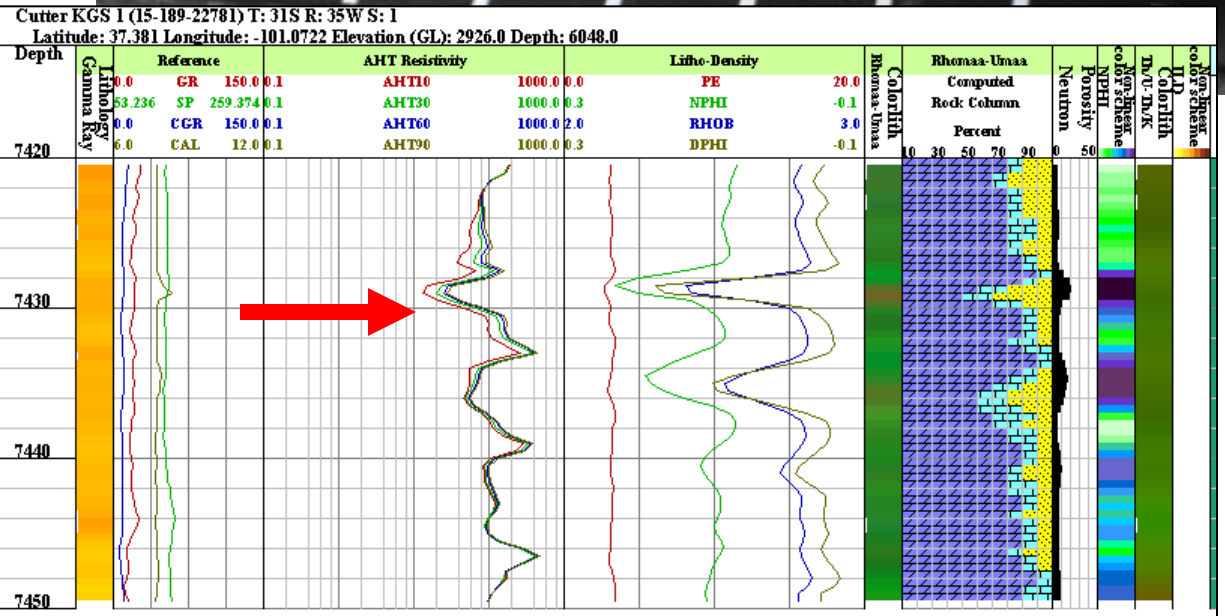
(core depth 3 ft high to log)



Gray-brown, packstone with quartz sandstone, cm sized vugs that are interconnected cut across core, saddle dolomite, very porous breccia

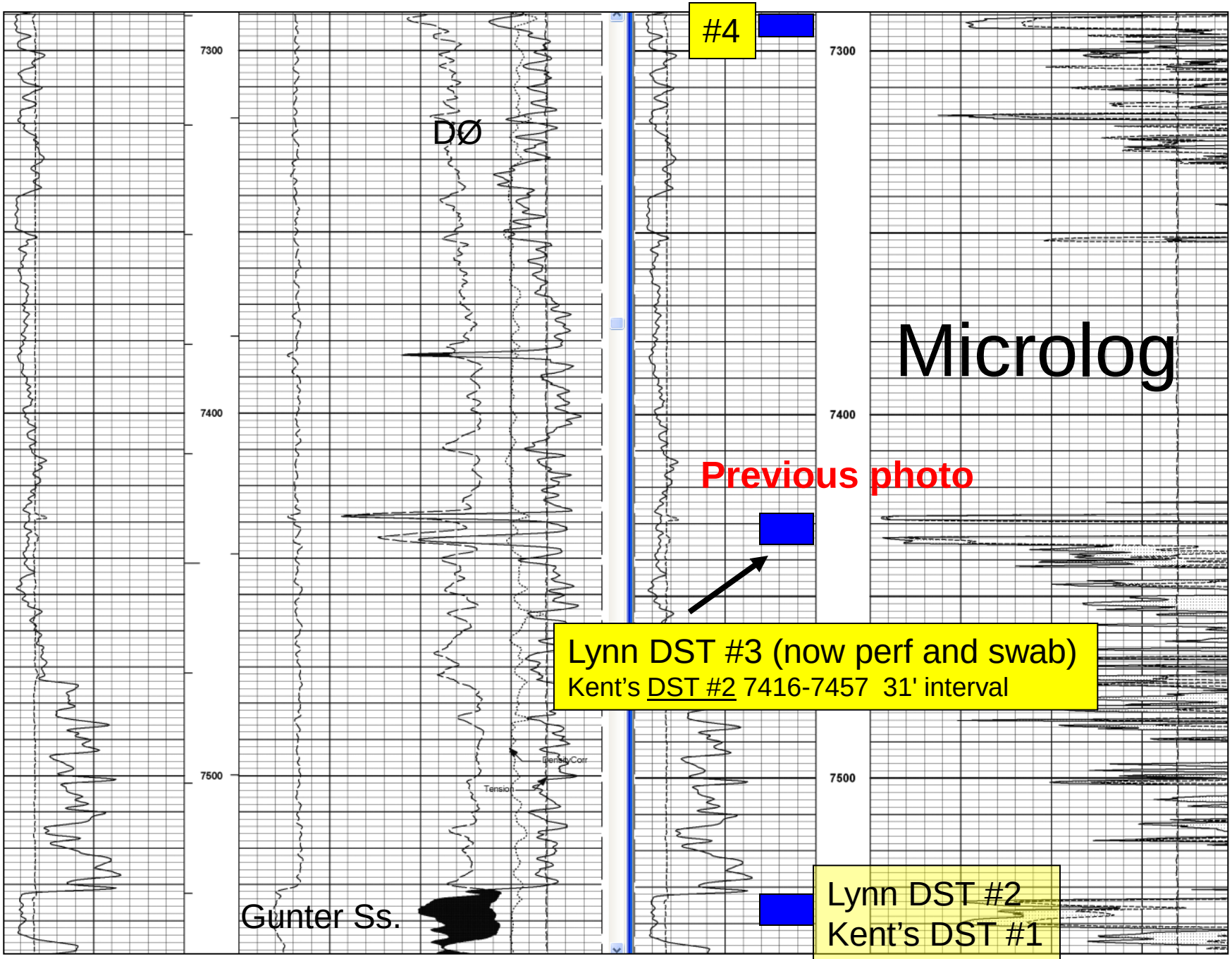
Lower Gasconade, 7427 ft

(core depth 3 ft high to log)



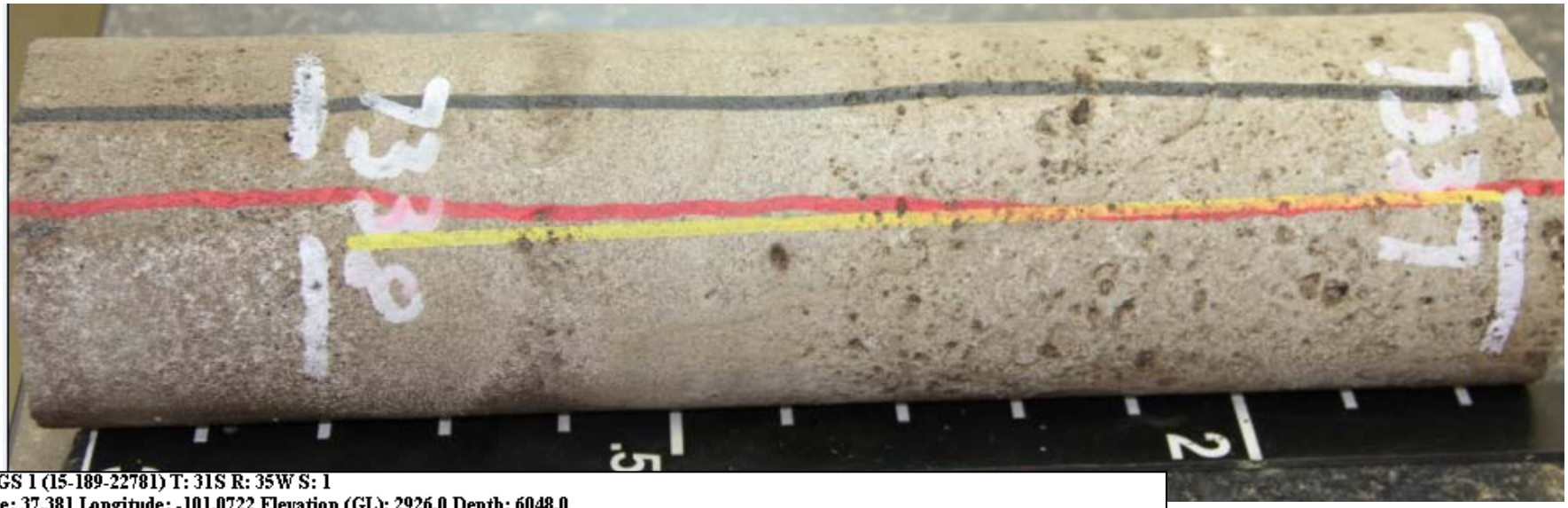
dolomitic packstone-grainstone, medium to coarse grained vugs, occ. diagonal fractures

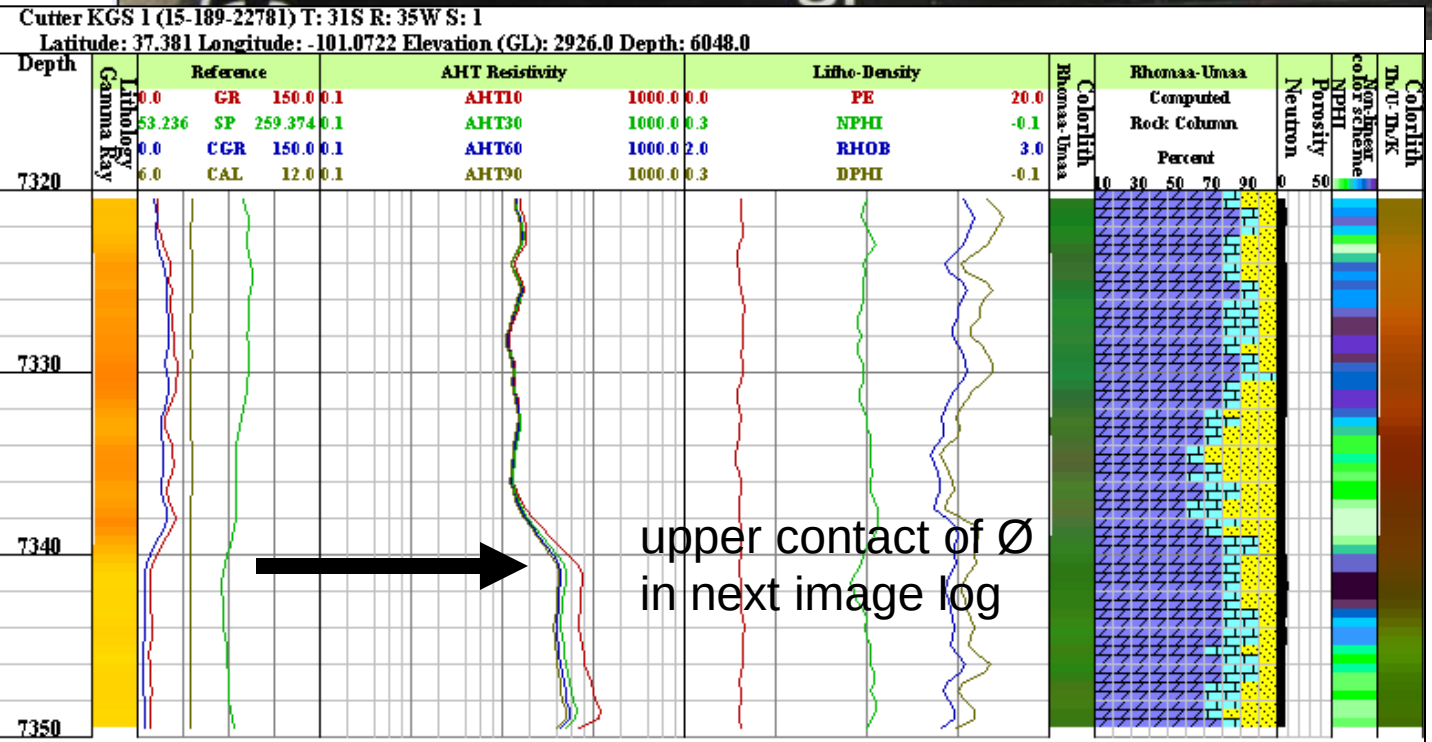
Lower Gasconade to Gunter Ss.



Lower Gasconade, 7337-38 ft

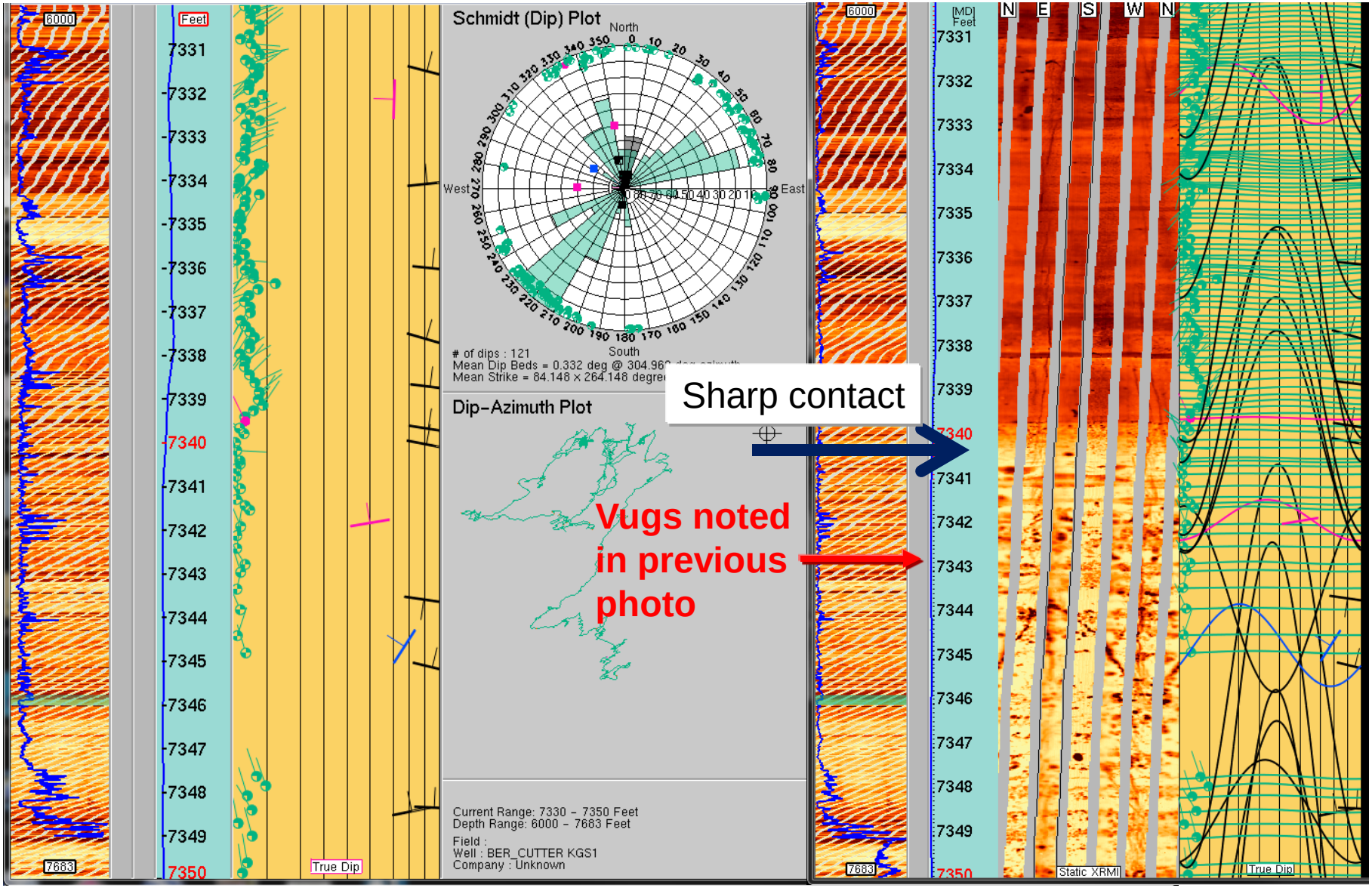
(core depth 3 ft high to log)



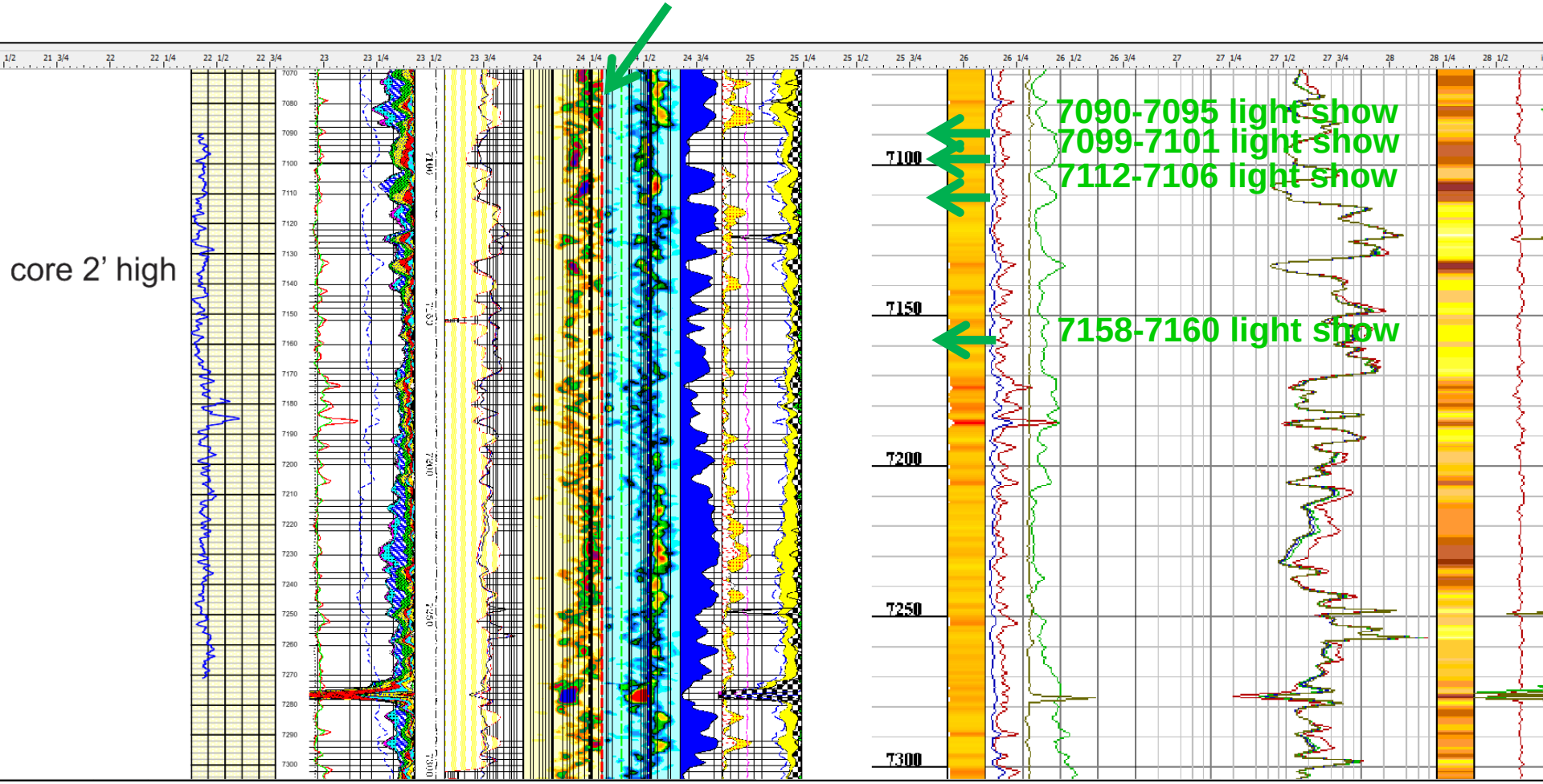


Dolopackstone to dolograinstone, brown fine vugs & molds of pelloids, fine to medium grained

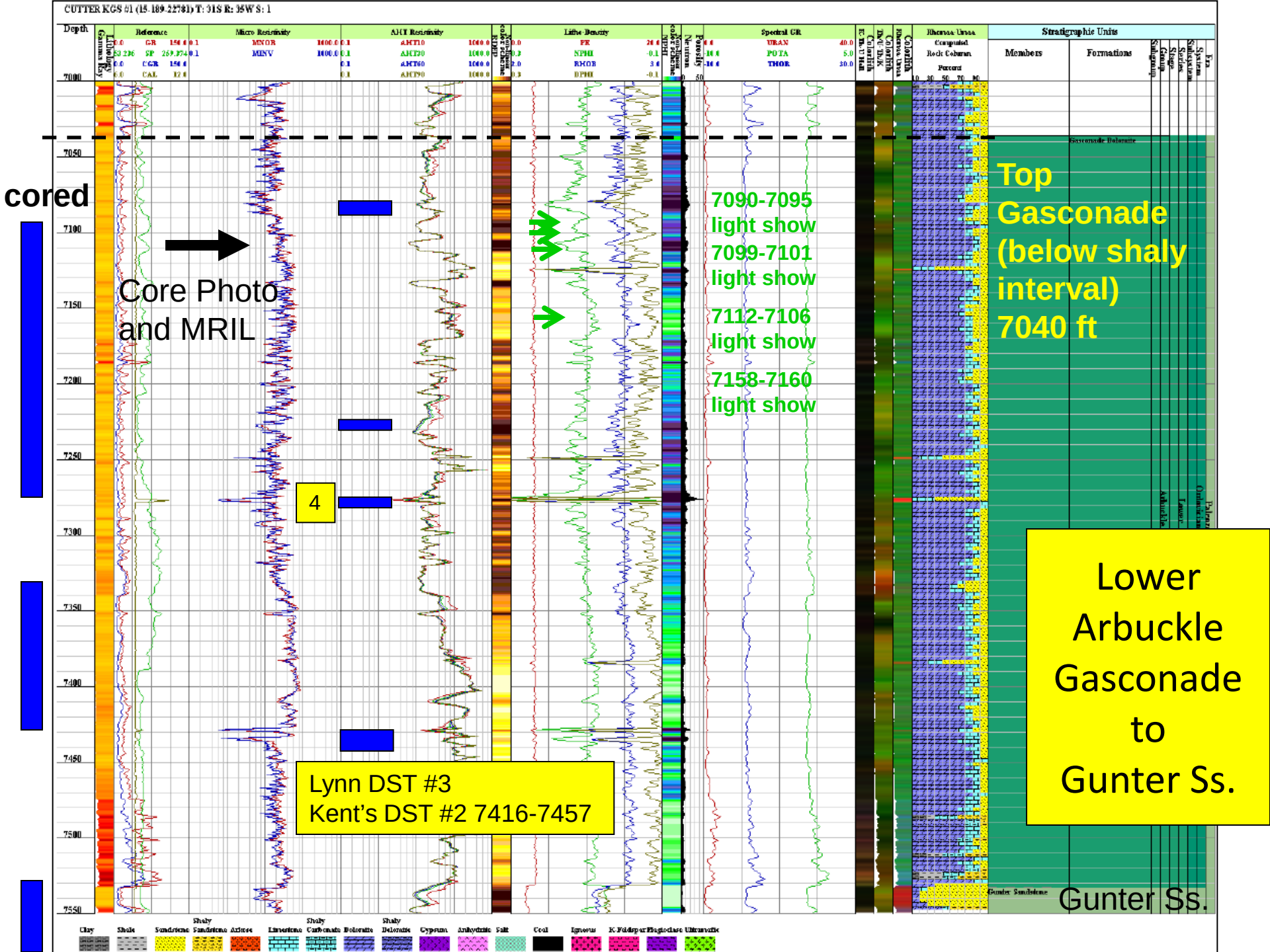
Lower Gasconade Dolomite, 7330-50 ft
Change in dip at tight/porous contact



Upper Gasconade Dolomite
-- UV fluorescence, light oil show

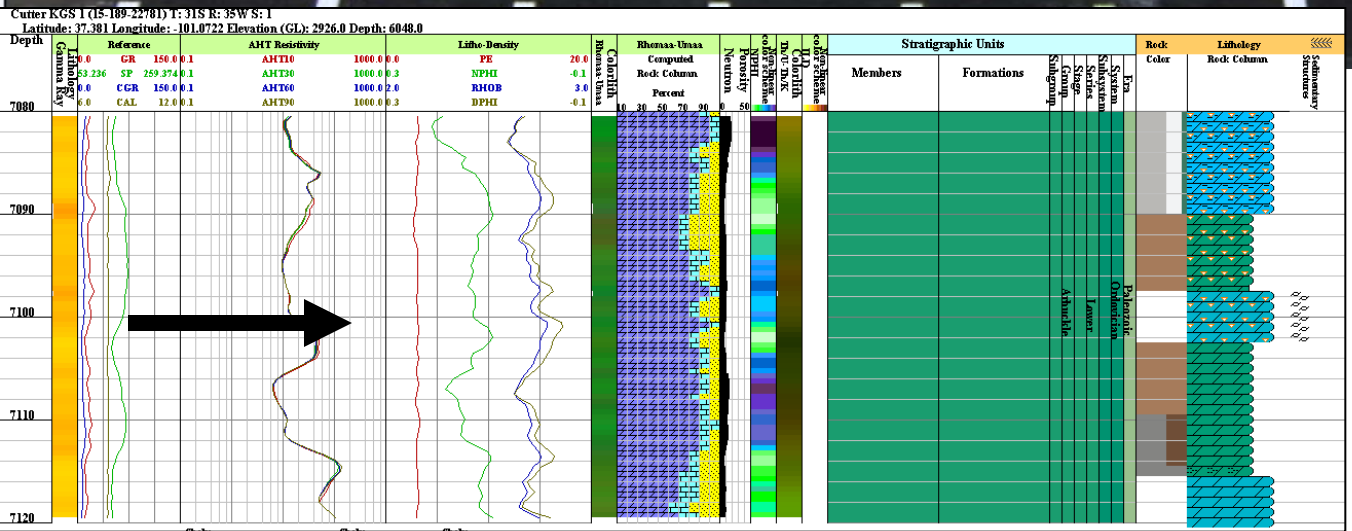


Base Gasconade 7532 ft.


cored
Core Photo and MRIL
4
7090-7095 light show
7099-7101 light show
7112-7106 light show
7158-7160 light show
Top Gasconade (below shaly interval) 7040 ft
Lynn DST #3
Kent's DST #2 7416-7457
Lower Arbuckle Gasconade to Gunter Ss.
Gunter Ss.

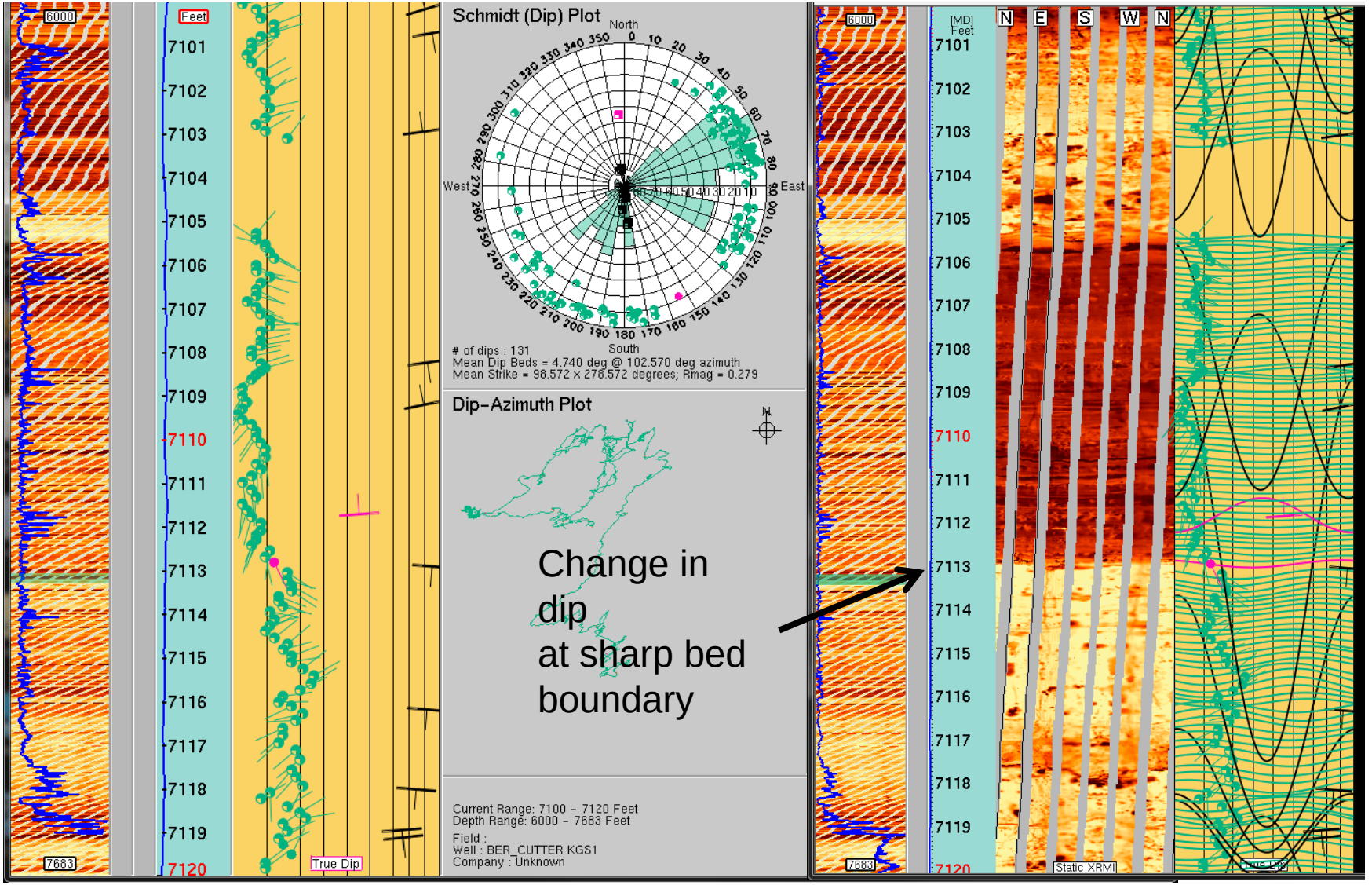
Upper Gasconade, 7100 ft

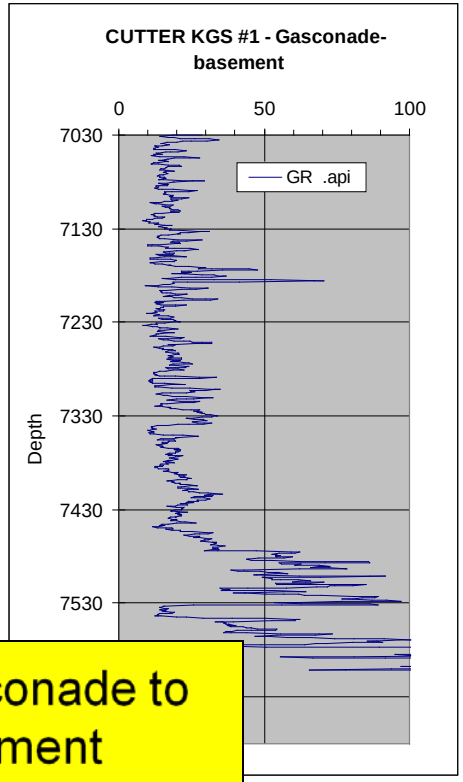
(core 2 ft high to log)

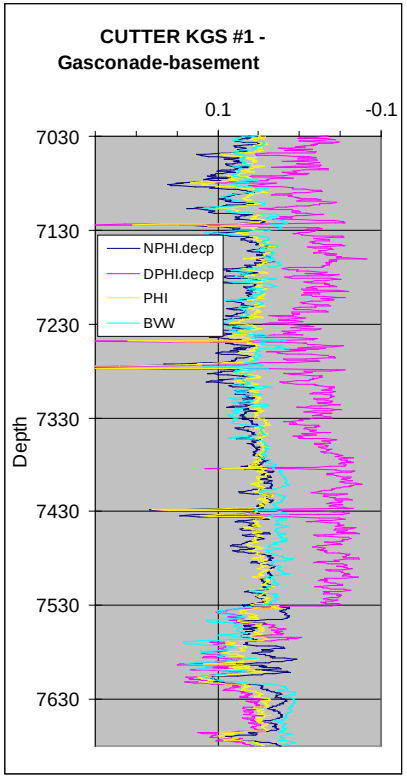


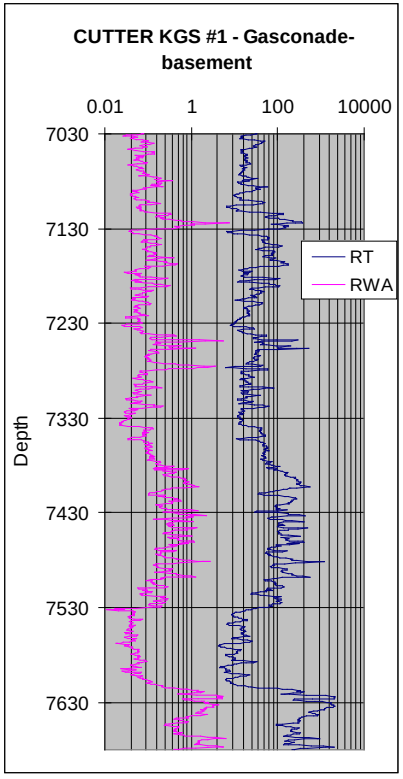
<u>packstone</u> with flat pebble conglomerate, horizontal disruptive bedding lenticular chert, pinpoint vugs, poor porosity.

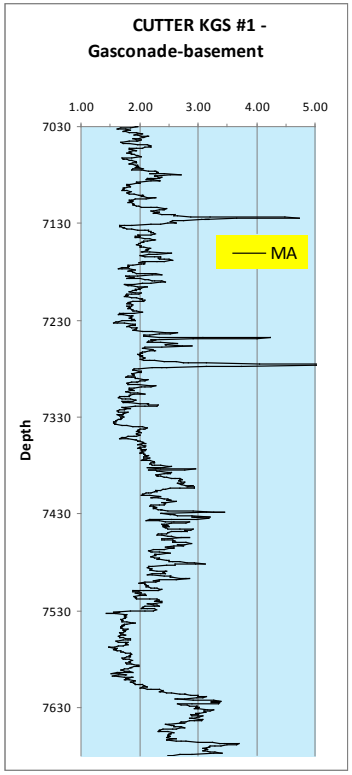
Upper Gasconade Dolomite, 7100-7120 ft
Interbedded tight and porous





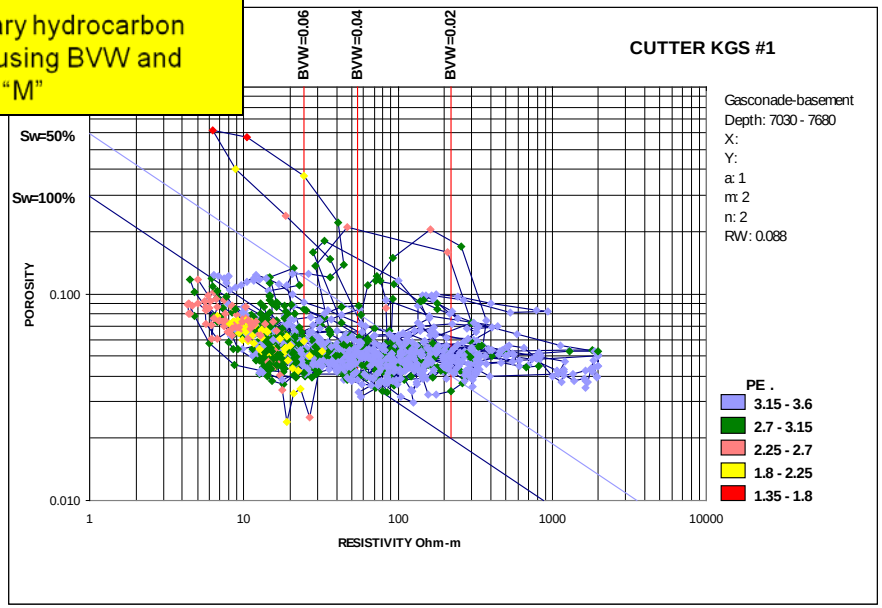


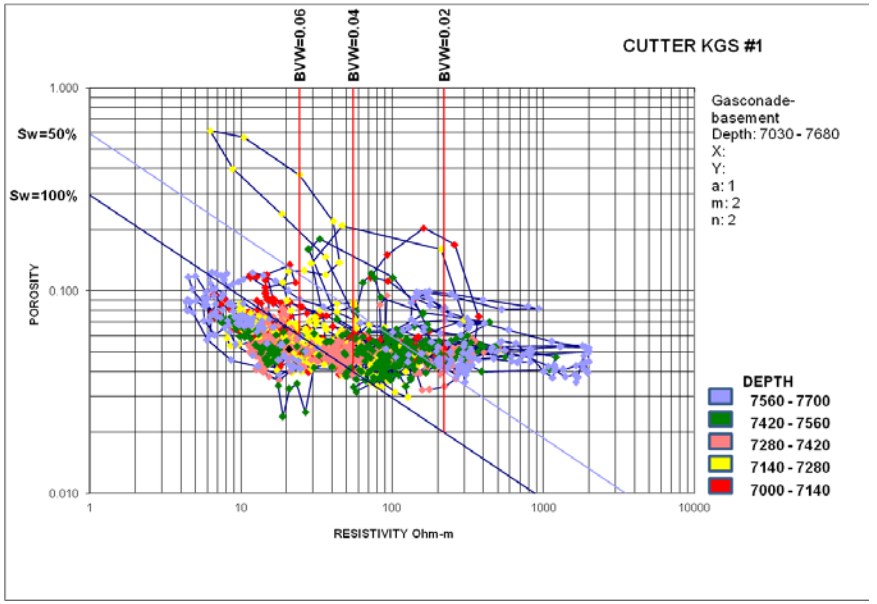




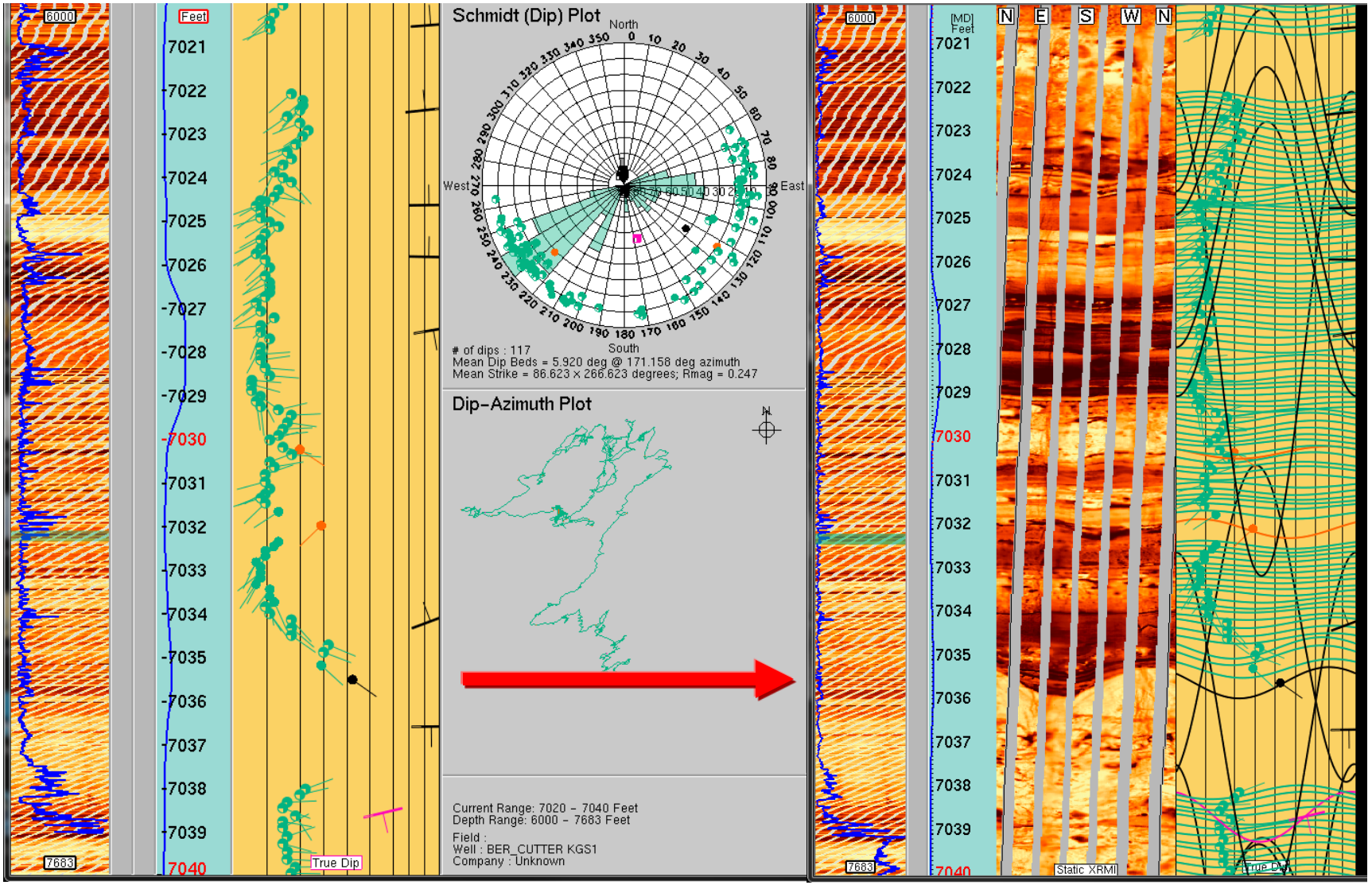
Gasconade to basement

Preliminary hydrocarbon analysis using BVW and apparent "M"

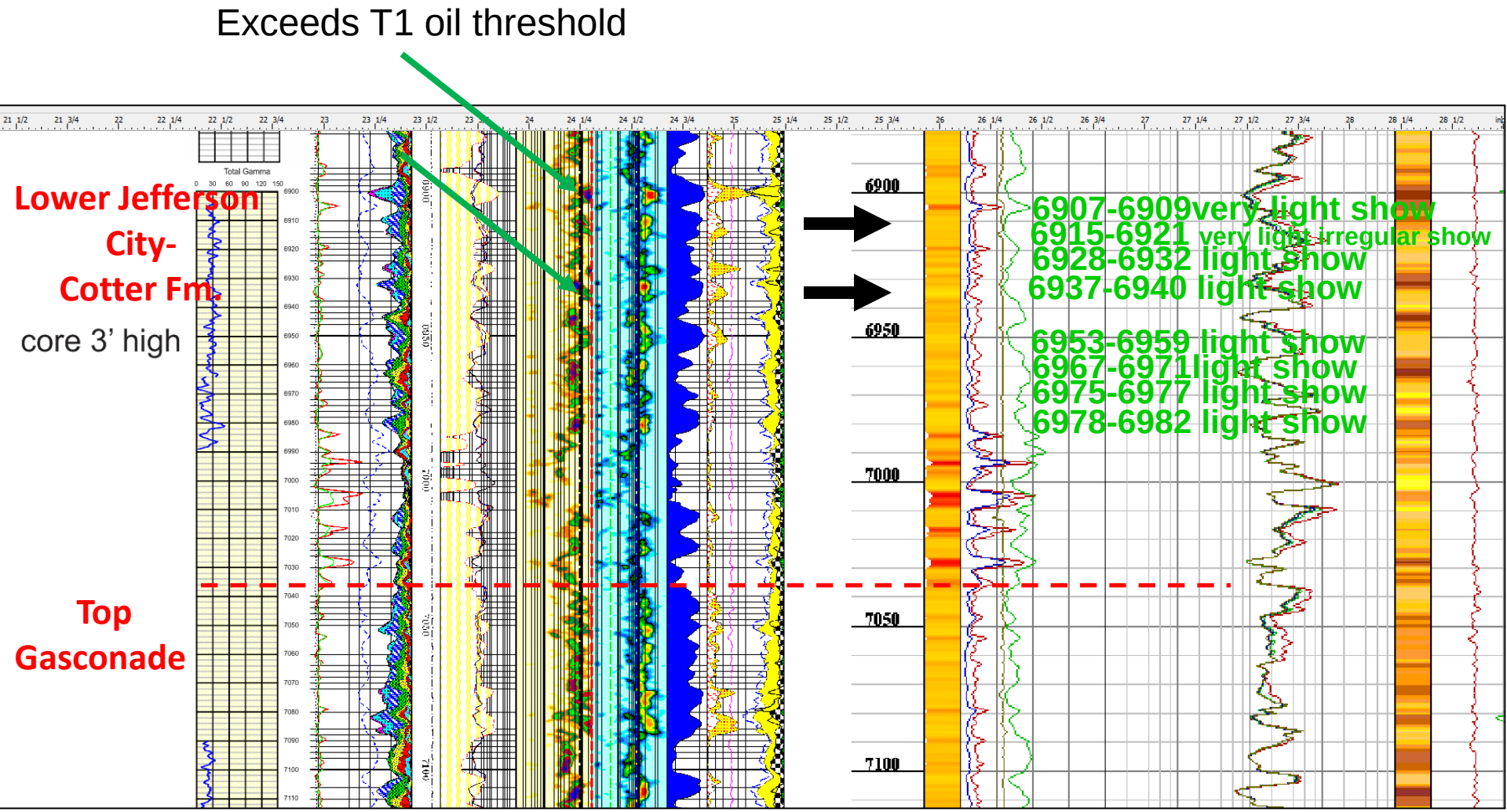


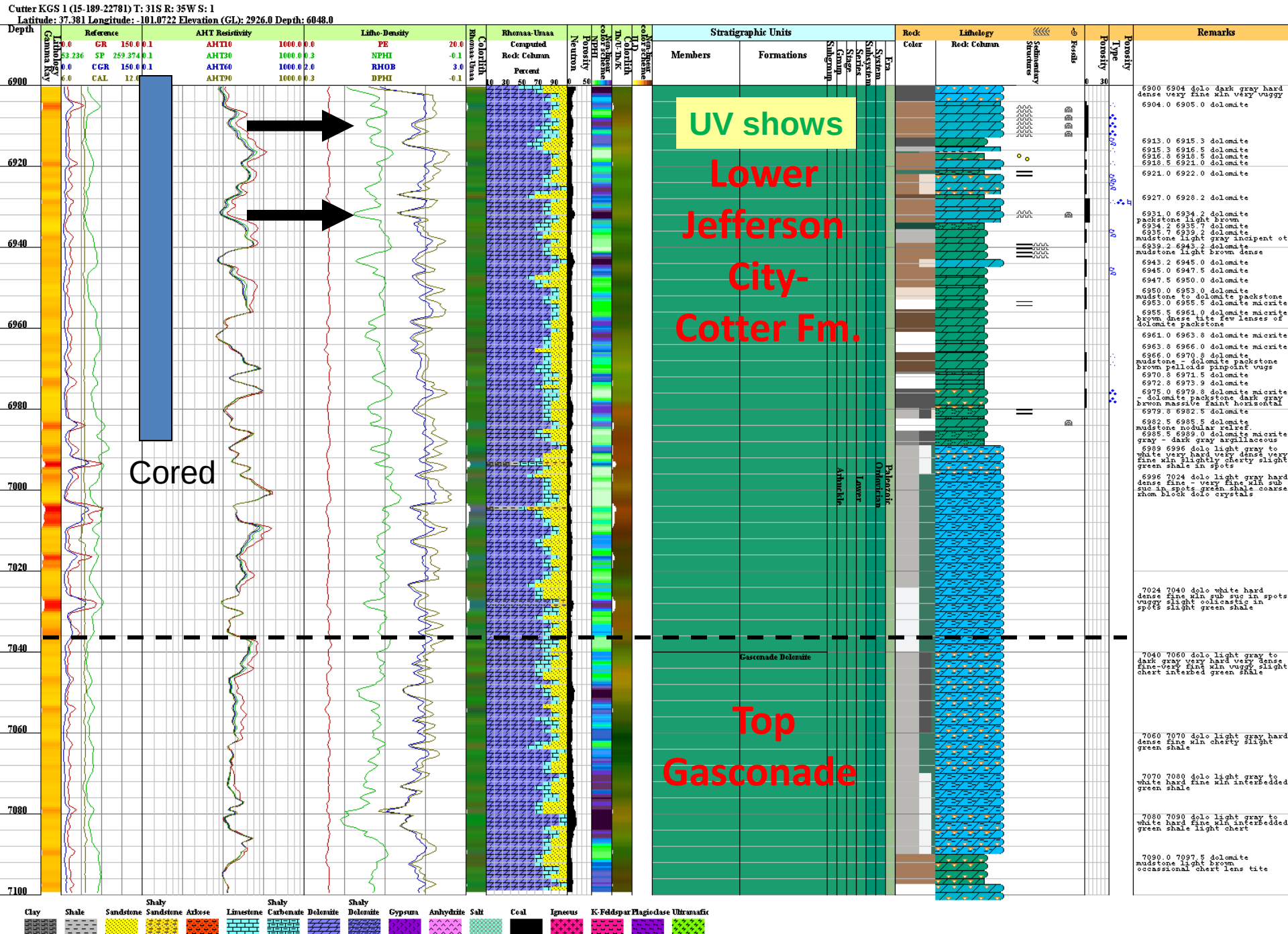


Contact between Jeff-City Cotter and Gasconade Dolomite, 7020-7040 ft

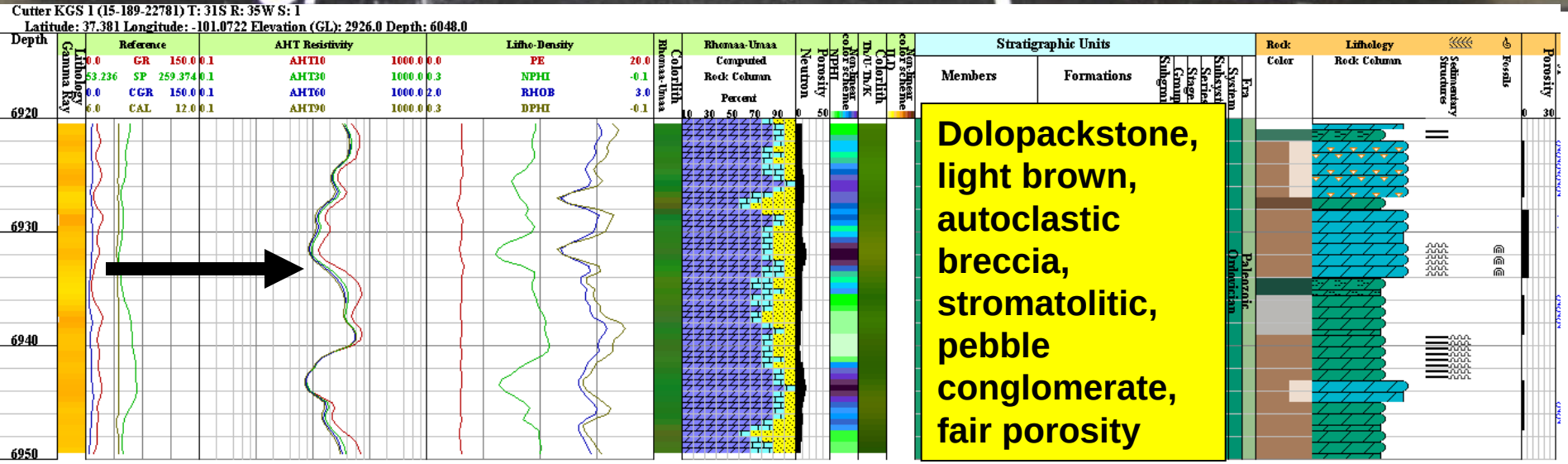


Lower Jefferson City-Cotter Fm.
More hydrocarbons shows and oil indications on MRIL




Cutter KGS 1 (15-189-22781) T: 31S R: 35W S: 1
Latitude: 37.381 Longitude: -101.0722 Elevation (GL): 2926.0 Depth: 6048.0
Depth
Reference
AHT Resistivity
Litho-Density
Rhomaa-Umaa
Neutron
Porosity
Stratigraphic Units
Members
Formations
Rock Color
Lithology
Rock Column
Sedimentary Structures
Fossils
Porosity
Remarks
UV shows
Lower Jefferson City-Cotter Fm.
Cored
Top Gasconade
Gasconade Dolomite
Arbuckle
Lower
Ordovician
Paleozoic
6900 6904 dolo dark gray hard dense very fine xln very vuggy
6904.0 6905.0 dolomite
6913.0 6915.3 dolomite
6915.3 6916.5 dolomite
6916.8 6918.5 dolomite
6918.5 6921.0 dolomite
6921.0 6922.0 dolomite
6927.0 6928.2 dolomite
6921.0 6934.2 dolomite packstone light brown
6934.2 6935.7 dolomite
6935.7 6939.2 dolomite mudstone light gray incipent ot
6939.2 6943.2 dolomite mudstone light brown dense
6943.2 6945.0 dolomite
6945.0 6947.5 dolomite
6947.5 6950.0 dolomite
6950.0 6953.0 dolomite mudstone to dolomite packstone
6953.0 6955.5 dolomite micrite
6955.5 6961.0 dolomite micrite brown dnese tite few lenses of dolomite packstone
6961.0 6963.8 dolomite micrite
6963.8 6966.0 dolomite micrite
6966.0 6970.8 dolomite mudstone - dolomite packstone brown pelloids pinpoint vugs
6970.8 6971.5 dolomite
6972.8 6973.9 dolomite
6975.0 6979.8 dolomite micrite - dolomite packstone dark gray brwon massive faint horizontal
6979.8 6982.5 dolomite
6982.5 6985.5 dolomite mudstone nodular relief
6985.5 6989.0 dolomite micrite gray - dark gray argillaceous
6989 6996 dolo light gray to white very hard very dense very fine xln slightly cherty slight green shale in spots
6996 7024 dolo light gray hard dense fine - very fine xln sub suc in spots green shale coarse rhom block dolo crystals
7024 7040 dolo white hard dense fine xln sub suc in spots vuggy slight colicastic in spots slight green shale
7040 7060 dolo light gray to dark gray very hard very dense fine-very fine xln vuggy slight chert interbed green shale
7060 7070 dolo light gray hard dense fine xln cherty slight green shale
7070 7080 dolo light gray to white hard fine xln interbedded green shale
7080 7090 dolo light gray to white hard fine xln interbedded green shale light chert
7090.0 7097.5 dolomite mudstone light brown occassional chert lens tite
Clay
Shale
Sandstone
Shaly Sandstone
Arkose
Limestone
Shaly Carbonate
Dolomite
Shaly Dolomite
Gypsum
Anhydrite
Salt
Coal
Igneous
K-Feldspar
Plagioclase
Ultramafic

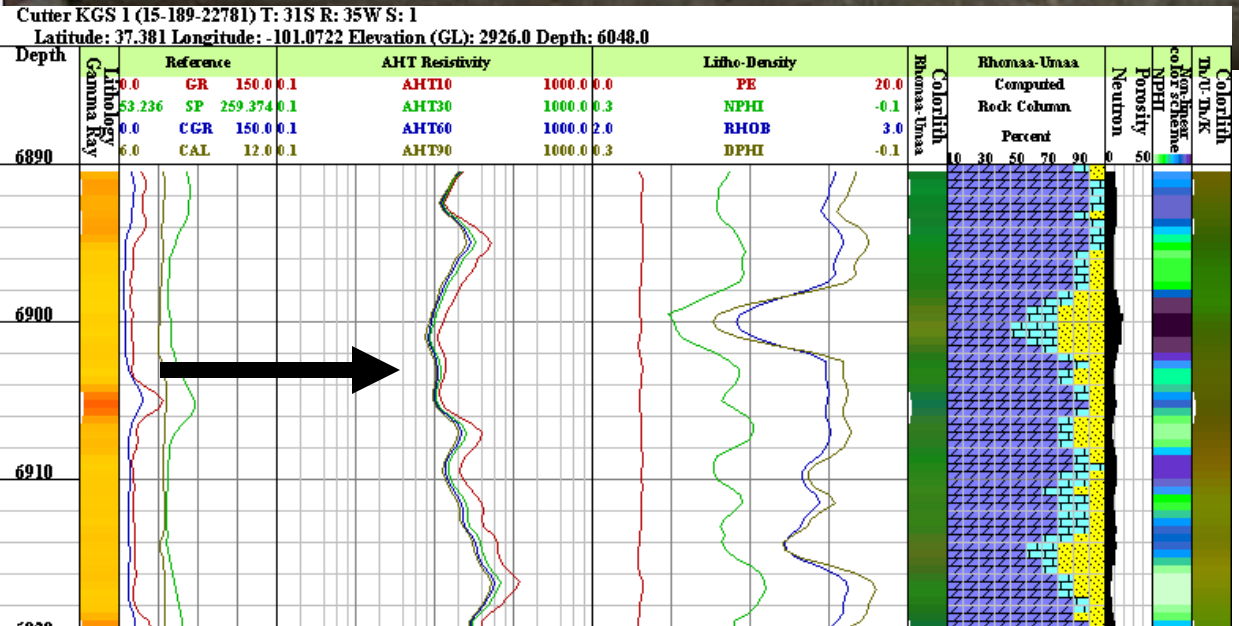
Lower Jefferson City-Cotter Fm, 6932 ft (core 3 ft high to log)



Lower Jefferson City-Cotter Fm, 6932 ft
(core 3 ft high to log)

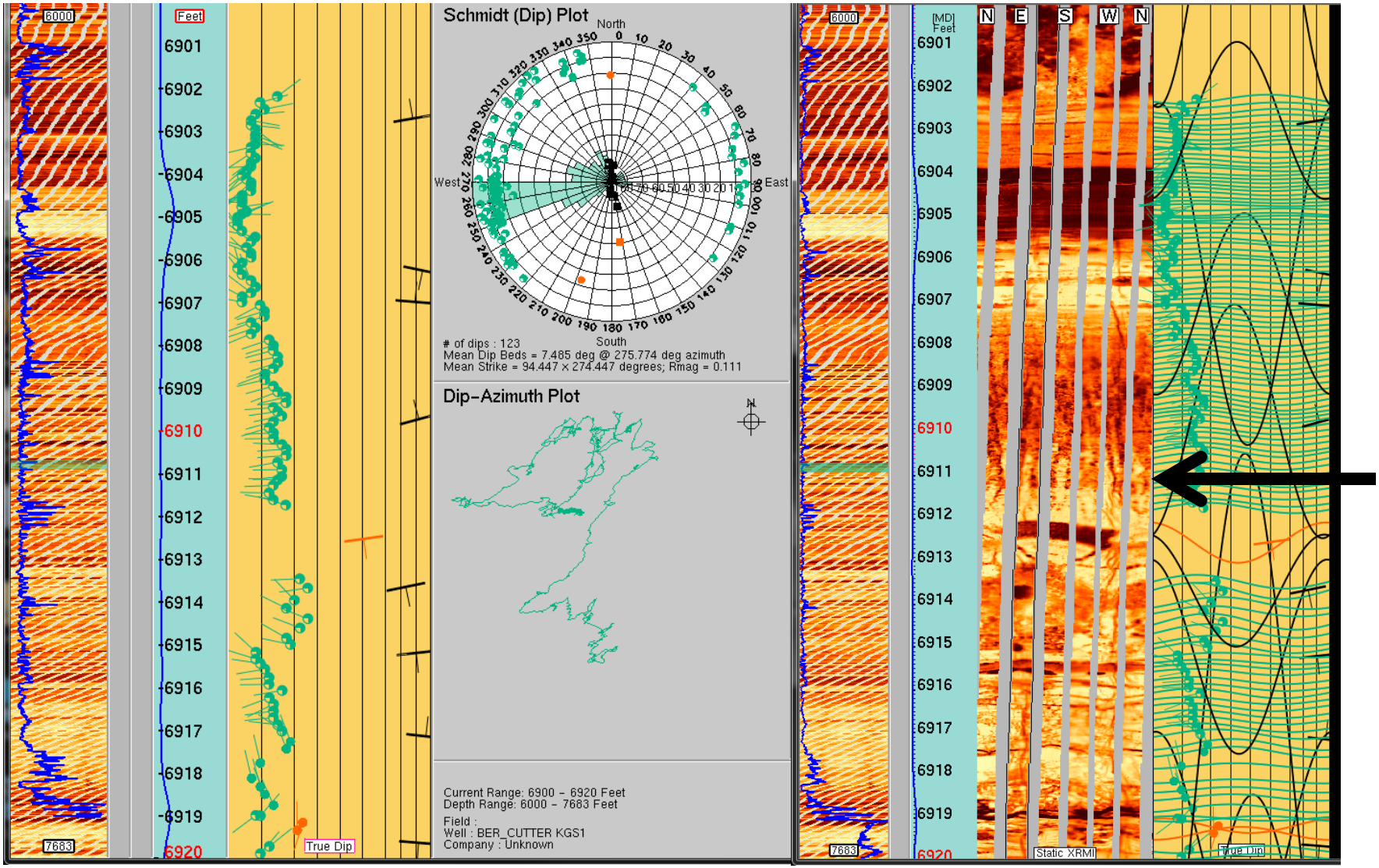
Lower Jefferson City-Cotter Fm, 6908-09 ft

(core 3 ft high to log)



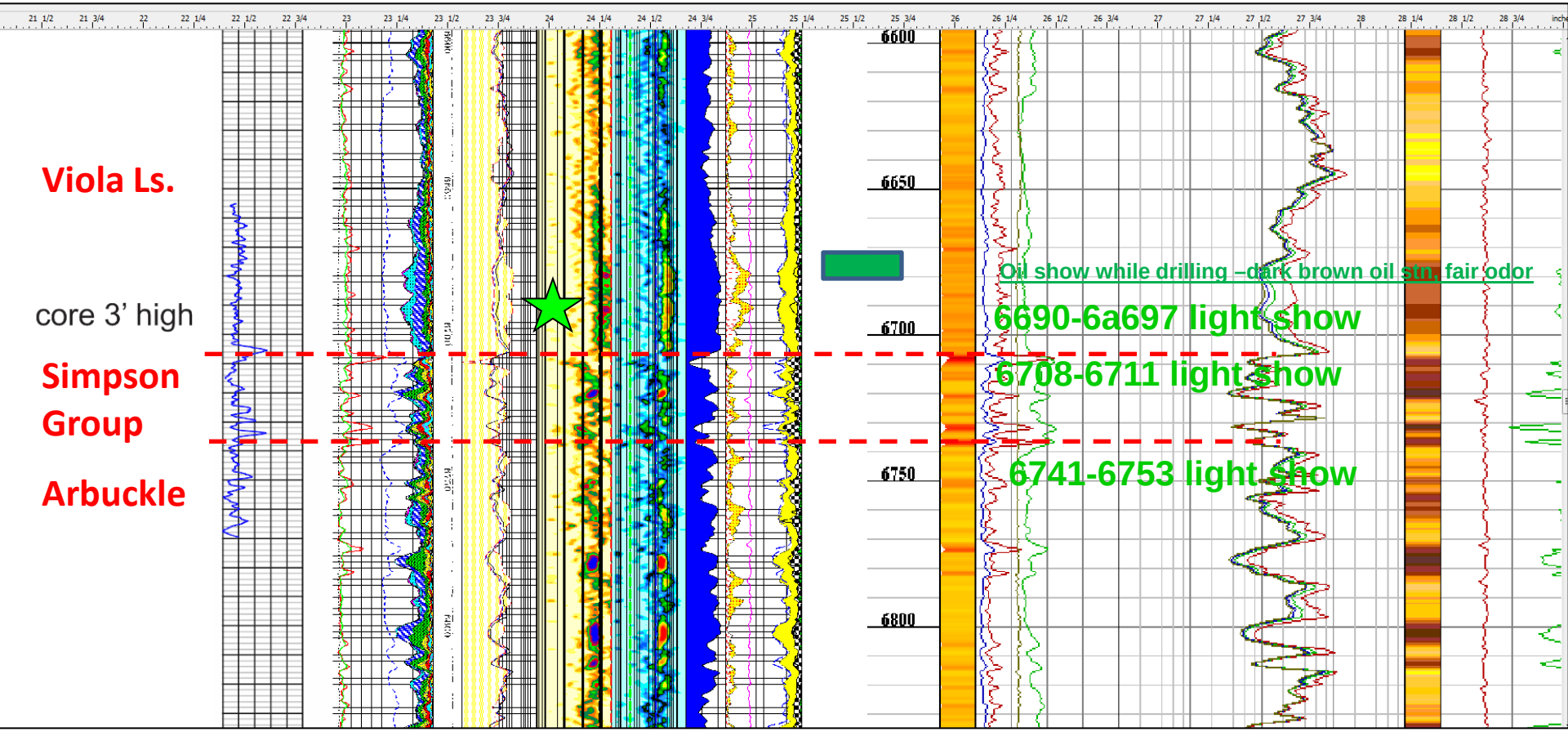
dolomite packstone to dolomite boundstone, light brown, stromatolite, mm-cm sized vugs, poor to fair porosity

Lower Jefferson City-Cotter Dolomite
UV Fluorescence Show in Stromatolite



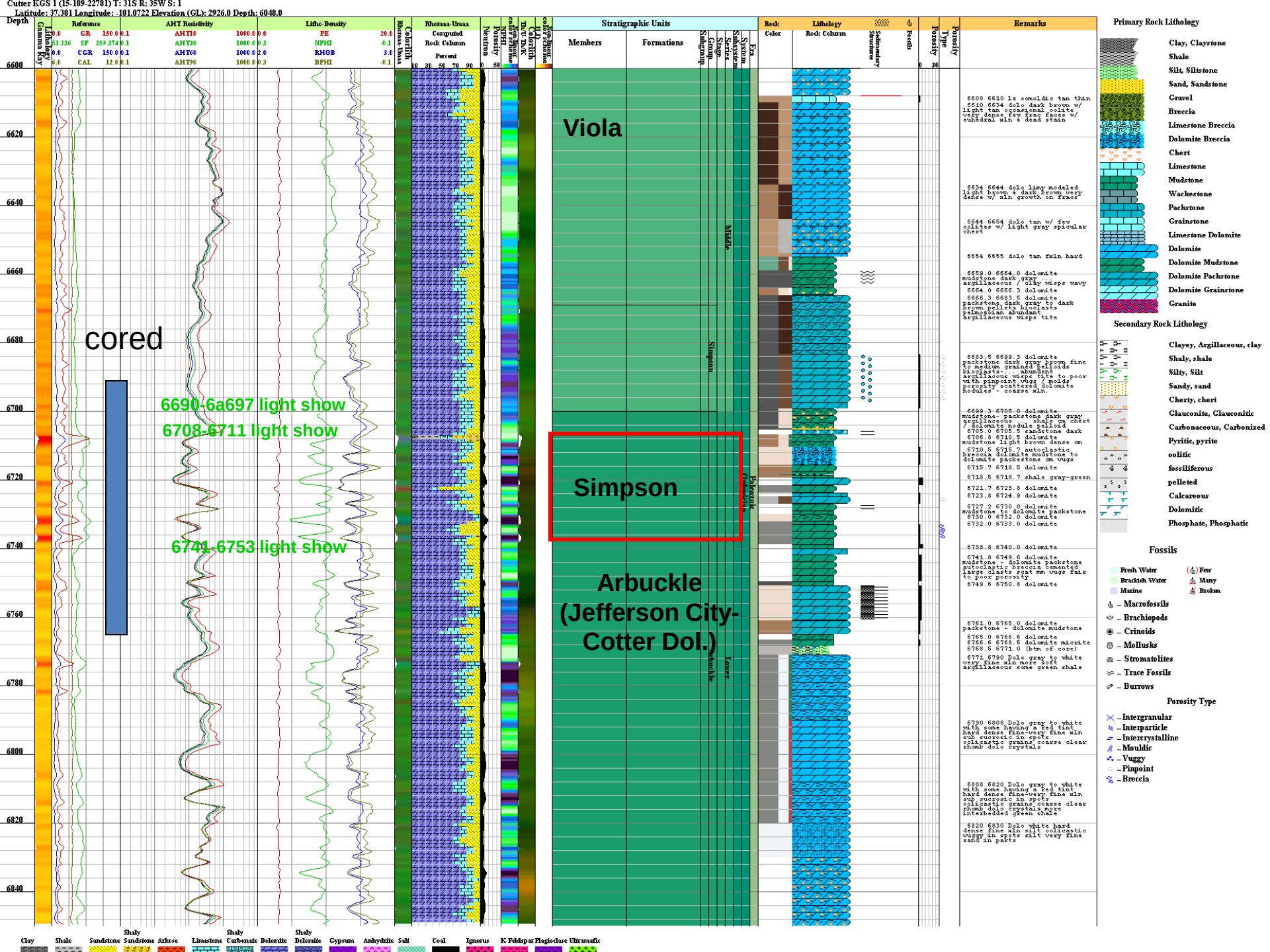
Base Viola Ls., Simpson Gp., and upper Arbuckle Gp.

-- More light oil shows

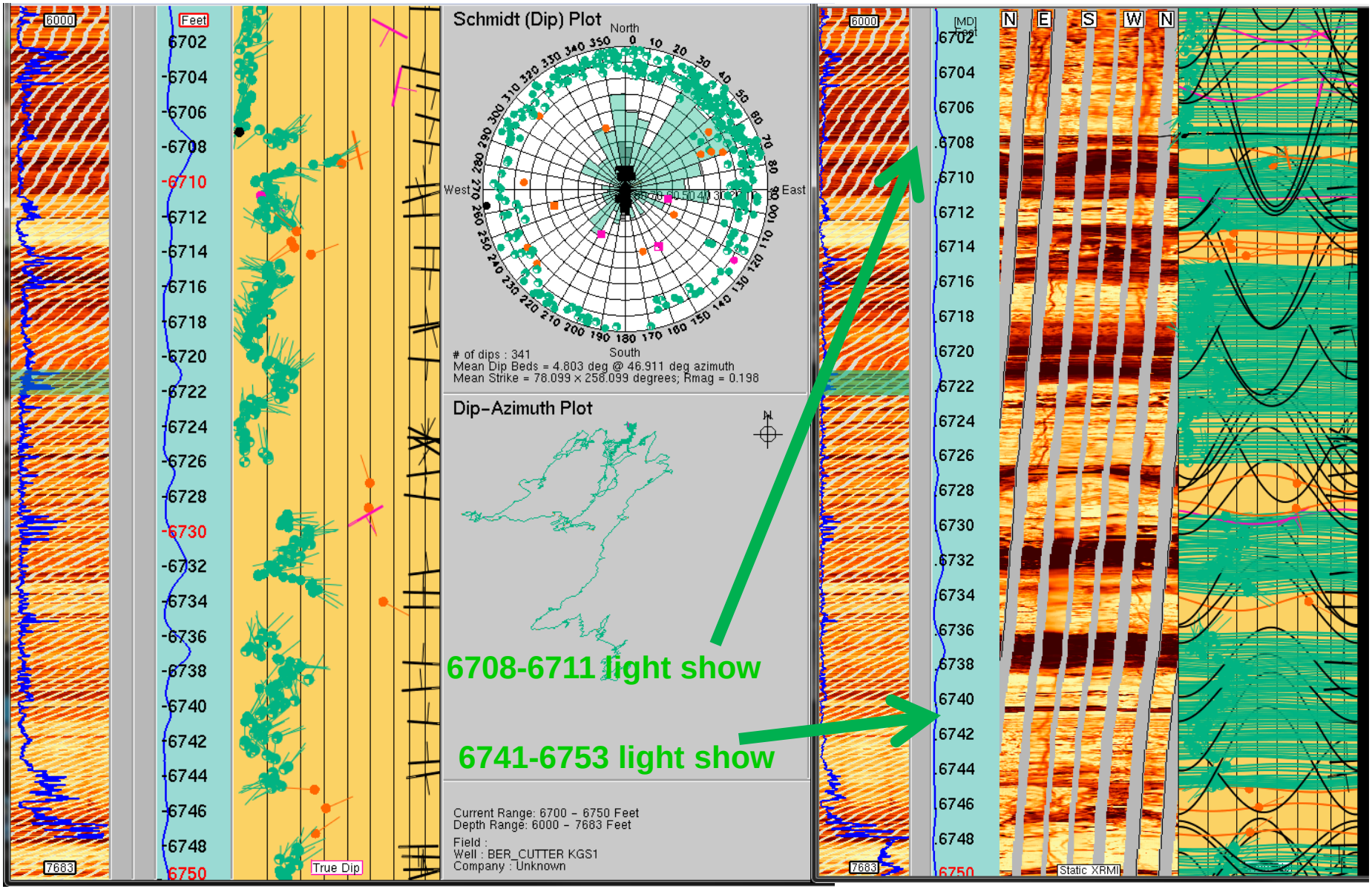


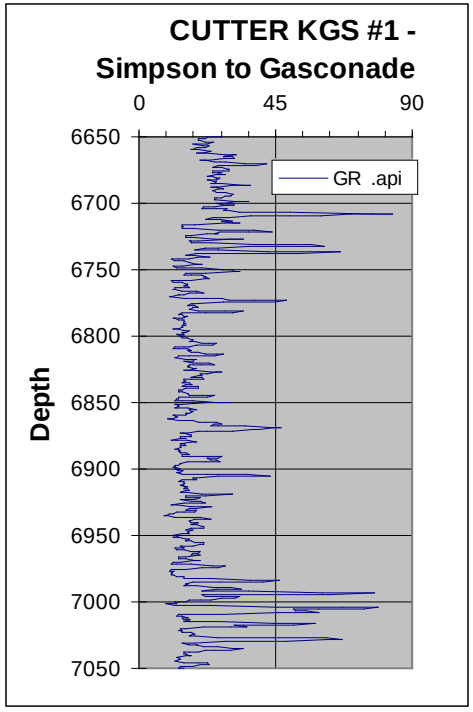
Cutter KGS 1 (15-189-22781) T: 31S R: 35W S: 1

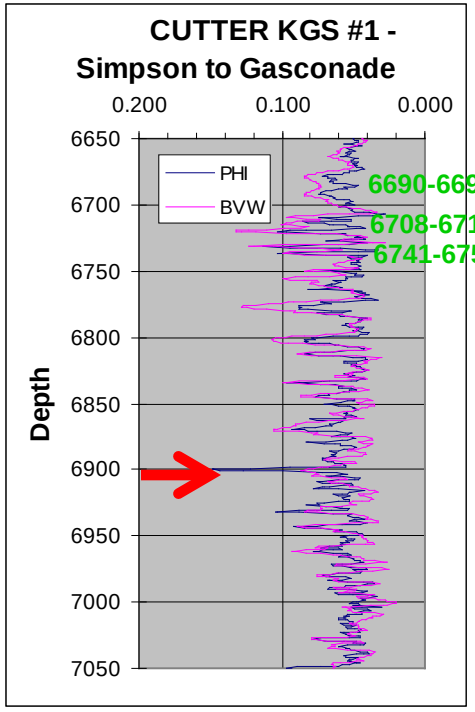
Latitude: 37.381 Longitude: -101.0722 Elevation (GL): 2926.0 Depth: 6048.0

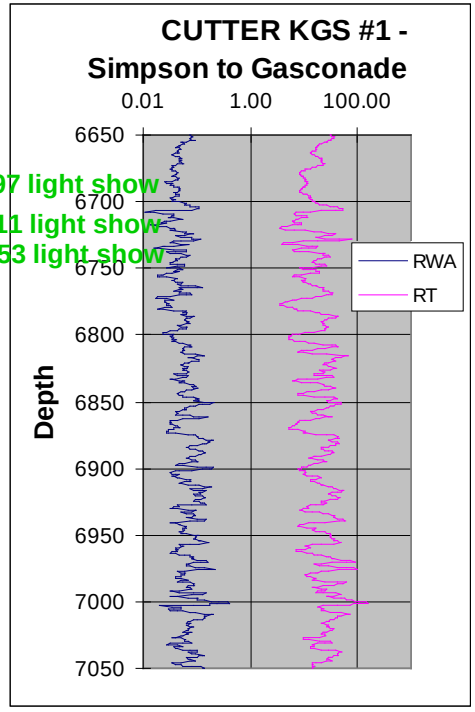


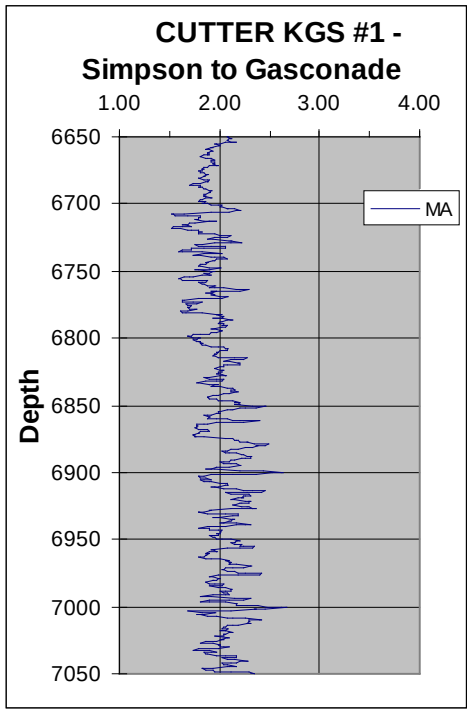
Simpson Group

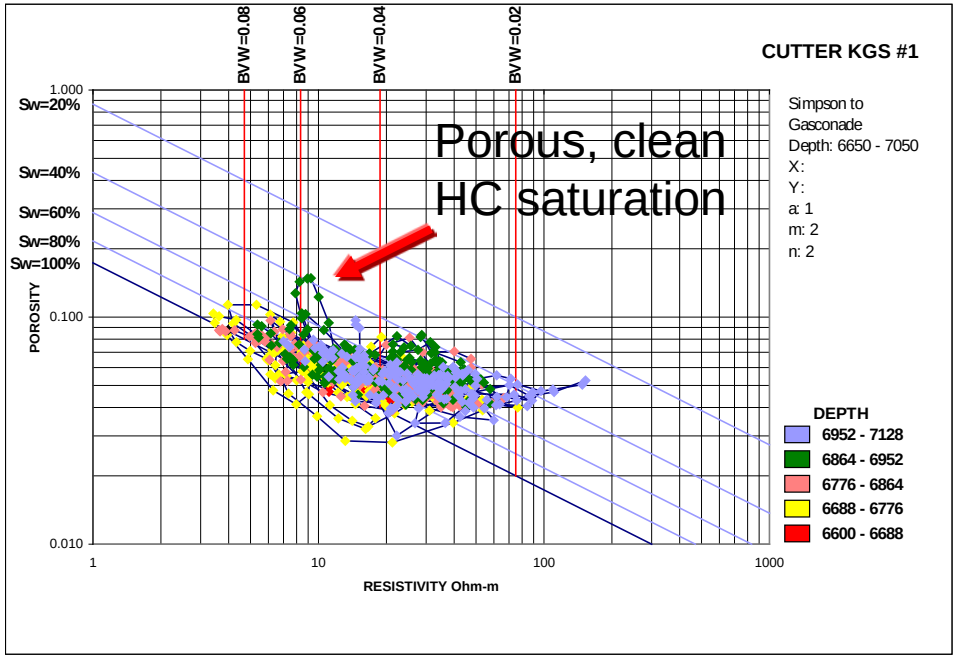


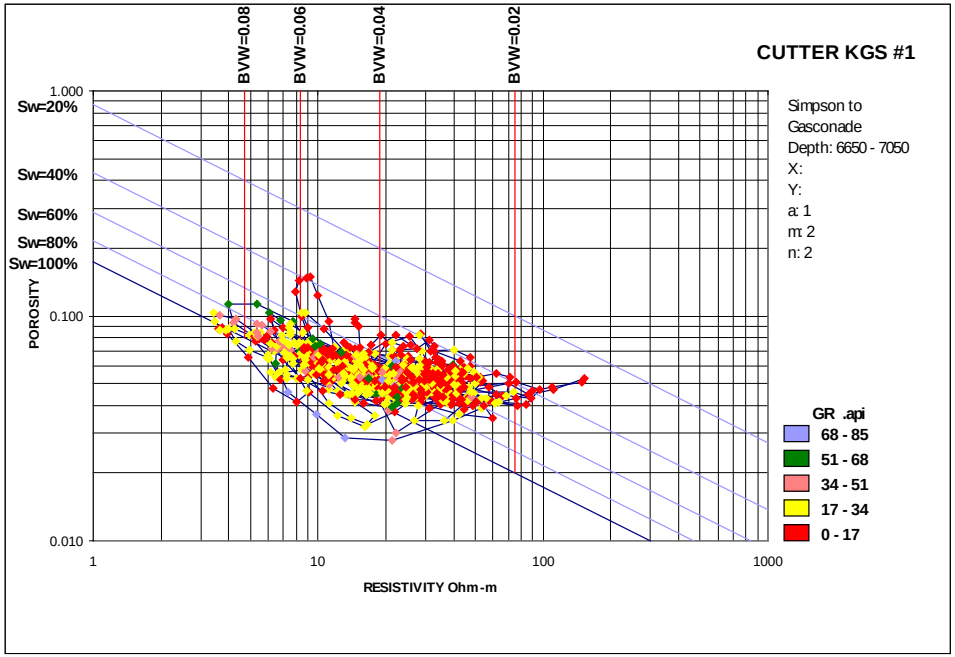

CUTTER KGS #1 -
Simpson to Gasconade
0
45
90
GR .api
Depth
6650
6700
6750
6800
6850
6900
6950
7000
7050


CUTTER KGS #1 -
Simpson to Gasconade
0.200
0.100
0.000
PHI
BVW
6690-6697 light show
6708-6711 light show
6741-6753 light show
Depth
6650
6700
6750
6800
6850
6900
6950
7000
7050

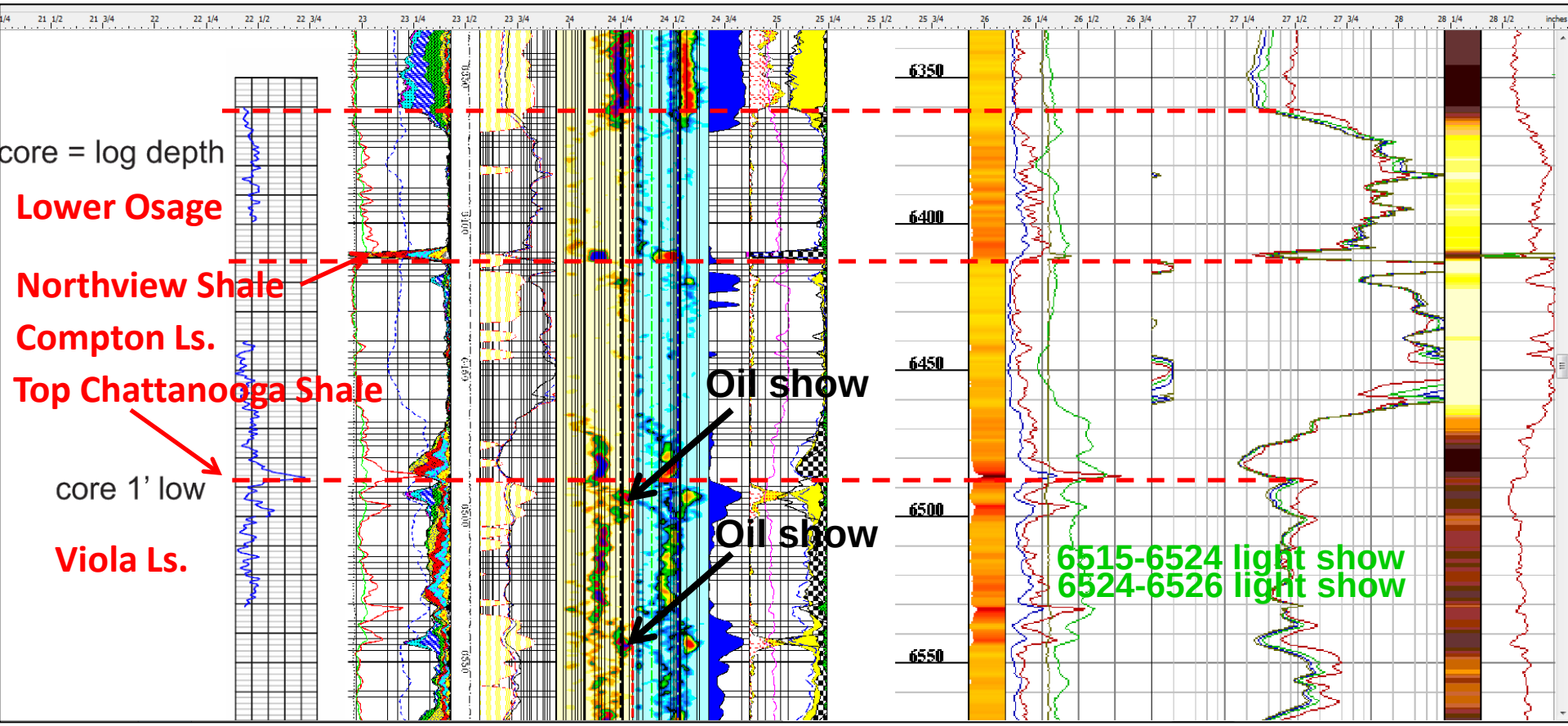

CUTTER KGS #1 -
Simpson to Gasconade
0.01
1.00
100.00
RWA
RT
Depth
6650
6700
6750
6800
6850
6900
6950
7000
7050

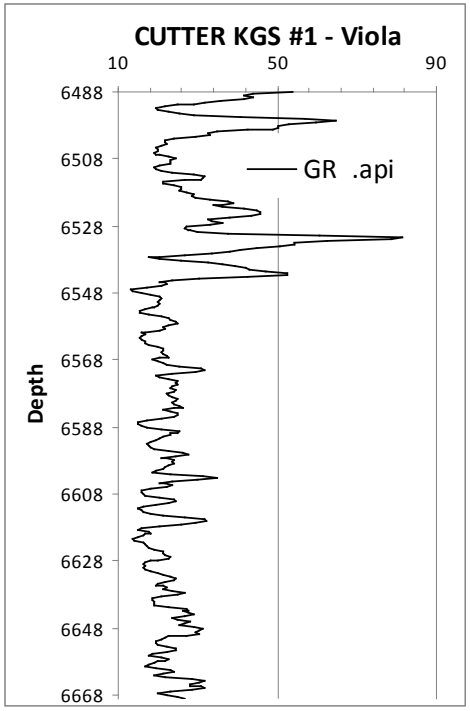

CUTTER KGS #1 -
Simpson to Gasconade
1.00
2.00
3.00
4.00
MA
Depth
6650
6700
6750
6800
6850
6900
6950
7000
7050

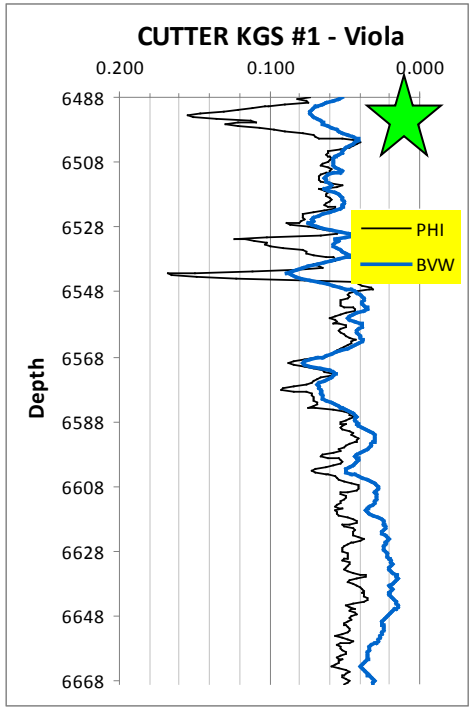

CUTTER KGS #1
BVW=0.08
BVW=0.06
BVW=0.04
BVW=0.02
Porous, clean
HC saturation
Sw=20%
Sw=40%
Sw=60%
Sw=80%
Sw=100%
POROSITY
1.000
0.100
0.010
1
10
100
1000
RESISTIVITY Ohm-m
Simpson to
Gasconade
Depth: 6650 - 7050
X:
Y:
a: 1
m: 2
n: 2
DEPTH
6952 - 7128
6864 - 6952
6776 - 6864
6688 - 6776
6600 - 6688

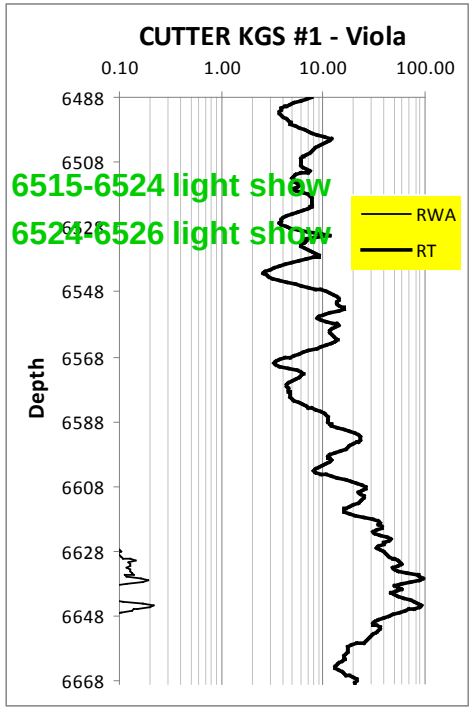

CUTTER KGS #1
BVW=0.08
BVW=0.06
BVW=0.04
BVW=0.02
Sw=20%
Sw=40%
Sw=60%
Sw=80%
Sw=100%
POROSITY
1.000
0.100
0.010
1
10
100
1000
RESISTIVITY Ohm-m
Simpson to
Gasconade
Depth: 6650 - 7050
X:
Y:
a: 1
m: 2
n: 2
GR .api
68 - 85
51 - 68
34 - 51
17 - 34
0 - 17

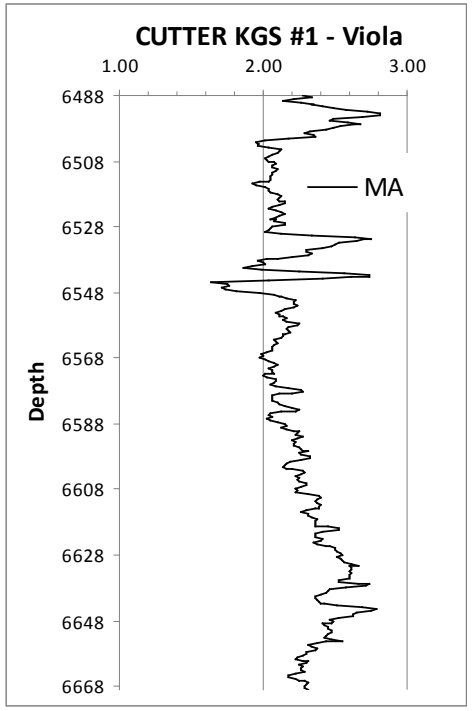
Lower Osage, Northview Sh., Compton Ls., Chattanooga Sh., and upper Viola Ls.

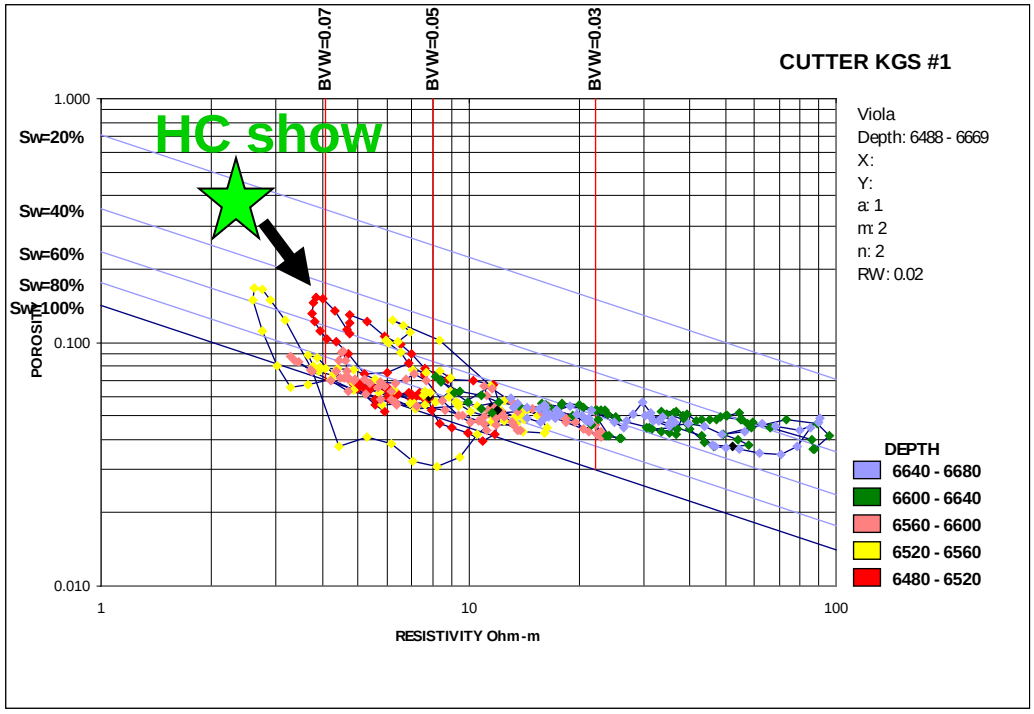



CUTTER KGS #1 - Viola
10
50
90
6488
6508
6528
6548
6568
6588
6608
6628
6648
6668
Depth
GR .api

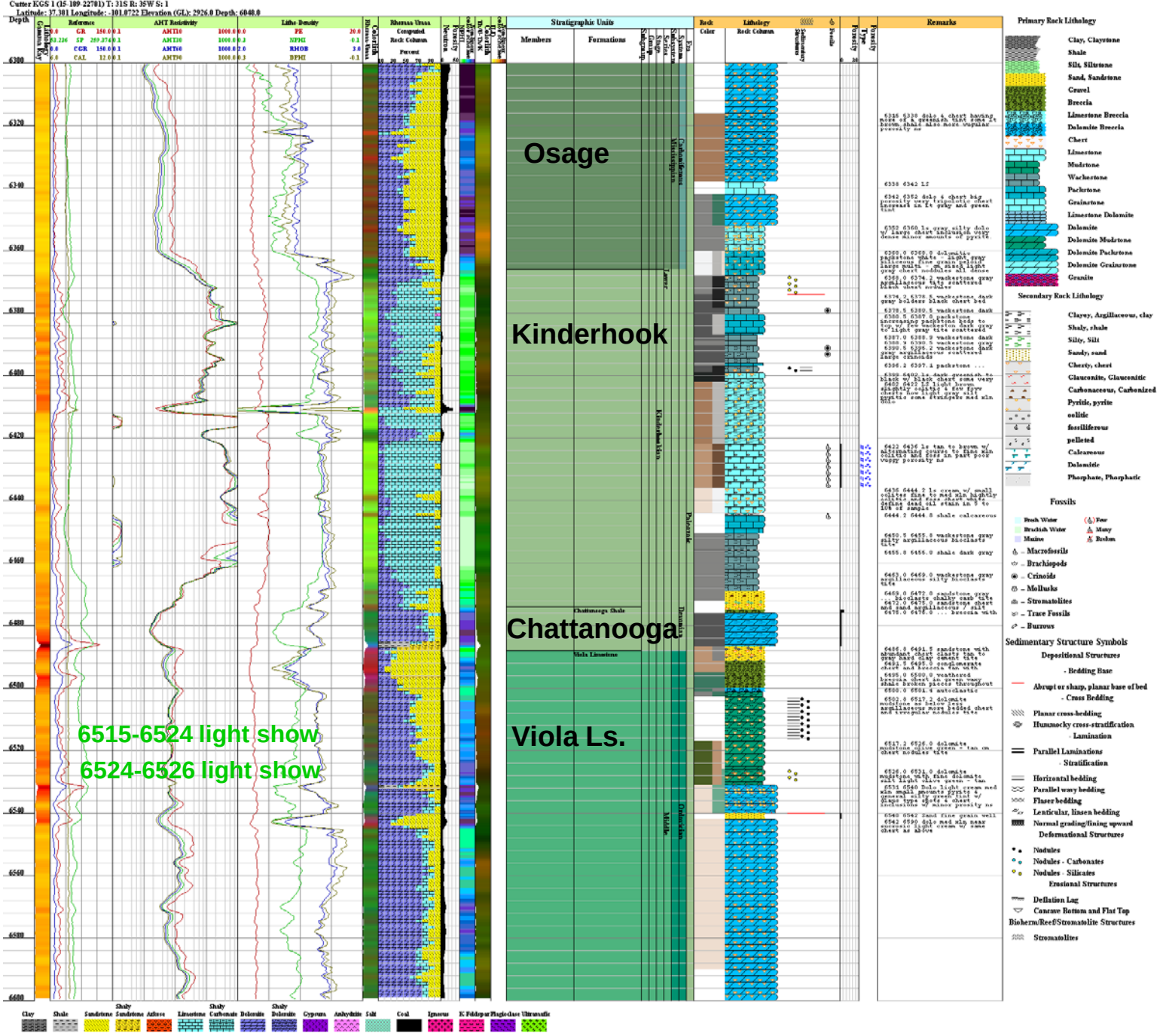

CUTTER KGS #1 - Viola
0.200
0.100
0.000
6488
6508
6528
6548
6568
6588
6608
6628
6648
6668
Depth
PHI
BVW


CUTTER KGS #1 - Viola
0.10
1.00
10.00
100.00
6488
6508
6528
6548
6568
6588
6608
6628
6648
6668
Depth
6515-6524 light show
6524-6526 light show
RWA
RT

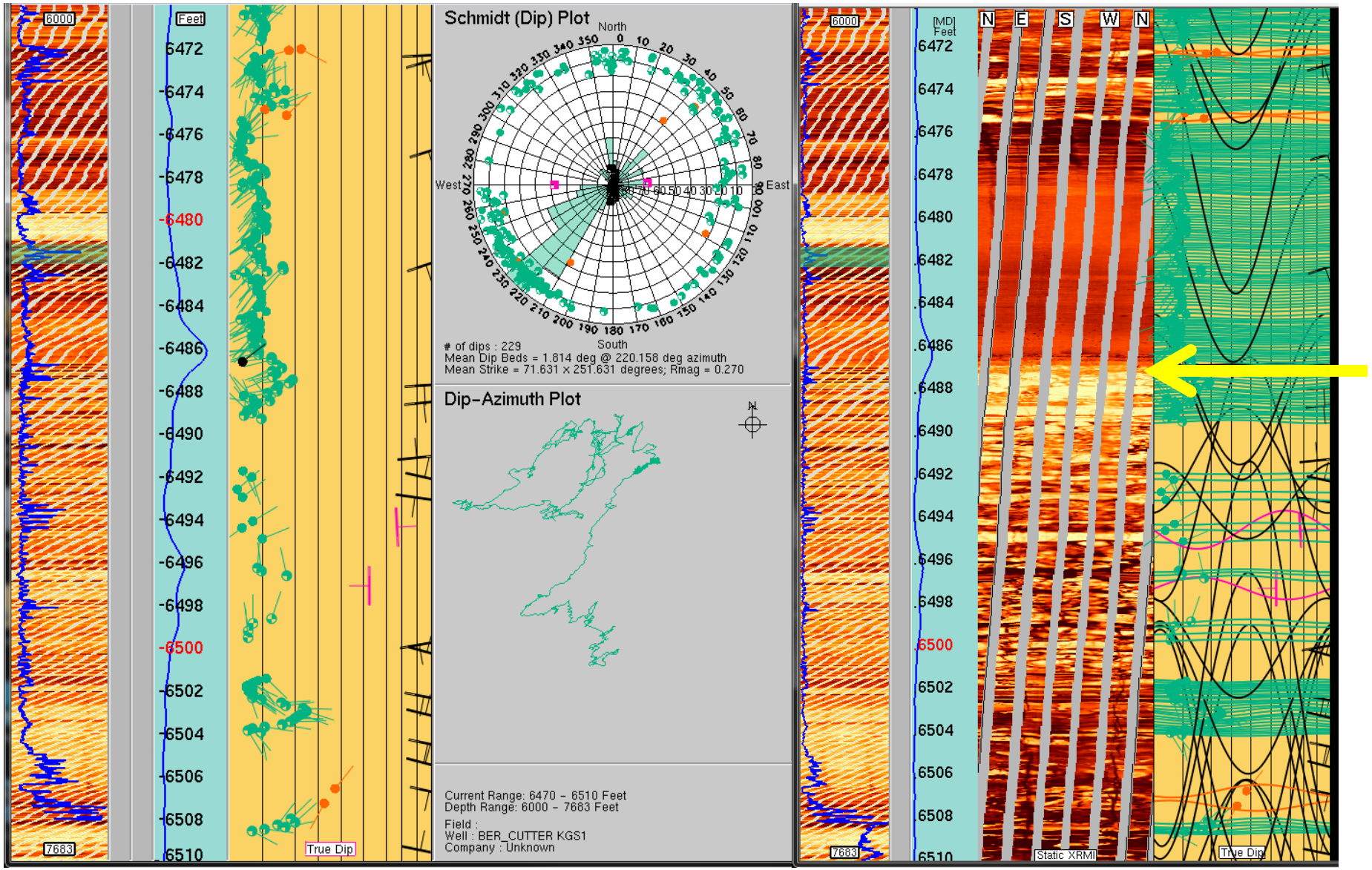

CUTTER KGS #1 - Viola
1.00
2.00
3.00
6488
6508
6528
6548
6568
6588
6608
6628
6648
6668
Depth
MA


BVW=0.07
BVW=0.05
BVW=0.03
CUTTER KGS #1
HC show
1.000
0.100
0.010
Sw=20%
Sw=40%
Sw=60%
Sw=80%
Sw=100%
POROSITY
1
10
100
RESISTIVITY Ohm-m
Viola
Depth: 6488 - 6669
X:
Y:
a: 1
m: 2
n: 2
RW: 0.02
DEPTH
6640 - 6680
6600 - 6640
6560 - 6600
6520 - 6560
6480 - 6520

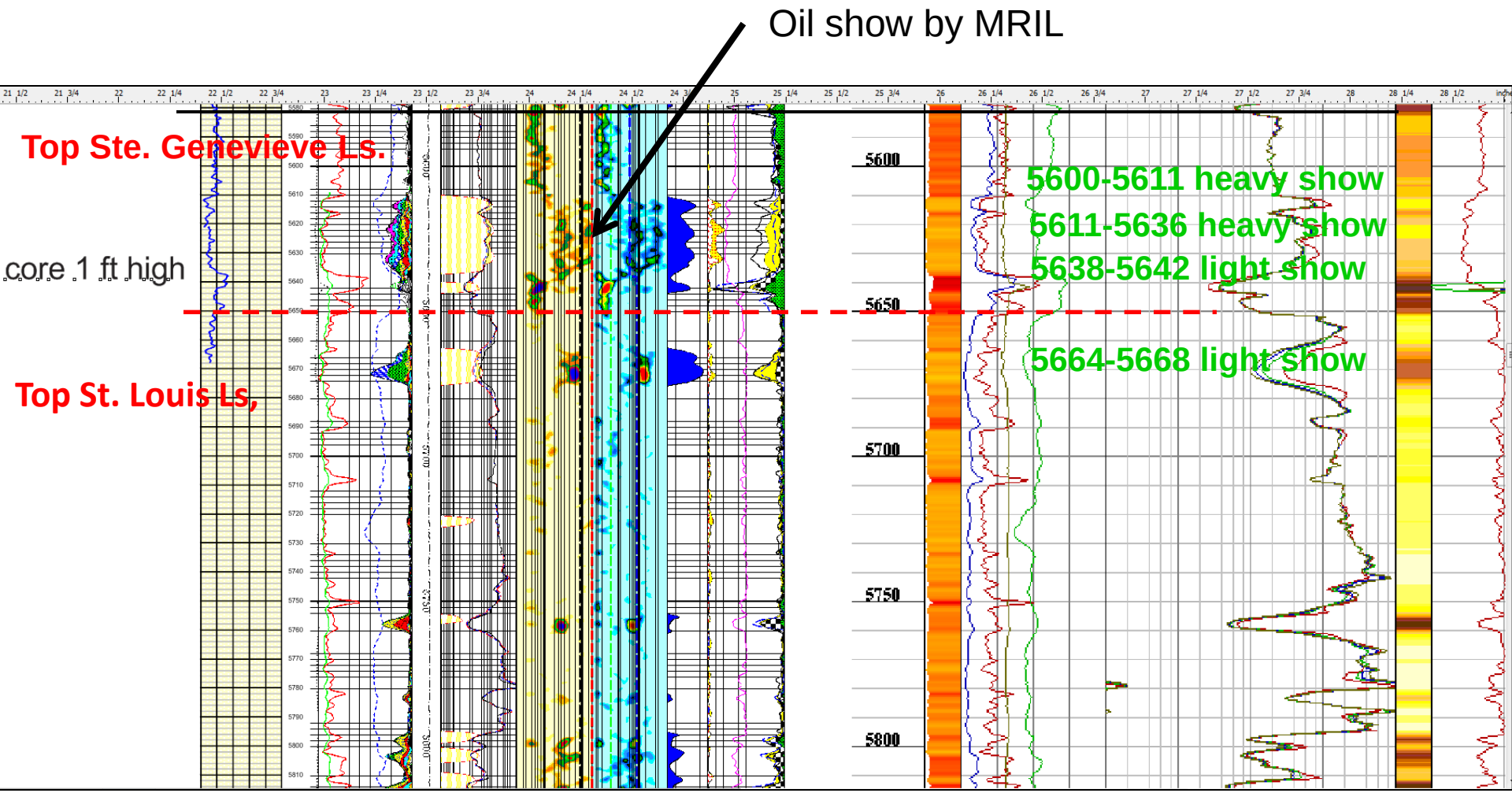
cored


Cutter KGS 1 (15-109-22701) T: 31S R: 35W S: 1
Latitude: 37.301 Longitude: -101.0722 Elevation (GL): 2926.0 Depth: 6048.0
Depth
Reference
Gamma Ray
GR 150.0 0.1
SP 250 -250 0.1
CGR 150.0 0.1
CAL 12.0 0.1
AHT Resistivity
AHT10 1000.0 0.2
AHT20 1000.0 0.2
AHT60 1000.0 2.0
AHT90 1000.0 0.2
Litho Density
PE 20.0 -0.1
NPHI 60 -0.1
RHOB 3.0 2.0
DPHI 60 -0.1
Rhomaa Urmaa
Compacted Rock Columns
Percent
Neutron
Density
Caliper
Stratigraphic Units
Members
Formations
Rock Color
Lithology
Rock Columns
Sedimentary Structures
Porosity
Remarks
Osage
Kinderhook
Chattanooga
Viola Ls.
6515-6524 light show
6524-6526 light show
Primary Rock Lithology
Clay, Claystone
Shale
Silt, Siltstone
Sand, Sandstone
Gravel
Breccia
Limestone Breccia
Dolomite Breccia
Chert
Limestone
Mudstone
Wackestone
Packstone
Grainstone
Limestone Dolomite
Dolomite
Dolomite Mudstone
Dolomite Packstone
Dolomite Grainstone
Granite
Secondary Rock Lithology
Clayey, Argillaceous, clay
Shaly, shale
Silty, Silt
Sandy, sand
Cherty, chert
Glauconite, Glauconitic
Carbonaceous, Carbonized
Pyritic, pyrite
oolitic
fossiliferous
pelleted
Calcareous
Dolomitic
Phosphate, Phosphatic
Fossils
Fresh Water
Brackish Water
Marine
Few
Many
Recbn
Macrofossils
Brachiopods
Crinoids
Mollusks
Stromatolites
Trace Fossils
Burrows
Sedimentary Structure Symbols
Depositional Structures
Bedding Base
Abrupt or sharp, planar base of bed
Cross Bedding
Planar cross-bedding
Hummocky cross-stratification
Lamination
Parallel Laminations
Stratification
Horizontal bedding
Parallel wavy bedding
Flaser bedding
Lenticular, Linsen bedding
Normal grading/fining upward
Deformational Structures
Nodules
Nodules - Carbonates
Nodules - Silicates
Erosional Structures
Deflation Lag
Concave Bottom and Flat Top
Bioherm/Reef/Stromatolite Structures
Stromatolites
Clay
Shale
Sandstone
Shaly Sandstone
Anhyd
Limestone
Shaly Carbonate
Dolomite
Shaly Dolomite
Gypsum
Anhydrite
Salt
Coal
Igneous
K Feldspar
Plagioclase
Ultramafic

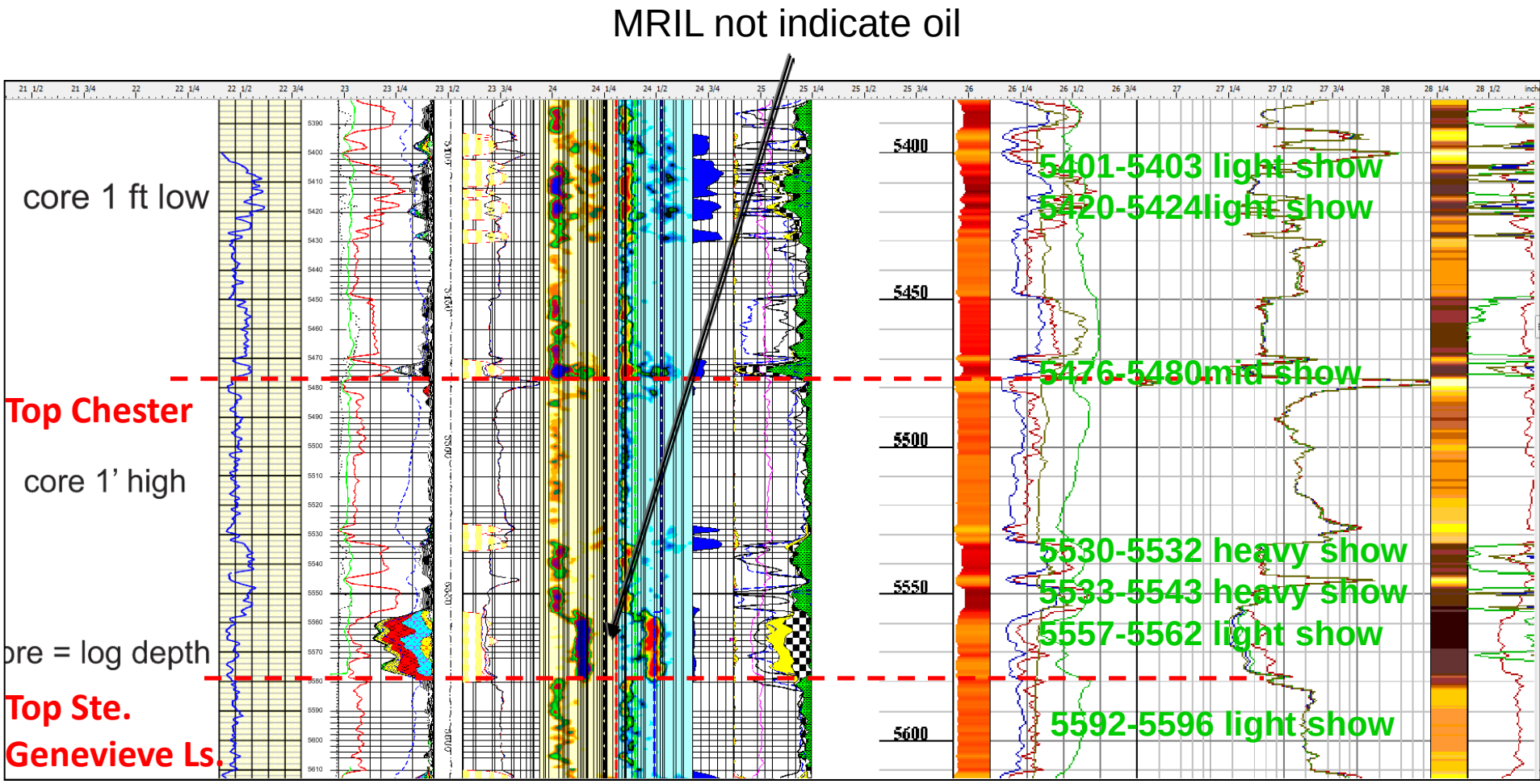
Chattanooga Shale-Viola Ls. Contact

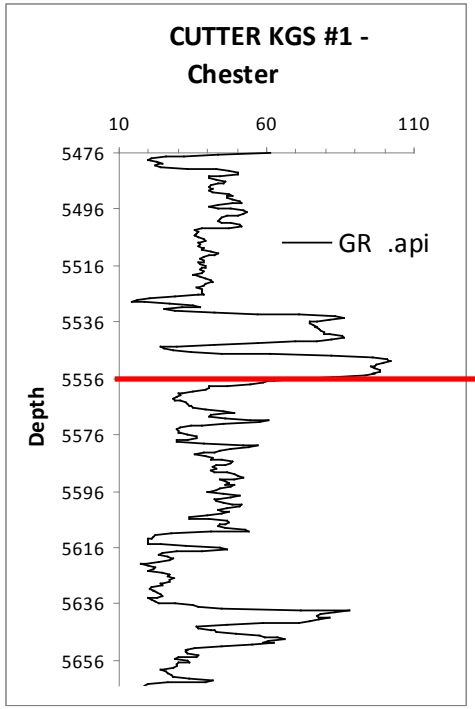


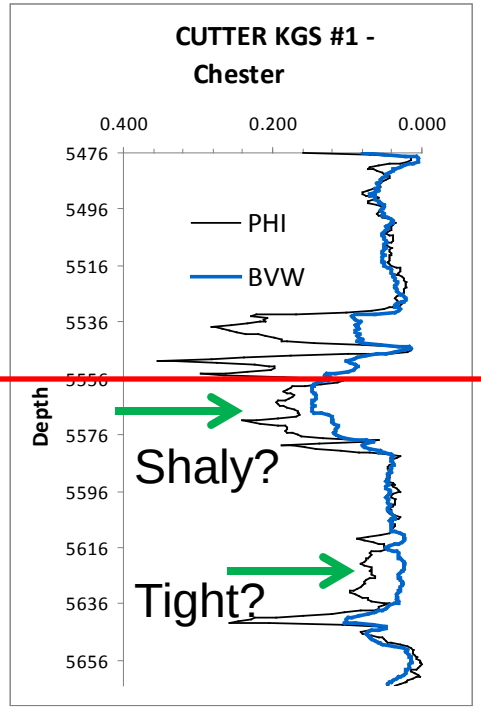
Lower Ste. Genevieve Ls. and upper St. Louis Ls.

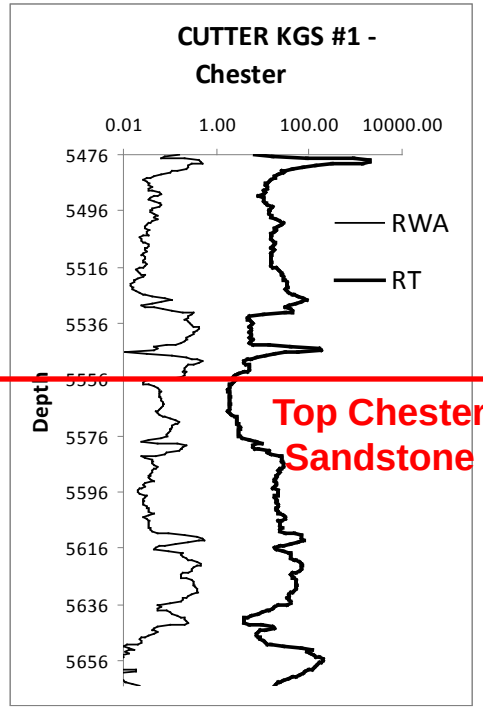


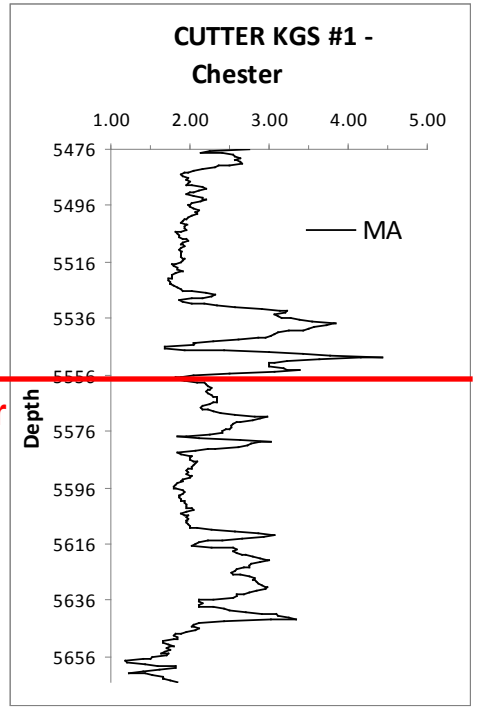
Lower Morrow to upper Chester

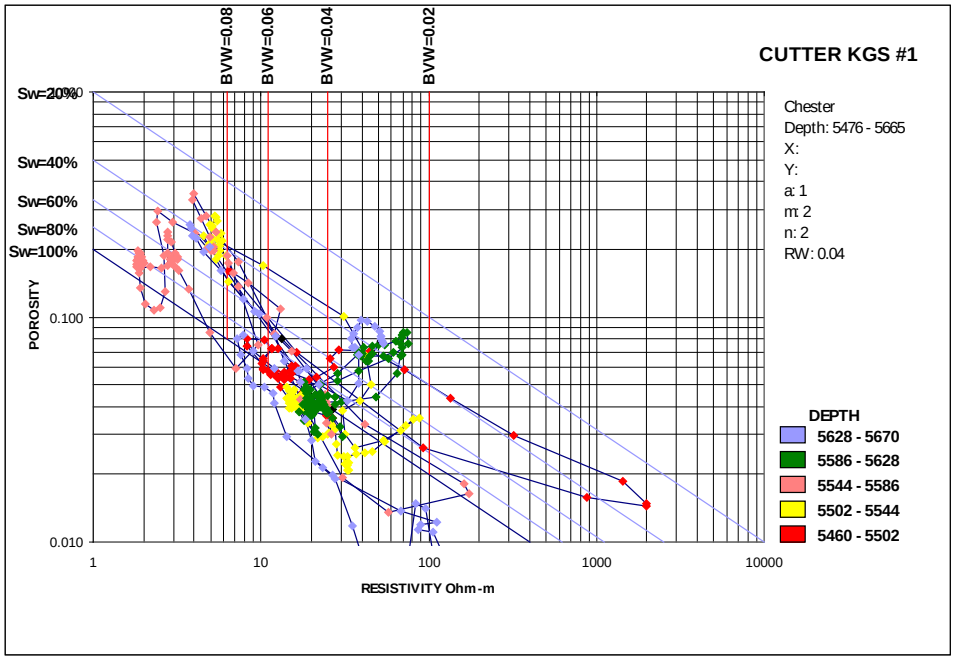


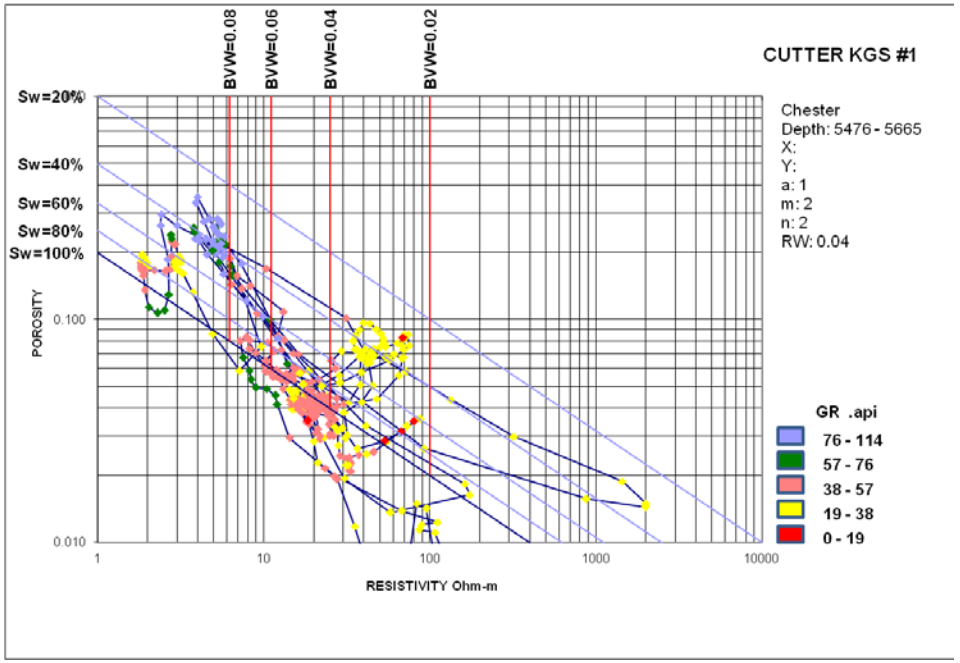

CUTTER KGS #1 - Chester
10
60
110
GR .api
Depth
5476
5496
5516
5536
5556
5576
5596
5616
5636
5656


CUTTER KGS #1 - Chester
0.400
0.200
0.000
PHI
BVW
Depth
Shaly?
Tight?

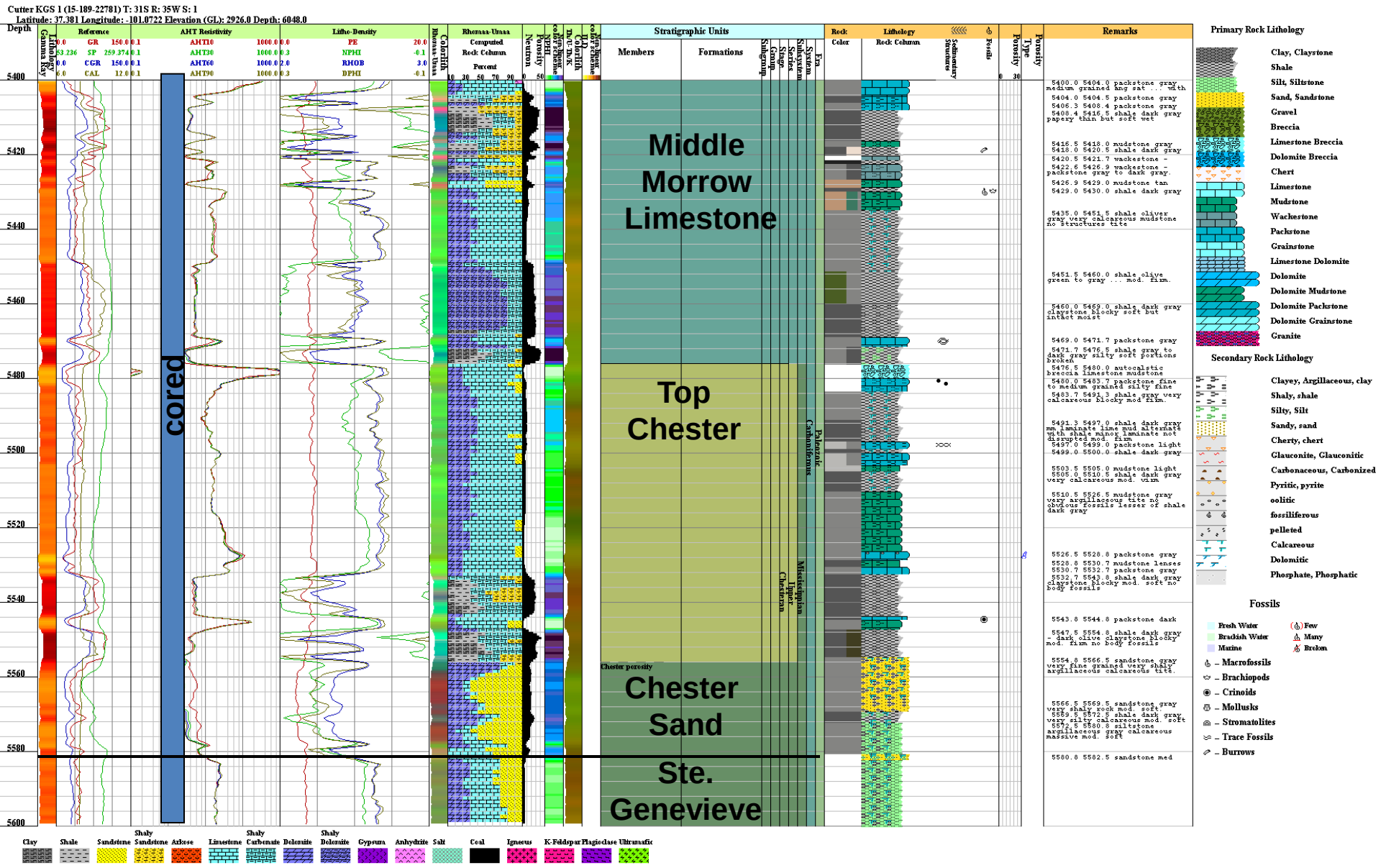

CUTTER KGS #1 - Chester
0.01
1.00
100.00
10000.00
RWA
RT
Depth
Top Chester Sandstone


CUTTER KGS #1 - Chester
1.00
2.00
3.00
4.00
5.00
MA
Depth

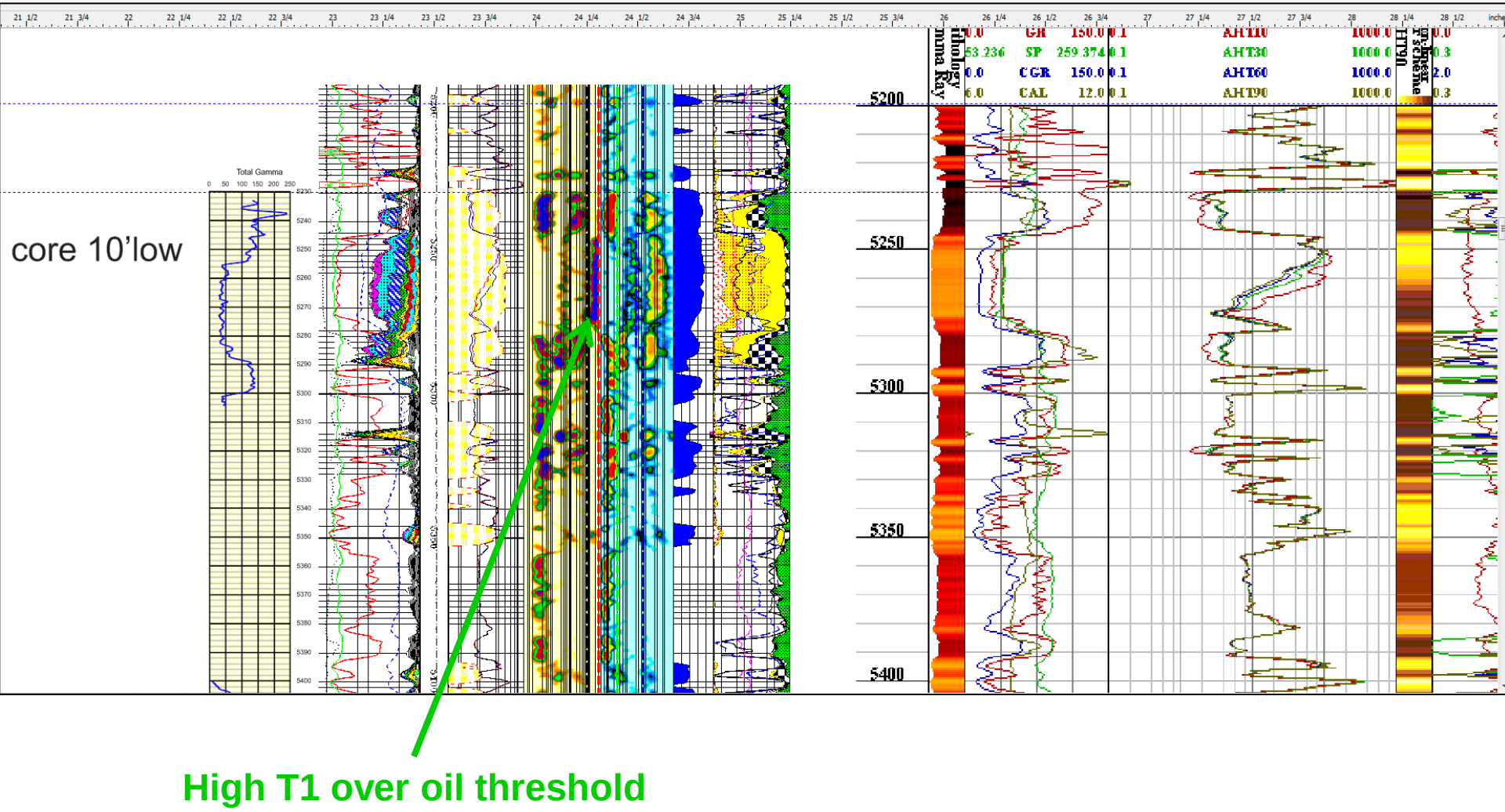

CUTTER KGS #1
BVW=0.08
BVW=0.06
BVW=0.04
BVW=0.02
Sw=20%
Sw=40%
Sw=60%
Sw=80%
Sw=100%
POROSITY
0.100
0.010
1
10
100
1000
10000
RESISTIVITY Ohm-m
Chester
Depth: 5476 - 5665
X:
Y:
a: 1
m: 2
n: 2
RW: 0.04
DEPTH
5628 - 5670
5586 - 5628
5544 - 5586
5502 - 5544
5460 - 5502


CUTTER KGS #1
BVW=0.08
BVW=0.06
BVW=0.04
BVW=0.02
Sw=20%
Sw=40%
Sw=60%
Sw=80%
Sw=100%
POROSITY
0.100
0.010
1
10
100
1000
10000
RESISTIVITY Ohm-m
Chester
Depth: 5476 - 5665
X:
Y:
a: 1
m: 2
n: 2
RW: 0.04
GR .api
76 - 114
57 - 76
38 - 57
19 - 38
0 - 19

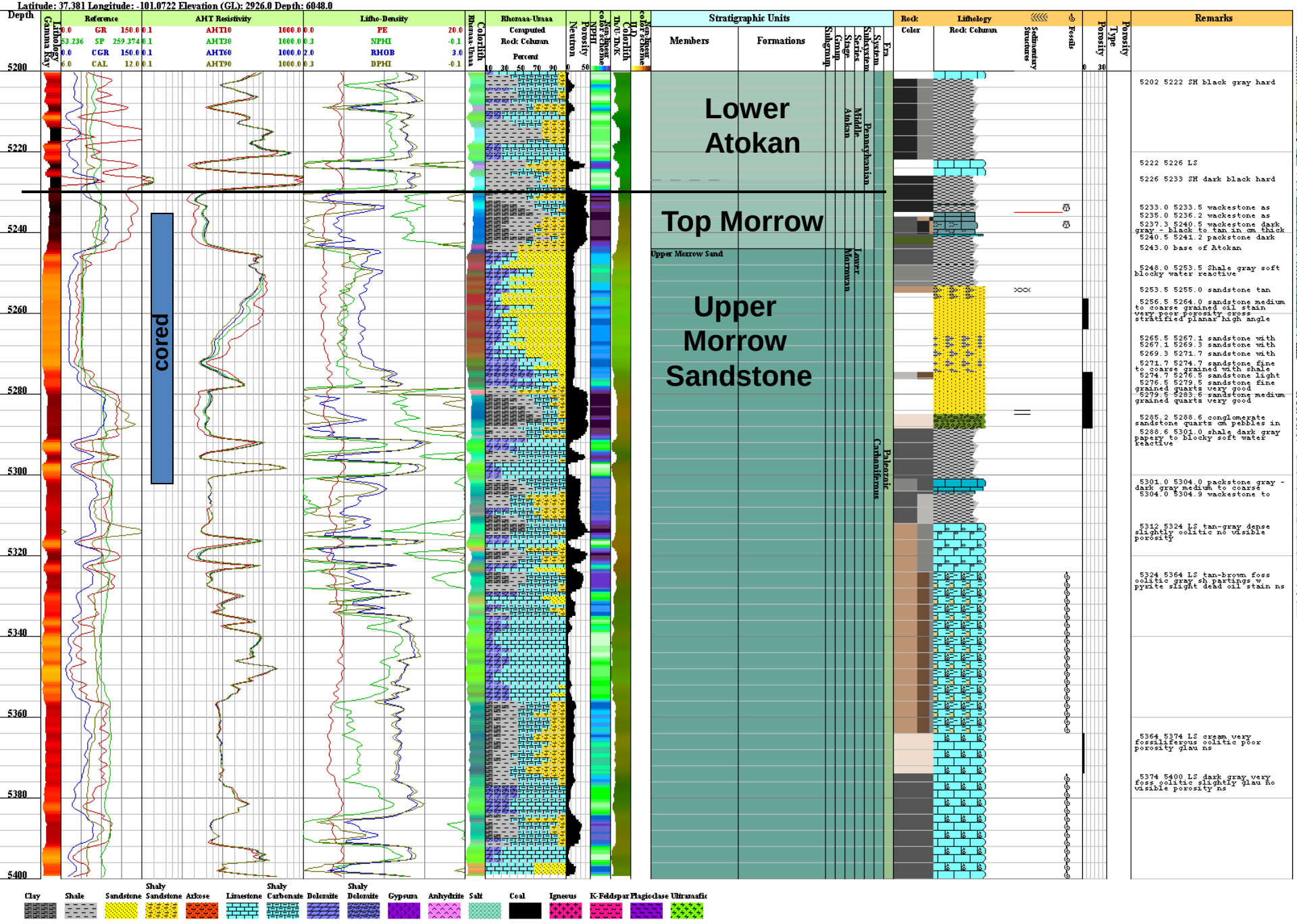
Lower Morrow to St. Genevieve Ls.

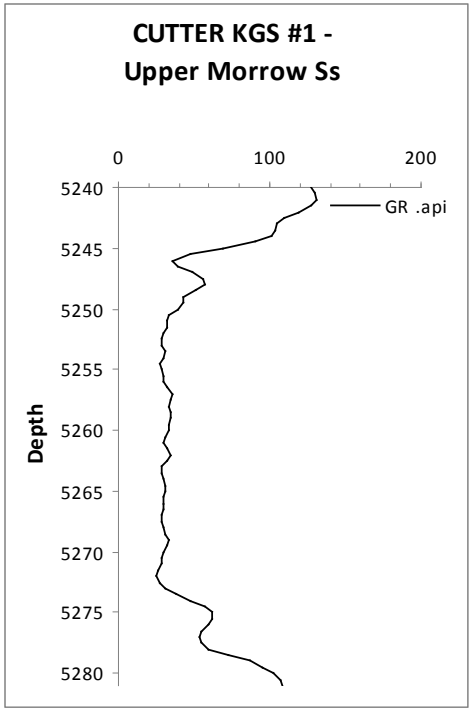


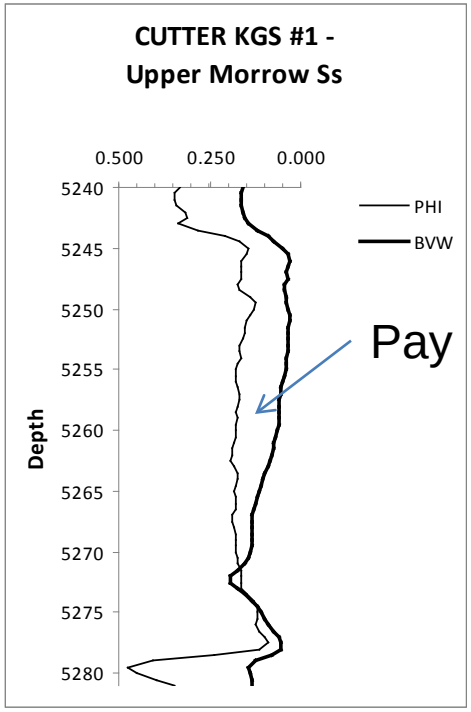
Upper Morrow Sandstone
-- Pay zone for Cutter Field

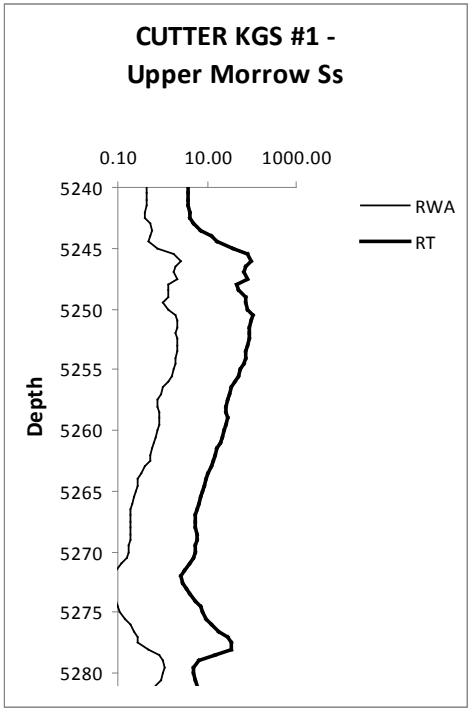


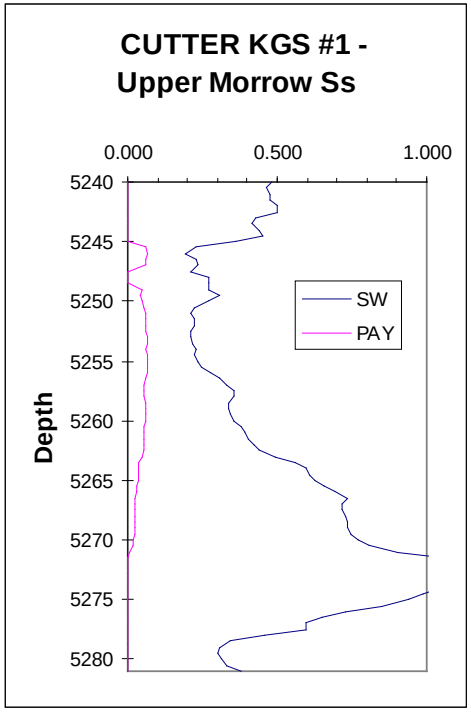
Cutter KGS 1 (15-189-22781) T: 31S R: 35W S: 1
Latitude: 37.381 Longitude: -101.0722 Elevation (GL): 2926.0 Depth: 6048.0

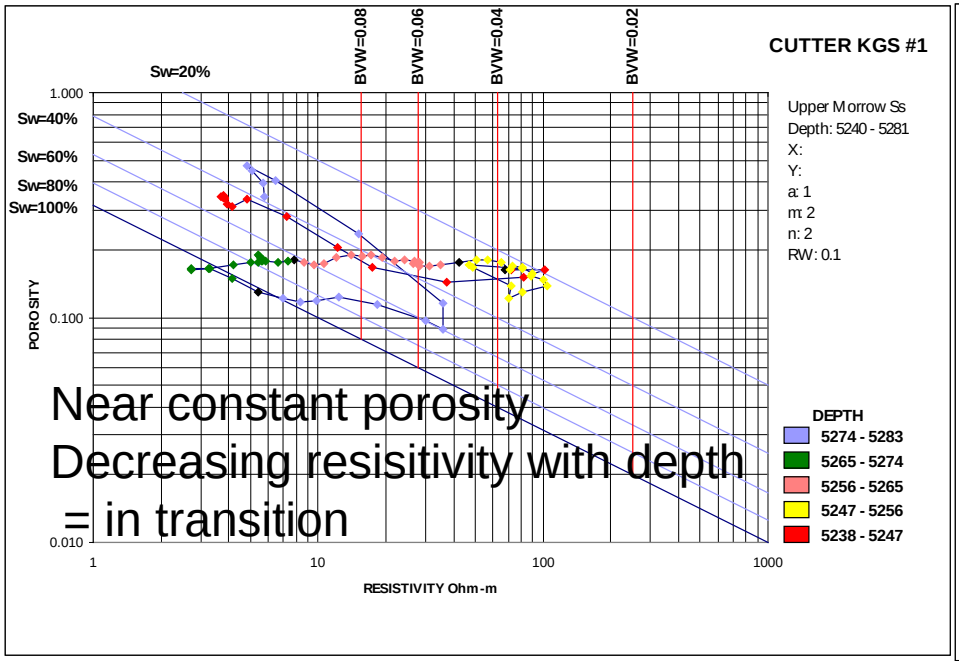


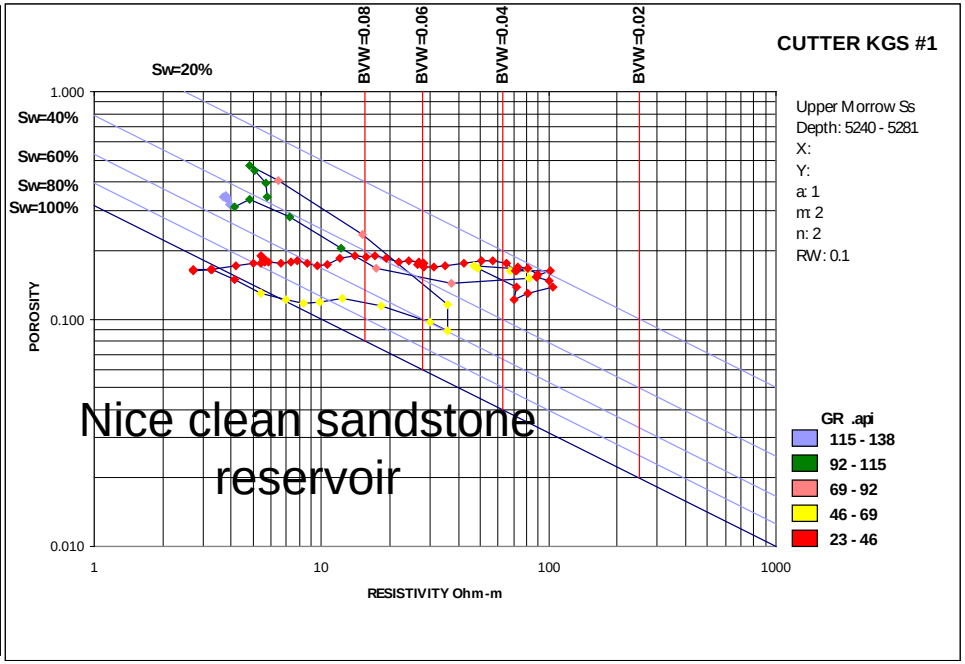

CUTTER KGS #1 -
Upper Morrow Ss
0
100
200
GR .api
Depth
5240
5245
5250
5255
5260
5265
5270
5275
5280


CUTTER KGS #1 -
Upper Morrow Ss
0.500
0.250
0.000
PHI
BVW
Pay
Depth
5240
5245
5250
5255
5260
5265
5270
5275
5280


CUTTER KGS #1 -
Upper Morrow Ss
0.10
10.00
1000.00
RWA
RT
Depth
5240
5245
5250
5255
5260
5265
5270
5275
5280


CUTTER KGS #1 -
Upper Morrow Ss
0.000
0.500
1.000
SW
PAY
Depth
5240
5245
5250
5255
5260
5265
5270
5275
5280


CUTTER KGS #1
BVW=0.08
BVW=0.06
BVW=0.04
BVW=0.02
Sw=20%
Sw=40%
Sw=60%
Sw=80%
Sw=100%
Upper Morrow Ss
Depth: 5240 - 5281
X:
Y:
a: 1
m: 2
n: 2
RW: 0.1
DEPTH
5274 - 5283
5265 - 5274
5256 - 5265
5247 - 5256
5238 - 5247
POROSITY
1.000
0.100
0.010
1
10
100
1000
RESISTIVITY Ohm-m
Near constant porosity
Decreasing resisitivity with depth
= in transition


CUTTER KGS #1
BVW=0.08
BVW=0.06
BVW=0.04
BVW=0.02
Sw=20%
Sw=40%
Sw=60%
Sw=80%
Sw=100%
Upper Morrow Ss
Depth: 5240 - 5281
X:
Y:
a: 1
m: 2
n: 2
RW: 0.1
GR .api
115 - 138
92 - 115
69 - 92
46 - 69
23 - 46
POROSITY
1.000
0.100
0.010
1
10
100
1000
RESISTIVITY Ohm-m
Nice clean sandstone
reservoir

Future Studies
Key Findings, Significance

- **Core analysis;** core-log correlation
- **Perf and Swab**; fluid sampling and pressure buildup; pressure monitoring in nearby wells
- **Interpret 3D seismic** and integrate in reservoir model of Upper Morrow Sandstone
- **Simulation** CO2-EOR (U. Morrow) and CO2 sequestration (Arb.)
- **Arbuckle is complex stack of meter-scale peritidal cycles**, porous and non-porous
- **Oil shows need to be validated** – hot wire, UV, core analysis/saturations, oil typing
- **Potentially significant implications for petroleum system**

Acknowledgements & Disclaimer

Acknowledgements

- *The work supported by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) under Grant DE-FE0002056 and DE-FE0006821, W.L. Watney and Jason Rush, Joint PIs. Project is managed and administered by the Kansas Geological Survey/KUCR at the University of Kansas and funded by DOE/NETL and cost-sharing partners, Brian Dressel, Program Manager.*