PMTurkeyCOLPEm Resource

From: Comar, Manny
Sent: Thursday, November 01, 2012 5:03 PM
To: TurkeyCOL Resource
Subject: FW: DRAFT RAI Responses FPL Turkey Point 6 & 7 for eRAI 6024 Basic Geologic and Seismic Information
Attachments: Draft Revised Response for NRC RAI Letter No. 041, RAI 02.05.01-33 (eRAI 6024).pdf; Draft Revised Response for NRC RAI Letter No. 041, RAI 02.05.01-2 (eRAI 6024).pdf; Draft Revised Response for NRC RAI Letter No. 041, RAI 02.05.01-26 (eRAI 6024).pdf; Draft Revised Response for NRC RAI Letter No. 041, RAI 02.05.01-31 (eRAI 6024).pdf; Draft Revised Response for NRC RAI Letter No. 041, RAI 02.05.01-5 (eRAI 6024).pdf

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From: Franzone, Steve [mailto:Steve.Franzone@fpl.com]
Sent: Friday, October 19, 2012 5:21 PM
To: Franzone, Steve; Comar, Manny
Cc: Burski, Raymond; Maher, William
Subject: RE: DRAFT RAI Responses FPL Turkey Point 6 & 7 for eRAI 6024 Basic Geologic and Seismic Information

Manny,

To support a future public meeting, FPL is providing draft revised responses for eRAI 6024 (RAI questions 02.05.01-2, 02.05.01-5, 02.05.01-26, 02.05.01-31, and 2.5.1-33) in the attached files.

If you have any questions, please contact me.
Thanks

Steve Franzone
NNP Licensing Manager - COLA
"Never give in--never, never, never, never, in nothing great or small, large or petty, never give in except to convictions of honour and good sense. Never yield to force; never yield to the apparently overwhelming might of the enemy. " Sir Winston Churchill, Speech, 1941, Harrow School
561.694.3209 (office)
754.204.5996 (cell)

Hearing Identifier: TurkeyPoint_COL_Public
Email Number: 704

Mail Envelope Properties (377CB97DD54F0F4FAAC7E9FD88BCA6D0B1656EF950)

Subject: FW: DRAFT RAI Responses FPL Turkey Point 6 & 7 for eRAI 6024 Basic Geologic and Seismic Information
Sent Date: 11/1/2012 5:03:13 PM
Received Date: 11/1/2012 5:03:20 PM
From: Comar, Manny

Created By: Manny.Comar@nrc.gov

Recipients:
"TurkeyCOL Resource" <TurkeyCOL.Resource@nrc.gov>
Tracking Status: None

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Files	**Size**	**Date & Time**
MESSAGE	1656	11/1/2012 5:03:20 PM
Draft Revised Response for NRC RAI Letter No. 041, RAI 02.05.01-33 (eRAI 6024).pdf	503147	
Draft Revised Response for NRC RAI Letter No. 041, RAI 02.05.01-2 (eRAI 6024).pdf	3751187	
Draft Revised Response for NRC RAI Letter No. 041, RAI 02.05.01-26 (eRAI 6024).pdf	572780	
Draft Revised Response for NRC RAI Letter No. 041, RAI 02.05.01-31 (eRAI 6024).pdf	248254	
Draft Revised Response for NRC RAI Letter No. 041, RAI 02.05.01-5 (eRAI 6024).pdf	235365	

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Recipients Received:

NRC RAI Letter No. PTN-RAI-LTR-041

SRP Section: 02.05.01 - Basic Geologic and Seismic Information

QUESTIONS from Geosciences and Geotechnical Engineering Branch 2 (RGS2)

NRC RAI Number: 02.05.01-33 (eRAI 6024)

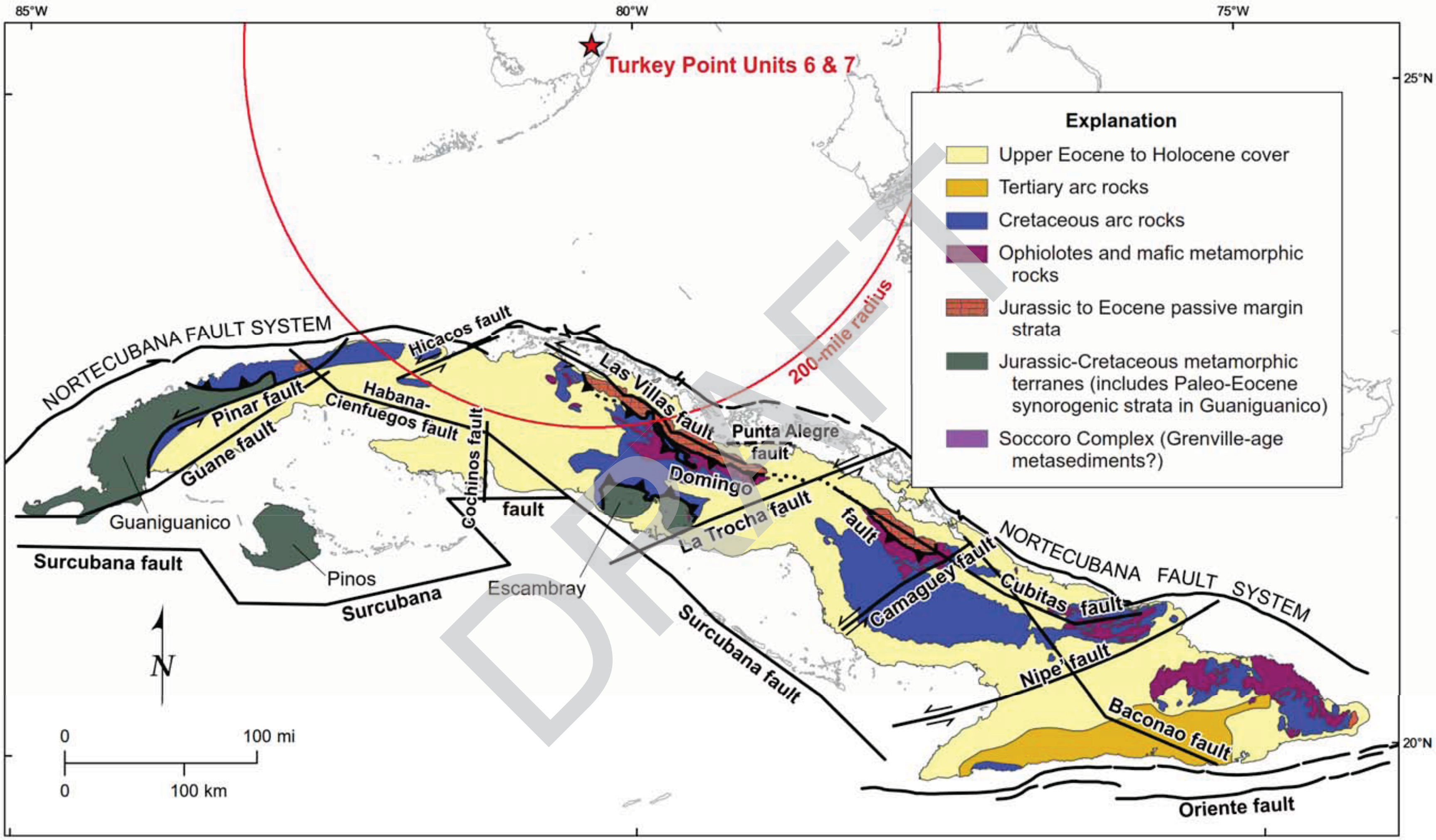
FSAR Section 2.5.1.1.1.3.2.4, "Structures of Cuba", cites FSAR Figures 2.5.1-247, 2.5.1-251 and 2.5.1-268, which illustrate Cuban tectonic features at present, however, many faults appear to be omitted entirely from figures including the Habana-Cienfuegos fault, Cubitas fault, Guane fault, Nipe fault, and Baconao fault.

In order for the staff to assess the tectonic and structural features within the site region and in accordance with 10 CFR 100.23, please provide a single figure, or composite figures that clearly depict all tectonic features discussed in FSAR Section 2.5.1.1.1.3.2.4.

FPL RESPONSE:

Figure 1 is a compilation map showing the faults in Cuba described in FSAR Subsection 2.5.1.1.1.3.2.4, including the Nortecubana fault system, Surcubana fault, Pinar fault, Guane fault, Habana-Cienfuegos fault, Hicacos fault, Cochinos fault, Las Villas fault, Domingo fault, La Trocha fault, Camaguey fault, Cubitas fault, Nipe fault, Baconao fault, Oriente fault, and Punta Alegre fault. Multiple sources were used to compile the faults shown on this map, including: Kerr et al. (1999), Tait et al. (2009), Pardo et al. (2009), Hall (2004), French and Schenk (1997), and Cotilla-Rodriguez et al. (2007) (FSAR References 2.5.1-443, -448, -439, -770, -492, and -494).

Figure 1 does not show the locations of Malloy and Hurley's (Reference 1) postulated Sierra de Jatibonica and offshore Las Villas faults, both of which are located in the Straits of Florida north of Cuba. Those structures are described and shown on maps that accompany revised responses to RAIs 02.05.01-27, 02.05.01-16, and 02.05.03-02.



Note: Multiple sources were used to compile this map, including: FSAR References 2.5.1-492, -443, -770, -494, 448 and 439.

Figure 1. Tectonic map of Cuba, showing faults in Cuba described in FSAR Subsection 2.5.1.1.1.3.2.4.

This response is PLANT SPECIFIC.

References:

1. Malloy, R.J. and Hurley, R.J., “Geomorphology and geologic structure: Straits of Florida,” *Geological Society of America Bulletin*, Vol. 81, pp. 1947–1972, 1970

ASSOCIATED COLA REVISIONS:

The text in the eleventh and twelfth paragraphs of FSAR Subsection 2.5.1.1.1.3.2.4 will be revised as follows in a future update of the FSAR:

Habana-Cienfuegos Fault

This northwest-striking left-lateral strike-slip fault is located in western and central Cuba (~~Figure 2.5.1-288~~Figure 2.5.1-247). This fault is not shown on Reference 480 or the 1:250,000 scale geologic map of Cuba (Reference 846). However, a dashed (postulated) structure on the 1:500,000 scale geologic map (Reference 848) is depicted as cutting Miocene strata, but covered by unfaulted Pleistocene strata. Cotilla-Rodríguez et al. (Reference 494) conclude this structure is active based upon an association with poorly located seismicity.

Guane Fault

The Guane fault is located in western Cuba and is covered by sediments of the Los Palacios Basin (~~Figure 2.5.1-251~~Figures 2.5.1-247 and 2.5.1-251). This northeast-striking structure is not depicted on the 1:250,000 scale geologic map (Reference 846). However, a dashed (postulated) structure on the 1:500,000 scale geologic map is depicted cutting Miocene strata, but covered by unfaulted Pliocene-Pleistocene units (Reference 848). Cotilla-Rodríguez et al. (Reference 494) conclude it is active based upon potential association with seismicity.

The text in the fifteenth paragraph of FSAR Subsection 2.5.1.1.1.3.2.4 will be revised as follows in a future update of the FSAR:

Cubitas Fault

Near the Camaguey fault, the Cubitas fault is a northwest-striking normal fault that forms the southern boundary of an area of higher topography (~~Figure 2.5.1-288~~Figure 2.5.1-247). It is described as post-middle Eocene in age and suggested to be partially responsible for up to 200 meters uplift of hills, possibly after the deposition of Plio-Pleistocene fluvial terraces (Reference 500). Cotilla-Rodríguez et al. (Reference 494) note that the Cubitas fault is associated with large scarps and assign it a Pliocene-Quaternary age.

The text in the seventeenth paragraph of FSAR Subsection 2.5.1.1.1.3.2.4 will be revised as follows in a future update of the FSAR

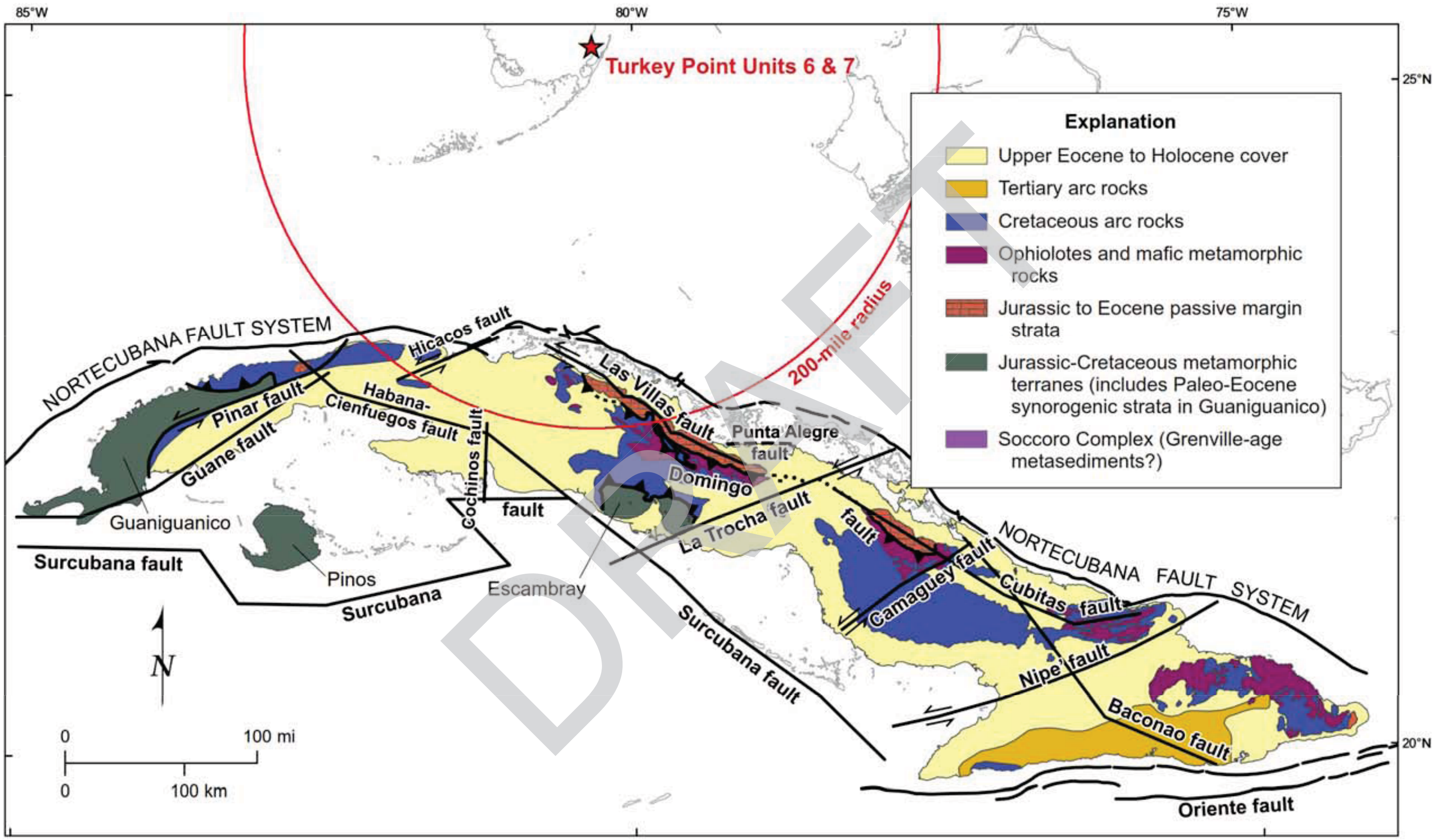
Baconao Fault

The Baconao fault is a northwest-striking fault, located in southeastern Cuba (~~Figure 2.5.1-288~~Figure 2.5.1-247). Cotilla-Rodríguez et al. (Reference 494) indicate that it may have normal, reverse, and left-lateral strike-slip kinematics. This fault is not shown on the Case and Holcombe (Reference 480) or the 1:250,000 scale geologic maps (Reference 846). However, a dashed (postulated) structure on the 1:500,000 scale geologic map is depicted cutting Oligocene-Miocene strata, but covered by unfaulted Pleistocene strata (Reference 848). It may deform Pleistocene and Quaternary terraces and is associated with poorly located seismicity (Reference 494).

The discussion of Cuban faults in FSAR Subsection 2.5.1.1.1.3.2.4 will be revised to provide reference to revised Figure 2.5.1-247 in a future update to the FSAR, as detailed in the response to RAI 02.05.01-21.

FSAR Figure 2.5.1-247 will be revised as shown below in a future FSAR revision:

Figure 2.5.1-247 Tectonic Map of Cuba



Note: Multiple sources were used to compile this map, including: FSAR References 2.5.1-492, -443, -770, -494, -448, and -439

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-041

SRP Section: 02.05.01 - Basic Geologic and Seismic Information

QUESTIONS from Geosciences and Geotechnical Engineering Branch 2 (RGS2)

NRC RAI Number: 02.05.01-2 (eRAI 6024)

FSAR Section 2.5.1.2.4 discusses limestone dissolution features and states that zones of preferential secondary porosity exist within (1) an upper zone within Key Largo Limestone and (2) a lower zone within Fort Thompson Formation, and that these zones include cavities verified from televiewer and caliper logs. Staff notes that the Key Largo LS will be the bearing layer for SSC buildings. In order for the staff to evaluate the dissolution potential at the TPNPP site and in support of 10 CFR 100.23, please address the following:

a) Discuss the possible origins of these subsurface voids and evaluate if this is still consistent with your statement “there is no evidence for sinkhole hazards or for the potential of surface collapse due to the presence of large underground openings” on page 2.5.1-229.

b) Discuss the possibility that these zones of secondary porosity are in the same stratigraphic unit that expresses the karst/sinkhole-like features seen immediately off shore to the east of the TPNPP site.

FPL RESPONSE:

a) Discuss the possible origins of these subsurface voids and evaluate if this is still consistent with your statement “there is no evidence for sinkhole hazards or for the potential of surface collapse due to the presence of large underground openings” on page 2.5.1-229.

As described in FSAR Subsection 2.5.1.2.4 two preferential secondary porosity zones, upper and lower zones are identified within the Biscayne Aquifer beneath the site and are the possible origin of the subsurface voids at the Turkey Point Units 6 & 7 site. The upper zone (referred to as the “Upper Higher Flow Zone” in FSAR Subsection 2.4.12.1.4) is located approximately at the boundary between the Miami and Key Largo limestones and is considered to represent a laterally continuous relatively thin layer of secondary porosity consisting of touching-vugs. The lower zone (referred to as the “Lower Higher Flow Zone” in FSAR Subsection 2.4.12.1.4) is located within the Fort Thompson Formation and is not considered to be a laterally persistent layer but rather isolated pockets of moldic porosity within the layer.

As described in FSAR Subsection 2.5.1.2.4, the two zones of secondary porosity were identified at the site following review of the geophysical logs, the geotechnical boring logs, and the shear wave velocity logs. In general, the zones of secondary porosity were identified based on increases in borehole diameter on the caliper logs, darkened areas on the acoustic televiewer images, typically lower P-S wave velocity values, and loss of drilling fluid and rod drops. Figures 1 through 3 show the approximate locations of the two zones of secondary porosity on three example-boring logs, B-604 (DH), B-608 (DH), and B-710 G (DH) and their locations at the Turkey Point Units 6 & 7 site are seen on FSAR Figure 2.5.1-228 and FSAR

Figure 2.5.4-202. Figures 1 through 3 were compiled using the lithology, caliper, natural gamma, acoustic televiewer, and velocity (Vs and Vp) logs.

As seen from the cores taken during the subsurface investigation and photos of the cores (FSAR Subsection 2.5.1 Reference 708), the potential origin of the touching-vug porosity within the upper zone is associated with original reef structure and, based on similar features described by Cunningham et al (FSAR Subsection 2.5.1 References 404 and 723), solution enlargement. Recent studies by Cunningham et al. (FSAR Subsection 2.5.1 References 404 and 723) suggest vuggy porosity is common within the Biscayne Aquifer (Miami and Key Largo limestones and Fort Thompson Formation) and that typical solution features associated with the touching-vug porosity include solution-enlarged fossil molds up to pebble size, molds of burrows or roots, irregular vugs surrounding casts of burrows or roots, and bedding plane vugs. Cunningham et al. (FSAR Subsection 2.5.1 Reference 404) show images of vugs in the Miami Limestone and Fort Thompson Formation, with cavernous vugs approximately 4 feet in height (Figure 4). The potential origin of the lower zone of secondary porosity is moldic porosity or separate-vug porosity (Reference 1) resulting from dissolution of in-situ bivalve shells. While touching-vug and moldic porosity similar to that noted by Cunningham et al., (FSAR Subsection 2.5.1 References 404 and 723) and Lucia (Reference 1) occur at the Turkey Point Units 6 & 7 site, it should be noted that only occasional small (less than 4 feet) rod drops were noted in 6 out of the 88 boreholes and approximately 9000 feet of rock cored at the site. Two of the rod drops (borings B-637 and B-805) occurred within the Miami Limestone which will be removed from beneath the nuclear island during construction; these two rod drops measured 2 and 3 feet. A rod drop of 1-foot occurred at the base of the Fort Thompson Formation (B-714) immediately before penetrating the sands of the Tamiami Formation. The remaining three rod drops (B-738, B-811, and B-814) occurred within sandy zones of the Fort Thompson Formation with rod drops ranging from 0.5 to 4 feet. The rod drop of 4 feet occurred at a sandy zone, unlike the 4-foot rod drop of Cunningham et al., (FSAR Subsection 2.5.1 Reference 404) which occurred in the Miami Limestone. None of the rod drops were in the Units 6 or 7 nuclear islands (FSAR Subsections 2.5.4.1.2.1, 2.5.4.4.5.5 and the supplemental response to RAI 02.05.04-1). In addition to Cunningham et al (FSAR Subsection 2.5.1 Reference 404), Cressler (Reference 6) explored 20 small, shallow caves in the Biscayne aquifer within the Miami Limestone (Figure 5). These caves are within the Turkey Point Units 6 & 7 site vicinity and are further discussed in the supplemental response to RAI 02.05.01-1.

Although the origins of the touching-vug and moldic porosity in the upper and lower zones of secondary porosity at the Turkey Point Units 6 & 7 site are the same or very similar to the origins of the vuggy porosity discussed by Cunningham et al (FSAR Subsection 2.5.1 Reference 404), there is no evidence that cavernous vugs (4 feet in height) such as those described by Cunningham et al (FSAR Subsection 2.5.1 Reference 404) are present at the site. Thus, “there is no evidence for sinkhole hazards or for the potential of surface collapse due to the presence of large underground openings”. FPL has reached its conclusions regarding the absence of extensive dissolution beneath the nuclear islands based on the integration of geological/geotechnical data collected during the drilling program as well as the use of three concurrent geophysical surveys (microgravity, seismic refraction, and multi-channel analysis of surface waves) as discussed in the supplemental response to RAI 02.05.04-1. The seismic refraction and multi-channel analysis of surface waves (MASW) data are helpful in removing the effects of the overlying less dense muck in the interpretation of the microgravity survey data. As shown in FSAR Figure 2.5.4-227 and supplemental response to RAI 02.05.04-1 Figure 1, the MASW survey data also indicate that the muck is thicker above surficial solution features (vegetated depressions) that appear to be floored by continuous Key Largo limestone. Hence, the "cavities" or void spaces described within these two zones of secondary porosity are not large cavities or underground openings associated with sinkhole hazards and surface collapse but instead appear to be zones of touching-vug or moldic porosity. Results of the microgravity survey are discussed in the supplemental response to RAI 02.05.04-1. FPL recognizes the uncertainties in these geophysical data and has proposed to conduct a microgravity survey in the Power Block during excavation to verify their conclusions.

b) Discuss the possibility that these zones of secondary porosity are in the same stratigraphic unit that expresses the karst/sinkhole-like features seen immediately off shore to the east of the TPNPP site.

Biscayne Bay has been modified and dredged and has an average water depth that ranges from 6 to 13 feet (1.8 to 4 meters) (Reference 2). Assuming the water level in the bay is at sea level, the bottom of the bay ranges in elevation from approximately -6 to -13 feet (MSL). According to Reich et al. (Reference 3), sediments overlying bedrock in the bay range in thickness from less than 6 inches to 30 feet. Using this information and the elevations of the bottom of the bay, FPL concludes that the surface elevation of bedrock that expresses the "karst/sinkhole-like features" beneath the bay (or alternatively the "local depressions" and "potholes" described in FSAR Subsection 2.5.3) is assumed to range from -6.5 to -43 feet MSL. The upper zone within the Biscayne Aquifer is located between the Miami and Key Largo limestones at an approximate elevation of -28 feet MSL. The lower zone is located within the Fort Thompson Formation at an approximate elevation of -65 feet MSL. Based on site stratigraphic data, the units are relatively flat and it appears that the upper zone is in the same stratigraphic unit(s) that express(es) the "karst/sinkhole-like features" in Biscayne Bay, that is the Miami and Key Largo limestones (see FSAR Figure 2.5.1-332).

While the touching-vug porosity exhibited in the upper zone and the "karst/sinkhole-like features" on the bottom of Biscayne Bay may be in the same stratigraphic unit(s), the formation of these dissolution features is somewhat different. Dissolution features such as vugs are typically post-depositional features that occur in a freshwater phreatic system in which groundwater has filled open spaces and causes dissolution. The "karst/sinkhole-like features" on the bottom of the bay appear to be paleo-dissolution features that formed during the Sangamon interglacial when the fresh water/brine interface was located at an elevation favorable for dissolution by surface water (rainwater) in the bay. More information on the development of the "karst/sinkhole-like features" on the bottom of Biscayne Bay is provided in the following paragraph together with a summary of the evolution of the bay.

The process of limestone deposition in Florida was variable during the Pleistocene period due to glacial runoff and sea level fluctuations (i.e. the Sangamon interglacial and Wisconsinan glacial). The Sangamon interglacial occurred between approximately 125,000 and 75,000 thousand years ago. During this time, sea level rose globally and in Florida resulted in an increase in marine carbonate deposition. Sea level was approximately 20 feet (6 meters) higher than today (References 4 and 5) and covered the entire Florida peninsula south of Lake Okeechobee (Reference 5). The marine sediments (i.e. the Miami and Key Largo limestones) that accumulated during the Sangamon interglacial high sea level stand were lithified and their depositional morphology preserved. Two elongated sediment ridges that formed the Key Largo Ridge and the Atlantic Coastal Ridge resulted in the limestone basin that is now filled by Biscayne Bay, Card Sound, and Barnes Sound. During lower sea level stands of the Wisconsinan glacial, the Florida platform became emergent (sea level was approximately 300 feet (91.4 meters) lower than today) and the sea floor of Biscayne Bay was exposed. The exposed sea floor of Biscayne Bay was altered by rainwater. Dissolution, reprecipitation, and vegative soil formation cemented the calcareous surface and slowly produced a very hard reddish limestone “soil crust” over the surface. Carbonate dissolution resulting from precipitation and infiltration produced solution holes and pipes into the underlying limestone and solution hole drainage, in particular dendritic drainage patterns became exposed on the limestone portions of Biscayne Bay. The paleo-dissolution morphology and depositional morphology resulting from the Sangamon interglacial high sea level stand and Wisconsinan glacial low sea level stand are preserved on the sea floor of Biscayne Bay (References 4 and 5).

Figure 1. The two zones of secondary porosity on B-604 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (1 of 3)

Log ID: **B-604 (DH)**
Total Depth: **165 ft**
Northing: **396,916 (NAD83/90)**
Easting: **876,592 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 29.0 ft; 4" from 29.0 to 165.0 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/19/08 Completed 3/23/08**
Drilled By: **P. Pitts / R. Landeros**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 20.05 to 105 feet bgs.
Caliper (lower section) from 39.05 to 157 feet bgs.
Natural Gamma (lower and upper sections) from 20.05 to 157 feet bgs.
Reciever to reciever Vs and Vp from 26.3 to 150.9 feet bgs.
Acoustic Televiewer from 22.78 to 120.65 feet bgs.

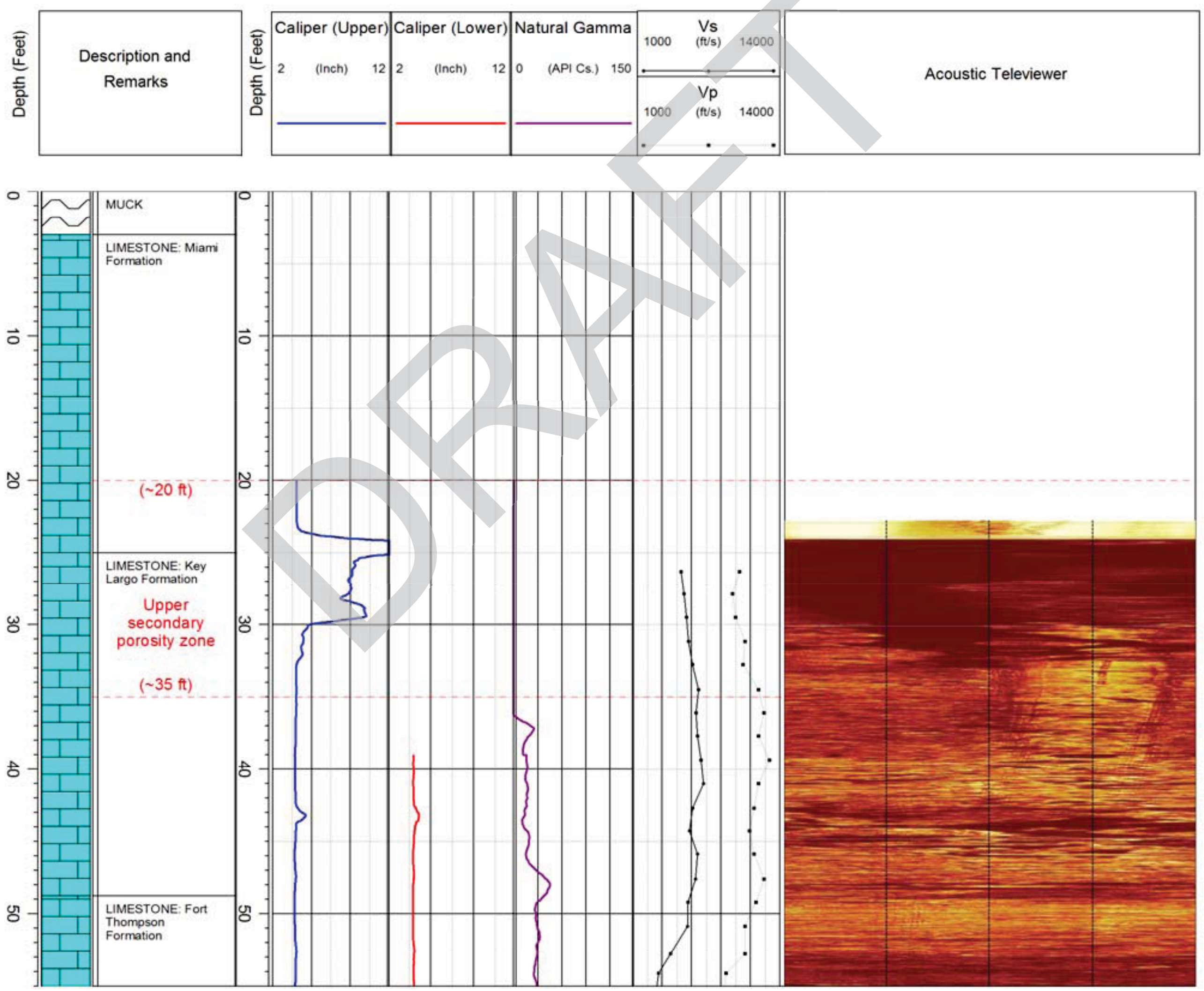


Figure 1. The two zones of secondary porosity on B-604 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (2 of 3)

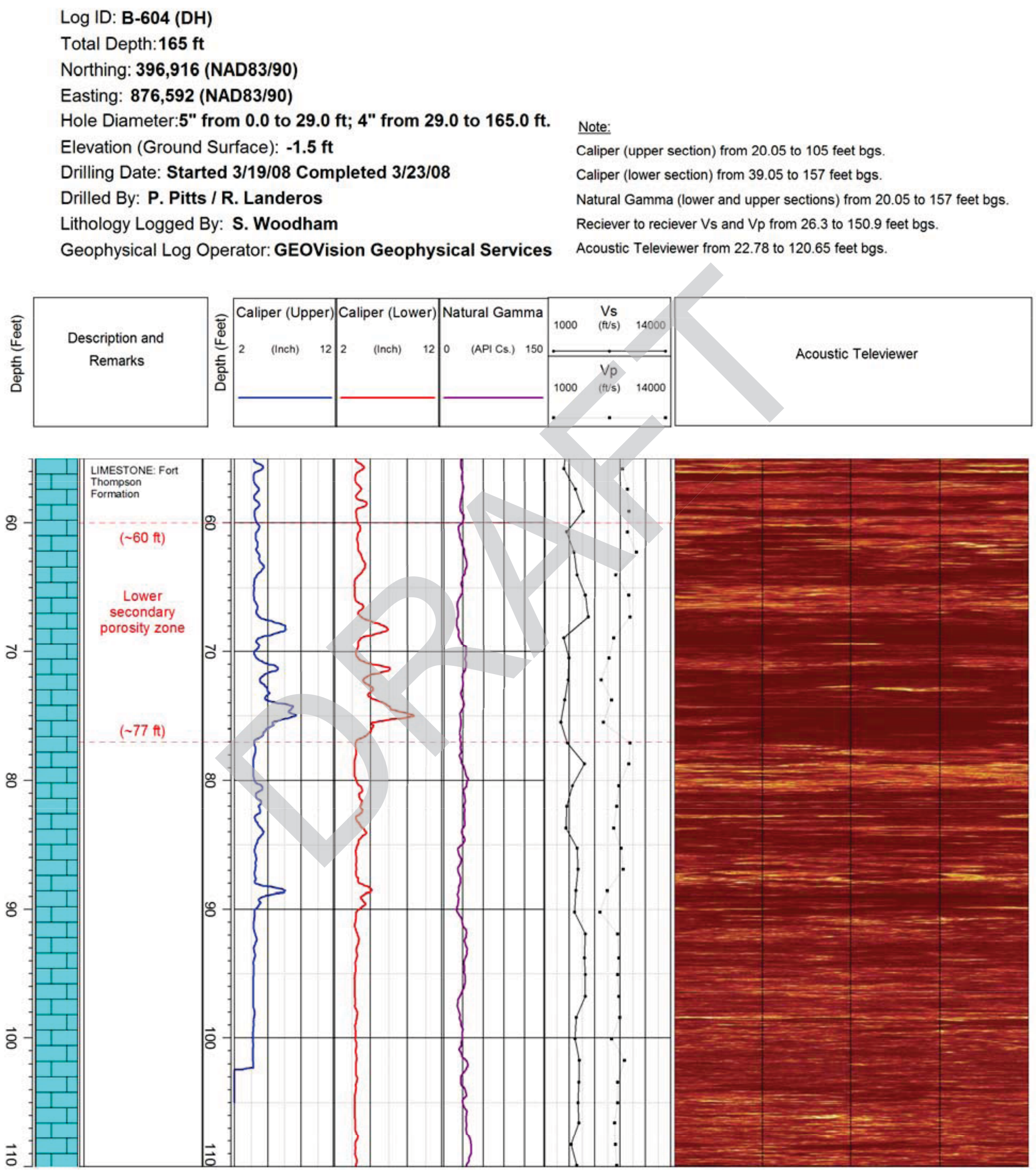


Figure 1. The two zones of secondary porosity on B-604 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (3 of 3)

Log ID: **B-604 (DH)**
Total Depth: **165 ft**
Northing: **396,916 (NAD83/90)**
Easting: **876,592 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 29.0 ft; 4" from 29.0 to 165.0 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/19/08 Completed 3/23/08**
Drilled By: **P. Pitts / R. Landeros**
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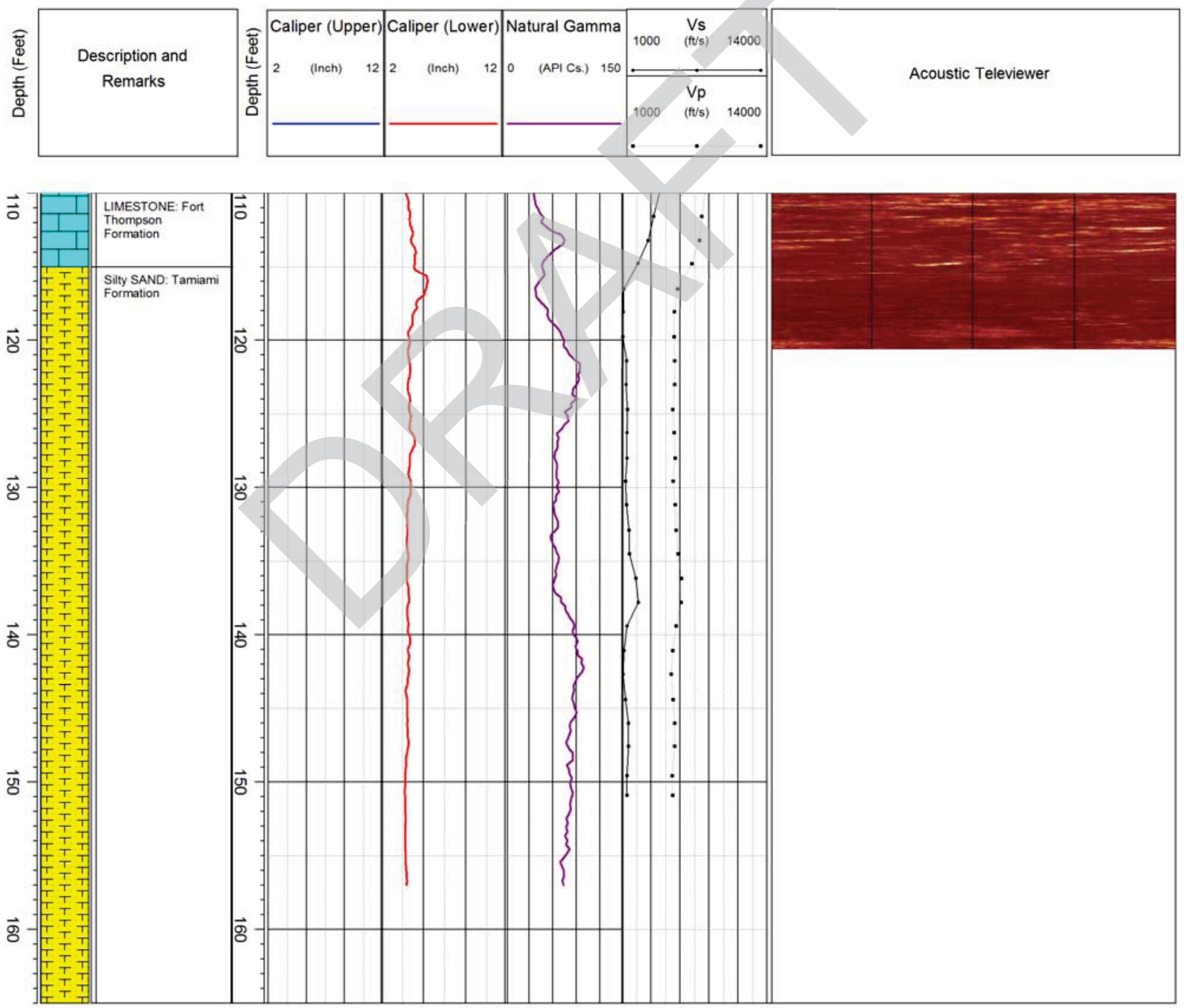
Reciever to reciever Vs and Vp from 26.3 to 150.9 feet bgs.
Acoustic Televiewer from 22.78 to 120.65 feet bgs.



Source: FSAR Subsection 2.5.1 Reference 708

Figure 2. The two zones of secondary porosity on B-608 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (1 of 5)

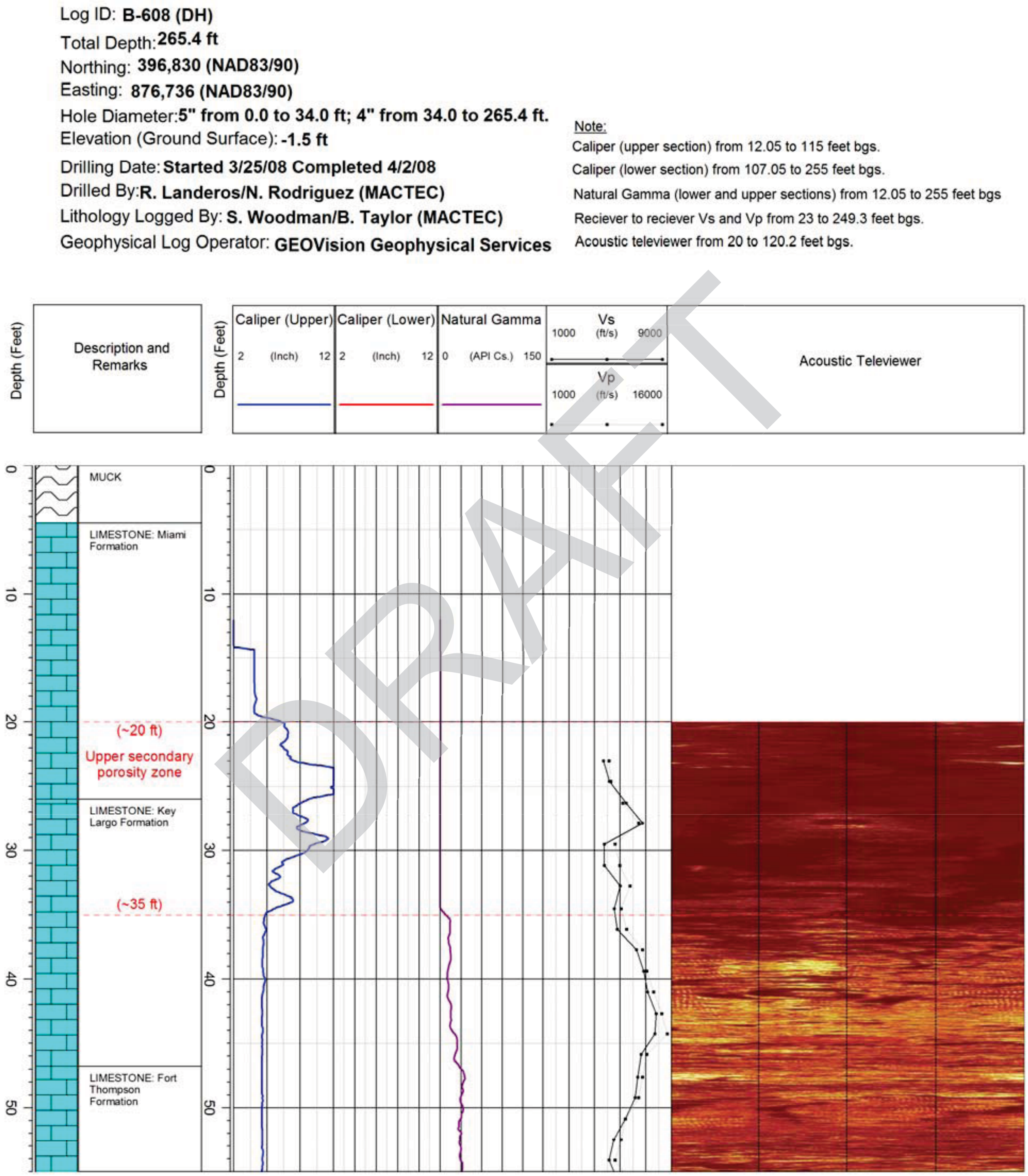


Figure 2. The two zones of secondary porosity on B-608 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (2 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 12.05 to 115 feet bgs.
Caliper (lower section) from 107.05 to 255 feet bgs.
Natural Gamma (lower and upper sections) from 12.05 to 255 feet bgs
Reciever to reciever Vs and Vp from 23 to 249.3 feet bgs.
Acoustic televiewer from 20 to 120.2 feet bgs.

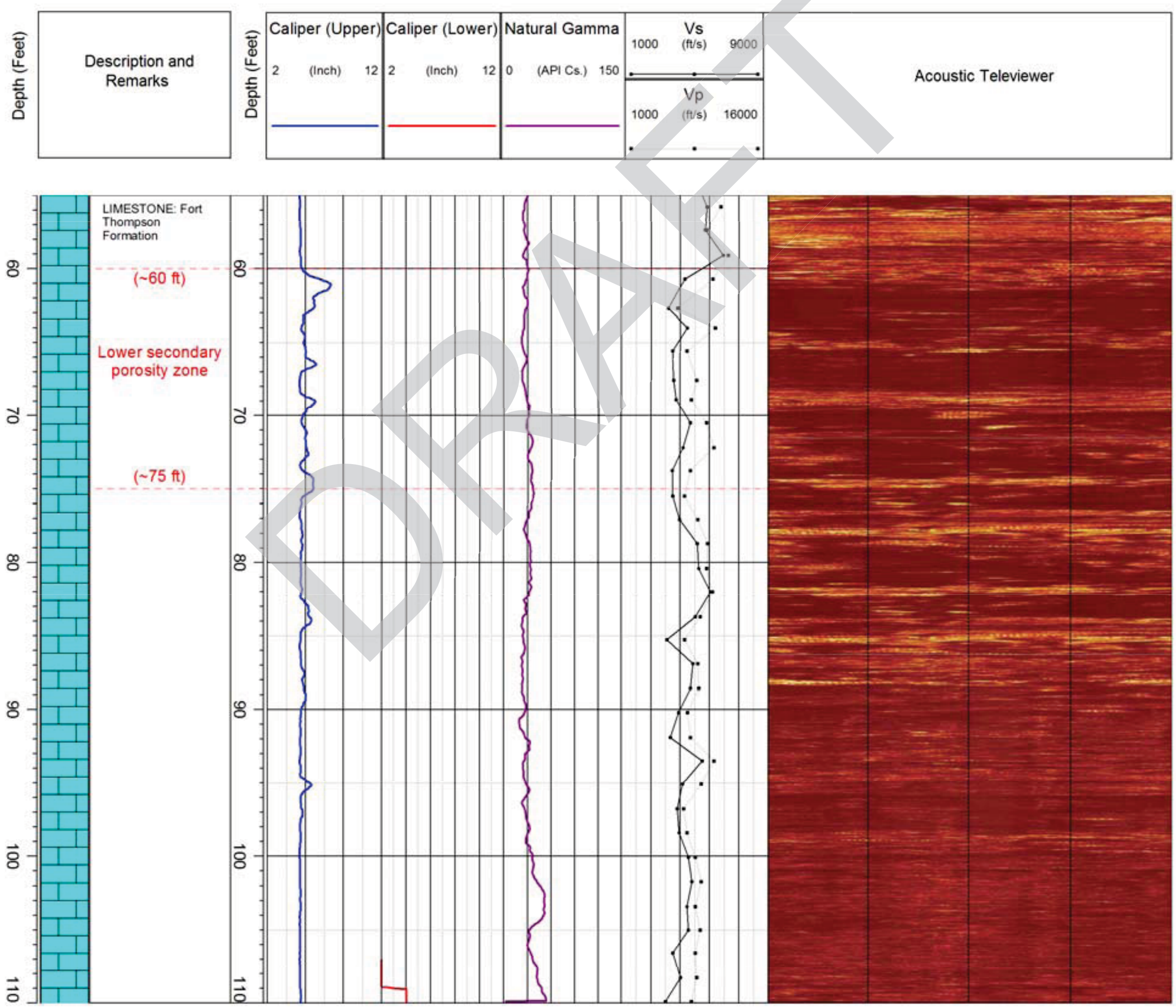


Figure 2. The two zones of secondary porosity on B-608 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (3 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 12.05 to 115 feet bgs.
Caliper (lower section) from 107.05 to 255 feet bgs.
Natural Gamma (lower and upper sections) from 12.05 to 255 feet bgs
Reciever to reciever Vs and Vp from 23 to 249.3 feet bgs.
Acoustic televiewer from 20 to 120.2 feet bgs.

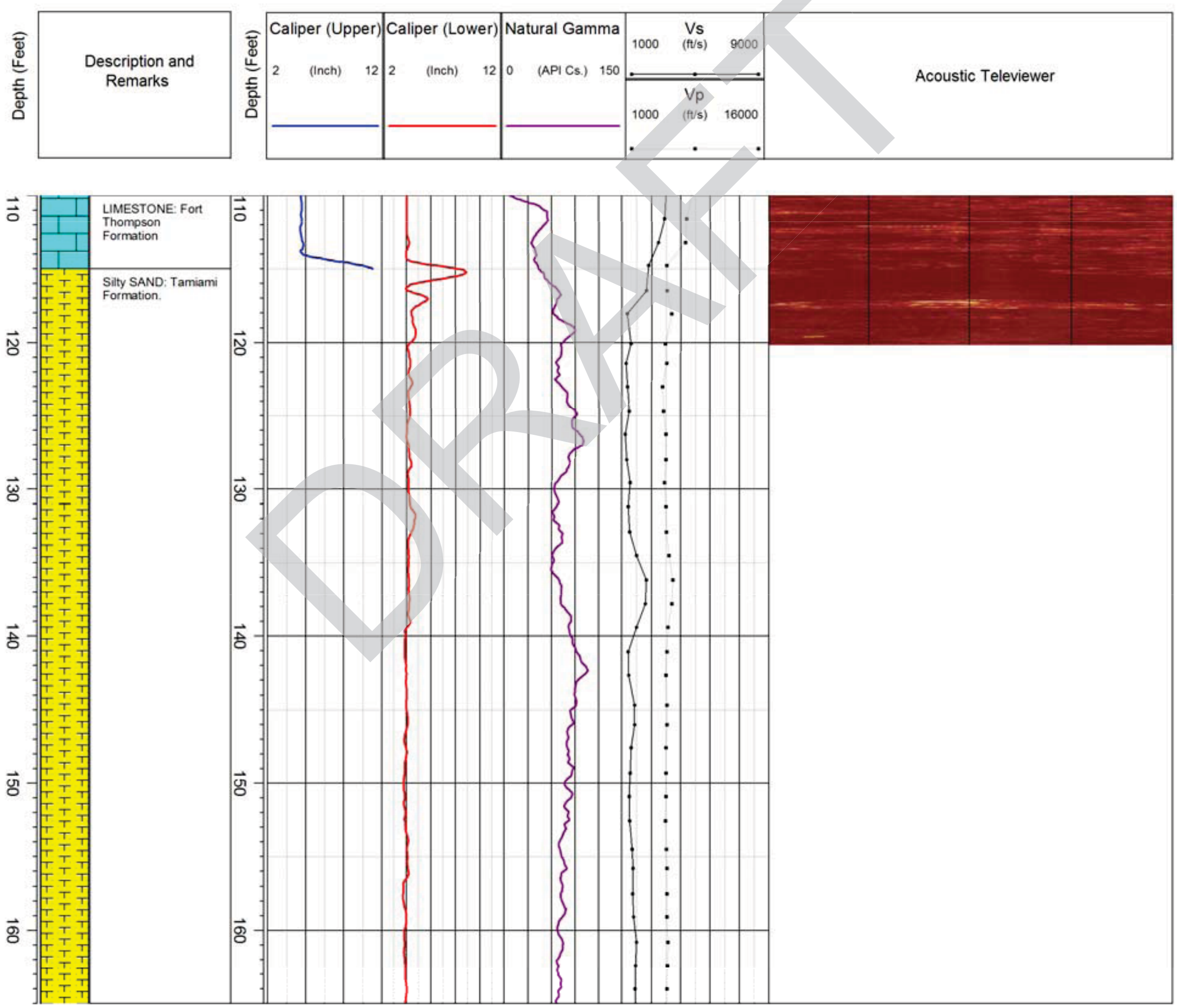


Figure 2. The two zones of secondary porosity on B-608 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (4 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 12.05 to 115 feet bgs.
Caliper (lower section) from 107.05 to 255 feet bgs.
Natural Gamma (lower and upper sections) from 12.05 to 255 feet bgs
Reciever to reciever Vs and Vp from 23 to 249.3 feet bgs.
Acoustic televiewer from 20 to 120.2 feet bgs.

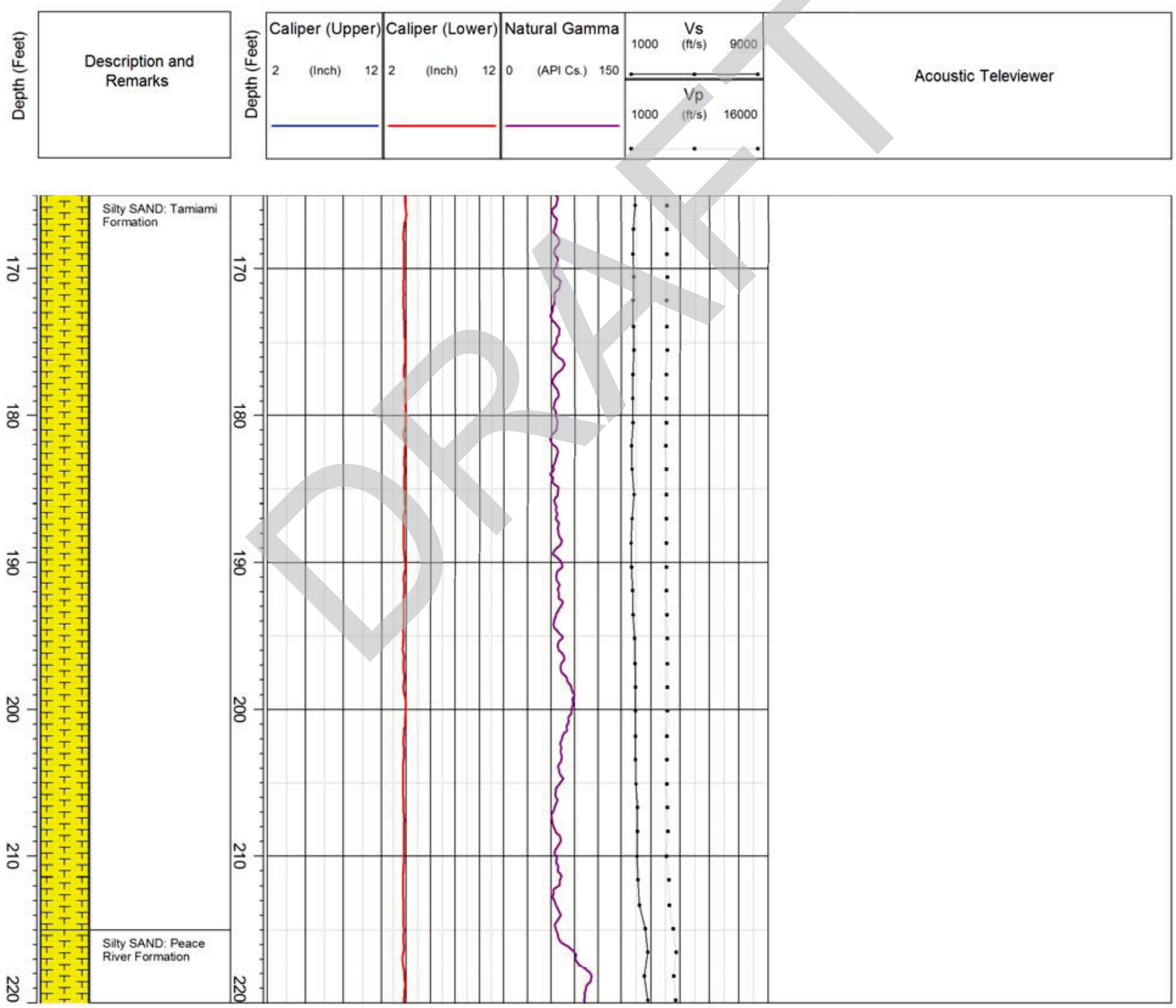
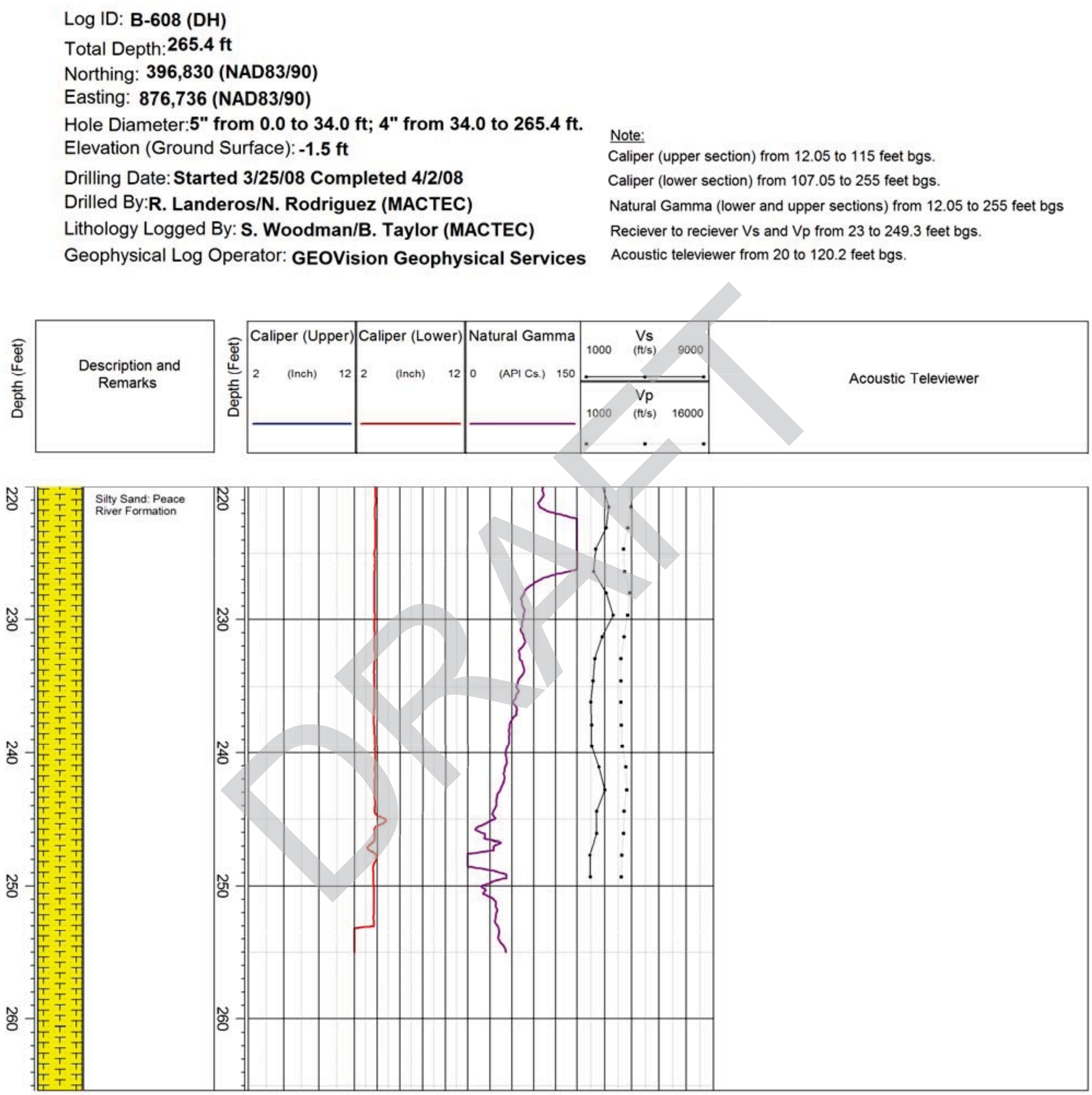


Figure 2. The two zones of secondary porosity on B-608 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (5 of 5)



Source: FSAR Subsection 2.5.1 Reference 708

Figure 3. The two zones of secondary porosity on B-710 G (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (1 of 5)

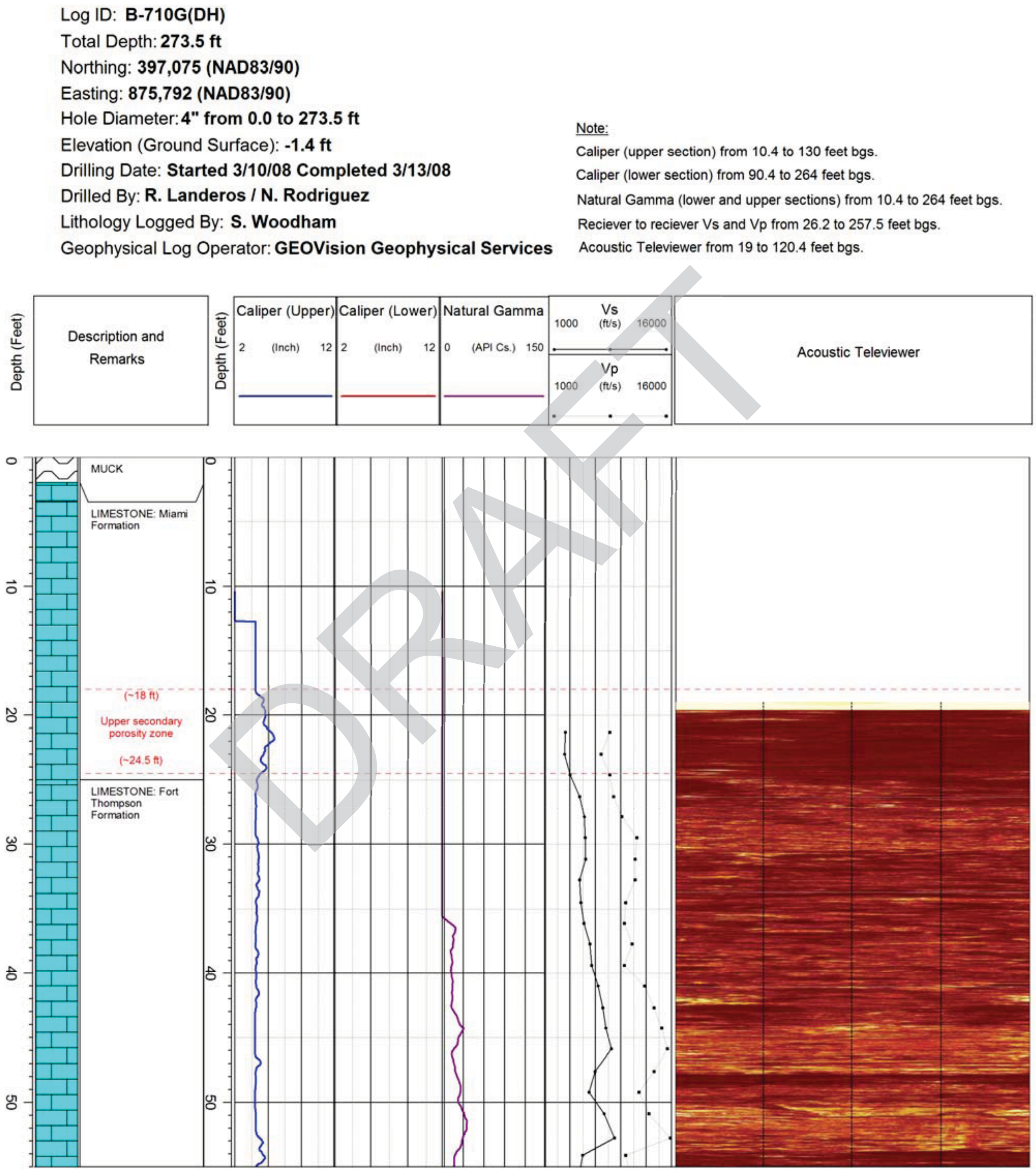


Figure 3. The two zones of secondary porosity on B-710 G (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (2 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.

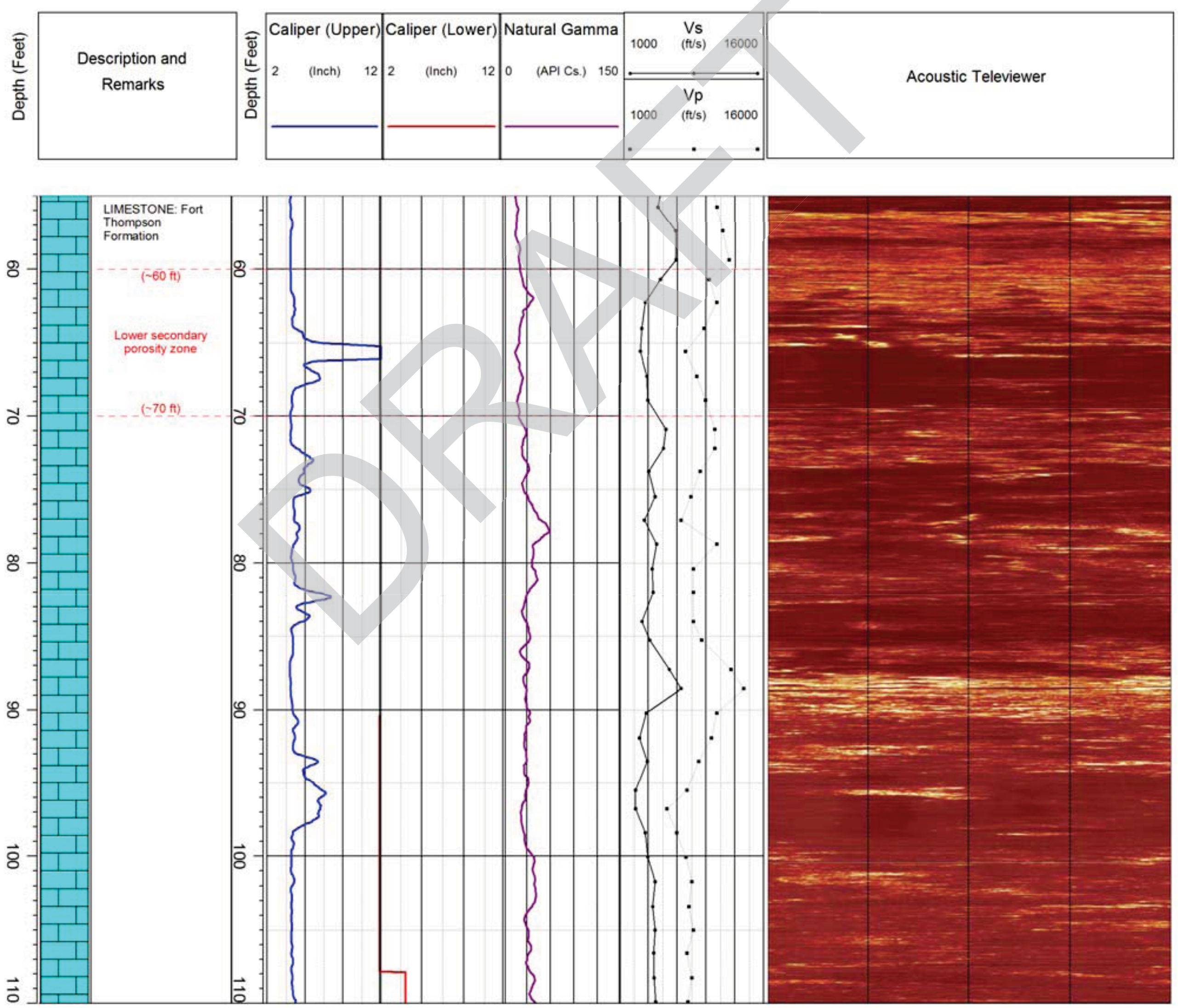


Figure 3. The two zones of secondary porosity on B-710 G (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (3 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.

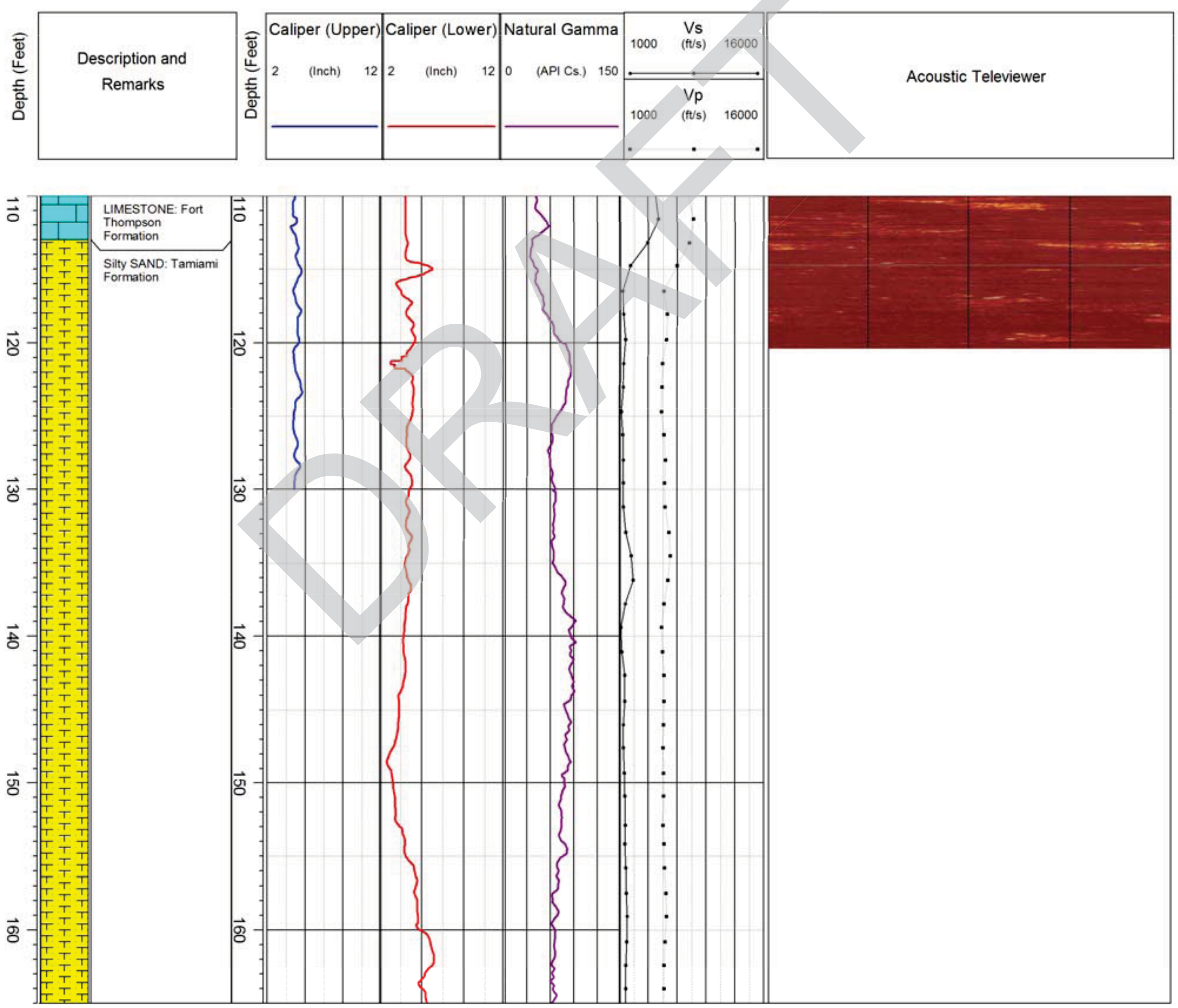


Figure 3. The two zones of secondary porosity on B-710 G (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (4 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.

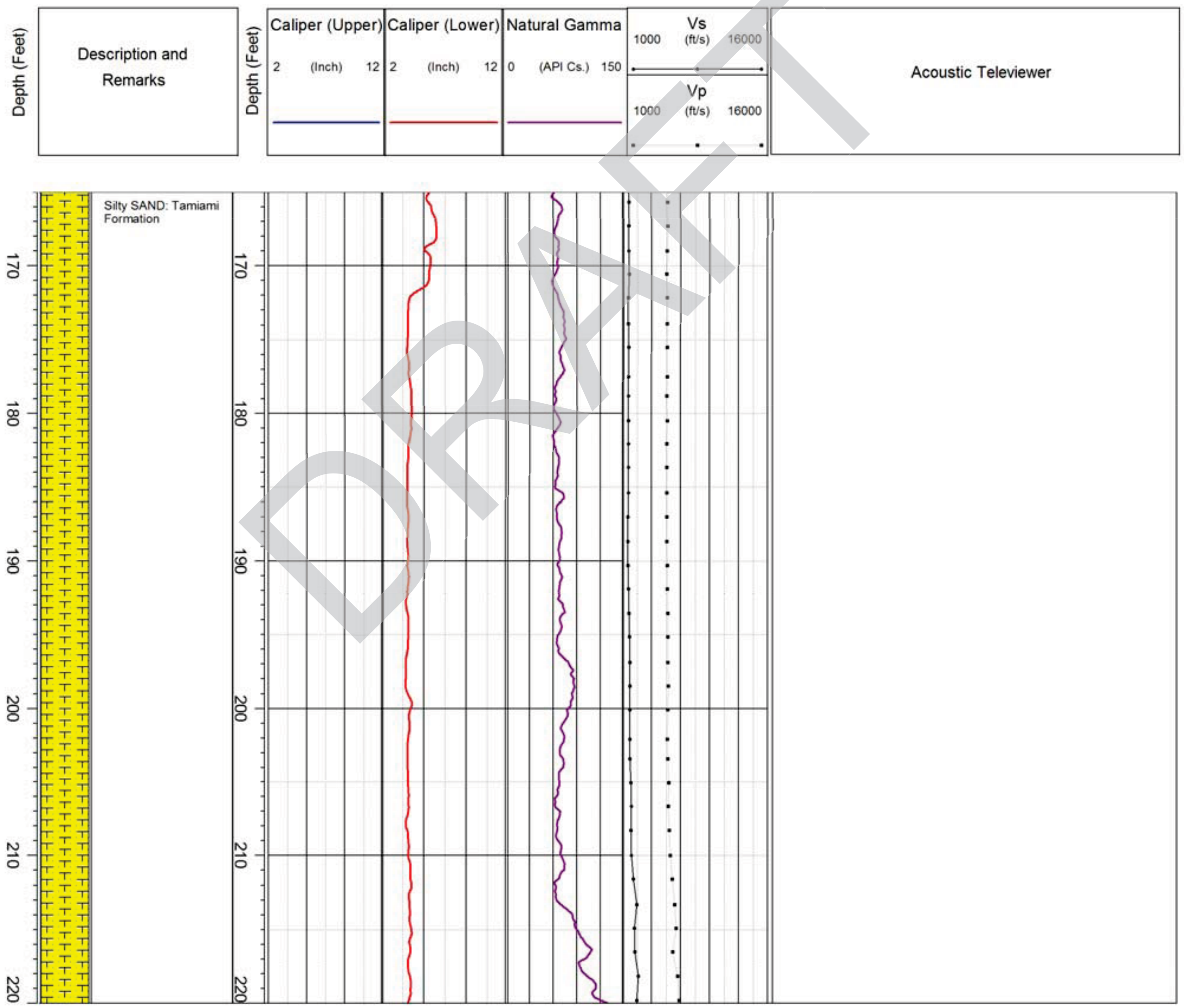


Figure 3. The two zones of secondary porosity on B-710 G (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (5 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
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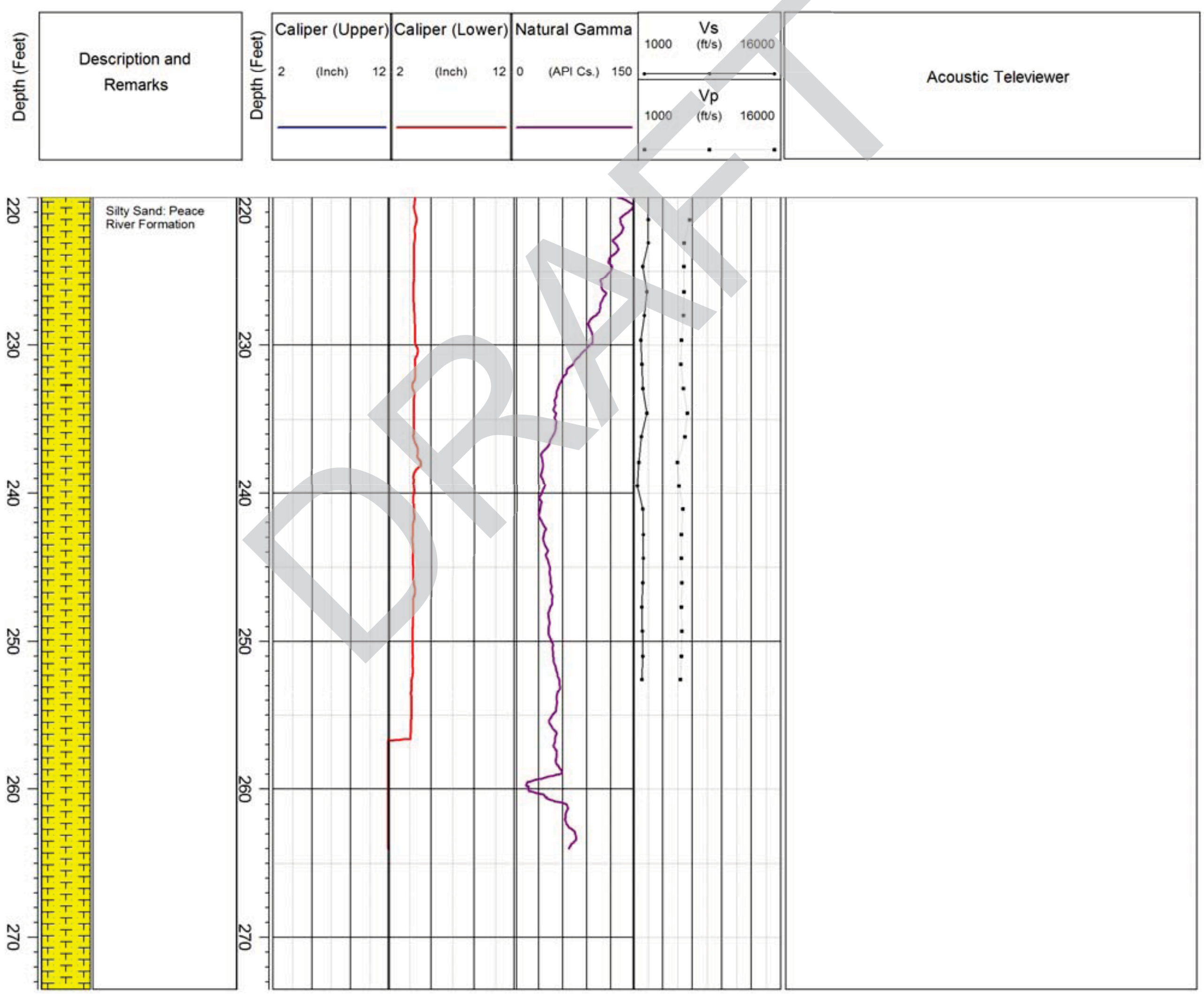
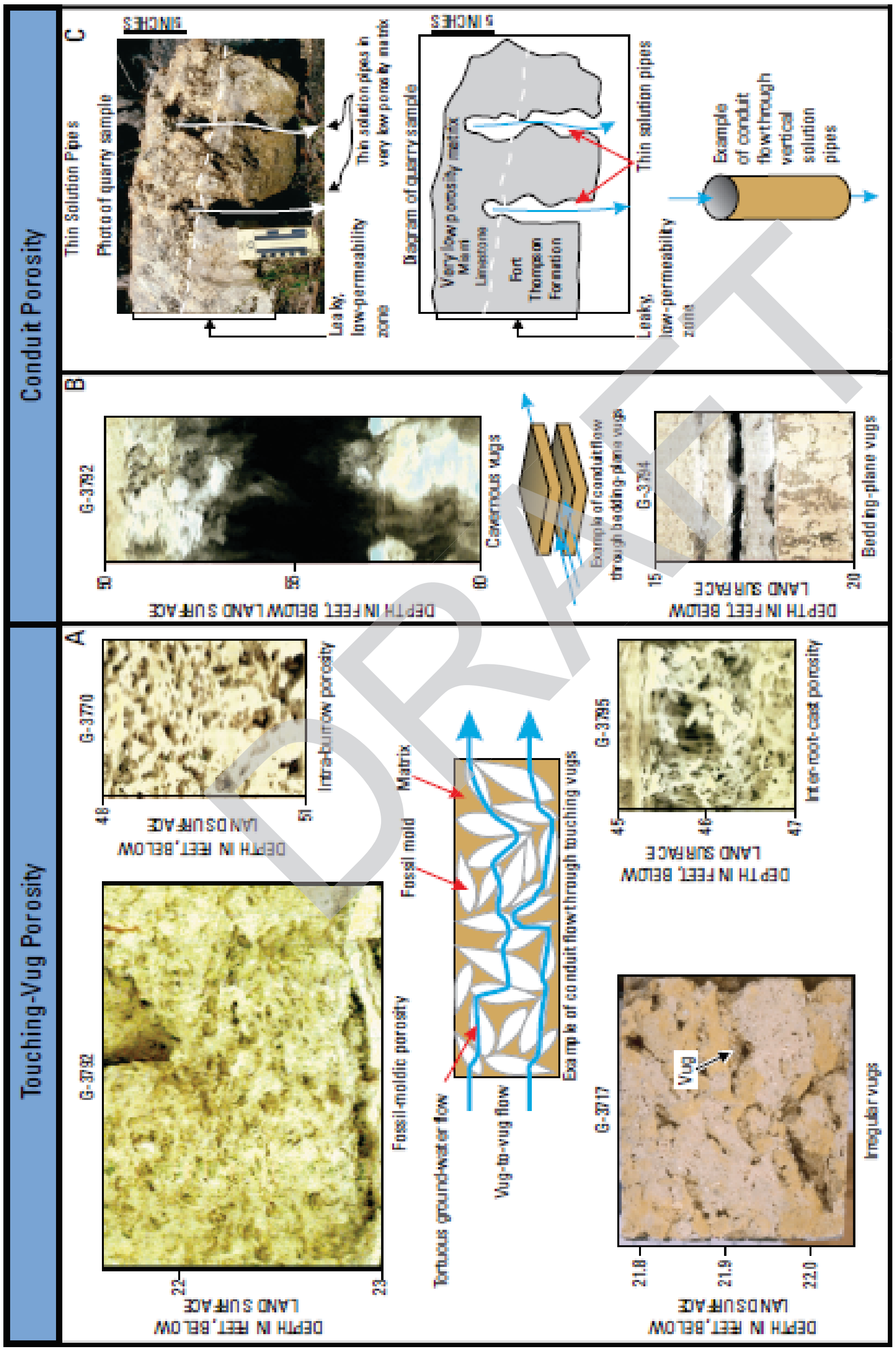


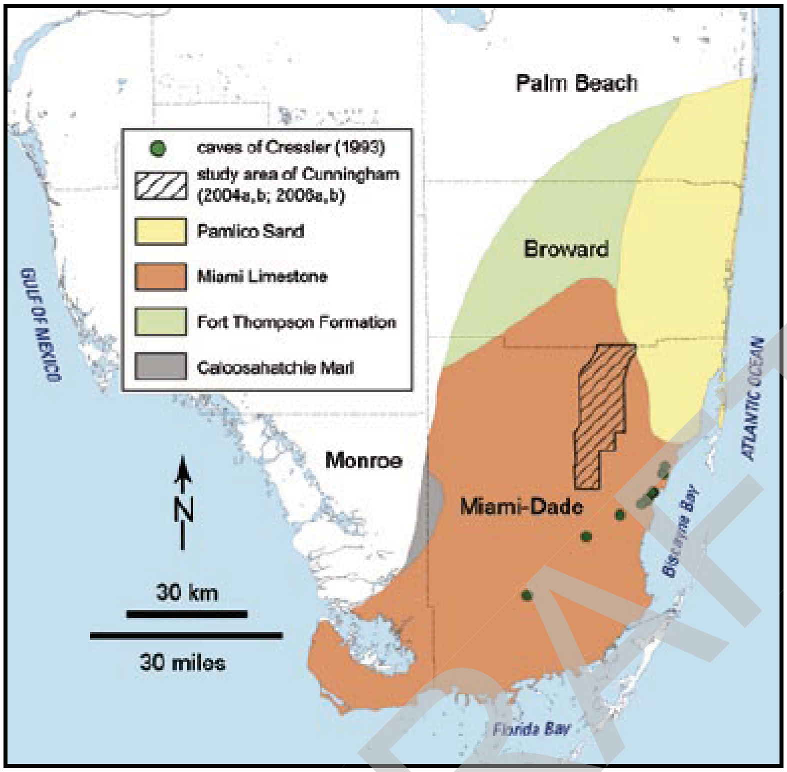
Source: FSAR Subsection 2.5.1 Reference 708

Figure 4. Relation between Touching-Vug Porosity and Conduit Porosity for the Fort Thompson Formation and Miami Limestone of the Biscayne Aquifer in Cunningham et al (FSAR Subsection 2.5.1 Reference 404) Study Area



Source: modified from FSAR Subsection 2.5.1 Reference 404

Figure 5. Map of southern Florida showing the locations of Cressler Caves



Source: Reference 7

This response is PLANT SPECIFIC.

References:

1. Lucia, F. J., Rock-Fabric / Petrophysical classification of Carbonate Pore Space for Reservoir Characterization. AAPG Bulletin, Vol.79, No. 9, p. 1275-1300, September 1995.
2. Cantillo, A. Y., (editor) 1983 Biscayne Bay Hydrocarbon Study, NOAA National Ocean Service, USDC, February, 2005.
3. Reich, C, Halley, R.B., Hickey, T., and Swarzenski, P., Groundwater Characterization and Assessment of Contaminants in Marine Areas of Biscayne National Park, U.S. Department of the Interior, National Park Service Technical Report NPS/NRWRD/NRTR-2006/356, 163 p., 2006.
4. Reich, C. D., Hickey, T. D., DeLong, K. L., Poore, R. Z., and Brock, J. C., Holocene Core Logs and Site Statistics for Modern Patch-Reef Cores: Biscayne National Park, Florida, USGS Open File Report 2009-1246, 26 p., 2009.
5. Wanless, H., Geologic Setting and Recent Sediments of the Biscayne Bay Region, Florida in Biscayne Bay: Past/Present/Future, Thorhaug, A. and Volker, A. (editors). A Symposium presented by the University of Miami April 2-3, 1976.
6. Cressler, A., The caves of Dade County, Florida, in Georgia Underground: Dogwood City Grotto, Inc., of the National Speleological Society, v. 30, no. 3, p. 9–16, 1993.
7. Cunningham, K., and Florea, L.J., "The Biscayne Aquifer of Southeastern Florida" Caves and Karst of the USA. In Arthur N. Palmer (editor) Huntsville: National Speleological Society, pp.196-199, 2009.

ASSOCIATED COLA REVISIONS:

A new paragraph will be added after the sixth paragraph of FSAR Subsection 2.5.1.2.4, Site Geologic Hazards, in a future revision of the FSAR as follows:

An FGS investigation (Reference 724) concludes that most of Miami-Dade County is underlain by limestone containing solution cavities. **The two zones of secondary porosity were identified at the site following review of the geophysical logs, the geotechnical boring logs, and the shear wave velocity logs. In general, the zones of secondary porosity were identified based on increases in borehole diameter on the caliper logs, darkened areas on the acoustic televiewer images, typically lower P-S wave velocity values, and loss of drilling fluid and rod drops, although limited, on the boring logs. Figures 2.5.1-351 through 2.5.1-353 show the approximate locations of the two zones of secondary porosity on three example-boring logs, B-604 (DH), B-608 (DH), and B-710G (DH) and their locations at the Turkey Point Units 6 & 7 site are seen in Figure 2.5.1-228. Figures 2.5.1-351 through 2.5.1-353 were compiled using the lithology, caliper, natural gamma, acoustic televiewer, and velocity (Vs and Vp) logs. An upper zone (referred to as the "Upper Higher Flow Zone" in Subsection 2.4.12.1.4) from approximately -25 feet to -35 feet NAVD 88 is located approximately at the boundary between the Miami Limestone and Key Largo Limestone and is considered to represent a laterally continuous relatively thin layer of secondary porosity consisting of touching-vugs. A lower zone (referred to as the "Lower Higher Flow Zone" in Subsection 2.4.12.1.4) from approximately -65 feet to -75 feet NAVD 88 is**

located within the Fort Thompson Formation and is not considered to be a laterally persistent layer but rather isolated pockets of moldic porosity within the layer (Figures 2.5.1-351 through 2.5.1-353).

~~It indicates that a few localities in the Homestead/Turkey Point area may be underlain by open and sand-filled cavities in a zone occurring between depths of about 18 to 31 feet (5 to 9 meters). Information collected during the course of Units 6 & 7 subsurface investigations include rod drops, loss of drill fluid circulation, rock recovery, and Rock Quality Designation (RQD). Analysis of this information indicates that, while individual boreholes showed variation, data collected during the drilling of boreholes qualitatively points towards the existence of two preferential secondary porosity flow zones in the areas beneath and in the immediate vicinity of the Units 6 & 7 site:~~

- ~~An upper zone from approximately -25 feet to -35 feet NAVD 88 located predominantly within the Key Largo limestone (the start of this zone correlates roughly with the boundary between the overlying Miami Limestone and the underlying Key Largo Limestone).~~
- ~~A lower zone from approximately -65 feet to -75 feet NAVD 88 that correlates with a sandy zone within the Fort Thompson Formation.~~

As seen from the cores taken during the subsurface investigation and photos of the cores (Reference 708), the potential origin of the touching-vug porosity within the upper zone is associated with original reef structure and, based on Cunningham et al (References 404 and 723), solution enlargement. Recent studies by Cunningham et al. (References 404 and 723) suggest vuggy porosity is common within the Biscayne Aquifer (Miami and Key Largo limestones and Fort Thompson Formation) and that typical solution features associated with the touching-vug porosity include solution-enlarged fossil molds up to pebble size, molds of burrows or roots, irregular vugs surrounding casts of burrows or roots, and bedding plane vugs. Cunningham et al. (Reference 404) show images of vugs in the Miami Limestone and Fort Thompson Formation, with cavernous vugs approximately 4 feet in height. The potential origin of the lower zone of secondary porosity is moldic porosity or separate-vug porosity (Reference 912) resulting from dissolution of in-situ bivalve shells. While touching-vug and moldic porosity similar to that noted by Cunningham et al., (References 404 and 723) and Lucia (Reference 912) occur at the Turkey Point Units 6 & 7 site, it should be noted that only occasional small rod drops were noted in 6 out of the 88 boreholes and approximately 9000 feet of rock coring. None of which were in the Units 6 or 7 nuclear islands (Subsections 2.5.1.2.4, 2.5.4.1.2.1 and 2.5.4.4.5.5) (Table 2.5.1-208).

~~Analysis of the caliper, suspension velocity, and acoustic televiewer data collected from 10 borings during the Units 6 & 7 subsurface investigation provides additional evidence supporting the existence of these secondary porosity flow zones beneath Units 6 & 7. As stated in Reference 708, the location of cavities and weathered zones on the televiewer logs correspond precisely with increases in caliper log diameter and suspension P- and S-wave velocity drops. Study of the downhole geophysical data logs confirms that such cavities and weathered zones are commonly observed within the elevation ranges proposed for the upper and lower secondary porosity flow zones. A downhole video survey conducted in pilot hole MW-1, located on the Turkey Point Peninsula, also supports the existence of these secondary porosity zones. The downhole video shows evidence of highly permeable zones containing interconnected vugs between the elevations of approximately -21 feet to -43 feet NAVD 88 and -62 feet to -72 feet NAVD 88.~~

The following reference will be added in a future revision of the FSAR Subsection 2.5.1.3:

912 Lucia, F. J., Rock-Fabric / Petrophysical classification of Carbonate Pore Space for Reservoir Characterization. AAPG bulletin, V.79, No. 9, p. 1275-1300, September 1995.

The following figures will be added in a future revision of the FSAR Subsection 2.5.1

Figure 2.5.1-351. The two zones of secondary porosity on B-604 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (1 of 3)

Log ID: **B-604 (DH)**
Total Depth: **165 ft**
Northing: **396,916 (NAD83/90)**
Easting: **876,592 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 29.0 ft; 4" from 29.0 to 165.0 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/19/08 Completed 3/23/08**
Drilled By: **P. Pitts / R. Landeros**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 20.05 to 105 feet bgs.
Caliper (lower section) from 39.05 to 157 feet bgs.
Natural Gamma (lower and upper sections) from 20.05 to 157 feet bgs.
Reciever to reciever Vs and Vp from 26.3 to 150.9 feet bgs.
Acoustic Televiewer from 22.78 to 120.65 feet bgs.

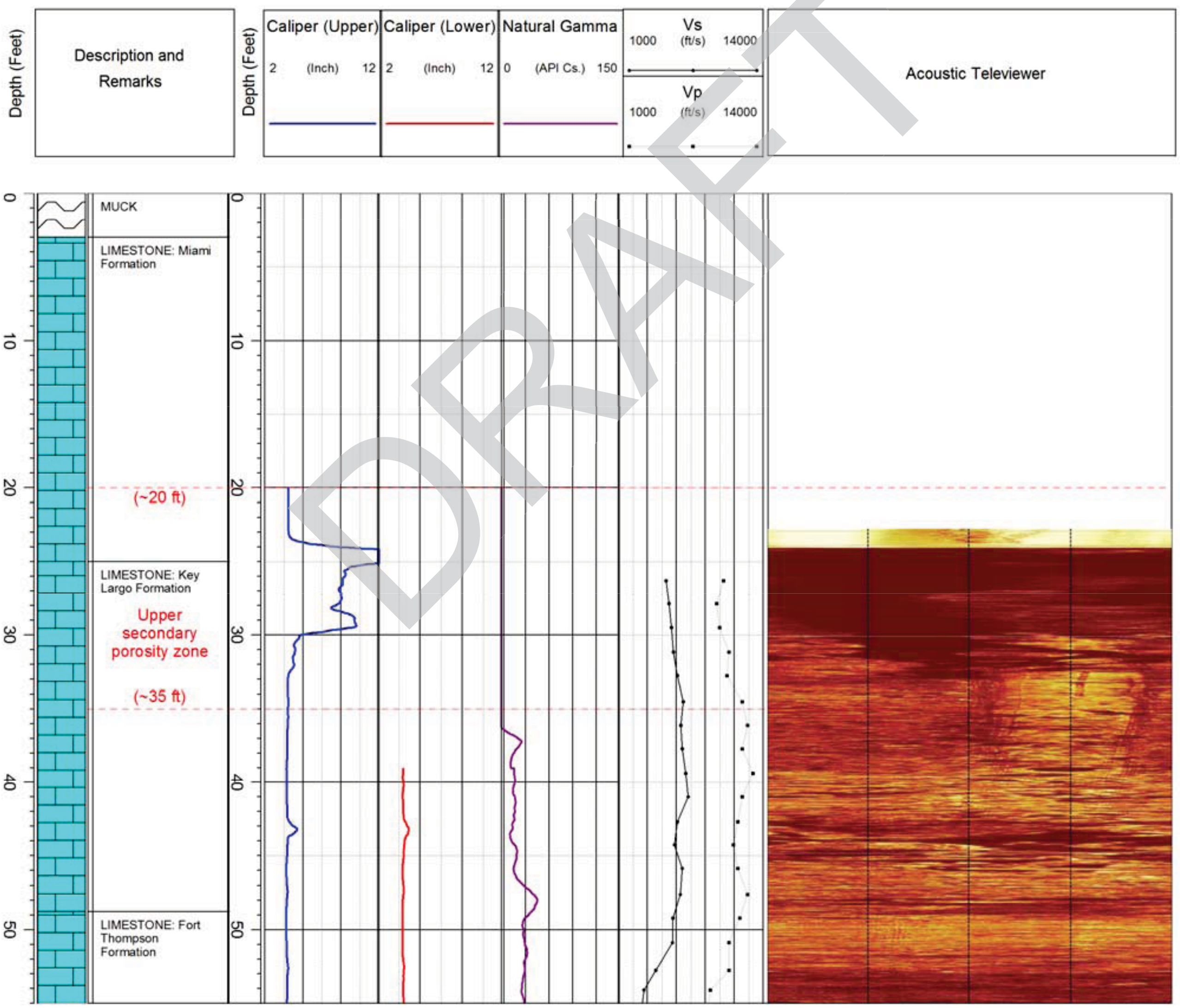


Figure 2.5.1-351. The two zones of secondary porosity on B-604 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (2 of 3)

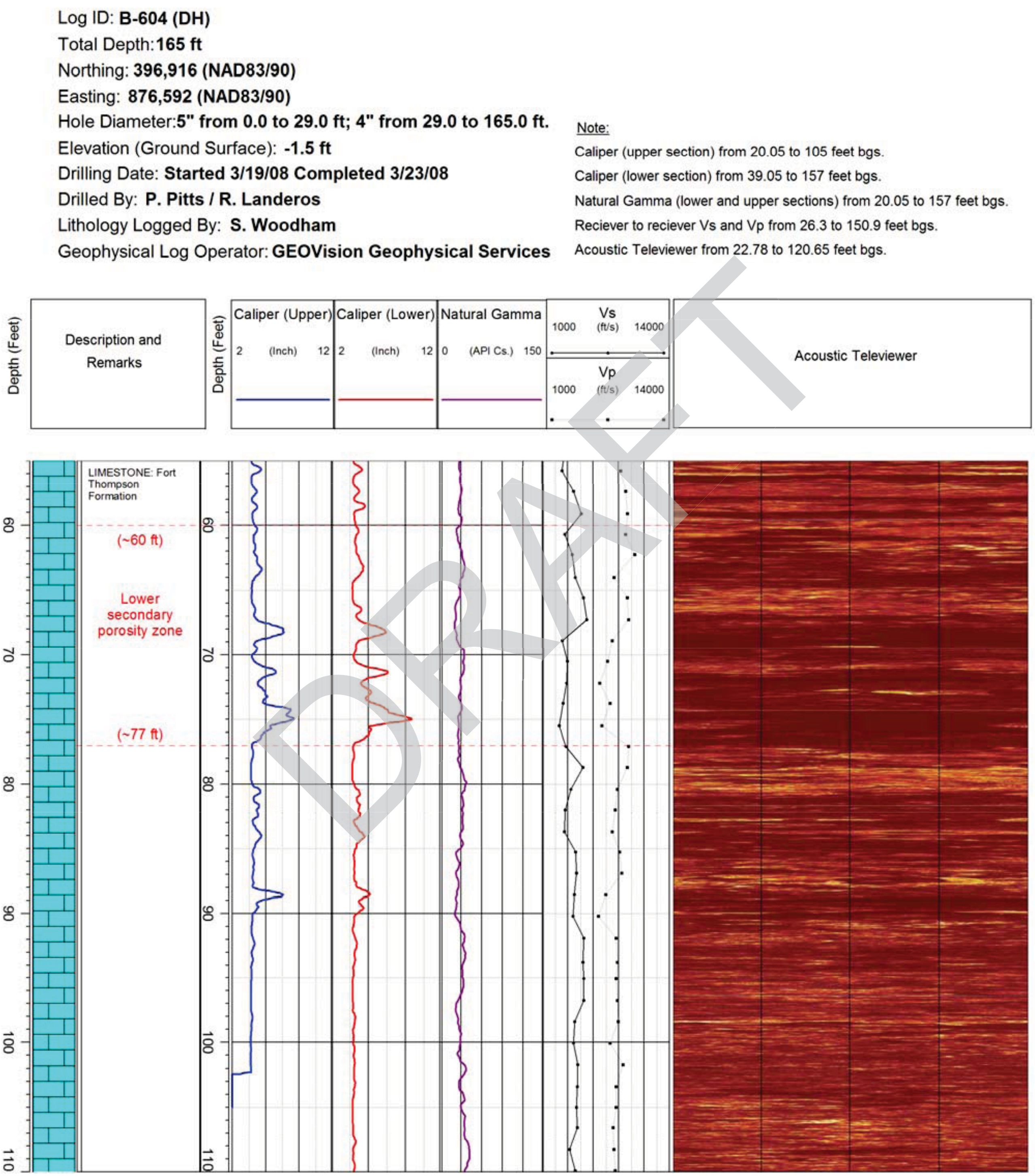
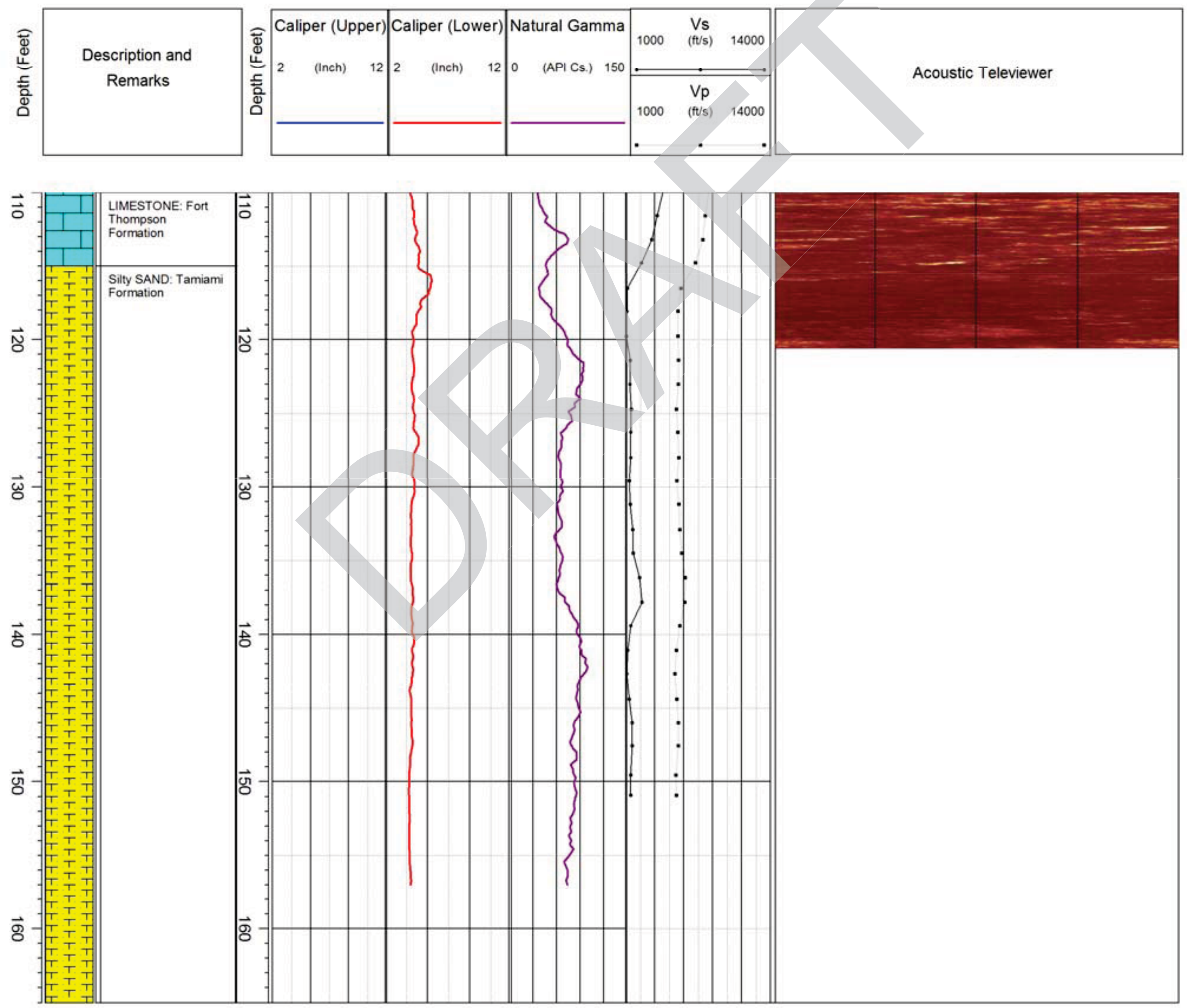


Figure 2.5.1-351. The two zones of secondary porosity on B-604 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (3 of 3)

Log ID: **B-604 (DH)**
Total Depth: **165 ft**
Northing: **396,916 (NAD83/90)**
Easting: **876,592 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 29.0 ft; 4" from 29.0 to 165.0 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/19/08 Completed 3/23/08**
Drilled By: **P. Pitts / R. Landeros**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 20.05 to 105 feet bgs.
Caliper (lower section) from 39.05 to 157 feet bgs.
Natural Gamma (lower and upper sections) from 20.05 to 157 feet bgs.
Reciever to reciever Vs and Vp from 26.3 to 150.9 feet bgs.
Acoustic Televiewer from 22.78 to 120.65 feet bgs.



Source: Reference 708

Figure 2.5.1-352. The two zones of secondary porosity on B-608 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (1 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 12.05 to 115 feet bgs.
Caliper (lower section) from 107.05 to 255 feet bgs.
Natural Gamma (lower and upper sections) from 12.05 to 255 feet bgs
Reciever to reciever Vs and Vp from 23 to 249.3 feet bgs.
Acoustic televiewer from 20 to 120.2 feet bgs.

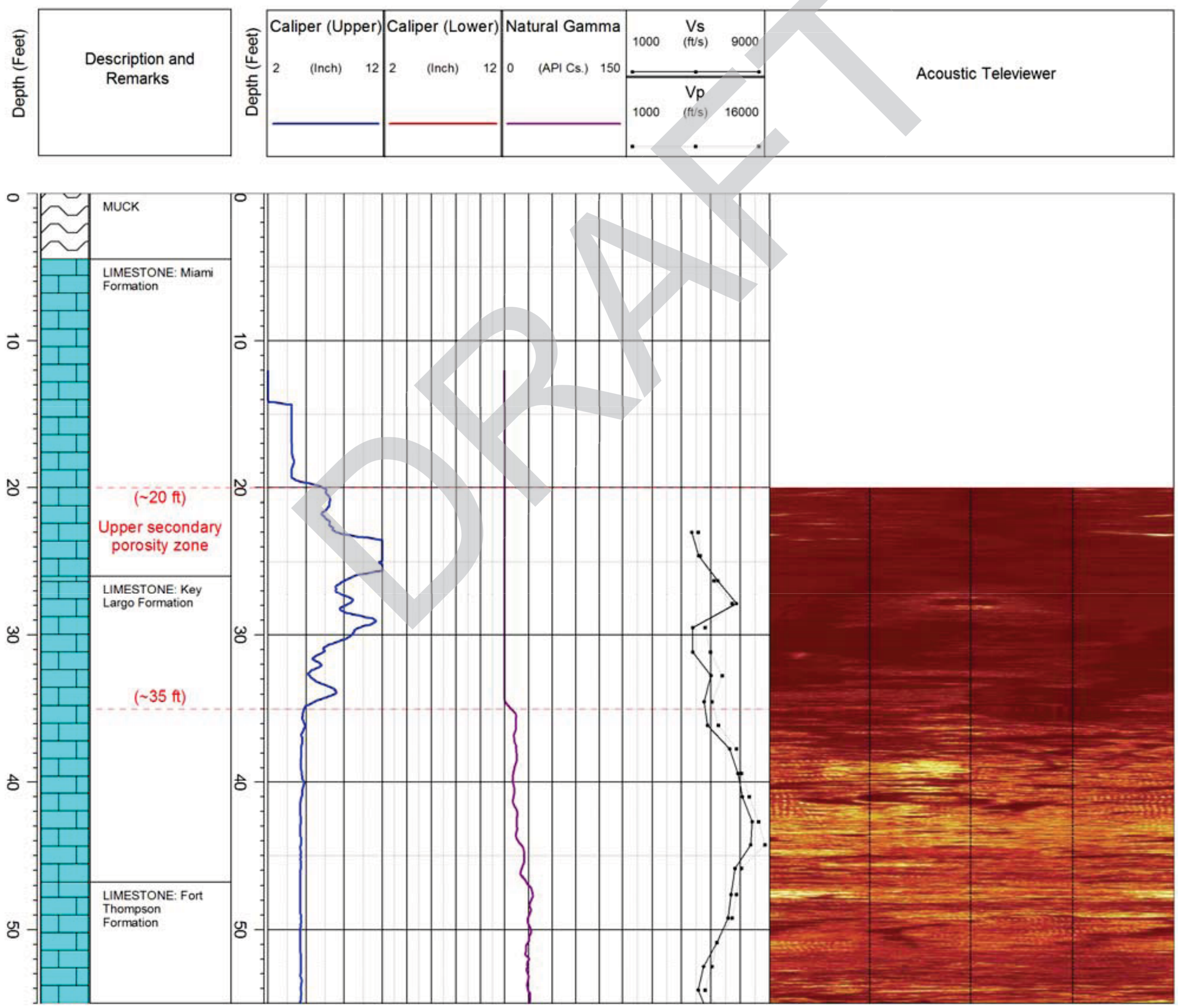


Figure 2.5.1-352. The two zones of secondary porosity on B-608 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (2 of 5)

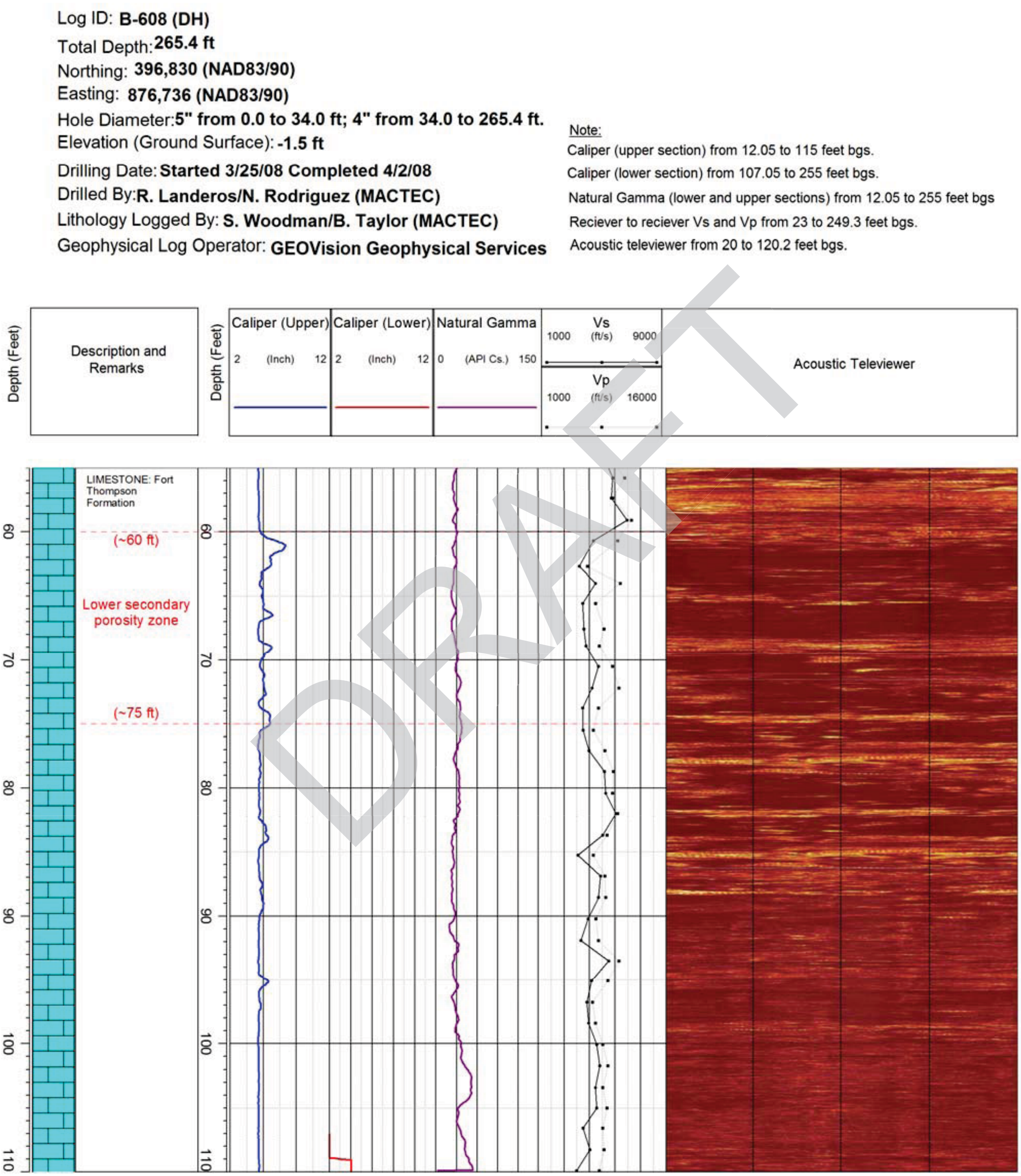


Figure 2.5.1-352. The two zones of secondary porosity on B-608 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (3 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 12.05 to 115 feet bgs.
Caliper (lower section) from 107.05 to 255 feet bgs.
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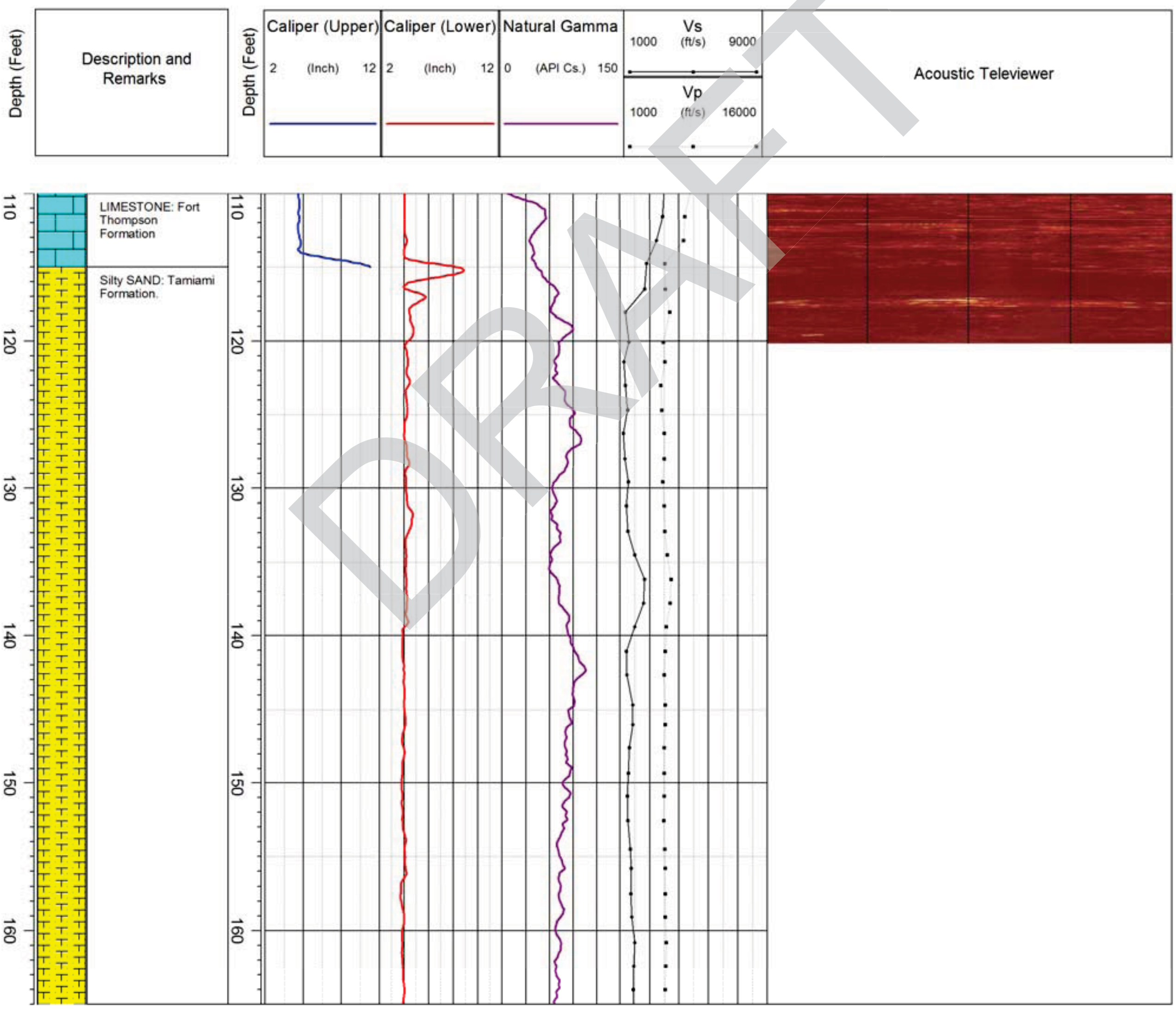

Figure 2.5.1-352. The two zones of secondary porosity on B-608 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (4 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 12.05 to 115 feet bgs.
Caliper (lower section) from 107.05 to 255 feet bgs.
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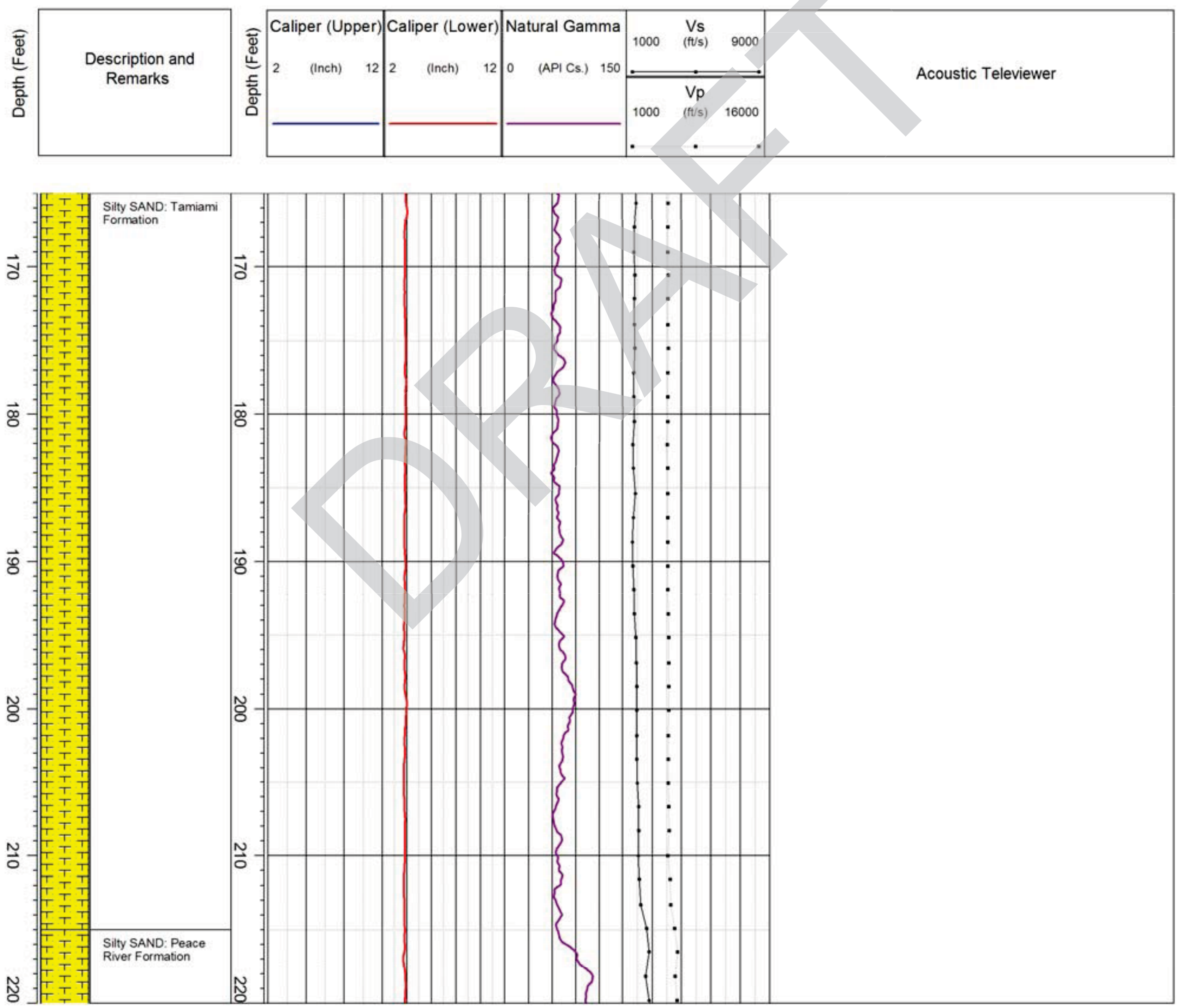

Figure 2.5.1-352. The two zones of secondary porosity on B-608 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (5 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
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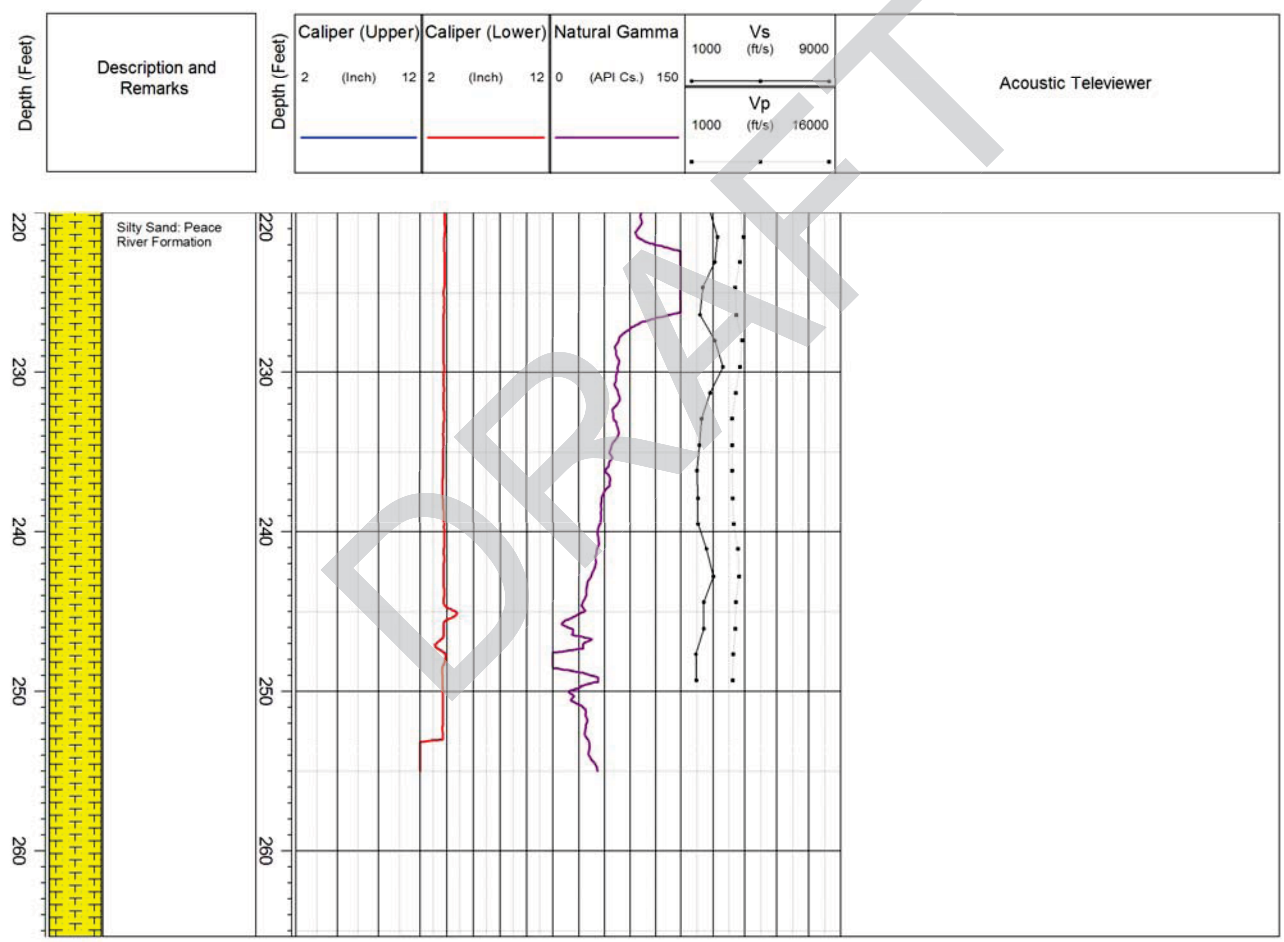


Source: Reference 708

Figure 2.5.1-353. The two zones of secondary porosity on B-710 G (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (1 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.

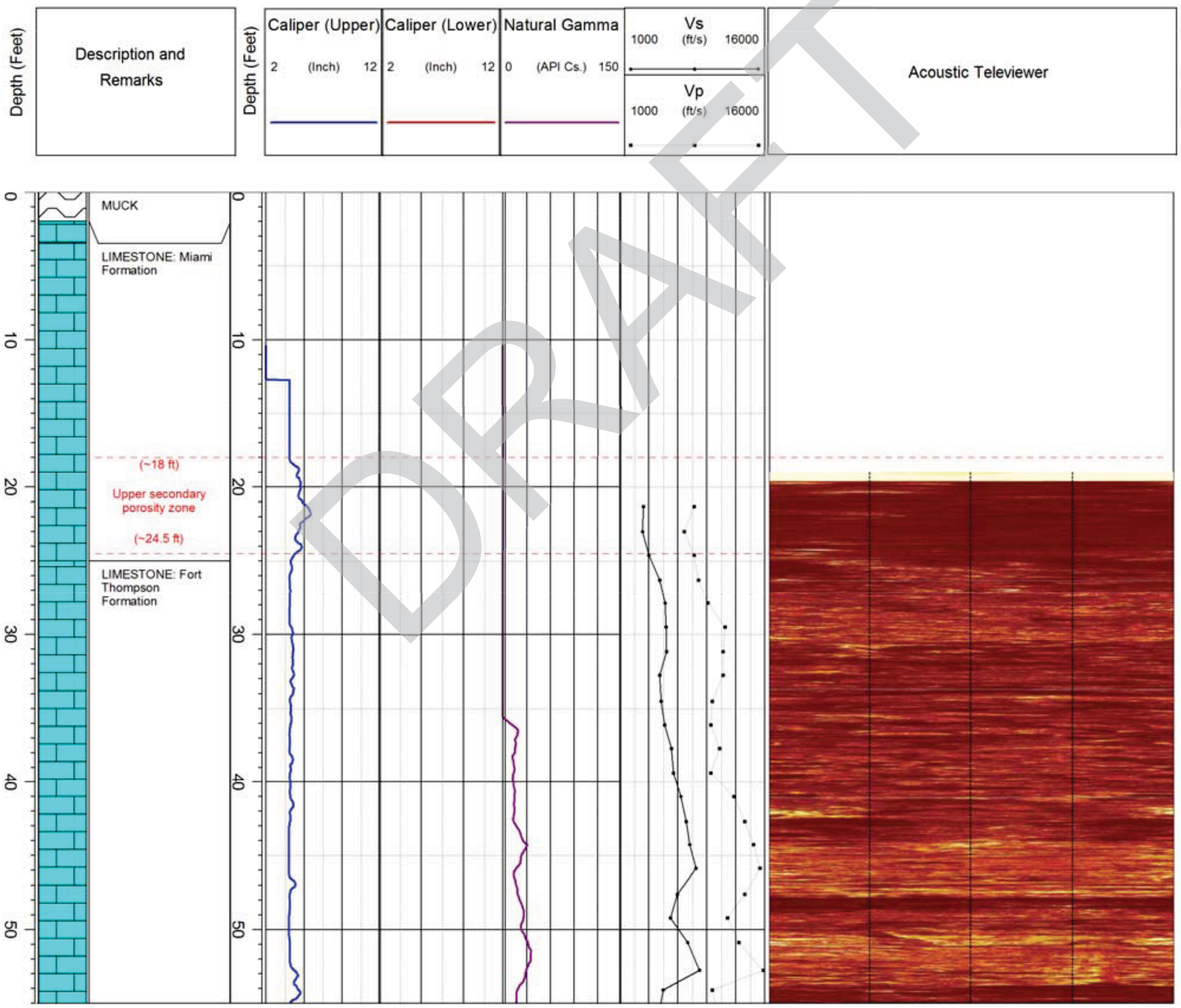


Figure 2.5.1-353. The two zones of secondary porosity on B-710 G (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (2 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.

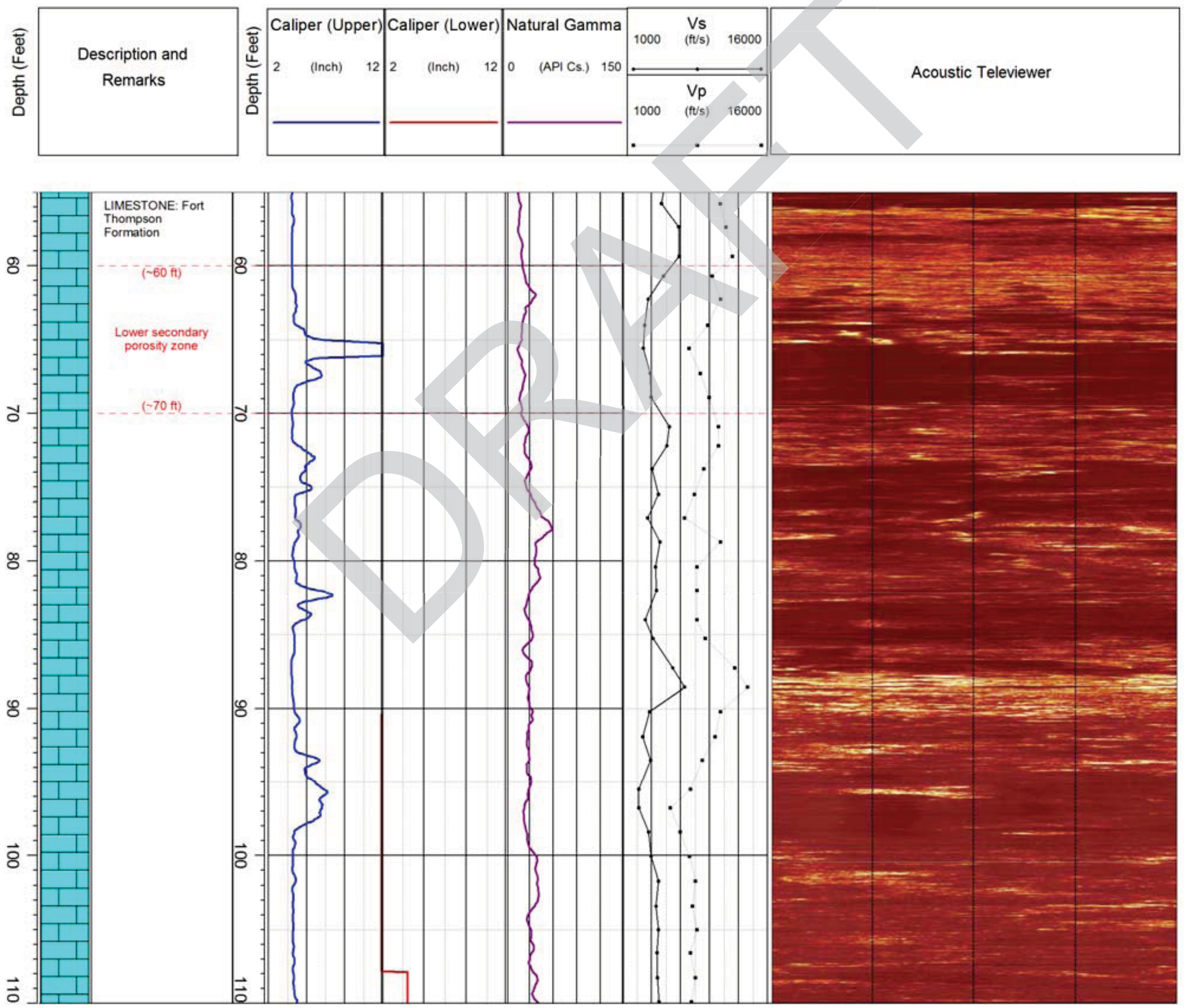


Figure 2.5.1-353. The two zones of secondary porosity on B-710 G (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (3 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.

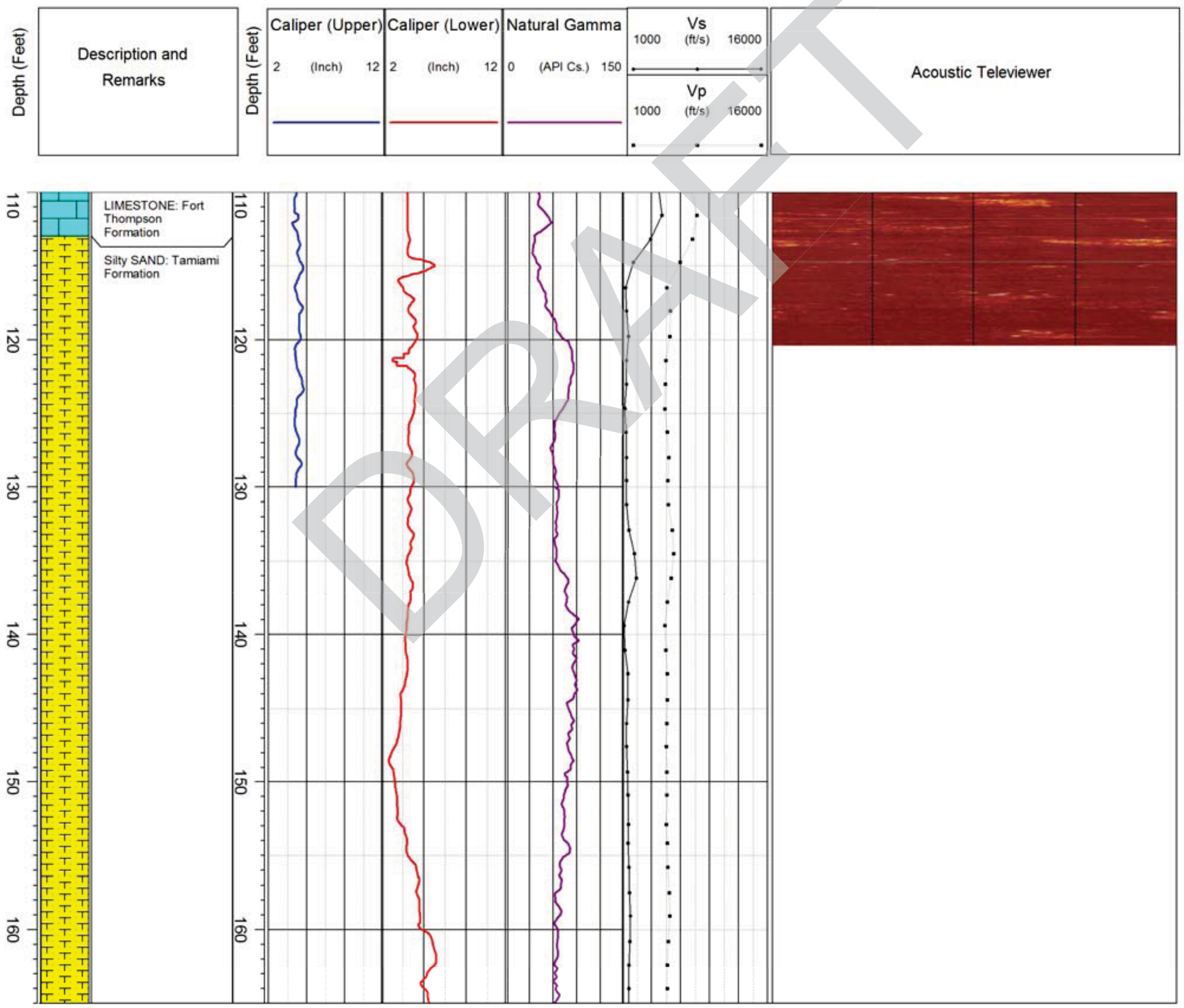


Figure 2.5.1-353. The two zones of secondary porosity on B-710 G (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (4 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.

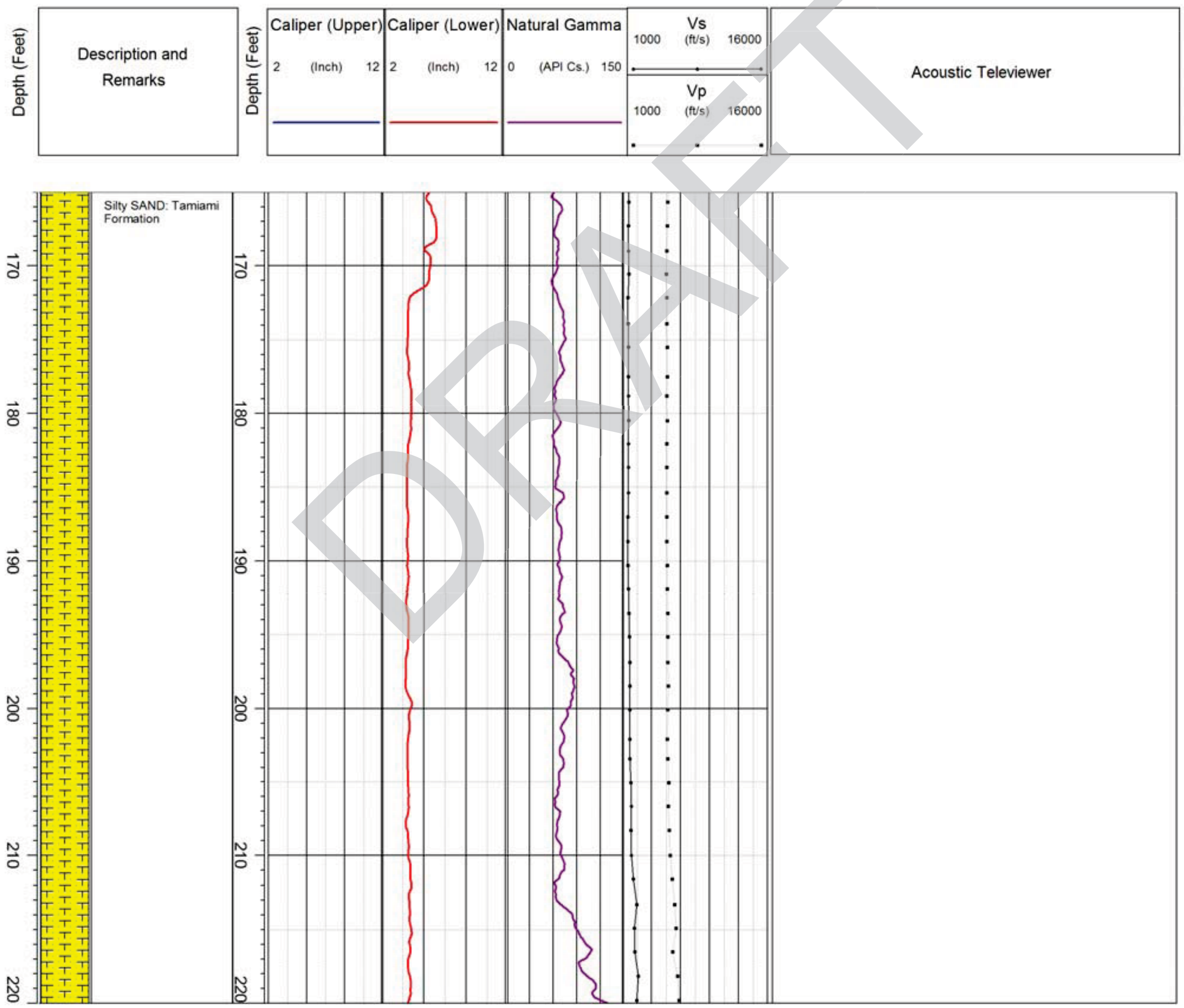
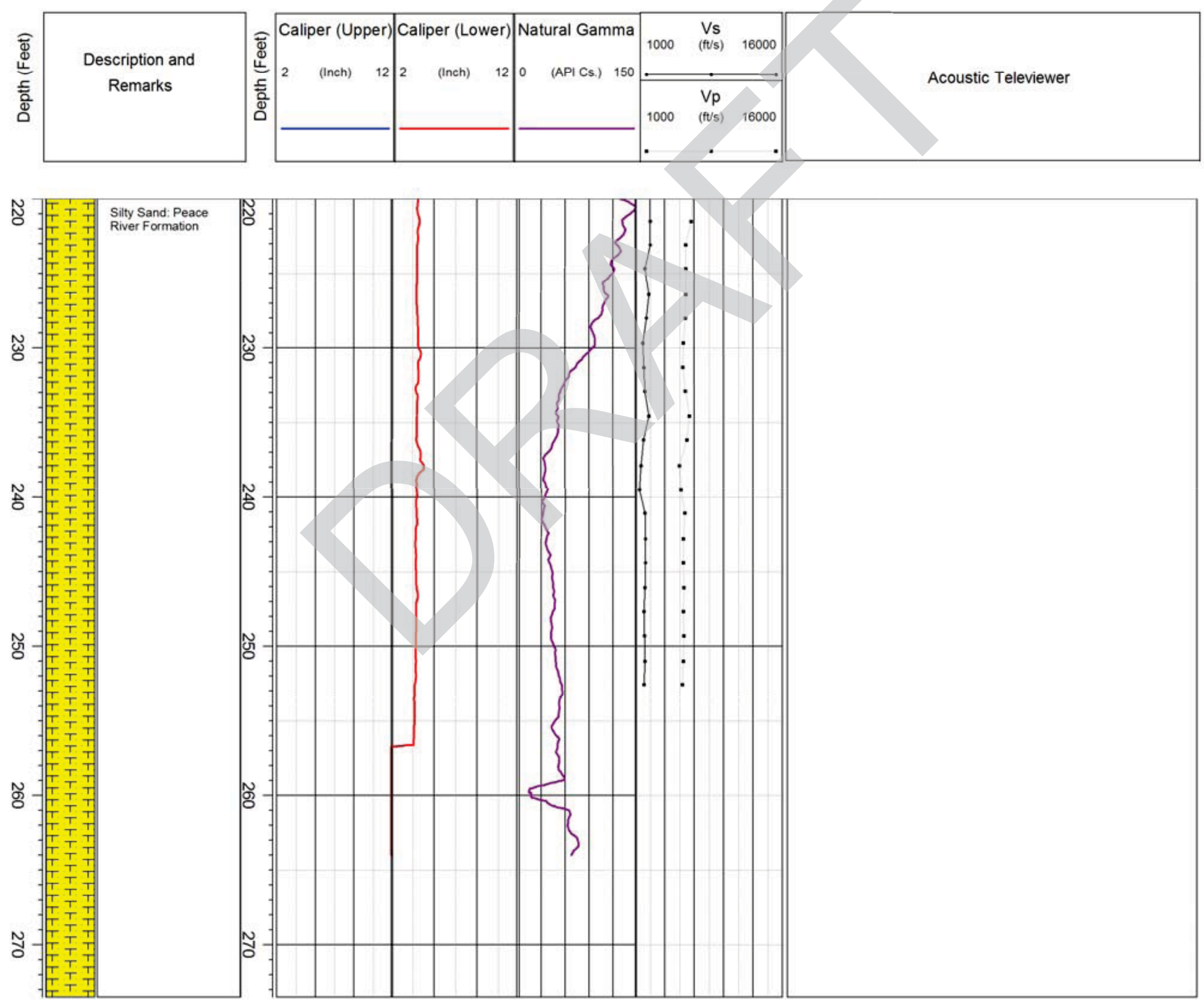


Figure 2.5.1-353. The two zones of secondary porosity on B-710 G (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (5 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.



Source: Reference 708

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-041

SRP Section: 02.05.01 - Basic Geologic and Seismic Information

QUESTIONS from Geosciences and Geotechnical Engineering Branch 2 (RGS2)

NRC RAI Number: 02.05.01-26 (eRAI 6024)

FSAR Section 2.5.1.1.1.3.2.4 states, in the “Cochinos Fault" passage, that Cotilla Rodriguez et al. (2007) provided no geologic evidence for activity in this fault and described it as covered by young sediments. The FSAR also indicates that the Cochinos fault appears to be geographically associated with sparse instrumental seismicity, but that these earthquakes are poorly located and no focal mechanisms are available.

In order for the staff to assess the tectonic and structural features within the site region and in accordance with 10 CFR 100.23, please address the following:

> a) Provide a map of the Cochinos fault with respect to topography and bathymetry, and discuss if the association of the Cochinos fault with bathymetric relief provides geologic evidence for activity.
> b) Map seismicity with respect to the Cochinos fault trace, showing location uncertainties, and discuss the relationship of the fault to seismicity.

FPL RESPONSE:

a) Provide a map of the Cochinos fault with respect to topography and bathymetry, and discuss if the association of the Cochinos fault with bathymetric relief provides geologic evidence for activity.

The Cochinos fault is a north- (e.g., Hall et al. 2004; Cotilla-Rodriguez et al. 2007) (FSAR References 770 and 494) to north-northwest-striking (e.g., Mann et al. 1990) (FSAR Reference 493) fault in south-central Cuba. Cotilla-Rodriguez et al. (2007) (FSAR Reference 494) describe the Cochinos fault as a “normal fault with a few inverse type sectors which demonstrates transcurrence to the left” (p. 514) and “normal and reverse type with left strike-slip” (p. 515). Figures 1A, 1B, and 2 show the location of the Cochinos fault with respect to topography and bathymetry. On these figures, shaded relief topography is based on Shuttle Radar Topography Mission (SRTM) 3-arcsecond (90 meter) data and shaded relief bathymetry is based on General Bathymetric Chart of the Oceans (GEBCO) 500 m data.

Various researchers present different locations and extents for the Cochinos fault. For example, Figures 1A and 1B show the location of the Cochinos fault after Hall et al. (2004) (FSAR Reference 770), who indicate the fault at its nearest point is approximately 205 miles (330 kilometers) from the Turkey Point Units 6 & 7 site. Cotilla-Rodriguez et al. (2007) (FSAR Reference 494) suggest this fault may extend northward to within 175 miles (280 kilometers) of the site, whereas mapping by Mann et al. (1990) (FSAR Reference 493) indicates a closest distance of approximately 210 miles (340 kilometers).

The Cochinos fault is depicted differently on various maps from the *Nuevo Atlas Nacional de Cuba* (Reference 1). The 1:1,000,000 scale geologic map of Cuba from this atlas (Oliva Gutierrez 1989 plate III.1.2-3) shows an approximately 87-mile-long (140-kilometer-long) unnamed fault in the vicinity of the Cochinos fault that extends from Cuba's northern coast where it is mapped in Pliocene-age deposits southward into the Bahia de Cochinos (Figure 2). The southernmost 18 miles (30 kilometers) of this fault are shown by a dashed line (Figure 2). At its nearest point, this fault is approximately 185 miles (300 kilometers) from the site. The 1:2,000,000 scale neotectonic map of Cuba from this atlas (Oliva Gutierrez 1989 plate III.2.4-8) shows an approximately 87-mile-long (140-kilometer-long) unnamed fault in the vicinity of the Cochinos fault, the southernmost 30 miles (50 kilometers) of which is offshore southern Cuba and shown by a dashed line. To the north, this fault on the neotectonic map is truncated by the Hicacos fault. The Cochinos fault is depicted and labeled on the 1:2,000,000 scale lineament map from this atlas (Oliva Gutierrez 1989 plate III.3.1-11). On this map, the Cochinos lineament is shown as an approximately 90-mile-long (140-km-long) feature, the southern 25 miles (40 km) of which is located off the southern shore of Cuba and labeled as "supuestos" (assumed or postulated). The 1:1,000,000 scale geomorphic map from the *Nuevo Atlas Nacional de Cuba* (Oliva Gutierrez 1989 plate IV.3.2-3) shows an approximately 37-mile-long (60-kilometer-long) unnamed fault in the vicinity of the Cochinos fault. The map explanation indicates that this fault cuts a Quaternary-age marine abrasion platform that is at an elevation of either 2 – 3 meters or 5 – 7 meters above sea level. They do not provide an explanation for the lack of specificity in elevation of the platform nor do they provide a precise age for the Quaternary abrasion platform.

The southern Cochinos fault is grossly expressed in the topography and bathymetry in the Bahia de Cochinos (Figure 2). The Cochinos fault is the only onshore feature in intraplate Cuba identified as "neotectonic" by Mann et al. (1990) (FSAR Reference 493) (FSAR Figure 2.5.1-286). They map the Cochinos fault as two parallel, north-northwest-striking normal faults that form a graben (FSAR Figure 2.5.1-286). The morphology of Bahia de Cochinos is consistent with this interpretation and suggests the possibility of fault control on the landscape. Cotilla-Rodríguez et al. (2007) (FSAR Reference 494) classify the Cochinos fault as active based on the possible association of seismicity with the fault. Cotilla-Rodríguez et al. (2007) (FSAR Reference 494, p. 514) provide no geologic evidence for activity on the Cochinos fault and describe the fault as "covered by young sediments." Indeed, the most detailed geologic maps inspected in the area (1:250,000 scale) show no fault cutting Miocene and younger strata (Pushcharovskiy et al. 1988) (FSAR Reference 846). It is not clear whether the Cochinos fault is depicted on Perez-Othon and Yarmoliuk's (1985) (FSAR Reference 848) inset map of fault ages in Cuba, but they seemingly indicate a Paleogene age for a northern extension of this fault. Pushcharovskiy's (1989) (FSAR Reference 847) 1:500,000 scale tectonic map of Cuba shows and labels the approximately 60-mile-long (100-kilometer-long) Cochinos fault. This fault does not extend as far north as the Hicacos fault, and the southern approximately 50 miles (80 kilometers) are shown as a dashed line. Garcia et al. (2003) (FSAR Reference 489) provide no discussion of the Cochinos fault.

b) Map seismicity with respect to the Cochinos fault trace, showing location uncertainties, and discuss the relationship of the fault to seismicity.

Seismicity in the vicinity of the Cochinos fault is sparse. Cotilla-Rodríguez et al. (2007) (FSAR Reference 494) list six earthquakes that they suggest may have occurred on the Cochinos fault. The largest of these is the December 16, 1982 Ms 5.0 earthquake. The project Phase 2 earthquake catalog developed for the Turkey Point Units 6 & 7 project does not include an earthquake on that date with similar magnitude and location. The project Phase 2 earthquake catalog does, however, include an M_w 5.4 earthquake near the Cochinos fault that occurred on November 16, 1982 (Figures 1A and 1B). Based on the similarity in location, magnitude, and year for the December 16 and November 16 earthquakes, it is assumed that these are the same earthquake and that the discrepancy in month is the result of a typographical error in Cotilla-Rodríguez et al.'s (2007) (FSAR Reference 494) manuscript. The remaining five earthquakes that Cotilla-Rodriguez et al. (2007) (FSAR Reference 494, p. 516) associate with the Cochinos fault "are all of low [and unspecified] intensity." In the project Phase 2 earthquake catalog, the 1982 earthquake is located approximately 3 miles (5 kilometers) northwest of the Cochinos fault trace (Figures 1A and 1B). Cotilla-Rodriguez et al. (2007) (FSAR Reference 494) suggest that the 1982 earthquake may instead have occurred on the Habana-Cienfuegos fault (Figures 1A and 1B). In addition to the 1982 earthquake, the project Phase 2 earthquake catalog shows only four other earthquakes within 20 miles (32 kilometers) of the Cochinos fault, the largest of which is assigned M_w 4.1 (Figures 1A and 1B). Cotilla-Rodriguez et al. (2007) (FSAR Reference 494) indicate there are no focal mechanisms associated with earthquakes in the vicinity of the Cochinos fault.

Earthquake location errors are not shown on Figures 1A and 1B because the data with which to estimate these errors for each earthquake are not available. According to Cotilla-Rodriguez et al. (2007) (FSAR 2.5.1 Reference 494, p.518), the "epicenter determination [for earthquakes] in the western, central, and central-eastern [portions of Cuba] have limitations because of scarce or no permanent seismic stations." Regarding the locations of pre-instrumental earthquakes in Cuba, Garcia et al. (2003) (FSAR 2.5.1 Reference 489, p. 2,569) state that, "Taking into account the complexity of the Cuban tectonic environment, the poor knowledge about the kinematic evolution of the principal fault systems, and the uncertainty in the hypocentral location of historical events (uncertainty of 15-20 kilometers or more in the historical coordinates is reasonable), it is impossible to associate earthquakes with individual faults." Therefore, the association of this sparse seismicity with the Cochinos fault or another mapped or unmapped fault in the vicinity is problematic due to the uncertainties associated with the locations of both faults and earthquakes in Cuba.

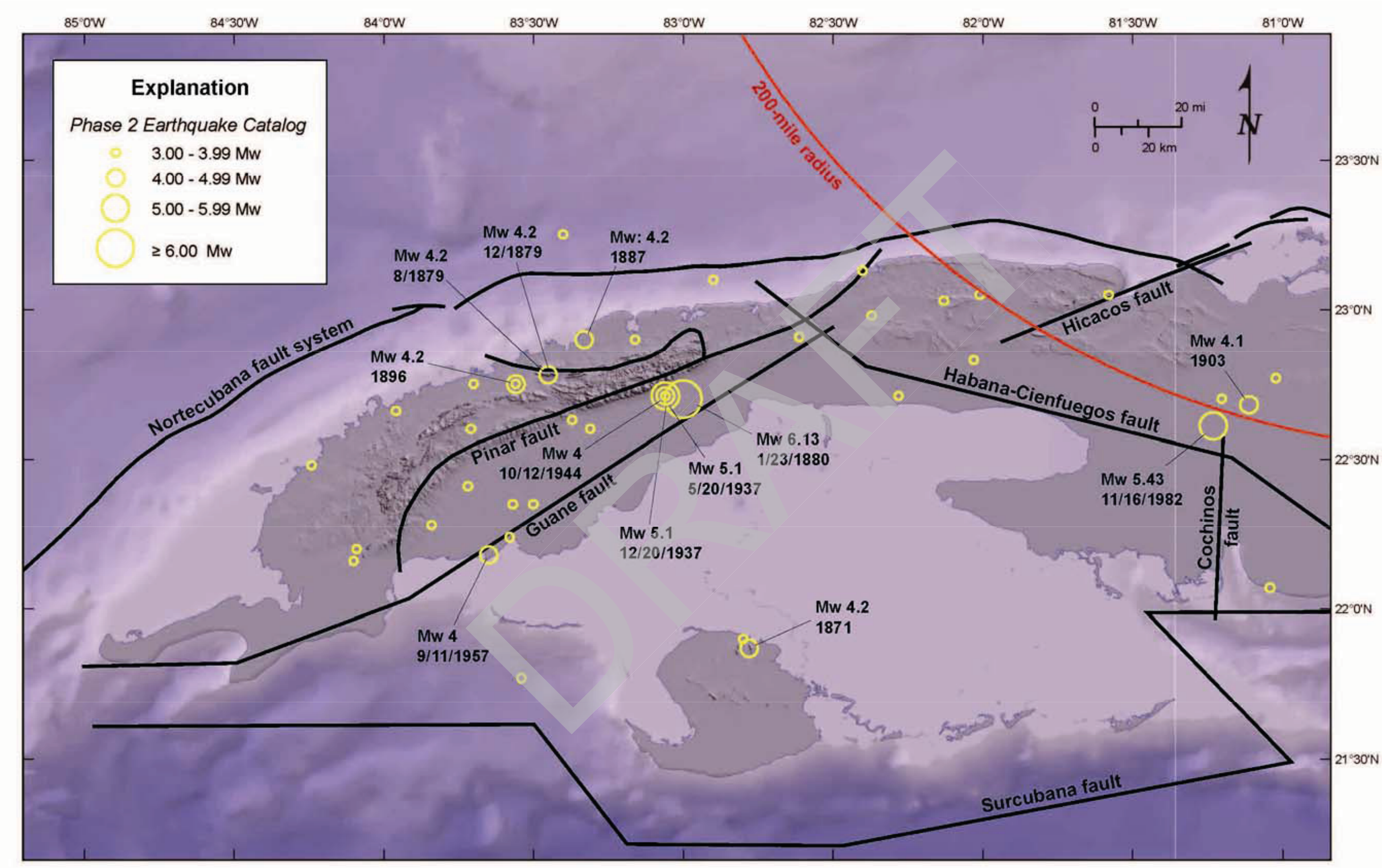


Figure 1A. Fault Map of Western Cuba Showing Earthquakes from the Project Phase 2 Earthquake Catalog.

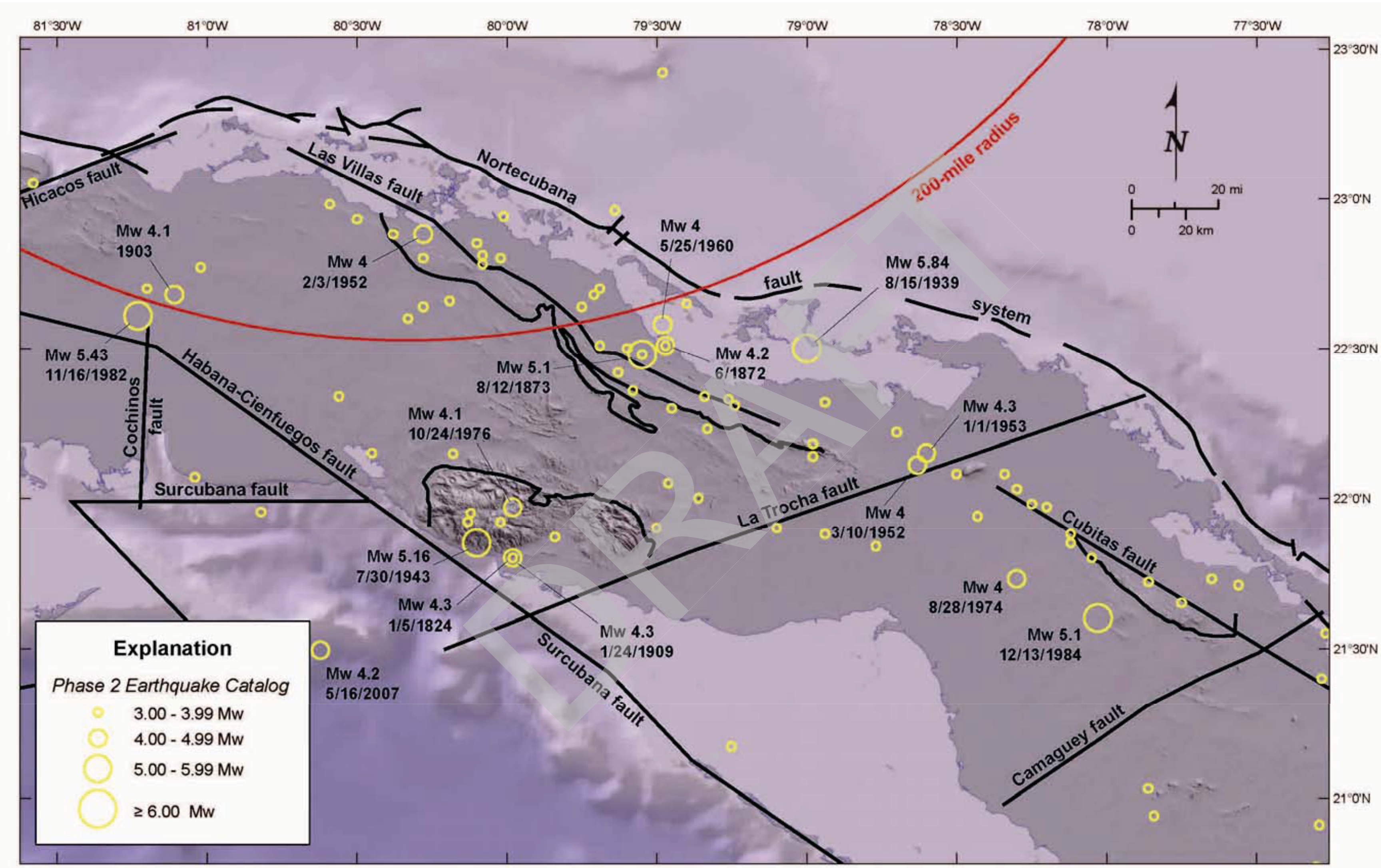


Figure 1B. Fault Map of Central Cuba Showing Earthquakes from the Project Phase 2 Earthquake Catalog

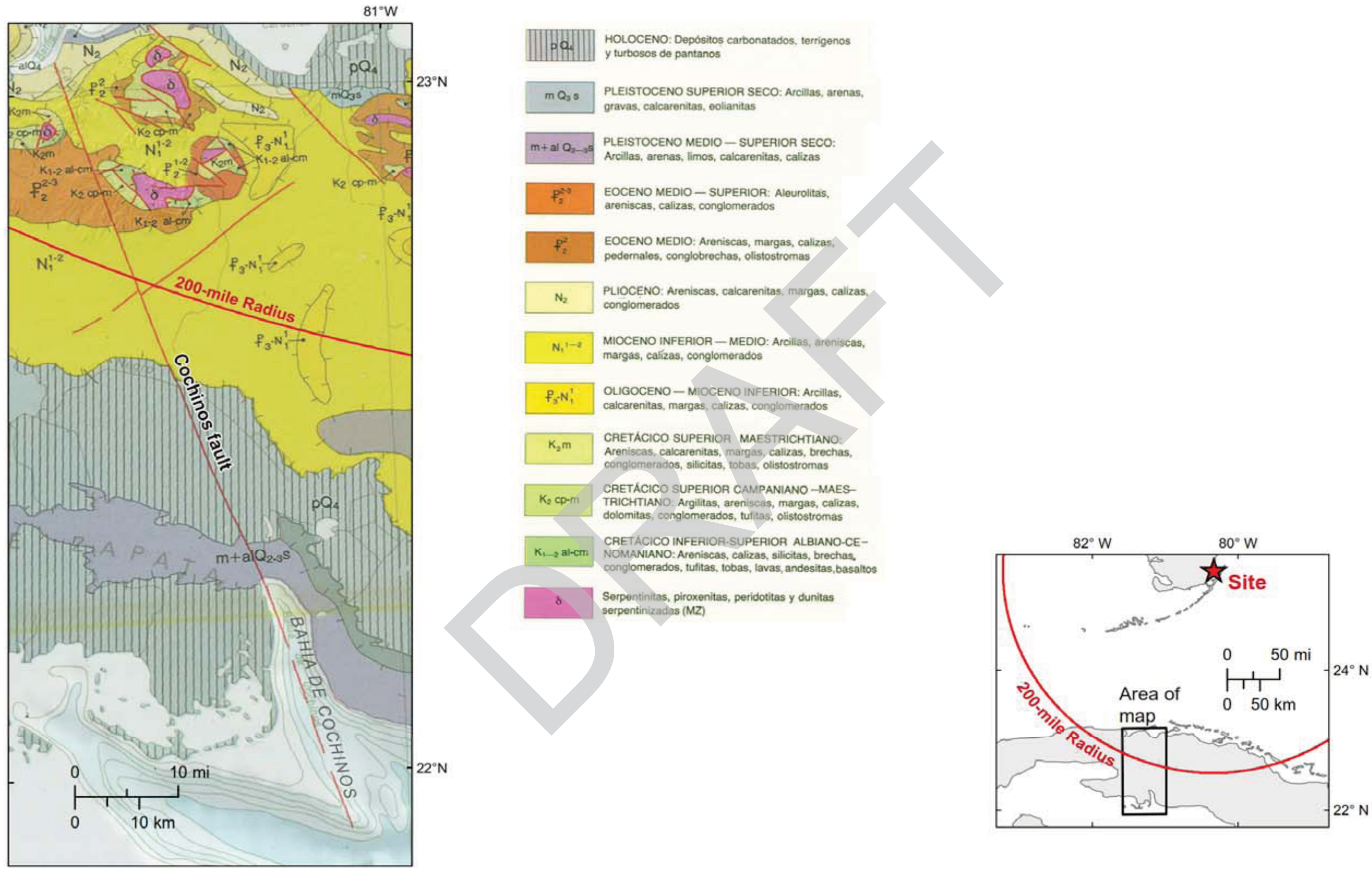


Figure 2. Geologic Map of Central Cuba Showing the Cochinos Fault (modified after Oliva Gutierrez 1989 plate III.1.2-3).

This response is PLANT SPECIFIC.

References:

1. Oliva Gutierrez, G. and Sanchez Herrero, E.A. (directors), 1989. Nuevo Atlas Nacional de Cuba, Instituto de Geografía de la Academia de Ciencias de Cuba, the Instituto Cubano de Geodesia y Cartografía, and the Instituto Geográfico Nacional de España, 220 pp.

ASSOCIATED COLA REVISIONS:

The COLA will be revised to include information provided in this response pertaining to the Cochinos fault. These COLA revisions are provided as part of the response to RAI 02.05.01-21.

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-041

SRP Section: 02.05.01 - Basic Geologic and Seismic Information

QUESTIONS from Geosciences and Geotechnical Engineering Branch 2 (RGS2)

NRC RAI Number: 02.05.01-31 (eRAI 6024)

FSAR Section 2.5.1.1.1.3.2.4, the “Seismicity of Cuba” passage, states that available geologic mapping (at 1:250000 and1:500000 scales) "largely indicates that the Pleistocene and younger strata are undeformed throughout the island." The staff notes that the same paragraph in the FSAR states that, "The scales of available geologic mapping do not provide sufficient detail to adequately assess whether or not individual faults in Cuba can be classified as capable tectonic structures." These two statements are seemingly contradictory.

In order for the staff to assess the tectonic and structural features within the site region and in accordance with 10 CFR 100.23, please address the following:

a) Clarify if available geologic mapping in Cuba is suitable for neotectonic fault evaluation.
b) If available geologic mapping is insufficient for the assessment of active faulting as stated above, clarify the first statement that mapping "largely indicates that the Pleistocene and younger strata are undeformed throughout the island."
c) If available geologic mapping is insufficient for the assessment of active faulting, as stated above, further discuss your fault-activity-conclusions based on small scale mapping.

FPL RESPONSE:

a) Clarify if available geologic mapping in Cuba is suitable for neotectonic fault evaluation.

Available geologic and tectonic maps for Cuba generally are from the 1980s and are small in scale, including, for example:

- Case and Holcombe’s (1980) (FSAR Reference 2.5.1-480) 1:2,500,000 scale map of the Caribbean;
- Perez-Othon and Yarmoliuk’s (1985) (FSAR Reference 2.5.1-848) 1:500,000 scale geologic map of Cuba;
- Pushcharovskiy et al.’s (1988) (FSAR Reference 2.5.1-846) 1:250,000 scale geologic map of Cuba;
- Pushcharovskiy’s (1989) (FSAR Reference 2.5.1-847) 1:500,000 scale tectonic map of Cuba; and
- Various geologic, tectonic, and lineament maps from the 1989 *Nuevo Atlas Nacional de Cuba* (Reference 1) that range in scale from 1:1,000,000 to 1:2,000,000.

Pardo (2009) (FSAR Reference 2.5.1-439) presents an overview of the stratigraphy, tectonics, and geologic structures of Cuba, written from the perspective of a hydrocarbon research and exploration geologist. Regarding the quality of available geologic and tectonic mapping of Cuba, Pardo (2009) (FSAR Reference 2.5.1-439, p. 311) states:

> *[T]he available material generally only shows very small-scale drawings; generalized very small-scale cross sections and maps are characteristic of Cuban structural literature.*
>
> *The Tectonic Map of Cuba 1:500,000 (Pushcharovsky et al., 1989)* [FPL COLA FSAR Reference 2.5.1-847] *is a good summary map. From an interpretive point of view, it shows only the case in which the basic igneous-volcanic province originated between metamorphic massifs and the North American continent. This map, as well as the older 1985 geologic map (Cuba, 1985a)* [FPL COLA FSAR Reference 2.5.1-848]*, shows several large crustal faults or deep fractures cutting across all structural trends. The bases for postulating these discontinuities are many: topography, gravity, magnetics, crustal seismic, and surface geology. These deep fractures might well exist, but most of them are very questionable. They date from the 1960s when Soviet experts, who did not believe in a thrusted orogenic belt origin for the island, invoked classic Soviet-era block faulting and in-situ magmatism (a la Beloussov [Khudoley, 1967; Khudoley and Meyerhoff, 1971]). Subsequently, most of these crustal fractures have disappeared from the literature, but some of them remain on the maps. Most such fractures probably do not exist or are not applicable in unraveling the geologic history of Cuba.*

Based on the small scales of these available maps, they are not well suited for use in neotectonic evaluations of individual faults in Cuba. However, these are the best-available maps that cover the whole of Cuba. These geologic and tectonic maps provide information on differing interpretations of lengths and locations for faults in Cuba, but do not necessarily provide clear geologic map relations and cross-cutting information that can be used to infer the ages of these faults. Larger-scale maps are available in the published literature for selected areas of Cuba, but these are limited in extent, variable in quality, and most were not developed for use in neotectonic evaluations, but rather for stratigraphic or other geologic studies.

b) If available geologic mapping is insufficient for the assessment of active faulting as stated above, clarify the first statement that mapping "largely indicates that the Pleistocene and younger strata are undeformed throughout the island".

The statements in the FSAR regarding potentially active faults in Cuba reflect the ambiguous and sometimes contradictory information available in the published literature and geologic mapping of the island. Based on available information, there is uncertainty regarding which faults in intraplate Cuba are active. The FSAR will be revised to clarify the issue of timing of activity for faults in Cuba and the usefulness of the available small scale geologic maps for the assessment of potentially active faults. Specifically, these geologic maps largely indicate that Pleistocene and younger strata throughout intraplate Cuba are undeformed. Given their coarse resolution, however, observations made from these maps alone are insufficient to characterize whether individual faults in intraplate Cuba are Quaternary active.

c) If available geologic mapping is insufficient for the assessment of active faulting, as stated above, further discuss your fault-activity-conclusions based on small scale mapping.

Conclusions regarding fault activity in intraplate Cuba are based on the best available data, including assessment of small scale (1:250,000 to 1:2,000,000) geologic and tectonic maps of Cuba, published literature (e.g., Cotilla-Rodriguez et al. (2007) (FSAR Reference 2.5.1-494), and the possible association of mapped faults with seismicity, including earthquakes included in the project Phase 2 earthquake catalog. It is possible that some of the faults mapped in intraplate Cuba could be active or capable tectonic sources. However, there are no definitive data to support which, if any, of the faults mapped in intraplate Cuba are active or capable tectonic sources. Therefore, based on limitations for evaluating neotectonic activity in intraplate Cuba, the seismic source characterization developed for the Turkey Point Units 6 & 7 project utilizes an areal source zone for Cuba instead of discrete fault sources.

This response is PLANT SPECIFIC.

References:

1. Oliva Gutierrez, G., Sanchez Herrero, E.A. (directors), *Nuevo Atlas Nacional de Cuba*, Instituto de Geografía de la Academia de Ciencias de Cuba, the Instituto Cubano de Geodesia y Cartografía, and the Instituto Geográfico Nacional de España, 220 pp., 1989.

ASSOCIATED COLA REVISIONS:

The COLA will be revised to include information provided in this response. These COLA revisions are provided as part of the response to RAI 02.05.01-21.

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-041

SRP Section: 02.05.01 - Basic Geologic and Seismic Information

QUESTIONS from Geosciences and Geotechnical Engineering Branch 2 (RGS2)

NRC RAI Number: 02.05.01-5 (eRAI 6024)

FSAR Section 2.5.1.2.4, the "Dissolution Features" passage, states that potential hydrostatic stress mechanisms to initiate sinkhole collapse are unlikely at the site area because the water table is presently near the surface and is not expected to fall or rise greatly. The staff notes that there may be a change in hydrostatic stress during dewatering at the site during construction, thus more discussion is needed to evaluate the potential of sinkhole collapse.

In order for the staff to evaluate dissolution potential, and in support of 10 CFR 100.23, please discuss the potential for initiation of sinkhole collapse during site construction or during a potential rise in sea-level during the planned lifetime of Units 6 & 7.

FPL RESPONSE:

The potential for initiation of sinkhole collapse during site construction will be mitigated using a dewatering system that will consist of a reinforced diaphragm wall and grout plug. The deepest excavation level at the Turkey Point Units 6 & 7 site is El. –35 feet NAVD 88 (i.e., extending 35 feet below the ground water level) (FSAR Subsection 2.5.4.5.4).

Power block excavations are primarily open cuts, with temporary ground support provided by a reinforced concrete diaphragm wall surrounding each power block excavation area. The reinforced diaphragm walls resist lateral earth and hydrostatic pressures while providing a barrier to ground water flow. The reinforced diaphragm walls are seated at approximately El. –60 feet NAVD 88, just below the most competent portion of the Fort Thompson Formation. Tiebacks to provide resistance to the lateral earth and hydraulic pressures are installed based on the final design that includes embedment, spacing, and other details, as applicable. The completed reinforced diaphragm walls effectively impede any overturning or sliding on the concrete fill, provided as a sub-basemat for Category I seismic structures, confined within the walls (FSAR Subsection 2.5.4.5.4).

FSAR Subsection 2.5.4.6.2 discusses the pumping rates that are required for dewatering each unit and describes how these rates can be reduced significantly by installing a grout plug between approximately El. -35 feet NAVD 88 and the bottom of the diaphragm wall at approximately El. -60 feet. FSAR Subsection 2.5.4.6.2 describes how, prior to excavation, grout will be injected, under pressure, in a series of primary grout holes until minimal grout take is achieved. Secondary grout holes will then be drilled between the primary grout holes and grout will be injected until minimal grout take occurs. Tertiary grout holes will probably be required. Quaternary grout holes may be needed at some locations but probably only where excessive seepage is observed as the excavation progresses. With the grout plug installed, the seepage will be significantly reduced and, therefore, controlled during excavation using sumps and discharge pumps. Any potential change in hydrostatic stress due to dewatering during construction is not expected to induce sinkhole collapse or affect the excavation due to the installation of the diaphragm wall, the grout plug and the concrete fill.

The revised response to RAI 02.05.01-1 contains a discussion of the current salinity conditions of groundwater at the Turkey Point Units 6 & 7 site. As stated in FSAR Section 2.5.1.1.1.1.1.1, limestone dissolution generally occurs when fresh, weakly acidic groundwater circulates through soluble carbonate rock. Atmospheric carbon dioxide is converted in the soil horizon to an aqueous state, where it combines with rainwater to form carbonic acid, which dissolves carbonate rock. Because the groundwater in the Biscayne aquifer in the Turkey Point Units 6 & 7 site area contains saline to salt water (FSAR Subsection 2.4.12.1.2.1), and the site is not a location of fresh water discharge or fresh water/salt water mixing, the mechanisms necessary to form large solution cavities are not present. Therefore, since any potential rise in sea level would increase the ocean hydrostatic head and result in the fresh water/salt water interface migrating inland and away from the site, a potential rise in sea level is not likely to lead to limestone dissolution at the site (Revised RAI response 02.05.01-1), and therefore it is not likely that sinkhole collapse could occur (Revised RAI response 02.05.01-2).

This response is PLANT SPECIFIC.

References:

None

ASSOCIATED COLA REVISIONS:

None

ASSOCIATED ENCLOSURES:

None