PS Short Junction Field Core Description and Petrophysical Analysis of the Hunton Group, Cleveland County, Oklahoma*

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Abstract

The Short Junction field in northeast Cleveland County, Oklahoma, has produced approximately 22 million barrels of oil since 1948 from two units in the Hunton Formation. of an estimated 250 million OOIP. The less than 9% recovery even after a secondary water flood leaves a sizable target for a revitalized field. Trey Resources, Inc. cored the Hunton in the WSJU 109H and acquired a full petrophysical suite including image logs. In 2008, the WSJU 109H was recompleted as a horizontal lateral and included borehole imaging logs. These data were used to model the Bois d'Arc. The core was oriented to determine principle stress direction and structural position. Additional whole core samples were analyzed for directional permeability and plugs samples were measured permeability in the east west direction. Three plugs were selected for conventional CT scan analysis to help determine electrical properties. Advanced interpretation techniques were applied on the acquired borehole images and correlated with the core results. The objective was to characterize the heterogeneities present in the formation. With the creation of full borehole images, it was possible to better identify various heterogeneities and classify them as connected or isolated vugs, fractures connecting vugs or heterogeneity developed along bed boundaries. Matrix versus vuggy porosity type was compared across these intervals.

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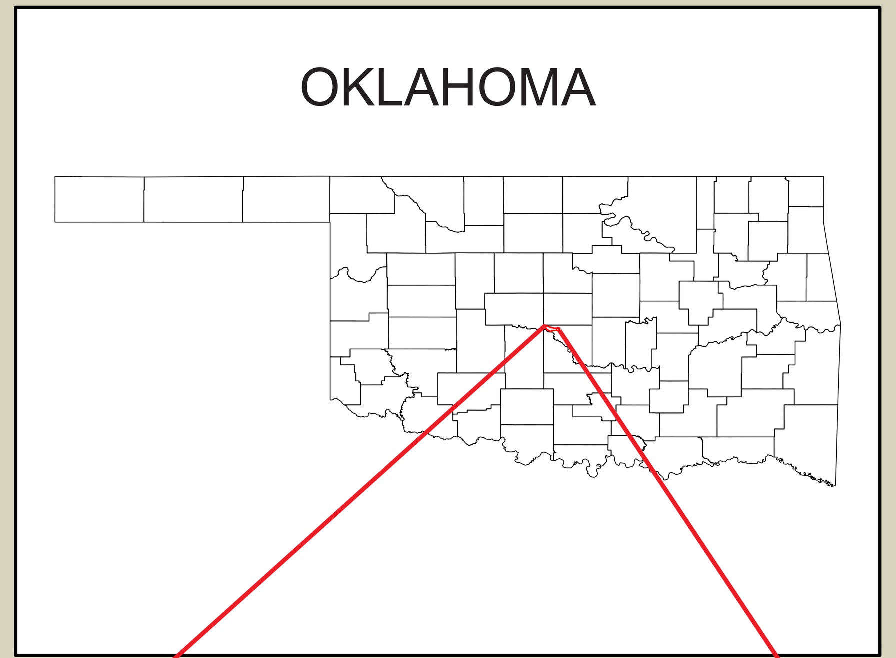
Abstract

Two units comprise most of the Short Junction field, which produces from the Hunton group, located in northwest Cleveland County, Oklahoma. The units have produced approximately 22 million barrels of oil since 1948 of an estimated 250 million OOIP. The less than 9% recovery even after a secondary water flood leaves a sizable target for a revitalized field.

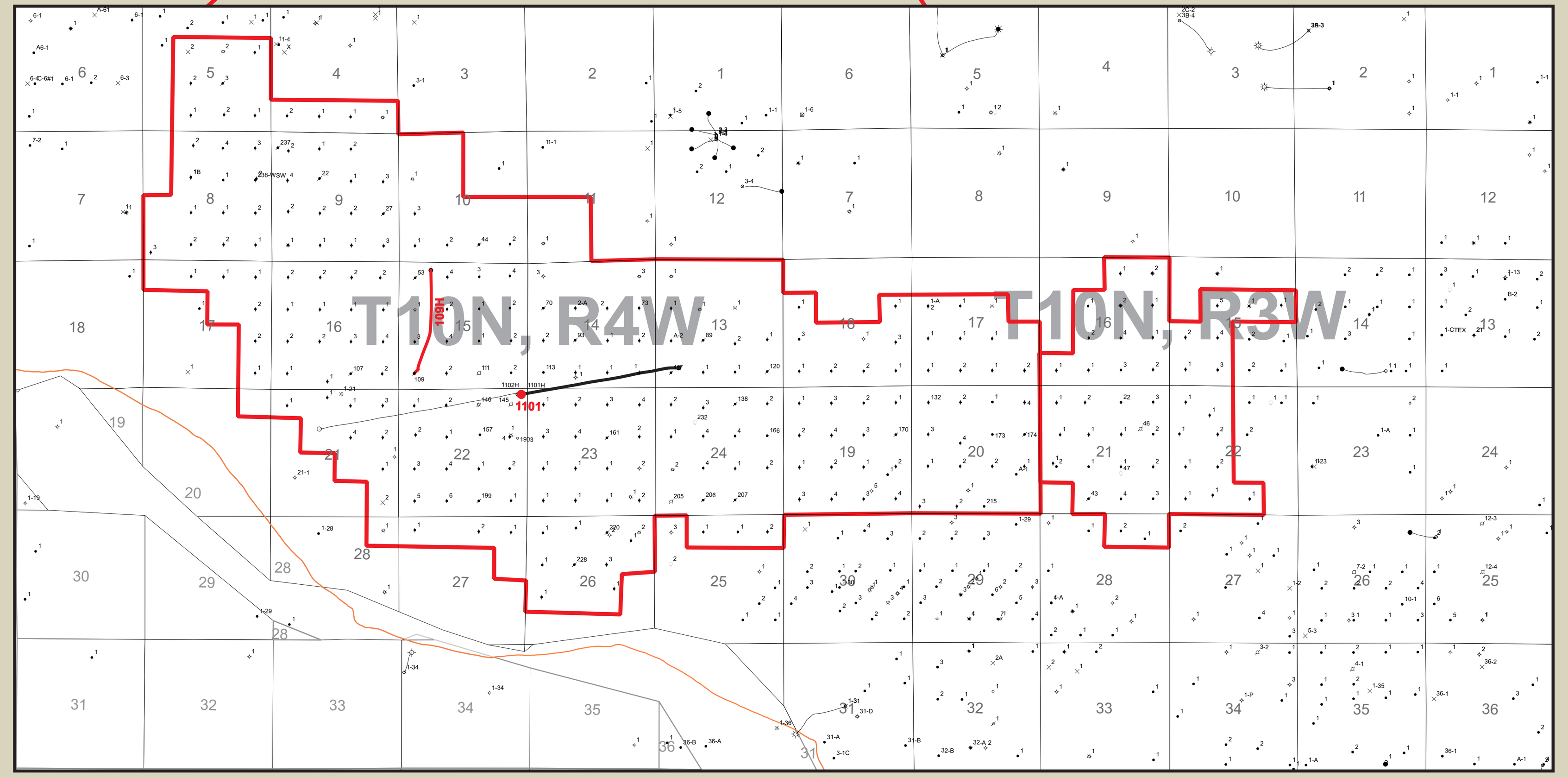
In 2008, the WSJU 109H, was recompleted as a horizontal lateral and included borehole imaging logs. Trey Resources acquired the units in 2014 and drilled the WSJU 1101H. The entire Hunton (Bois d'Arc to Chimneyhill) was cored as well as a full petrophysical suite including borehole imaging logs. These data were used to model the Bois d'Arc.

The core was oriented to determine principle stress direction and structural position. Additional whole core samples were analyzed for directional permeability and plugs samples were measured permeability in the east west direction. Three plugs were selected for conventional CT scan analysis to help determine electrical properties.

Advanced interpretation techniques were applied on the acquired borehole images and correlated with the core results. The objective was to characterize the heterogeneities present in the formation. With the creation of full borehole images covering the entire borehole surface, it was possible to better identify various heterogeneities (including vugs and fractures) and classify them as connected or isolated vugs, fractures connecting vugs or heterogeneity developed along bed boundaries. Intervals where the matrix porosity was the predominant component to the overall porosity were highlighted, versus intervals where the vuggy porosity has an important contribution.



Short Junction Location Map

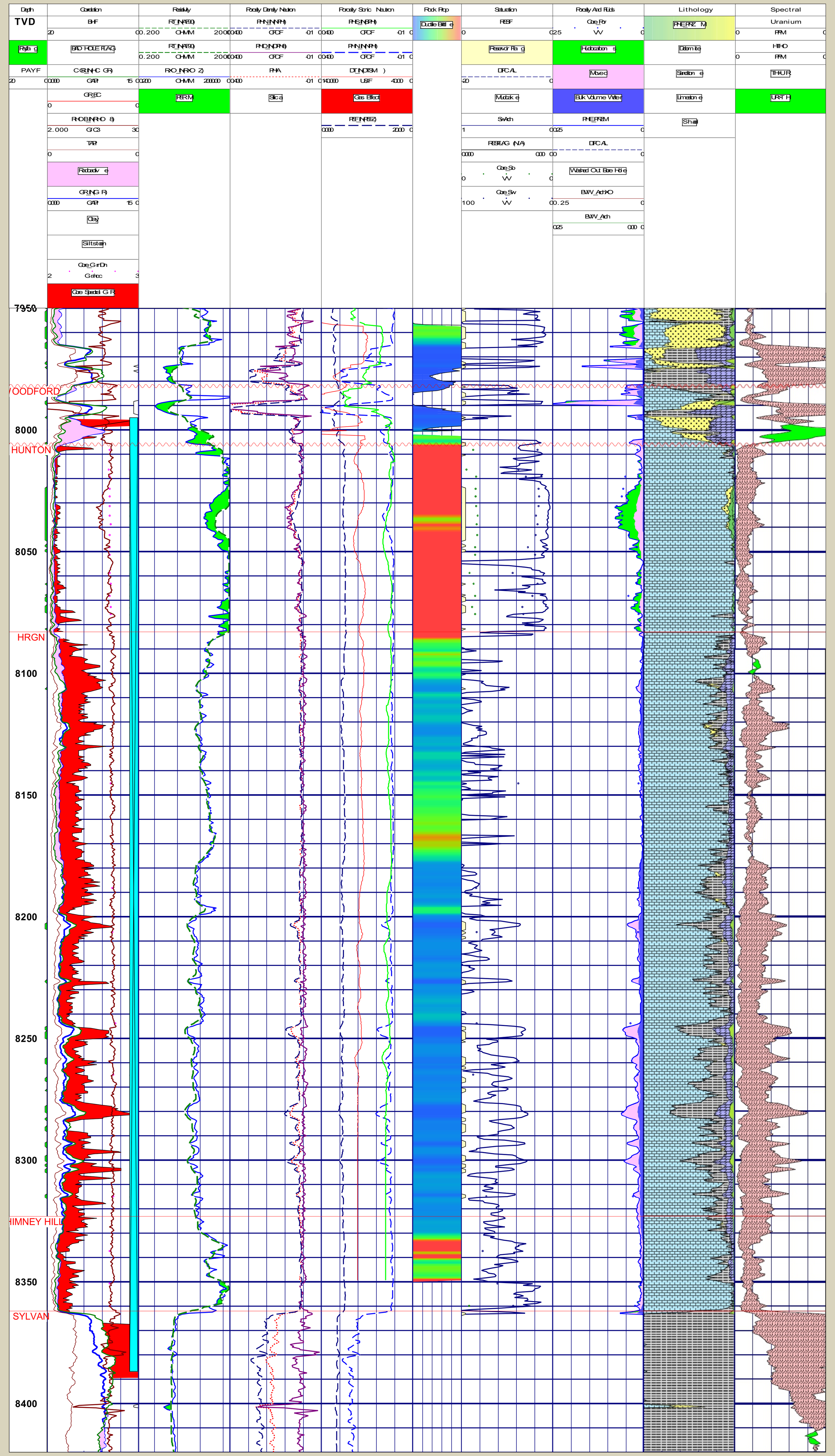


Simplified Stratigraphic Column

Short Junction Field

System	Series	Stage	Group	Formation
Permian	Leonardian			Garber - Wellington
	Wolfcampian			Neva
Pennsylvanian	Virgilian	Shawnee		Pawhuska
				Hoover
		Douglas		Tonkawa
	Missouri	Skiatook		Hogshooter
				Checkerboard
	Des Moines	Marmaton		Big Lime
				Oswego
		Cherokee		Prue
				Verdigris
				Skinner
				Pink Lime
				Red Fork
				Inola
				Bartlesville
	Atoka			Absent @ Short Junction
	Morrow			
Mississippian	Chester			Absent @ Short Junction
	Meramec			
	Osage			
	Kinderhook			Woodford
Devonian				Misener
			Hunton Grp	Frisco
				Bois d'Arc/Haragan
Silurian				Henryhouse
			Chimneyhill Subgroup	Clarita
				Cochrane
				Keel
Ordovician				Sylvan
				Viola
			Simpson Grp	Bromide/Wilcox
				Tulip Creek
				McLish
				Oil Creek
				Joins
			Arbuckle Grp	
Cambrian				
				Reagan
Precambrian				Granitic Basement

Trey Resources, Inc
West Short Junction Unit #1101H



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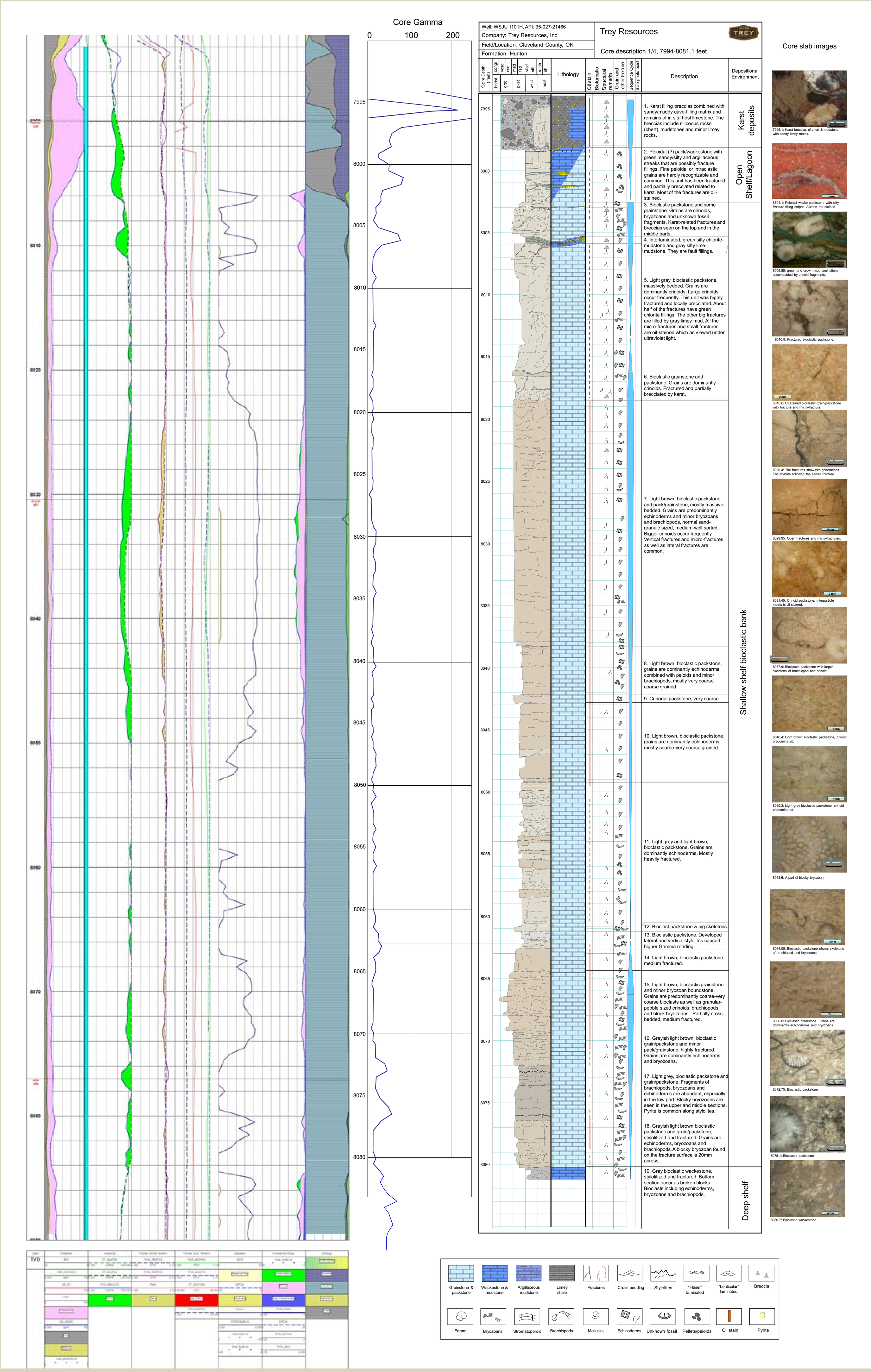
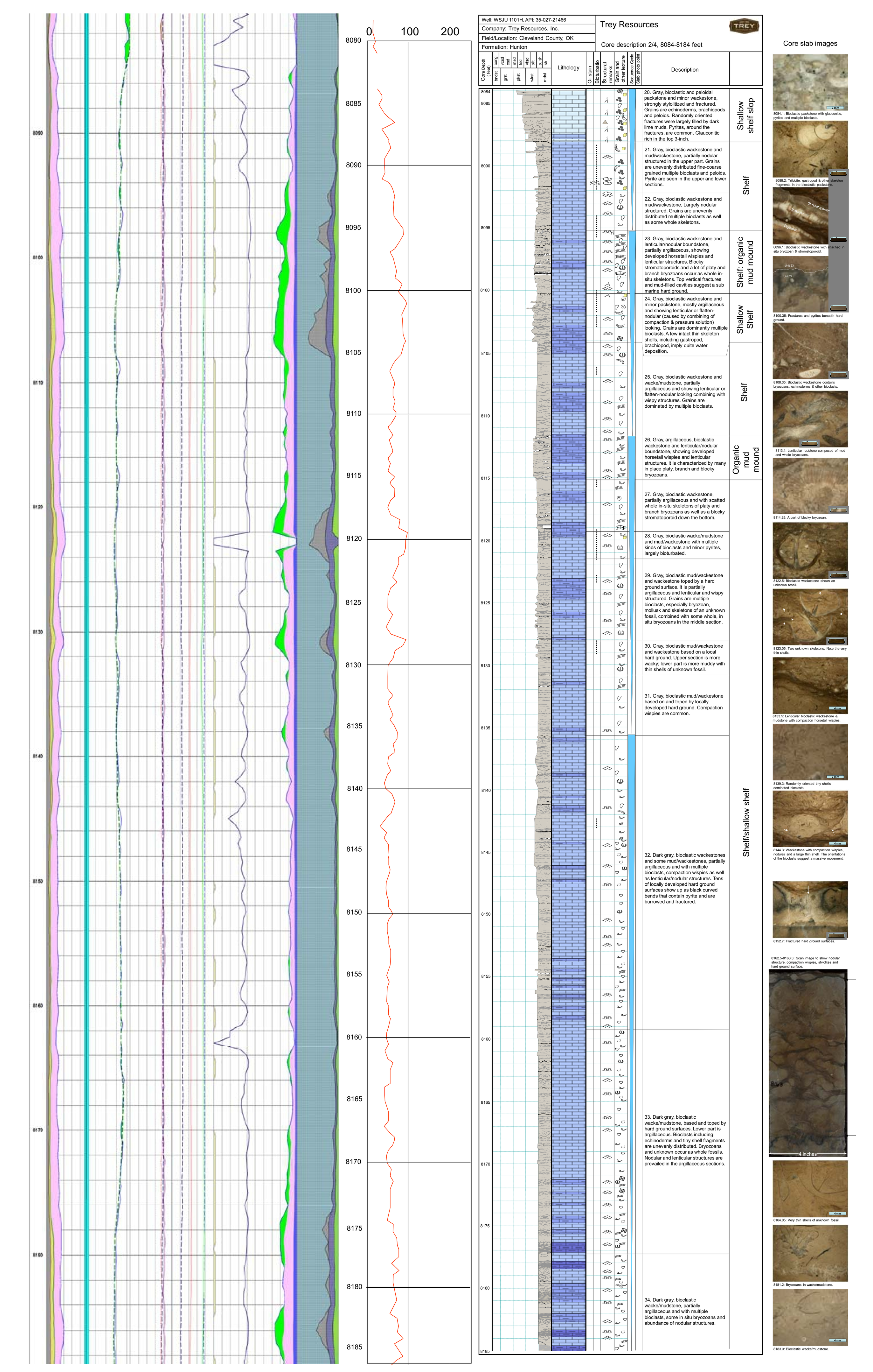


Core description WSJU #1101 Page 2 of 3



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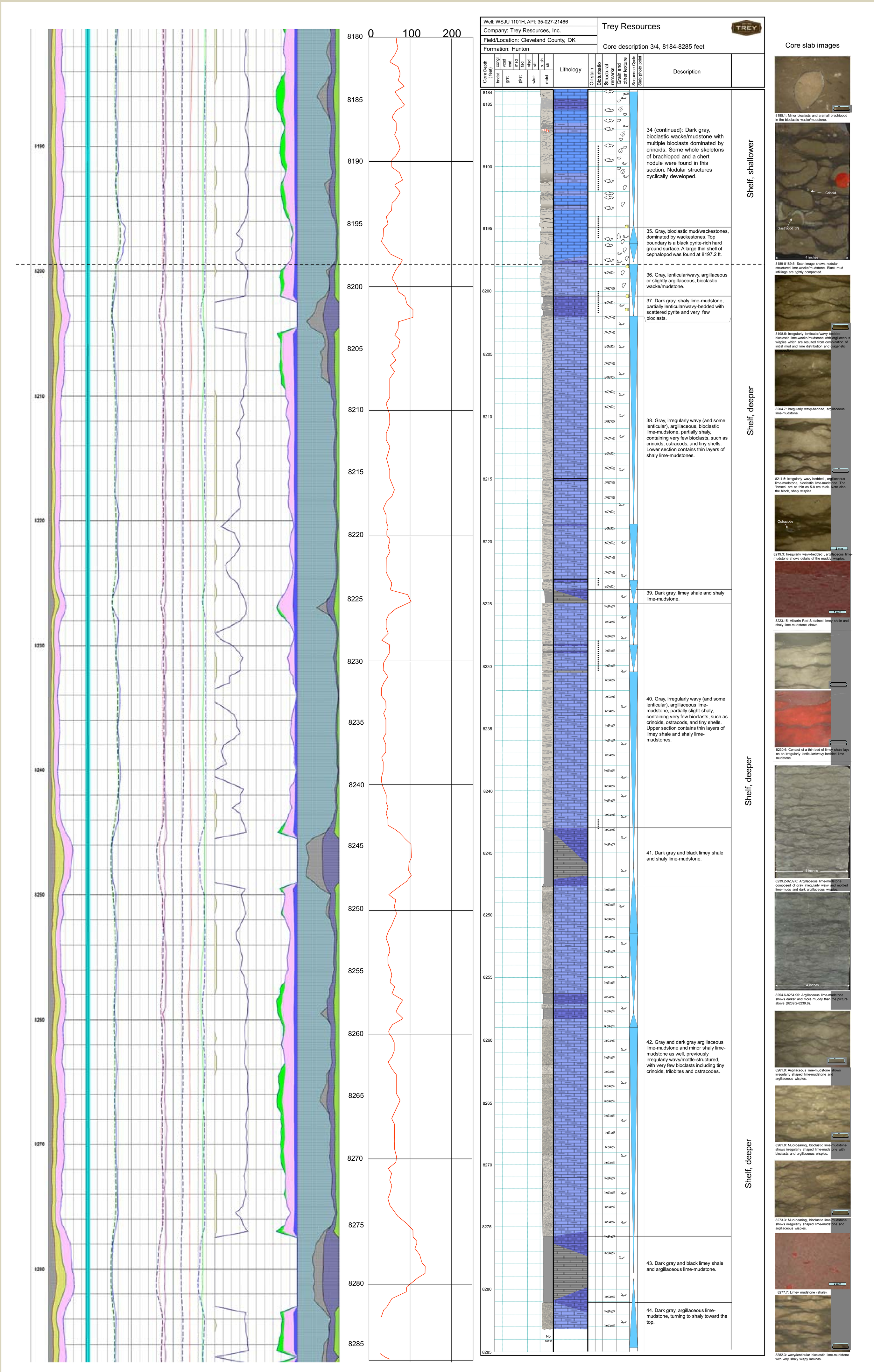
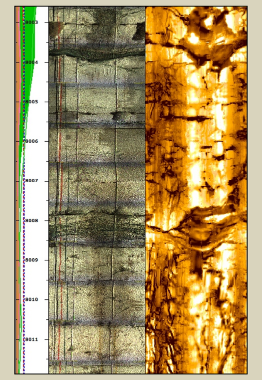
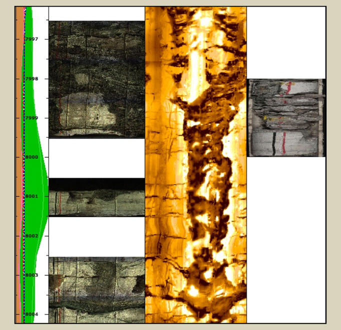


Image to core comparison

core description fault fillings,and karst related features



Core description karst filling breccias



WSJU #1101 FMI Interpretation

On the left, part of the PoroTex results, applied to the WSJU 1101H
Track 1: Depth Reference, scale 1:24
Track 2: Zonations highlighting intervals used for setting thresholds
Track 3: Full Calibrated image
Track 4: Calibrated FMI* Microresistivity curve with 0.2” vertical resolution
Track 5: Heterogeneity Image delineation. Refer to legend top of log.
Track 6: Image Porosity Map. Increase in darkness equals increase in image porosity.
Track 7: Spectrum of porosity distribution
Track 8: Cumulative porosity distribution
Track 9: Average image porosity at each heterogeneity type
Track 10: Cross plot porosity and total porosity computed from image porosity. Value corresponds to average at each depth level of image porosity curve.

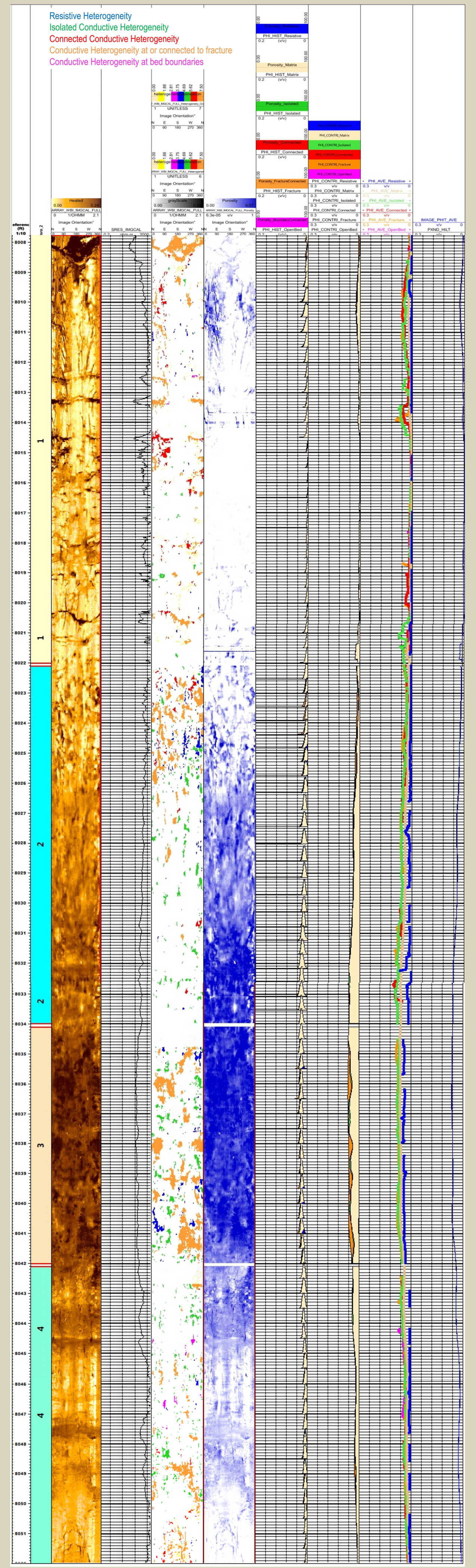
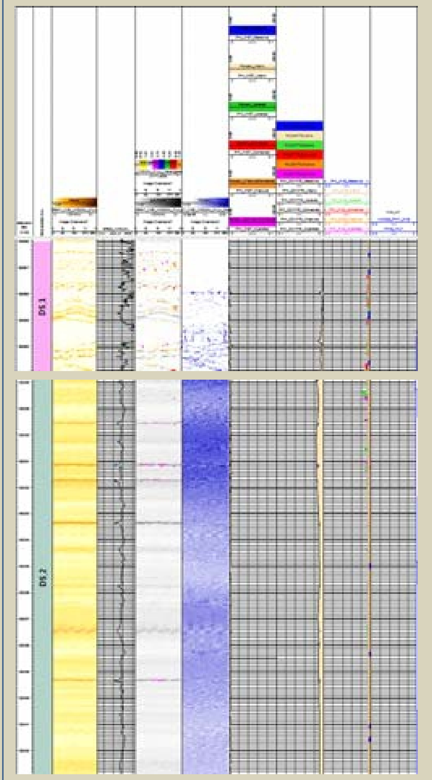


Image Porosity Analysis Workflow

This state of the art workflow includes textural analysis, image porosity analysis and fracture analysis to fully characterize the porosity distribution in the carbonate reservoir. This technology was applied in the West Short Junction Unit 1101 and in the West Short Junction Unit 109H.

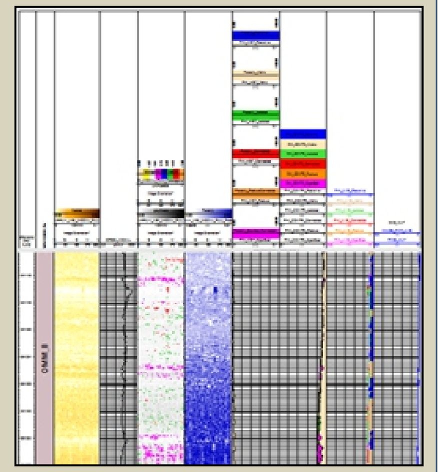
1) Full image creation: this step utilizes geostatistics to generate an image that represents full borehole coverage
2) Conductive and Resistive heterogeneities are delineated utilizing thresholds on contrast and resistivity values. Changes in resistivities compared to the matrix corresponds to heterogeneities: highly resistive heterogeneities correspond to cemented zones, while low values of resistivities correspond to vugs or fractures (Delhomme, 1992)
3) Combining the detailed features identification done in the manual dip picking phase, with the heterogeneity delineation, allow the classification of heterogeneities in different categories.
4) Porosity map from image is constructed utilizing a well established method which computes porosity from a modified Archie’s equation applicable to the flushed zone and having as input each conductivity curve’s measure by the Formation Micro Imager (Newberry et al, 1996)

Response of Porotex in Deep Shelfal environment



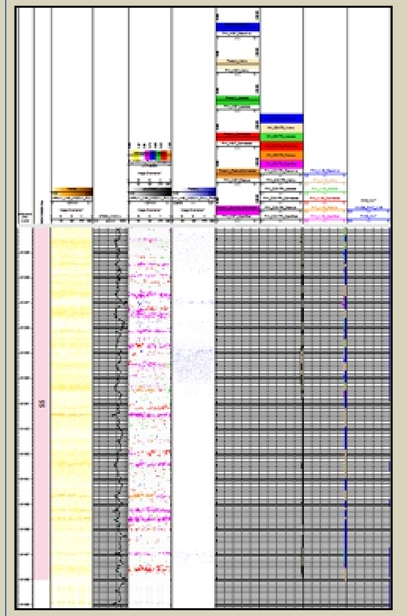
The general response in Deep shelfal environment is lack of heterogeneities and overall porosity from image from low to medium

Response of Porotex in Organic Mud Mound



The general response in the organic mud mound is of presence of heterogeneities contributing to the overall medium image porosity. Heterogeneities are predominantly along beddings and isolated

Response of Porotex in Shallow Shelf



The general response in shallow shelf environment is abundance of heterogeneities along beddings and overall porosity from image low

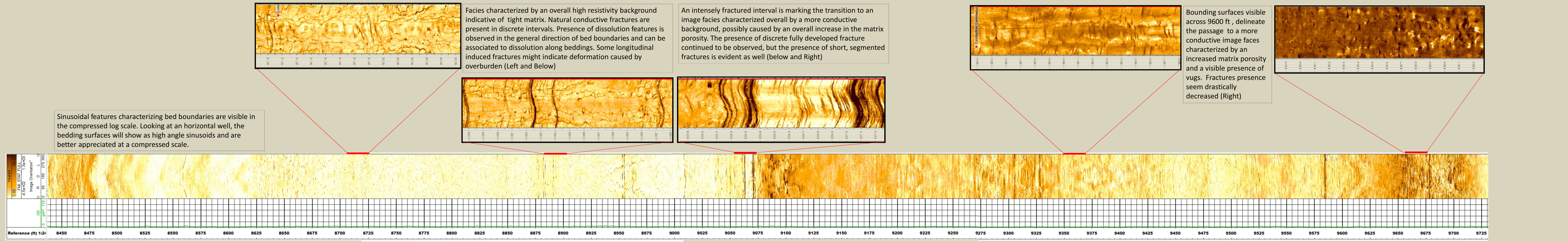
Formation Micro Imager of horizontal lateral West Short Junction Unit #109H

Facies characterized by an overall high resistivity background indicative of tight matrix. Natural conductive fractures are present in discrete intervals. Presence of dissolution features is observed in the general direction of bed boundaries and can be associated to dissolution along beddings. Some longitudinal induced fractures might indicate deformation caused by overburden (Left and Below)

An intensely fractured interval is marking the transition to an image facies characterized overall by a more conductive background, possibly caused by an overall increase in the matrix porosity. The presence of discrete fully developed fracture continued to be observed, but the presence of short, segmented fractures is evident as well (below and Right)

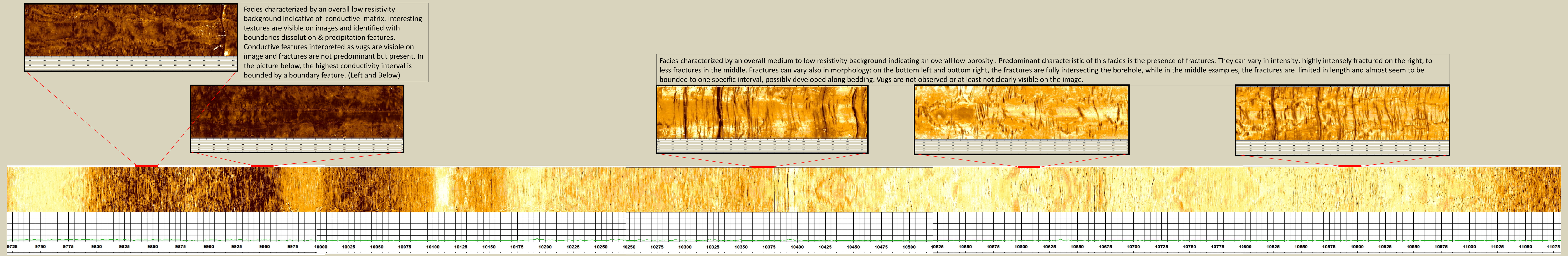
Bounding surfaces visible across 9600 ft , delineate the passage to a more conductive image faces characterized by an increased matrix porosity and a visible presence of vugs. Fractures presence seem drastically decreased (Right)

Sinusoidal features characterizing bed boundaries are visible in the compressed log scale. Looking at an horizontal well, the bedding surfaces will show as high angle sinusoids and are better appreciated at a compressed scale.

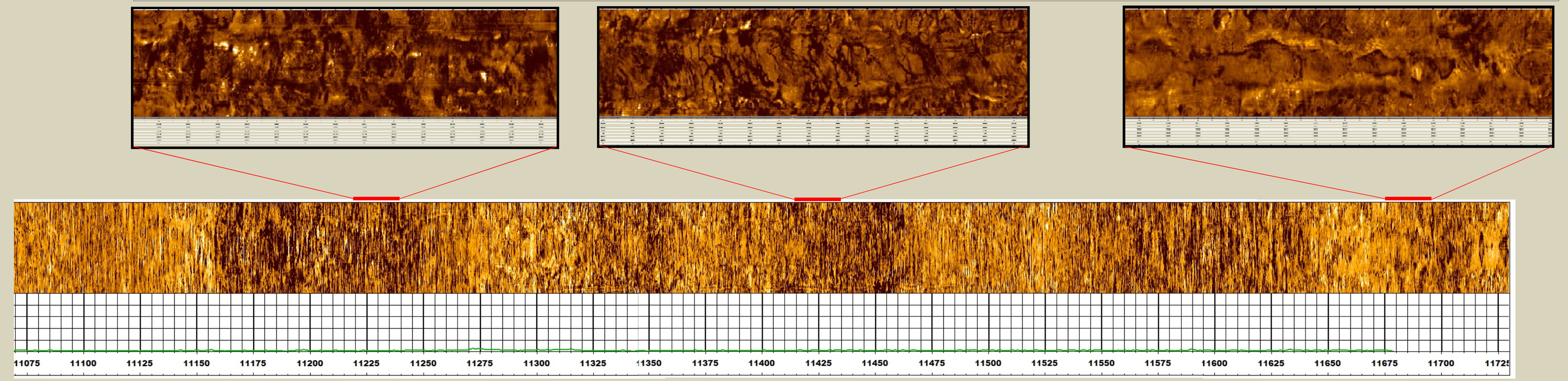


Facies characterized by an overall low resistivity background indicative of conductive matrix. Interesting textures are visible on images and identified with boundaries dissolution & precipitation features. Conductive features interpreted as vugs are visible on image and fractures are not predominant but present. In the picture below, the highest conductivity interval is bounded by a boundary feature. (Left and Below)

Facies characterized by an overall medium to low resistivity background indicating an overall low porosity . Predominant characteristic of this facies is the presence of fractures. They can vary in intensity: highly intensely fractured on the right, to less fractures in the middle. Fractures can vary also in morphology: on the bottom left and bottom right, the fractures are fully intersecting the borehole, while in the middle examples, the fractures are limited in length and almost seem to be bounded to one specific interval, possibly developed along bedding. Vugs are not observed or at least not clearly visible on the image.



The toe of the well is characterized by an overall lower background resistivity and presence of slightly different facies, but all characterized by an increased presence of dissolution features. In the middle snapshot below, it is evident how some of this enlarged dissolution features are intersection fractures. From the left snapshot to the right we see an overall decrease in the vugs, but we also observe differences in fracture presence: left medium occurrence, middle high occurrence and right low occurrence. Looking at the compressed scale log gives a very good idea of the facies lateral variation the overall color change is indicative of a tighter or more porous matrix. These variations can occur in a very short interval.



Conclusions

Advanced image log analysis can be utilized to derived facies variations related to depositional environments supported and consolidated by a detailed core description.

The facies variation can be observed equally across vertical and horizontal borehole.

The identification and classification of heterogeneities in the vertical and horizontal well shows somehow good matches allowing the identification of different facies along the horizontal well comparable to the vertical one: in particular

Facies 1 & 2 in the horizontal is comparable to the deep shelfal facies in the vertical well

Facies 4 in the horizontal well is comparable to the shallow shelf facies in the vertical well

Facies 5 in the horizontal well is comparable to the Shallow shelf bioclastic mud mound

This information can provide valuable insight to the distribution of porosity in carbonate reservoirs and help identify sweet spots for production.

Overall a total of 5 FMI image facies were identified and below is represented the output of the porosity classification analysis:

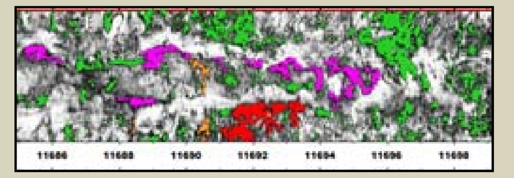
1) High background matrix resistivity with discrete fracture presence
2) Medium to High background resistivity with high presence of fractures
3) Medium background resistivity with segmented fractures
4) Low background resistivity with vuggy texture
5) Low background resistivity with vuggy texture and fractures

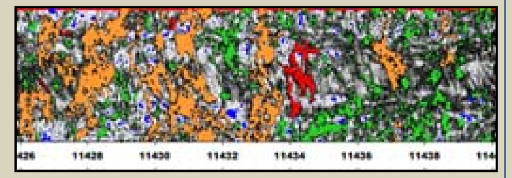
FACIES 1
Low presence of heterogeneities
Discrete fractures are the contributors to reservoir properties

FACIES 2
Low presence of heterogeneities and if present connected to fractures
High presence of fractures is the contributor to reservoir properties

FACIES 3
Increased presence of heterogeneities of various nature
Segmented fractures and heterogeneities equally present

FACIES 4
Increased presence of heterogeneities and overall increased matrix porosity. Heterogeneities seem to be predominant along boundaries, connected or isolated.
Fractures do not represent a predominant feature





FACIES 5
Increased matrix porosity and increased heterogeneity presence. Vugs connected to fractures are the most predominant feature.
Fractures and vugs are equally highly contributing to increased reservoir properties