FPL.

L-2015-056
10 CFR 52.3

March 3, 2015

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

Re: Florida Power & Light Company
Proposed Turkey Point Units 6 and 7
Docket Nos. 52-040 and 52-041
Voluntary Revised Response to NRC Request for Additional Information Letter No. 041 (eRAI 6024) SRP Section: 02.05.01 - Basic Geologic and Seismic Information

Reference:

FPL Letter L-2014-281 to NRC dated October 3, 2014, Voluntary Revised Response to NRC Request for Additional Information Letter No. 041 (eRAI 6024) SRP Section: 02.05.01 - Basic Geologic and Seismic Information

In the Reference provided, FPL submitted revised responses to Requests for Additional Information (RAI) 02.05.01-16 and 02.05.01-20. In subsequent discussions to the submittal, the NRC staff requested that for the revised response to RAI 02.05.01-16 FPL label the faults on Figure 11 to provide clarity to the discussion of the DNAG map. FPL has updated the response to include labels for the faults on Figure 11 of the response, including editorial changes. For RAI 02.05.01-20, the NRC staff noted that Attachment A was not included with the response. FPL has updated the response to replace the reference to Attachment A with a citation to Angell and Hitchcock.

If you have any questions, or need additional information, please contact me at 561-691-7490.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on March 3, 2015.

Sincerely,

William Maher
Senior Licensing Director – New Nuclear Projects

WDM/RFB

Attachment 1: FPL Revised Response to NRC RAI No. 02.05.01-16 (eRAI 6024)
Attachment 2: FPL Revised Response to NRC RAI No. 02.05.01-20 (eRAI 6024)

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NRO

cc:
PTN 6 & 7 Project Manager, AP1000 Projects Branch 1, USNRC DNRL/NRO
Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Plant 3 & 4

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

SRP Section: 02.05.01 – Basic Geologic and Seismic Information

Question from Geosciences and Geotechnical Engineering Branch

NRC RAI Number: 02.05.01-16 (eRAI 6024)

FSAR Section 2.5.1.1.1.3.2.2 states, with respect to the Straits of Florida Normal Faults, that middle to late Eocene to early middle Miocene strata were deposited uniformly over most of the southern Straits of Florida and that similarly; continuous, unfaulted strata drape the edges of the Florida and Bahamas Platforms along the Straits of Florida. The staff needs more details with respect to the timing and location of the Straits of Florida Normal Faults.

In order for the staff to completely understand the geologic setting of the TPNPP site and in support of 10 CFR 100.23, Provide a discussion of the structural and stratigraphic evidence for the location and timing of deformation along the Mitchell, Pourtales, and Miami escarpments, the Las Villas and the Sierra de Jatibonico fault zones, and other tectonic features present in the bathymetry of subsurface of the Straits of Florida within the site region, including those located offshore northern Cuba, and in light of references such as Uchupi, 1966[a] and Malloy and Hurley, 1970[b] .

[a] Uchupi, E., 1966, Shallow structure of the Straits of Florida, Science, New Series, Vol 153, no.3735, pp.529-531, published by AAAS.

[b] Malloy and Hurley, 1970, Geomorphology and Geologic Structure: Straits of Florida, Geological Society of America Bulletin, v. 81, p. 1947-1972, 19 figs., July 1970

FPL RESPONSE:

INTRODUCTION

This response is a revision to information previously submitted to the NRC in FPL letter L-2014-281, "Voluntary Revised Response to NRC Request for Additional Information Letter No. 041 (eRAI 6024) SRP Section: 02.05.01 - Basic Geologic and Seismic Information," dated October 3, 2014 (Reference 8). Subsequent to that submittal, the NRC staff requested that FPL label the faults on Figure 11 of the RAI response to provide clarity to the discussion of the DNAG map. This submittal contains a revised Figure 11 with the two additional faults on the DNAG map labeled and provides clarification in the RAI response text related to the labeled faults. Additionally, this submittal provides editorial corrections for the FSAR reference citation format for FSAR References 2.5.1-848 and 2.5.1-849, and corrects the FSAR reference number in the title of Figure 10 of the RAI response.

REVISIONS TO RAI 02.05.01-16

As described in FSAR Subsection 2.5.1.1.1.3.2.2, deformation within the Straits of Florida is characterized by a series of short, steep, normal faults buried by Eocene or younger sediments (FSAR Reference 2.5.1-480) (FSAR Figure 2.5.1-229) (Figure 1). An early study by Malloy and Hurley (Reference 3) additionally hypothesized faulting along some geomorphic escarpments in the central Straits of Florida, particularly the

Pourtales escarpment (the southwestern continuation of the Miami escarpment), the Mitchell escarpment, and an unnamed escarpment farther south (Figure 1). Malloy and Hurley (Reference 3) used bathymetric and other published geologic data to interpret scarps representing the Sierra de Jatibonico and Las Villas faults to the south near Cuba (Figure 1). This response presents a review of the Straits of Florida normal faults, followed by a discussion of the hypothesized faulting at the escarpments and a discussion of the Sierra de Jatibonico and Las Villas faults.

The most informative publications describing the Straits of Florida normal faults include Denny et al. (FSAR Reference 2.5.1-221) and Angstadt et al. (FSAR Reference 2.5.1-482). Denny et al. (FSAR Reference 2.5.1-221) present a detailed analysis of the seismic stratigraphy in the Straits of Florida. They identify a southward flexure in Eocene-age deposits that they interpret as the result of loading from the collision of Cuba with the Florida-Bahama Platform. Although Denny et al. (FSAR Reference 2.5.1-221) recognize the thickening of Eocene strata in the southern portion of the Straits of Florida in response to this collision, they do not interpret these strata as recording much faulting (FSAR Figures 2.5.1-272 and 2.5.1-273; Figures 2, 3, and 4). The youngest faulting observed in that study is the normal fault shown in FSAR Figure 2.5.1-273, which terminates between S5, a middle-to-late Eocene unconformity, and S6, an early-middle Miocene unconformity. Farther west, however, Angstadt et al. (FSAR Reference 2.5.1-482) present seismic reflection lines closer to Cuba that they interpret as showing normal faults that deform the Paleocene to Eocene strata (FSAR Figure 2.5.1-209). In FSAR Figure 2.5.1-209, normal faults cut the Paleocene and Eocene strata and terminate at or immediately above the base of seismic unit C, which is correlated with middle Eocene to middle Miocene strata. Similarly, FSAR Figure 2.5.1-287 shows some of the normal faults cutting the flexural basin as a result of this loading, and closer inland, thrust faults associated with the Cuban thrust belt (FSAR Reference 2.5.1-484).

Although Case and Holcombe (FSAR Reference 2.5.1-480) do not provide information about the normal faults they show north of Cuba (Figure 1), Angstadt et al. (FSAR Reference 2.5.1-482) interpret seismic reflection profiles in the same area to depict faulted Paleocene and Eocene strata, typically overlain by undeformed Miocene and younger strata (e.g., FSAR Figure 2.5.1-209). Similarly, isopach maps that show thickened Paleocene to Eocene strata adjacent to the Cuban margin and Miocene and younger strata of constant thickness indicate the faults responsible for thinning the overthickened foreland strata should have terminated at the end of the Eocene (FSAR References 482 and 221).

The Straits of Florida normal faulting is interpreted as syntectonic deformation of the Cuban foreland basin during its Eocene collision with the Florida-Bahama Platform (FSAR References 794 and 482). The undeformed Miocene and younger strata overlying these faults indicate that subsidence of the straits had largely ceased with a change in tectonic regime at the end of the Eocene. However, Moretti et al. (FSAR Reference 2.5.1-484) also indicate that some faults along the Cuban margin could have been reactivated in response to later Tertiary compressional stresses (e.g., FSAR Figures 2.5.1-282 and 2.5.1-287), and hence could be active into the Miocene.

Reactivation along the Cuban margin is also found farther east in the Santaren Channel. Bergman (FSAR Reference 2.5.1-906) uses multi-channel, high resolution seismic reflection survey data to interpret faults adjacent to paleo-bank margins in the Santaren Channel that extend into late Tertiary strata or younger strata and suggests faulting as young as Early Pliocene. For example, a seismic line in the northern Santaren Channel shows faulting extending to just above the 12.2 Ma reflector (Figure 5b). A seismic line south of Cay Sal records a more complicated structure (Figure 5a). Three northeast-vergent thrust faults deform a shallow-water carbonate margin, while steeper faults extend up into shallower stratigraphy. Most of these steep faults are truncated in Miocene strata, but one is drawn to the seafloor (Figure 5a). Bergman (FSAR Reference 2.5.1-906) does not comment on the fault that is drawn to the seafloor and instead states that faulting in the Santaren Channel "continued into the late Miocene and possibly Pliocene" (p. 169). Structures in the Santaren Channel are interpreted to be contractional features associated with the Cuban fold-and-thrust belt rather than the Straits of Florida normal faults (Figure 5).

The short, steep, normal faults that accommodated the formation of a foreland basin in the Straits of Florida in the Paleocene and Eocene, with possible reactivations in the late Tertiary (FSAR 2.5.1 References 480, 221, and 484), are distinct from the geomorphic escarpments that are mapped by Malloy and Hurley (Reference 3) (Figure 1) and addressed below in this response.

Provide a discussion of the structural and stratigraphic evidence for the location and timing of deformation along the Mitchell, Pourtales, and Miami escarpments

The data presented in Uchupi (FSAR Reference 2.5.1-790) and Malloy and Hurley (Reference 3) represent the earliest speculation and coarsest views of the escarpments in the Straits of Florida. More recent seismic imaging has yielded much more detailed views of the subsurface, illuminating that these features reflect a dynamic depositional system rather than a fault-related or tectonic origin (Reference 4).

The Pourtales terrace is the southern extension of the Miami terrace (Figure 1). Both terraces are located in water depths of 650–1500 feet (200–450 meters) and represent a drowned Miocene carbonate platform (References 2 and 4). The moderate-to-steep escarpments at the eastern edge of the Miami terrace and southern edge of the Pourtales terrace are noted in early studies of the region (e.g., FSAR Reference 2.5.1-790). South of the Pourtales escarpment in the southern Straits of Florida, two smaller ledges in the bathymetry were noted by Malloy and Hurley (Reference 3). These include the Mitchell escarpment and an unnamed escarpment to the south (Figure 1).

Uchupi (FSAR Reference 2.5.1-790) presents results of a seismic survey conducted throughout the Straits of Florida (FSAR Figure 2.5.1-262) and suggests that "the steepness of the slopes flanking the Miami and Pourtales terraces along their seaward sides, and the presence of drag folds along the slope south of Pourtales Terrace, suggest that these features may be fault-line scarps. If faulting produced the slopes flanking the terraces, it probably occurred in Miocene or post-Miocene time, as the cores of both terraces consist of Lower Miocene limestones" (FSAR Reference 2.5.1-790, p. 531). However, the seismic survey did not provide any direct evidence of faulting beneath these features (FSAR Figure 2.5.1-262).

Malloy and Hurley (Reference 3) present mapping of the Straits of Florida based on bathymetry and seismic reflection data (Figure 1), but were more equivocal in their interpretation of the Pourtales and Mitchell escarpments. A seismic reflection profile of the Mitchell escarpment shows possible faulting (Figure 6), but Malloy and Hurley (Reference 3) state that whatever faulting may have occurred, it is doubtful that displacements are of regional tectonic significance. Moreover, Malloy and Hurley (Reference 3, p. 1968) state "there is evidence of features that may be normal faults on the southern side of the Southern Straits [of Florida]. It is by no means obvious that any of these faults have any regional tectonic significance. In fact, there is no need to postulate extensive faulting here."

According to Malloy and Hurley (Reference 3), seismic reflection data across the Pourtales escarpment show "the near-flat strata of the terrace possibly in fault contact with consolidated strata dipping locally 7° (apparent) to the south" (p.1966) (Figure 7). However, they also state that "the Pourtales escarpment may not represent a fault scarp, but an original sedimentary feature associated with sediments deposited against the steeper face of the old reef front. It would seem that such relationships should be expected in this region" (Reference 3, p. 1968). Indeed, Uchupi et al. (FSAR Reference 2.5.1-428) also suggest that such escarpments are commonly formed along the Bahamas and Gulf of Mexico through carbonate accretion by Mesozoic reefs and not by tectonic deformation.

As hypothesized by Malloy and Hurley (Reference 3), the Pourtales escarpment and similar steep-sided escarpments throughout the Gulf of Mexico, Straits of Florida, and Bahamas have now been recognized as relict carbonate platform margins, sometimes steepened and modified by erosion (Figures 8, 9, and 10) (e.g., References 2 and 4, FSAR Reference 2.5.1-687). For example, Mullins and Neuman (Reference 4) conclude that there is no evidence for faulting at the eastern edge of the Miami terrace and that truncated reflectors near the surface indicate that erosion was responsible for the stratigraphic variations.

Detailed seismic mapping by Anselmetti et al. (FSAR Reference 2.5.1-228) and Eberli et al. (Reference 1) indicates that the steep west edge of the Bahama bank displays an unfaulted sedimentary transition from shallow-water carbonates to slope carbonates to drift sediments (e.g., FSAR Figure 2.5.1-245). Along the Pourtales escarpment, this margin is overlain by, and is adjacent to, large drifts of sediment that have been prograding along the Straits of Florida since the Miocene (FSAR Reference 2.5.1-221). Where these drifts rest against the paleo-reefs, discordant dips are observed that were previously interpreted as potentially fault-related (e.g., Reference 3) (compare Figures 7 and 8). Denny et al. (FSAR Reference 2.5.1-221) also describe seismic reflection lines that cross the Pourtales escarpment showing no evidence of shallow faulting (Figures 3 and 4). Two lines that obliquely cross the Mitchell escarpment (Figures 9a and 9b) (Reference 6) display similar stratigraphic characteristics near the escarpment, with drifts resting against each other in the shallow stratigraphy and erosional truncations that do not extend to depth.

In summary, the majority of the data collected in the study of the Mitchell, Pourtales, and Miami escarpments provide little basis for concluding that these features are the product of fault activity. Instead, Malloy and Hurley (Reference 3) and Uchupi et al. (FSAR Reference 2.5.1-428) suggest that these escarpments are sedimentary features common to the Bahamas and Gulf of Mexico, and later, more detailed seismic imaging has confirmed this (e.g., Reference 4, FSAR 2.5.1 References 221 and 906). Although the faults mapped along the Pourtales, Mitchell, and unnamed escarpments from Malloy and Hurley (Reference 3) are included in compilation maps such as the DNAG Map of North America (Figure 11) (Reference 7), it is unclear whether this represents the initial compilation efforts of the early 1980s, or whether newer, but unpublished, mapping supports the notion of faulting at that location. The relationships indicated on the DNAG map indicate that the faults cut surficial sediments with ages as young as Pliocene, and the faults are generally dashed in Quaternary strata (Figure 11) (Reference 7).

Provide a discussion of the structural and stratigraphic evidence for the location and timing of deformation along the Las Villas and the Sierra de Jatibonico fault zones, and other tectonic features present in the bathymetry of subsurface of the Straits of Florida within the site region, including those located offshore northern Cuba

Khudoley (FSAR Reference 2.5.1-910, p. 672) identifies the Las Villas fault as a "deep" fault of Cuba "whose length is approximately 800 kilometers, generally paralleling the island." Despite this, Khudoley's (FSAR Reference 2.5.1-910) map shows the Las Villas fault as approximately 220 miles (350 kilometers) long (Figure 12). As mapped by Khudoley (FSAR Reference 2.5.1-910), the Las Villas fault extends along the northern coast of Cuba from approximately 80°W to 83°W, transitioning from an onshore to an offshore structure near Carahatas, Cuba (Figure 12). The total offshore length of Khudoley's (FSAR Reference 2.5.1-910) Las Villas fault is approximately 120 miles (200 kilometers). Khudoley (FSAR Reference 2.5.1-910) does not describe the data that constrain the location and extent of the offshore portions of the Las Villas fault, but this is presumably based on bathymetric data.

Khudoley (FSAR Reference 2.5.1-910, p. 672) describes the Sierra de Jatibonico fault as a "disjunctive dislocation" that is "approximately parallel with the trend of the island" and "is at least 450 kilometers long." Khudoley indicates that, according to unspecified geological and geophysical investigations, 124 miles (200 kilometers) of the fault are onshore, and 186 miles (250 kilometers) of the fault are offshore. However, in Figure 12, the Sierra de Jatibonico fault is mapped as over 620 miles (1000 kilometers) long, with a western 277 mile-long (447 kilometer-long) offshore segment transitioning to a central 302-mile-long (488 kilometer-long) onshore segment near Carahatas, Cuba. The fault then transitions offshore again near Guardalavaca, where it is mapped for an additional 126 miles (204 kilometers). As Khudoley (Reference 2.5.1-910) does not specify what data are used to define the location and extent of the offshore portion of the Sierra de Jatibonico fault, FPL presumes this mapping is based on bathymetric data.

Malloy and Hurley (Reference 3) present compiled bathymetric and seismic reflection data for the Straits of Florida. They identify escarpments in the Straits of Florida and postulate the existence of faults, including the offshore Las Villas fault and offshore Sierra de Jatibonico fault (Figure 1). Malloy and Hurley (Reference 3, p. 1962) indicate that "since traverses could not be made within 12 [nautical miles] of Cuba, no seismic reflection profiles were obtained of these steep and complex slopes." As such, they base their offshore mapping of the Las Villas fault on Khudoley's (Reference 2.5.1-910) previous mapping and on their compiled bathymetric data. Malloy and Hurley's

(Reference 3) depiction of the offshore Las Villas fault extends for approximately 120 miles (200 kilometers) from roughly Matanzas Bay westward to Havana. Malloy and Hurley (Reference 3, p. 1962) state that "the Las Villas fault appears to be reflected in the bathymetry as a scarp," but they do not provide any description of scarp dimensions, including length, height, and continuity. The offshore portion of the Sierra de Jatibonico fault is mapped north of the Las Villas fault, from 81°W to 81°20'W. Malloy and Hurley (Reference 3) state that a scarp is expressed along this portion of the fault for 20 nautical miles (37 kilometers); however, specifics such as height and continuity are not discussed. Malloy and Hurley (Reference 3) note that beyond 81°35'W, nothing in the bathymetry suggests that the fault continues farther west, and they depict the fault as dashed for that segment.

More recent depictions of the Las Villas fault indicate that this structure is located mostly or entirely onshore in central Cuba (see RAI 02.05.01.21). For example, the depiction of the Las Villas fault on Figure 3 from Pardo (FSAR Reference 2.5.1-439) extends offshore near Carahatas, Cuba, and continues offshore to the northwest roughly parallel and close to the coast for only about 40 miles (65 kilometers). Pardo (FSAR Reference 2.5.1-439) does not describe bathymetric expression of this fault. Cotilla-Rodriguez et al. (FSAR Reference 2.5.1-494) show the Las Villas fault as entirely onshore and therefore not expressed in the bathymetry; however, the offshore Las Villas fault as mapped by Malloy and Hurley (Reference 3) appears to be spatially coincident with Cotilla-Rodriguez et al.'s (FSAR Reference 2.5.1-494) Nortecubana fault. The 1:2,000,000 scale lineament map of Cuba from the *Nuevo Atlas Nacional de Cuba* (Reference 5, plate III.3.1-11) depicts and labels the Las Villas fault as an approximately 120-mile-long (190-kilometer-long), northwest-striking feature that is located entirely onshore. The 1:2,000,000 scale neotectonic map of Cuba from the same atlas (Reference 5, plate III.2.4-8) shows an unnamed fault in the vicinity of the Las Villas fault that is located entirely onshore. Based on its location, FPL assumes that this unnamed fault is the Las Villas fault. Perez-Othon and Yarmoliuk (FSAR Reference 2.5.1-848) show an unnamed fault on their 1:500,000 scale geologic map of Cuba. This unnamed fault is located in the vicinity of the Las Villas fault and is located entirely onshore. Pushcharovskiy's (FSAR Reference 2.5.1-847) 1:500,000 scale tectonic map of Cuba depicts and labels the Las Villas fault as a thrust fault located entirely onshore.

These more recent compilations do not show the offshore Sierra de Jatibonico fault as mapped by Khudoley (Reference 2.5.1-910) or Malloy and Hurley (Reference 3). It is not included in the 1:500,000 scale tectonic map of Cuba (FSAR Reference 2.5.1-847), nor is it shown in any of the 1:2,000,000 maps in the Nuevo Atlas Nacional de Cuba (Reference 5). Similarly, Cotilla-Rodriguez et al. (FSAR Reference 2.5.1-494) do not indicate any such fault north of Matanzas Bay. Pardo (FSAR Reference 2.5.1-439, Figure 172) does indicate a "Jatibonico fault"; however, it is entirely onshore, over 200 kilometers west of Matanzas Bay.

Bathymetry in the Straits of Florida from Malloy and Hurley (Reference 3) indicate that the Pourtales escarpment, the Mitchell escarpment, and the north slope of Cuba are the most prominent geomorphic features expressed in the region. The slope north of Cuba is somewhat steeper and more irregular than the slope south of Florida, but no particular faults or scarps are identified there in the regional study of Mann et al. (FSAR

Reference 2.5.1-493). Only portions of the mapped trace of the Las Villas fault from Malloy and Hurley (Reference 3) coincide with the steepest portions of the slope, and Malloy and Hurley's (Reference 3) Sierra de Jatibonico fault does not appear to coincide with any scarps in the bathymetry (Figure 1). The DNAG Map of North America (Reference 7) shows the same faults as Malloy and Hurley (Reference 3) in the Straits of Florida region, with two additions near the Las Villas and Sierra de Jatibonico faults (faults 1 and 2 on Figure 11). A fault is included south of the unnamed escarpment and northwest of the Sierra de Jatibonico fault that cuts Neogene sediments (fault 3 on Figure 11), and a segmented fault is included along the steep portion of the slope north of the small islands and east of the Sierra de Jatibonico fault that cuts Tertiary strata (fault 4 on Figure 11). The latter structure is coincident with representations of the Nortecubana fault in this area (e.g., FSAR Figure 2.5.1-202). The offshore area near the Nortecubana fault and south toward the Cuban coast is expected to be underlain by thrusts of the Cuban fold-and-thrust belt, which are covered by unfaulted late Tertiary and Quaternary strata (FSAR 2.5.1 References 484, 485, and 497) (FSAR Figures 2.5.1-279, 2.5.1-280, 2.5.1-282, 2.5.1-287, and 2.5.1-288).

In summary, little detail is known about the hypothesized offshore Las Villas and Sierra de Jatibonico structures drawn by Malloy and Hurley (Reference 3) on the basis of bathymetric data or about the similar structures compiled on the DNAG Map of North America (Reference 7). More recent compilations generally do not depict offshore versions of these faults (e.g., FSAR Reference 2.5.1-847), although the offshore Las Villas from Malloy and Hurley (Reference 3) is roughly coincident with the Nortecubana fault of Cotilla-Rodriquez et al. (FSAR Reference 2.5.1-494) and the steepest portions of the northern Cuba slope.

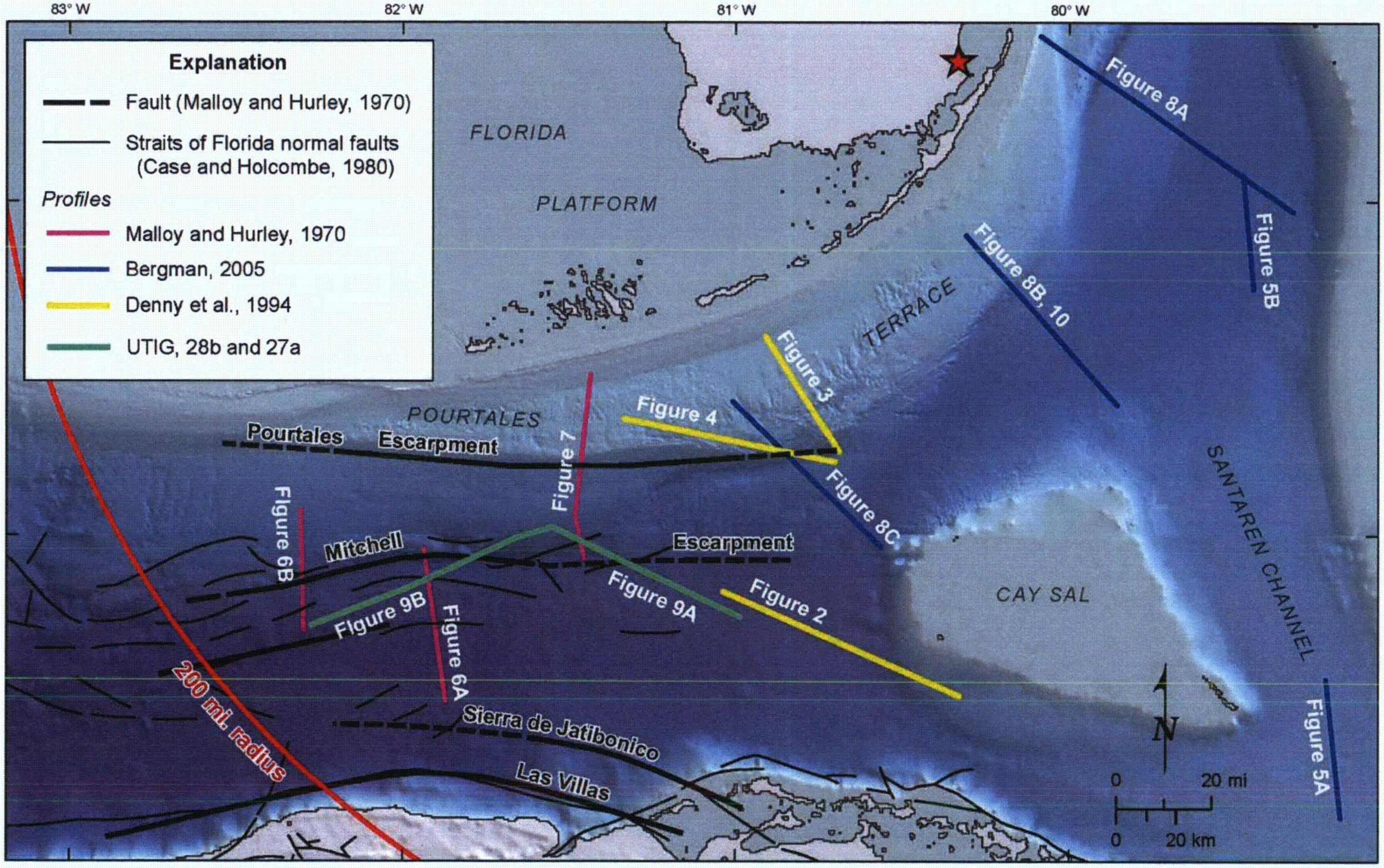


Figure 1. Location Map for Profiles Shown in Figures 2 through 10

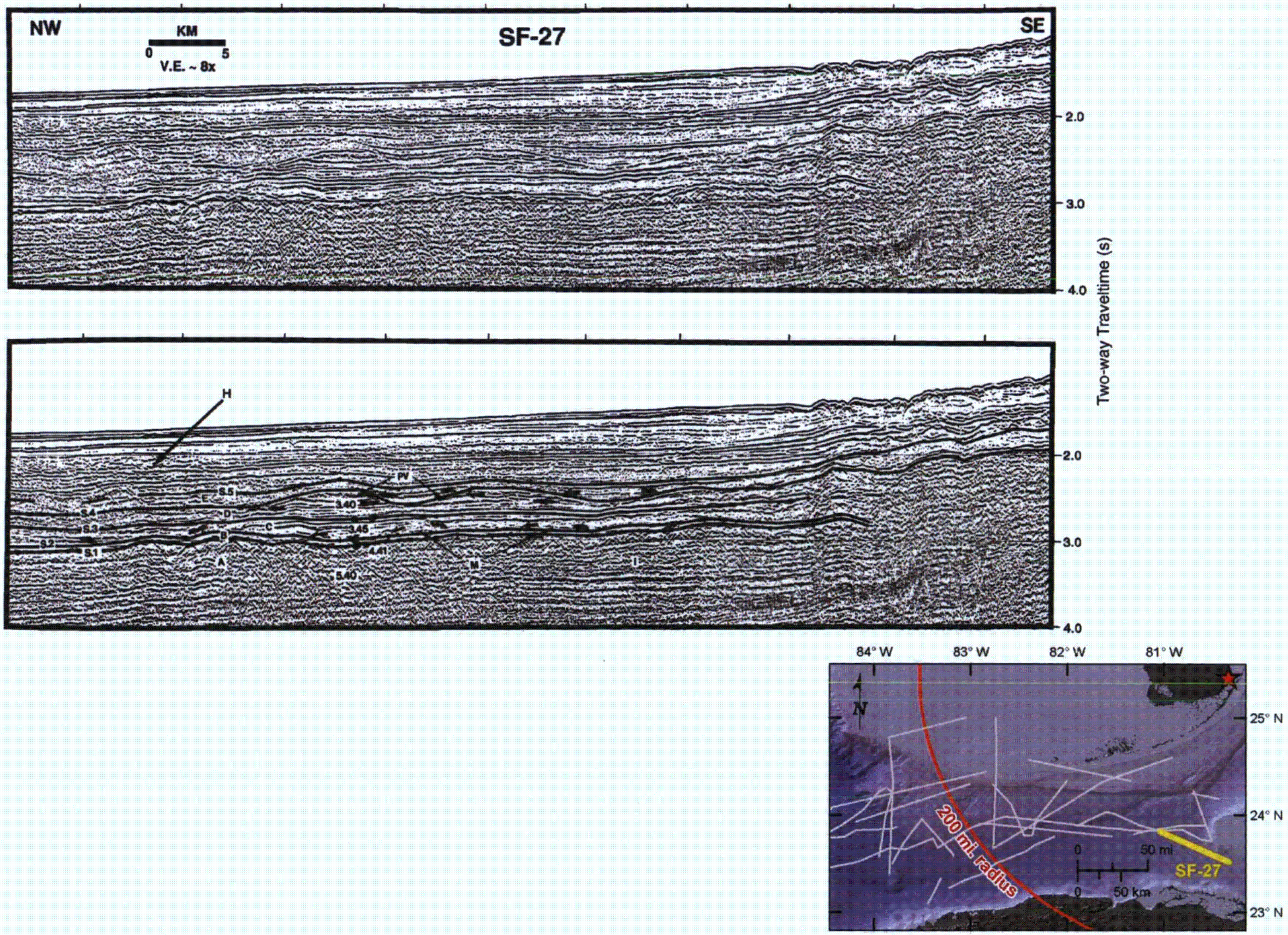


Figure 2. Seismic Line Demonstrating Unfaulted Strata in the Straits of Florida (from Denny et al., FSAR Reference 2.5.1-221)

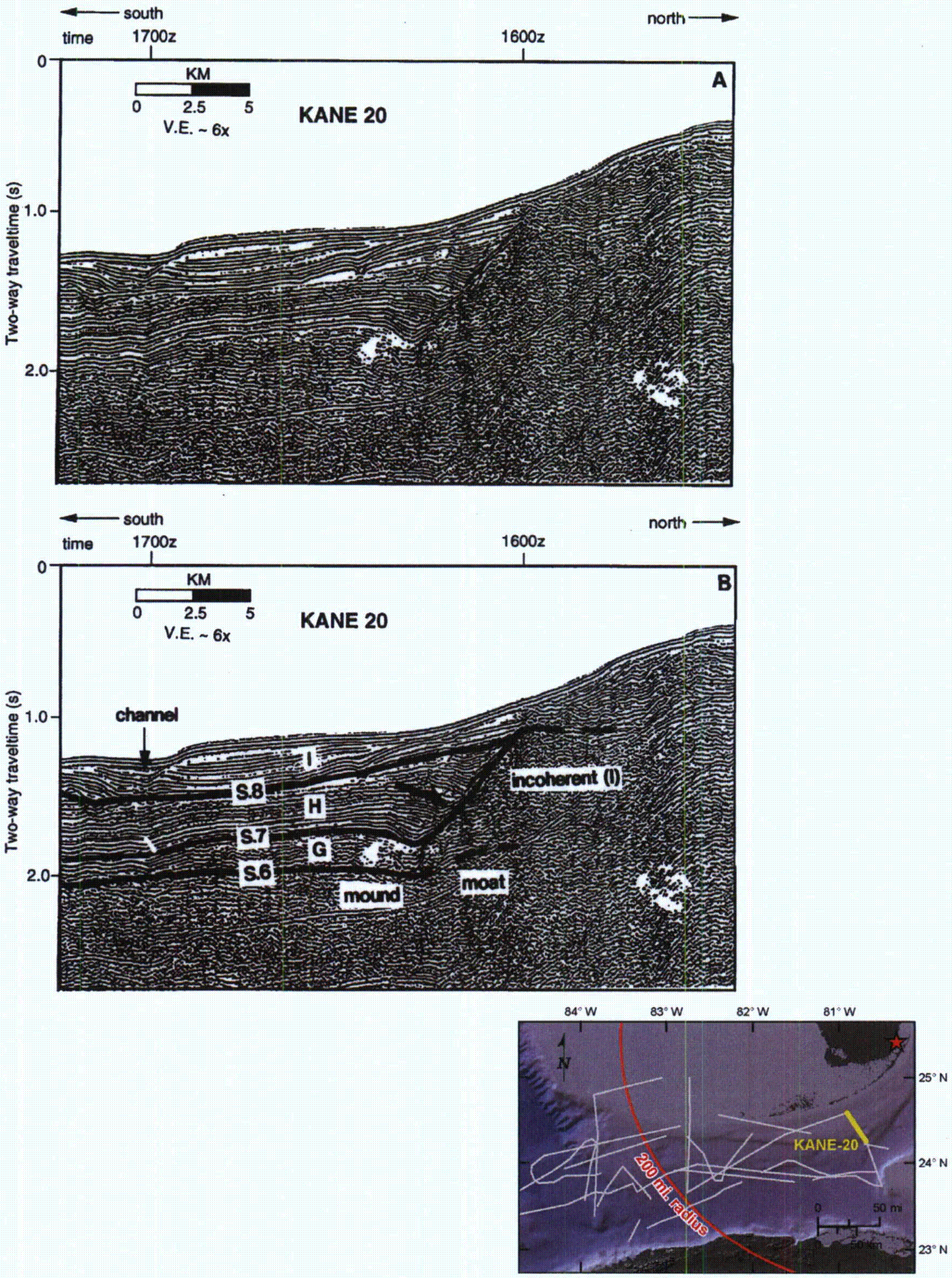


Figure 3. Seismic Line and Interpretation Crossing the Pourtales Terrace and Escarpment (from Denny et al., FSAR Reference 2.5.1-221)

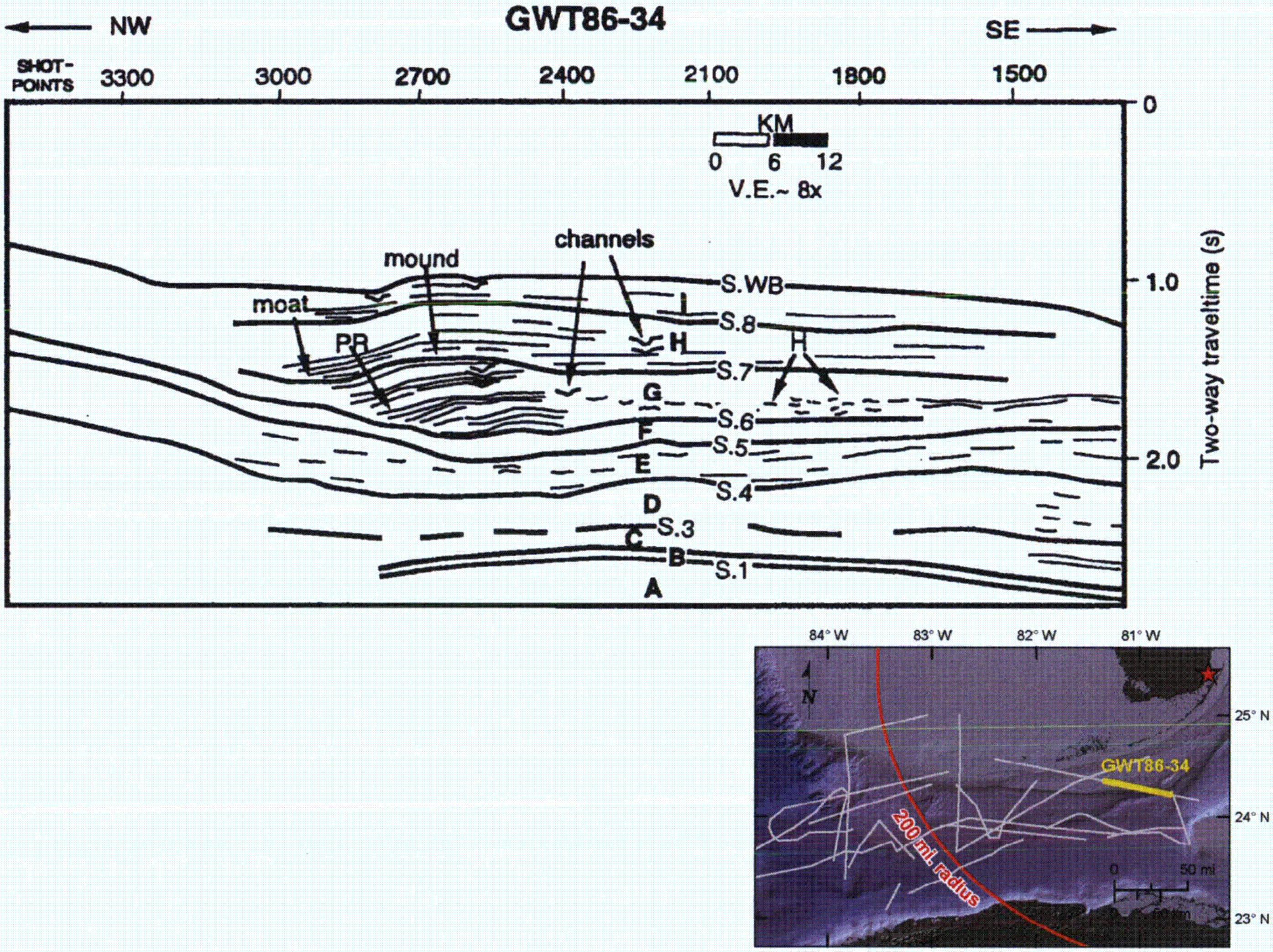


Figure 4. Interpreted Seismic Line Showing Current-Influenced Stratigraphy at the Base of the Pourtales Escarpment (from Denny et al., FSAR Reference 2.5.1-221)

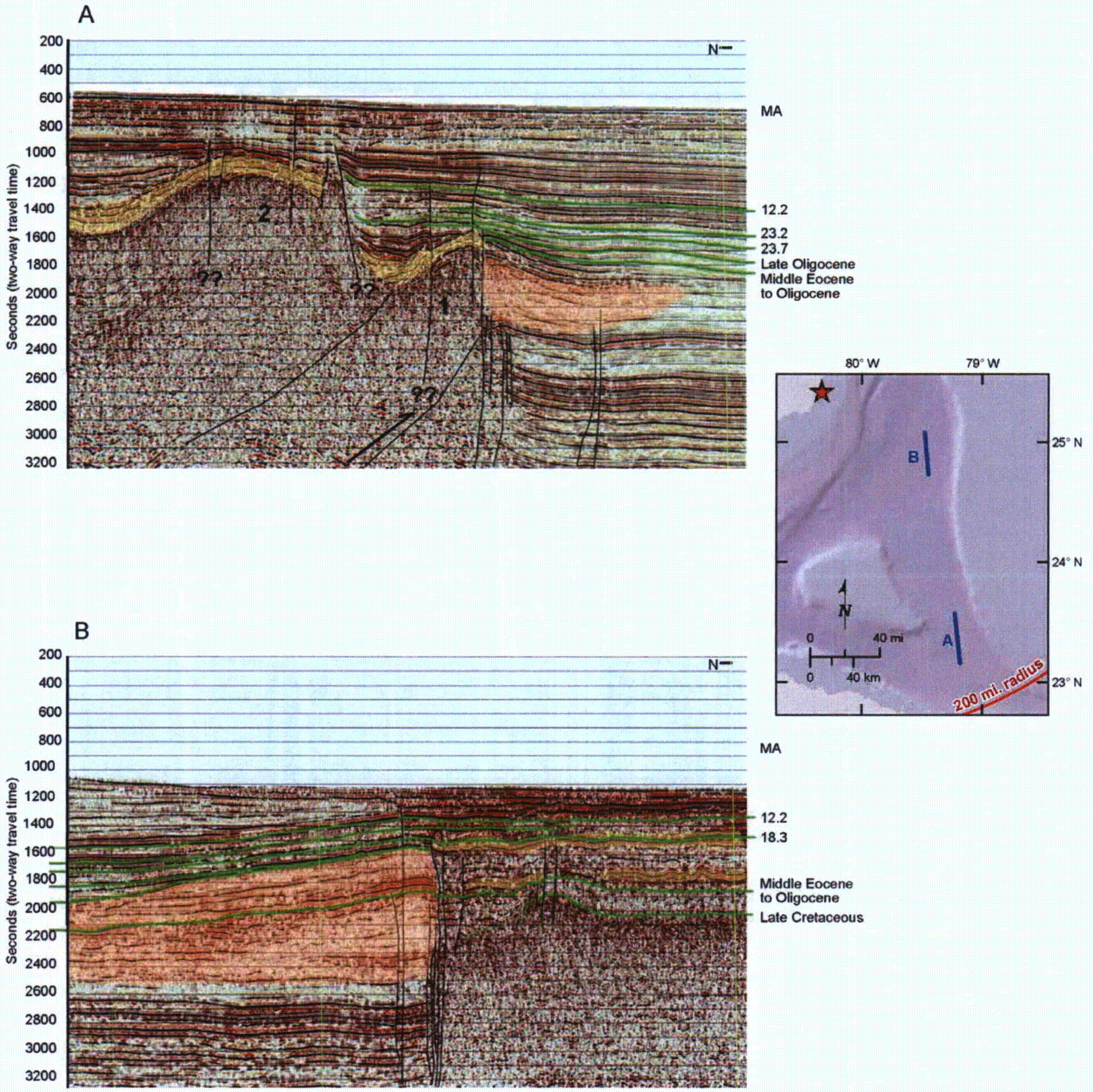
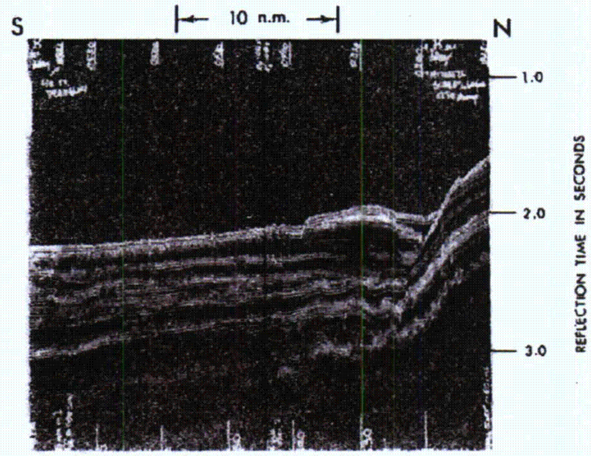


Figure 5. Santaren Channel Profiles A and B (from Bergman, FSAR Reference 2.5.1-906)



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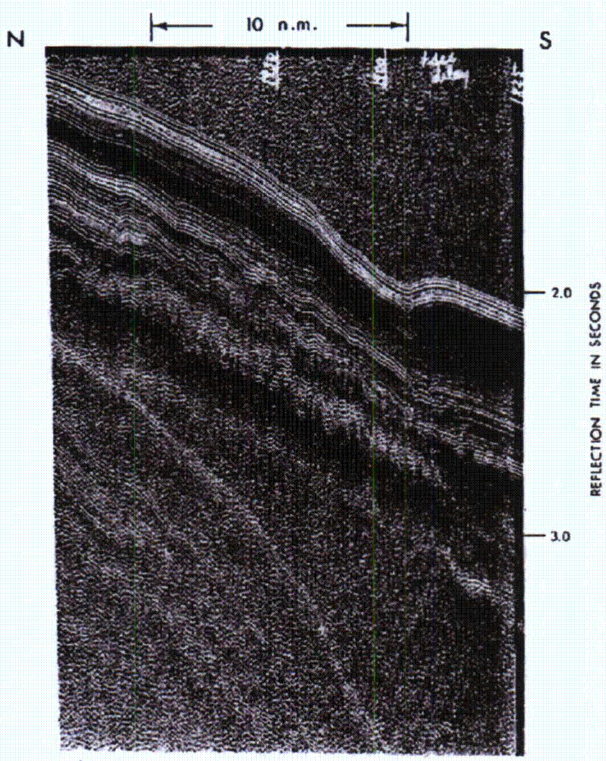


XXXIV

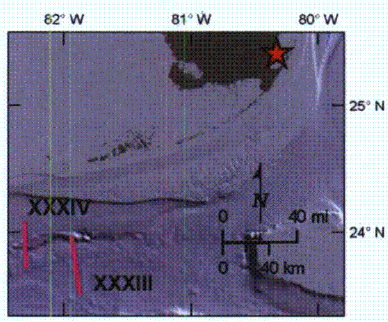
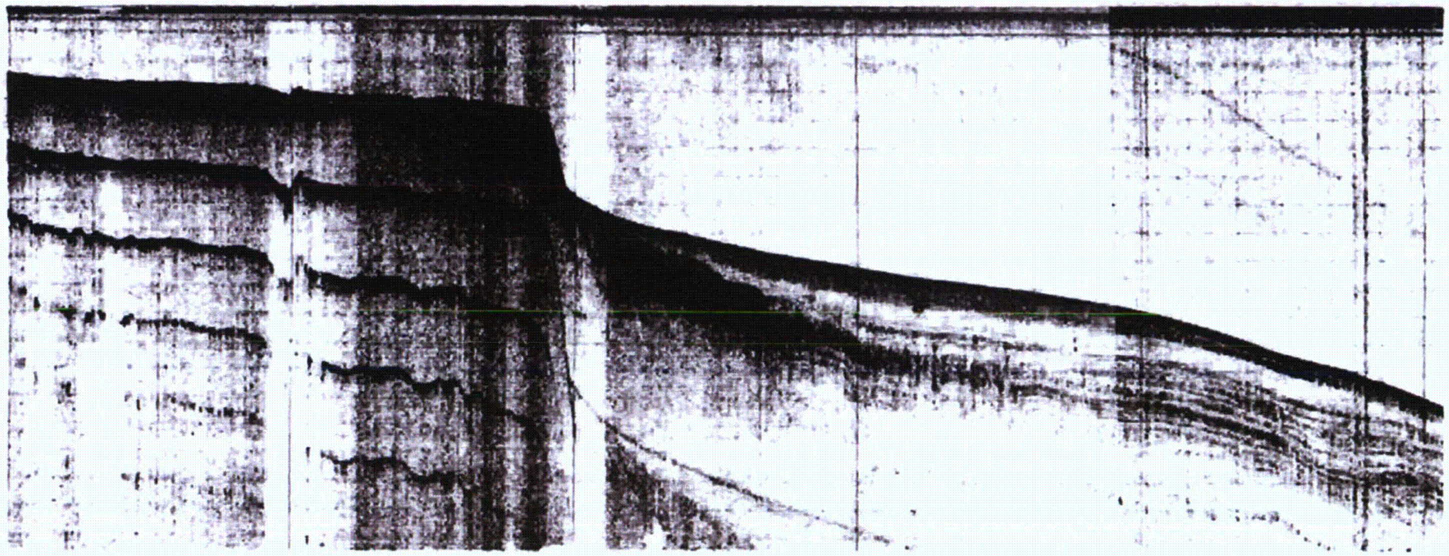


Figure 6. Portions of Seismic Lines Crossing the Mitchell Escarpment (from Malloy and Hurley, Reference 3)



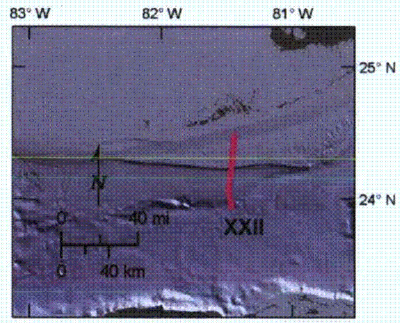
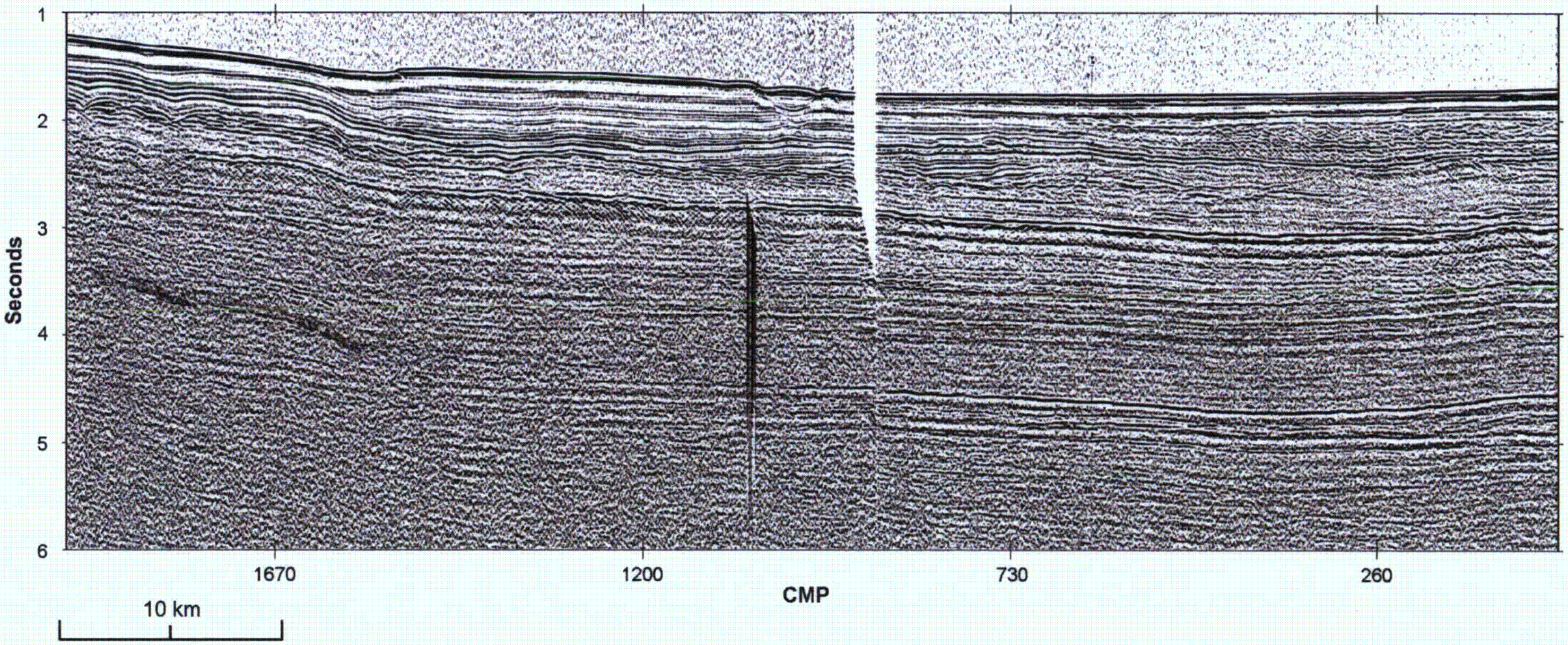


Figure 7. Portion of Seismic Line Crossing the Pourtales Escarpment (from Malloy and Hurley, Reference 3)



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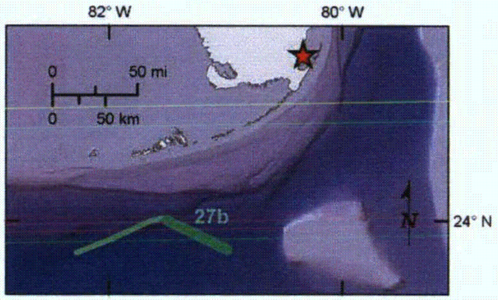
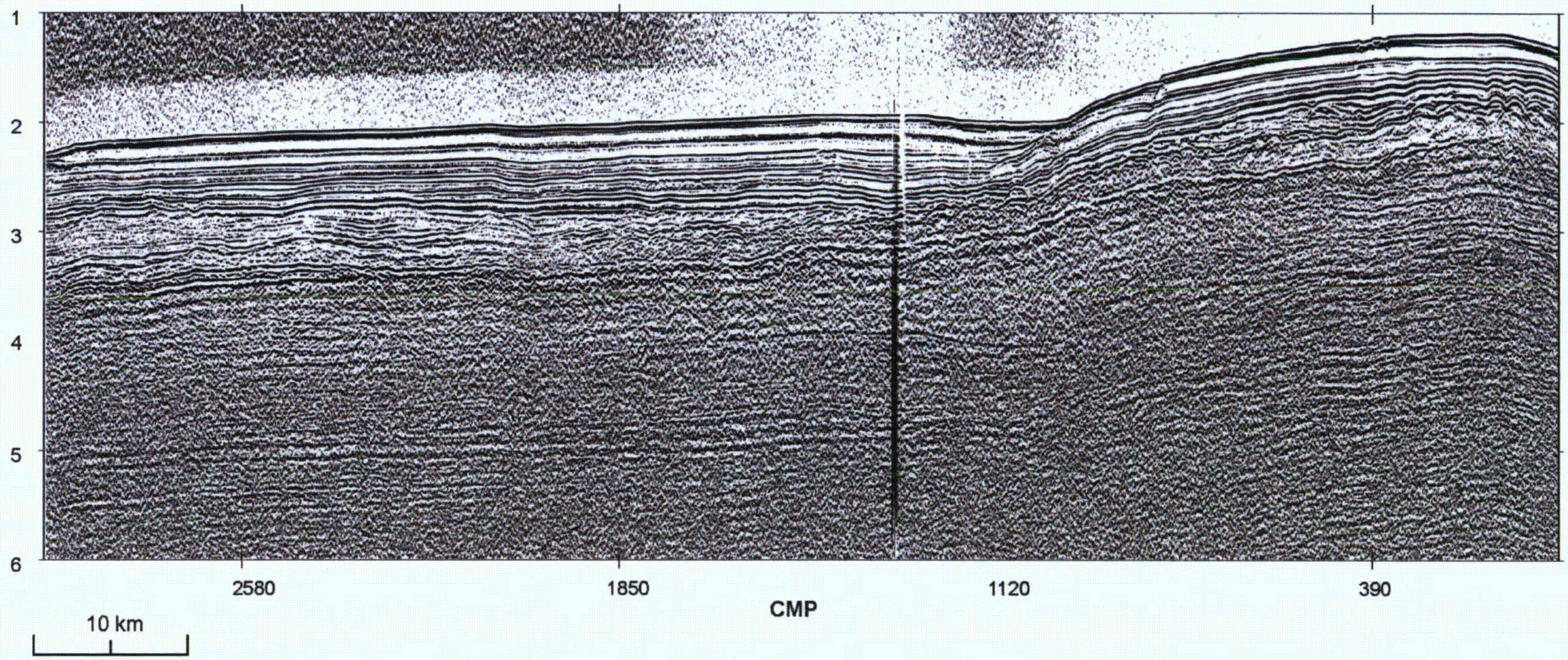


Figure 9a. Uninterpreted Seismic Line 27b across the Mitchell Escarpment (from UTIG, Reference 6)



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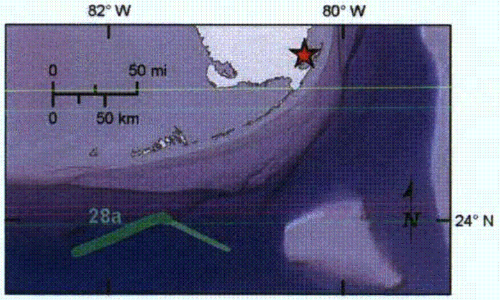


Figure 9b. Uninterpreted Seismic Line 28b across the Mitchell Escarpment (from UTIG, Reference 6)

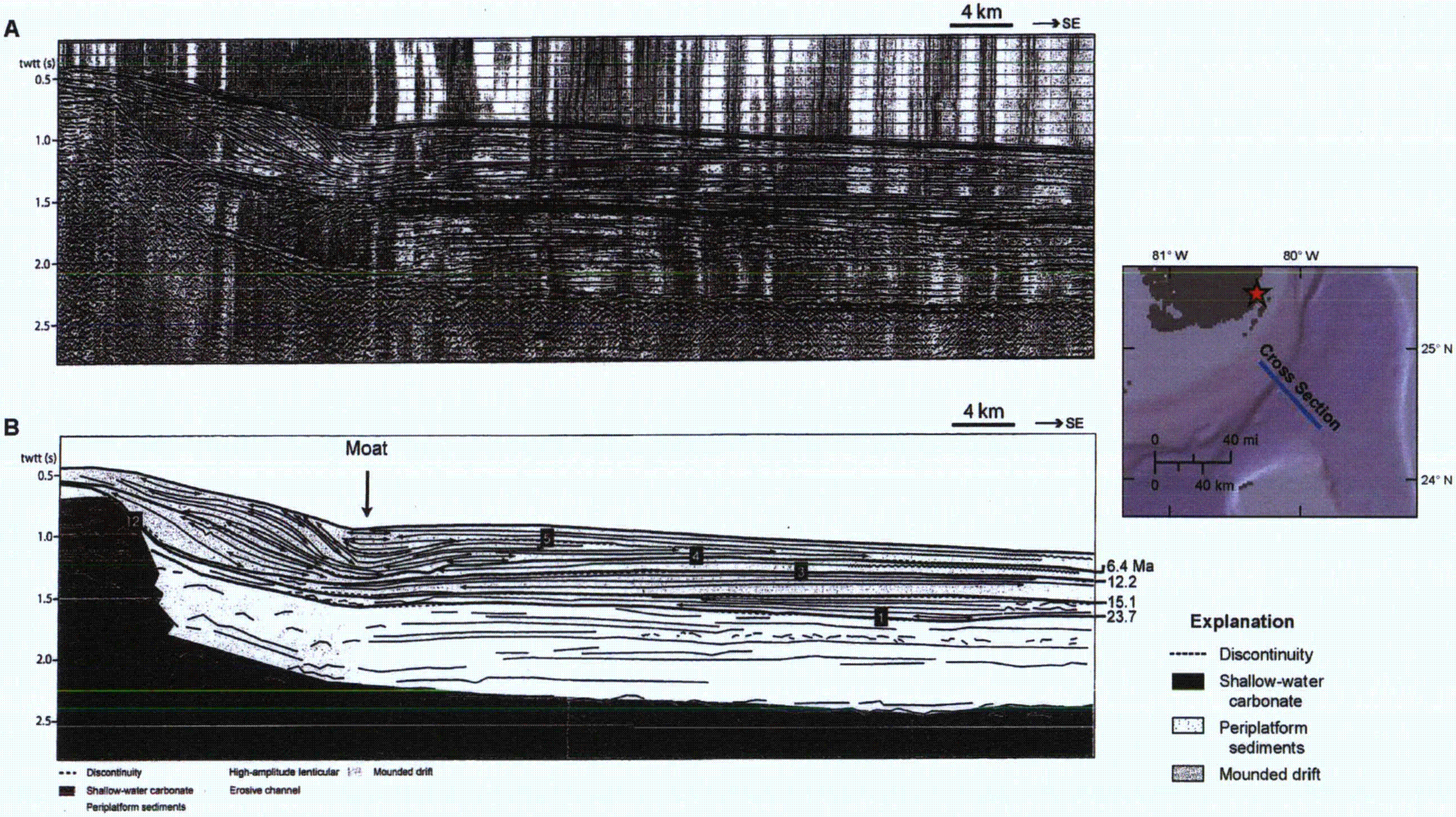
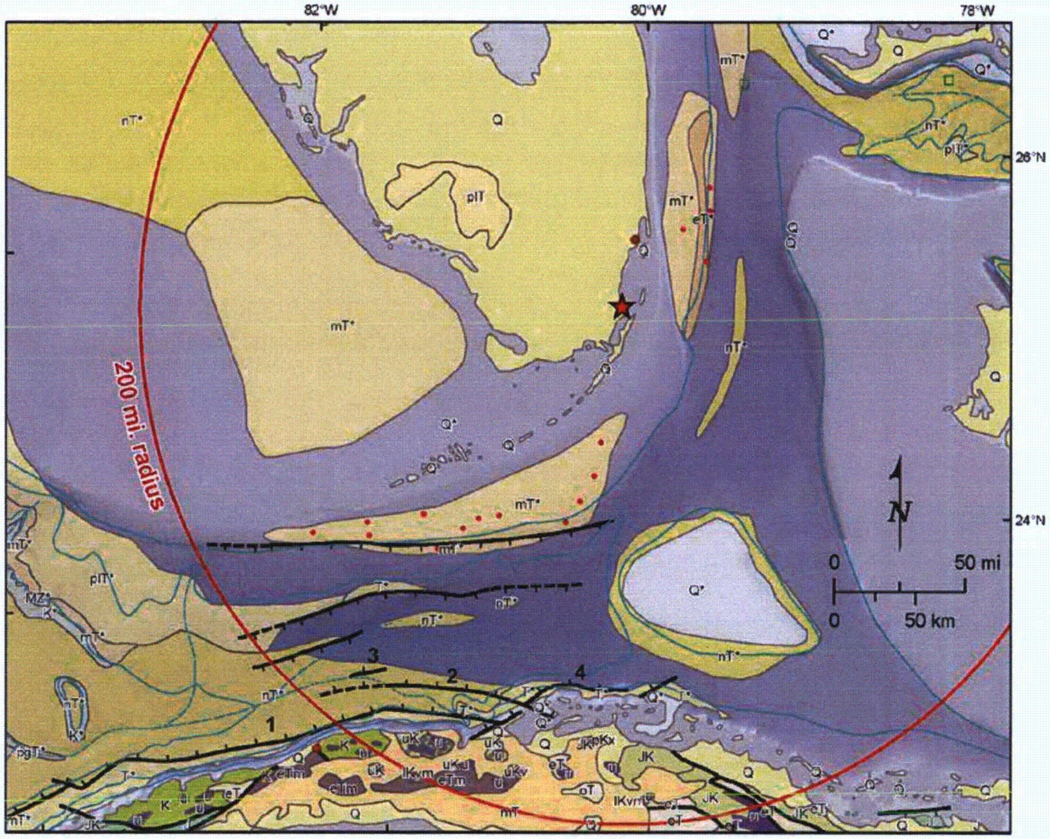


Figure 10. Seismic Line and Interpretation across the Pourtales Escarpment, Indicating Unfaulted Stratigraphy (from Bergman, FSAR Reference 2.5.1-906)



Geologic Units

- Q — Quaternary sedimentary rocks
- Q* — Quaternary (sea floor) sedimentary rocks
- T* — Tertiary (sea floor) sedimentary rocks
- nT* — Neogene (sea floor) sedimentary rocks
- plT — Pliocene sedimentary rock
- plT* — Paleogene (sea floor) sedimentary rocks
- mT — Miocene sedimentary rocks
- mT* — Miocene (sea floor) sedimentary rocks
- pgT* — Paleogene (sea floor) sedimentary rocks
- oT — Oligocene sedimentary rocks
- eT — Eocene sedimentary rocks
- eT* — Eocene (sea floor) sedimentary rocks
- eTin — Eocene plutonic diorite and gabbro
- MZ* — Mesozoic (sea floor) sedimentary rocks
- MZx* — Mesozoic high-grade metamorphic, undivided crystalline rocks (sea floor)
- uK — Upper Cretaceous sedimentary rocks
- uKv — Upper Cretaceous volcanic rocks
- K — Cretaceous sedimentary rocks
- K* — Cretaceous (sea floor) sedimentary rocks
- pKx — Cretaceous high-grade metamorphic, undivided crystalline rocks
- lKvi — Lower Cretaceous intermediate volcanics
- lKvm — Lower Cretaceous mafic volcanics
- JK — Jurassic-Cretaceous sedimentary rocks
- J — Jurassic sedimentary rocks
- u — Ultramafic rocks of unknown age

Explanation

- Phosphate nodule or pavement
- Normal fault, location accurate
- Normal fault, location approximate
- Strike-slip fault, location accurate
- Unclassified fault, location accurate
- Axis of submarine canyon, sea valley, or channel, location accurate
- Axis of submarine canyon, sea valley, or channel, location approximate

Key to Numbered Faults and Other Data Sources

1. Las Villas fault: Malloy and Hurley, 1970
2. Sierra de Jatibonico fault: Malloy and Hurley, 1970
3. Fault cutting Neogene sediments
4. Segmented fault cutting Tertiary sediments

Note: See Figure 1 for faults from Malloy and Hurley, 1970 and Case and Holcombe, 1980

Figure 11. DNAG Map - GMNA of Straits of Florida Region

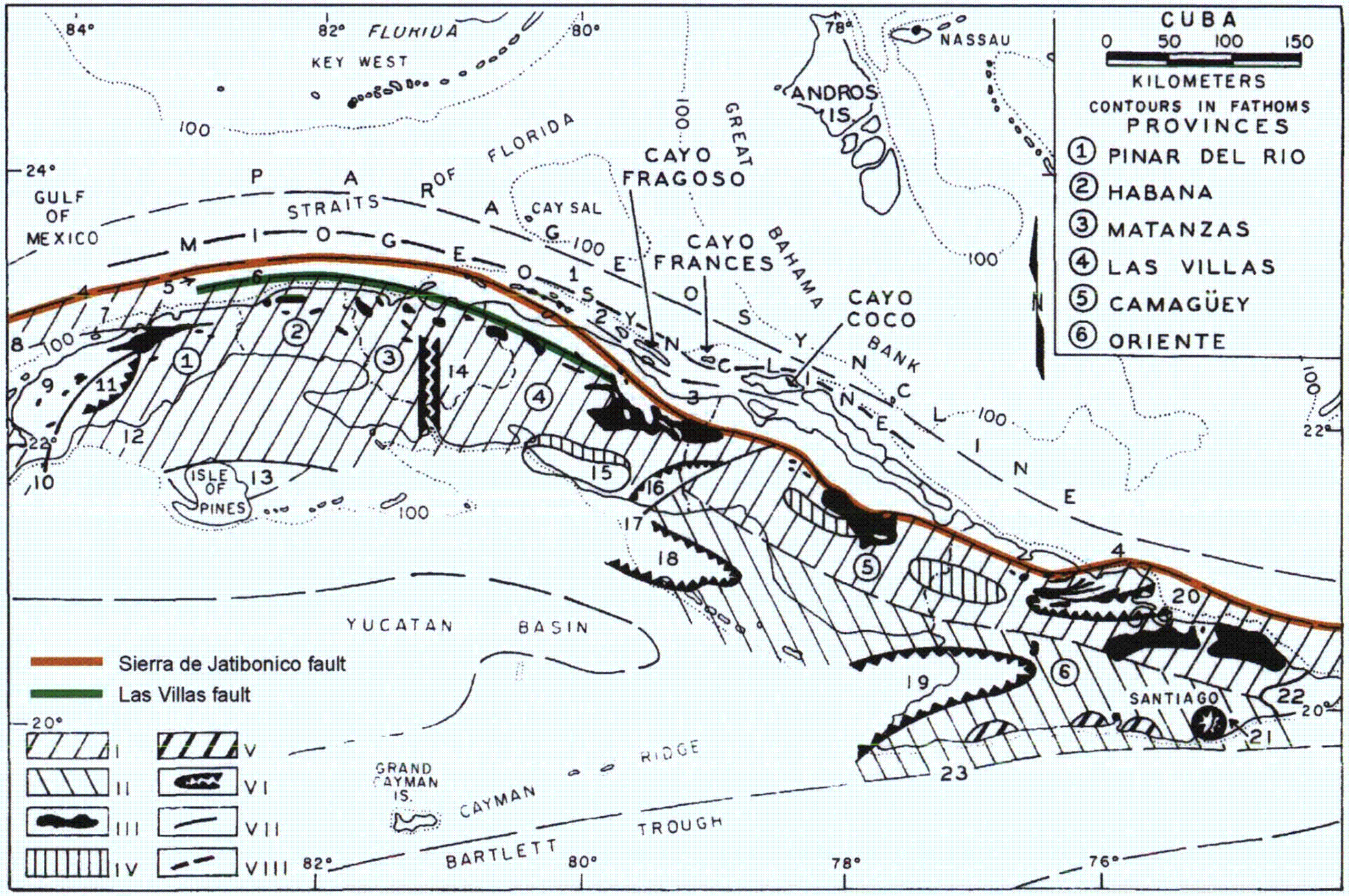


FIG. 1.—Tectonic sketch of Cuba. I–Cretaceous magmatic area (Zaza tectonic unit); II–Tertiary magmatic area (Cauto tectonic unit); III–Upper Cretaceous basic and ultrabasic intrusives; IV–Cretaceous granitoids; V–Tertiary granitoids; VI–Tertiary depressions; VII–deep fault; VIII–boundary between facies-structural zones (tectonic units).

Principal structures (north-south): *parageosyncline; miogeosyncline:* 1–Old Bahamas Channel depression; 2–Cayo Coco tectonic unit; 3–Remedios tectonic unit; 4 Sierra de Jatibonico deep fault; 5–Las Villas tectonic zone or marginal elevation; *eugeosyncline and intrageanticlines of Zaza tectonic unit:* 6–Las Villas deep fault; 7–Bahía Honda tectonic unit; 8–Consolación del Norte deep fault; 9–Pinar del Río tectonic unit; 10–Pinar del Río deep fault; 11–Palacios depression; 12–San Diego de los Baños tectonic unit; 13–Isla de Pinos tectonic unit; 14–Cochinos depression; 15–Trinidad tectonic unit; 16–Central basin depression; 17–La Trocha deep fault; 18–Ana María depression; 19–Cauto depression; 20–Nipe depression; 21–Guantánamo depression; 22–Oriente tectonic unit; 23–North Bartlett deep fault.

Figure 12. Map of the Las Villas and Sierra de Jatibonico Faults (from Khudoley, FSAR Reference 2.5.1-910)

This response is PLANT SPECIFIC.

References:

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7. Reed, J.C., Wheeler, J.O., and Tucholke, B.E., 2005, *Decade of North American Geology, Geologic Map of North America*, The Geological Society of America, Boulder, Colorado.
8. FPL letter L-2014-281 to NRC dated October 3, 2014, Voluntary Revised Response to NRC Request for Additional Information Letter No. 041 (eRAI 6024) SRP Section: 02.05.01 - Basic Geologic and Seismic Information.

ASSOCIATED COLA REVISIONS:

No additional changes to COLA Revision 6 have been identified as a result of this revised response.

ASSOCIATED ENCLOSURES:

None

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

SRP Section: 02.05.01 – Basic Geologic and Seismic Information

Question from Geosciences and Geotechnical Engineering Branch

NRC RAI Number: 02.05.01-20 (eRAI 6024)

FSAR Section 2.5.1.1.4, states with respect to the "Contemporary Stress Regime within the Site Region", that "the boundary between the mid-plate and Gulf Coast stress provinces terminates in the northern Florida Peninsula, but there is a lack of stress data from areas near the Florida Peninsula and most of Cuba. Because the southern Florida Peninsula doesn't exhibit the geologic features (such as salt-rooted normal faults) associated with the Gulf Coast stress province, the site region is generally interpreted to be part of the mid-plate stress province (Reference 705) (Figure 2.5.1-330)."

In order for the staff to determine the configuration of the state of stress within the site region and in support of 10 CFR 100.23, please address the following:

a) Address the focal mechanism for the Sept 10, 2006 Gulf of Mexico earthquake with respect to the Gulf Coast stress province and show stress orientation indicated by this focal mechanism on Figure 2.5.1-330.

b) Indicate on Figure 2.5.1-330 the boundary between the Gulf coast and mid plate stress provinces as it is currently interpreted within the TPNPP site region.

c) Explain if analyses were performed to characterize the stress direction and magnitude in northern Cuba in light of the abundant seismicity along the northern parts of Cuba. Indicate on Figure 330 how the boundaries of the Gulf Coast and the mid plate stress provinces resolve in the vicinity of northern Cuba.

FPL RESPONSE:

INTRODUCTION

This response is a revision to information previously submitted to the NRC in FPL letter L-2014-281, "Voluntary Revised Response to NRC Request for Additional Information Letter No. 041 (eRAI 6024) SRP Section: 02.05.01 - Basic Geologic and Seismic Information," dated October 3, 2014 (Reference 4). Subsequent to that submittal, NRC identified that Attachment A, which was mentioned in Part (a) of the response, was not included with the FPL letter L-2014-281. FPL notes that the reference to Attachment A should have been replaced with a citation to Angell and Hitchcock (2007, Figure 1) (Reference 1). In this submittal, FPL cites Angell and Hitchcock (2007, Figure 1) (Reference 1) instead of Attachment A. Additionally, FPL relocates, within the text, the citation to FSAR 2.5.1 Reference 703 to provide clarification in Part (a) of the RAI response and adds Lamont-Doherty Earth Observatory (LDEO, 2015) (Reference 2) as a reference for the azimuth and plunge of the primary compressive stress ($\sigma 1$) axis, as follows.

REVISIONS TO RAI 02.05.01-20

a) Address the focal mechanism for the Sept 10, 2006 Gulf of Mexico earthquake with respect to the Gulf Coast stress province and show stress orientation indicated by this focal mechanism on Figure 2.5.1-330.

As discussed in the FSAR (Subsection 2.5.1.1.4), the Gulf Coast stress province is characterized by northeast-southwest to north-northeast to south-southwest horizontal tension, driven by sediment loading and subsidence of the gulf. The resulting "typical" faults in this regime are down-to-the-gulf growth faults in Cenozoic cover sediments that glide over a weak salt layer, the Louann formation (e.g., Wu et al., 1990) (Reference 3). This is distinct from the mid-plate stress province that most of the CEUS falls into, characterized by northeast-southwest compression driven by forces originating at the mid-Atlantic Ridge.

The focal mechanism for the September 10, 2006 Gulf of Mexico earthquake, shown in Angell and Hitchcock (2007, Figure 1) (Reference 1), is representative of thrust faulting along a steep northwest- striking fault plane, with a primary compressive stress ($\sigma 1$) axis oriented at 214° with a plunge of 19° (LDEO, 2015) (Reference 2). This is consistent with the mid-plate stress province of the CEUS, rather than the Gulf Coast stress province, and mostly likely means that the Sept 10, 2006 earthquake was produced by basement faulting beneath the Louann salt formation (FSAR 2.5.1 Reference 703; Angell and Hitchcock, 2007) (Reference 1). This would be consistent with the depth of the earthquake, which at 22-31 kilometers (FSAR Reference 2.5.2-290) is well beneath the 5-14 kilometers of sedimentary cover in the gulf and associated stresses. Stresses acting on basement faults in the Gulf of Mexico would instead align with those experienced by the rest of the CEUS.

As described in FSAR Subsections 2.5.2.4.3.1 and 2.5.2.4.3.2, the original EPRI-SOG source zones within the site region were updated to account for the September 10, 2006 Emb 5.90 Gulf of Mexico earthquake. Figure 2.5.1-330 has now been revised to also include the stress orientation from this event.

b) Indicate on Figure 2.5.1-330 the boundary between the Gulf coast and mid plate stress provinces as it is currently interpreted within the TPNPP site region.
Figure 2.5.1-330 depicts the boundary between the Gulf Coast and mid-plate stress provinces as interpreted by Zoback and Zoback, 1991 (FSAR 2.5.1 Reference 705). We have not extended their stress boundary into the Florida Peninsula for two reasons. First, there is little stress data near the Florida Peninsula and Cuba that can be used to demarcate stress boundaries in this area. Second, the Florida Peninsula lacks the geologic features characteristic of the Gulf Coast stress province. Both of these points are discussed in Subsection 2.5.1.1.4 of the FSAR.

The Gulf Coast stress province describes the area where growth faulting in response to sedimentary loading and subsidence is observed, primarily in the northern gulf. The geomorphic expression of such faulting is clearly evident in the bathymetry depicted in Figure 2.5.1-330. The continental shelf and slope of the northwestern gulf appears highly broken, whereas the shelf of western Florida, the seafloor of the Florida Straits, and the shelf extending north from the Yucatan all appear to be relatively flat and continuous.

Given the lack of stress data and the absence of specific geologic features, the Gulf Coast stress province is not interpreted to lie within the TPNPP site region; as such, we would not draw a boundary between the Gulf Coast and mid-plate stress provinces there.

c) Explain if analyses were performed to characterize the stress direction and magnitude in northern Cuba in light of the abundant seismicity along the northern parts of Cuba. Indicate on Figure 330 how the boundaries of the Gulf Coast and the mid plate stress provinces resolve in the vicinity of northern Cuba.

Analyses were not performed to characterize the stress direction and magnitude in northern Cuba. The stress inversions required for such an analysis rely on a critical mass of focal mechanisms, rather than a catalog of seismicity. Cotilla-Rodriguez et al. (2007) (FSAR 2.5.1 Reference 494) state that focal mechanisms for Cuba are only available along the Oriente fault and at the eastern end of the Nortecubana fault. The magnitudes and locations of the earthquakes in northern Cuba are primarily based on intensity data instead of instrumentation; as such, few focal mechanisms are available for an analysis of the stresses in northern Cuba.

As explained in part (b) above, based on the absence of these salt-rooted normal faults, we do not interpret the Gulf Coast stress province to extend into the Florida Peninsula, nor do we interpret it to extend further south towards Cuba. We would expect that if the stress field in Cuba is different from that of the remainder of the TPNPP site region, (including most of the Florida Platform and portions of the Bahama Platform), the boundary between the two regions would be subparallel to and just offshore of the coast of Cuba. However, stress data are inadequate in the site region to reliably determine whether stress differences exist, and where those boundaries may be.

This response is PLANT SPECIFIC.

References:

1. Angell, M. and Hitchcock, C., *A geohazard perspective of recent seismic activity in the northern Gulf of Mexico, Offshore Technology Conference*, Houston, Texas, 8 p., 2007.
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4. FPL letter L-2014-281 to NRC dated October 3, 2014, Voluntary Revised Response to NRC Request for Additional Information Letter No. 041 (eRAI 6024) SRP Section: 02.05.01 - Basic Geologic and Seismic Information.

ASSOCIATED COLA REVISIONS:

No additional changes to COLA Revision 6 have been identified as a result of this revised response.

ASSOCIATED ENCLOSURES:

None