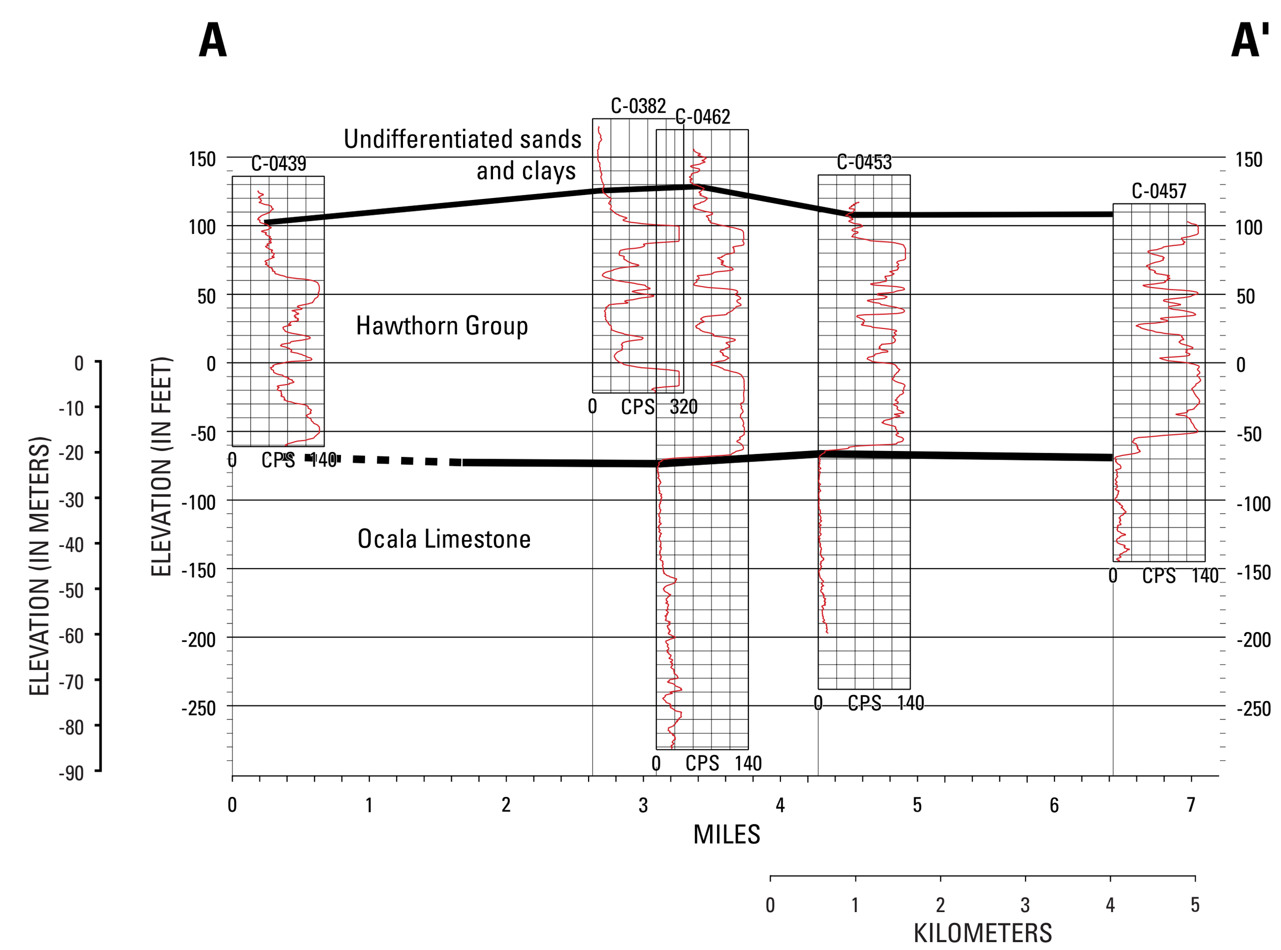
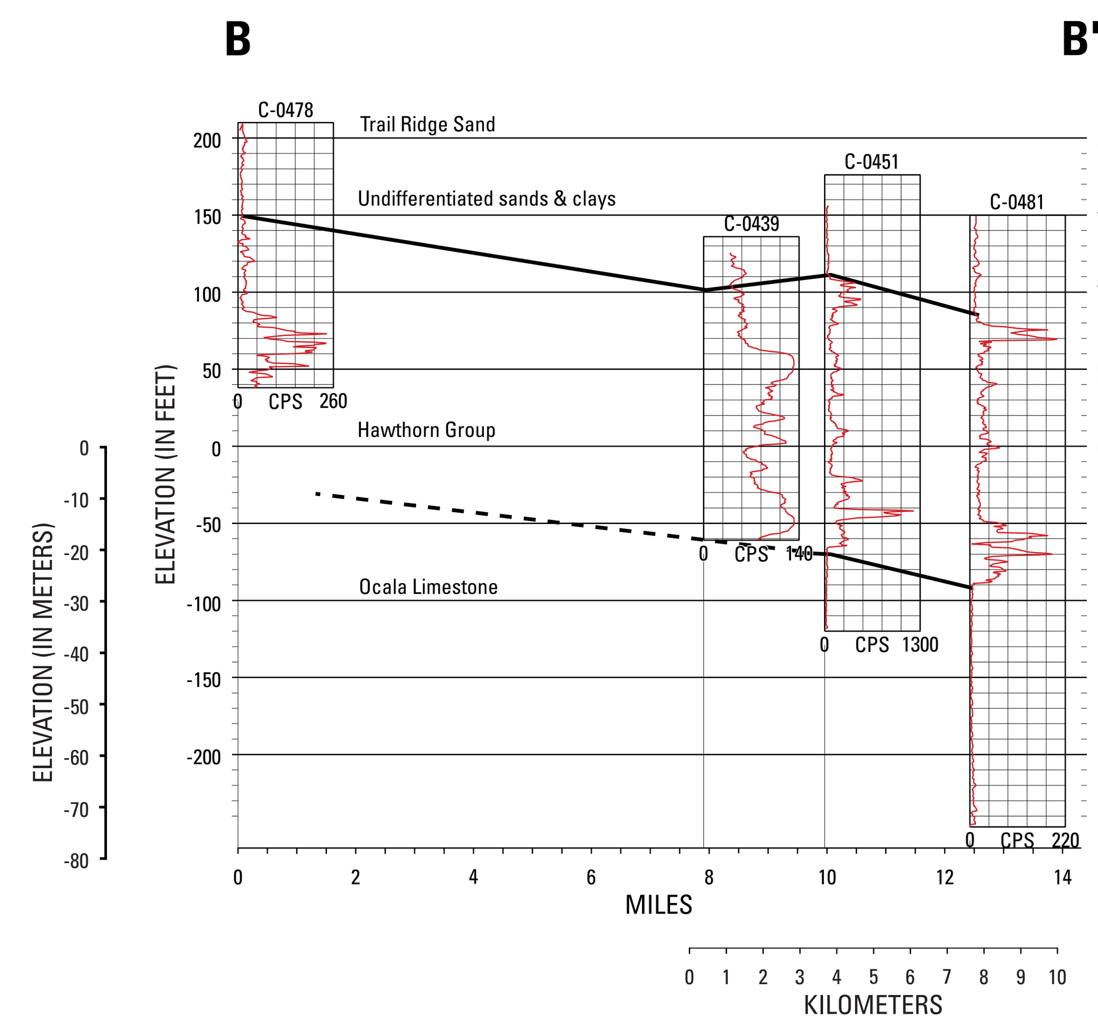
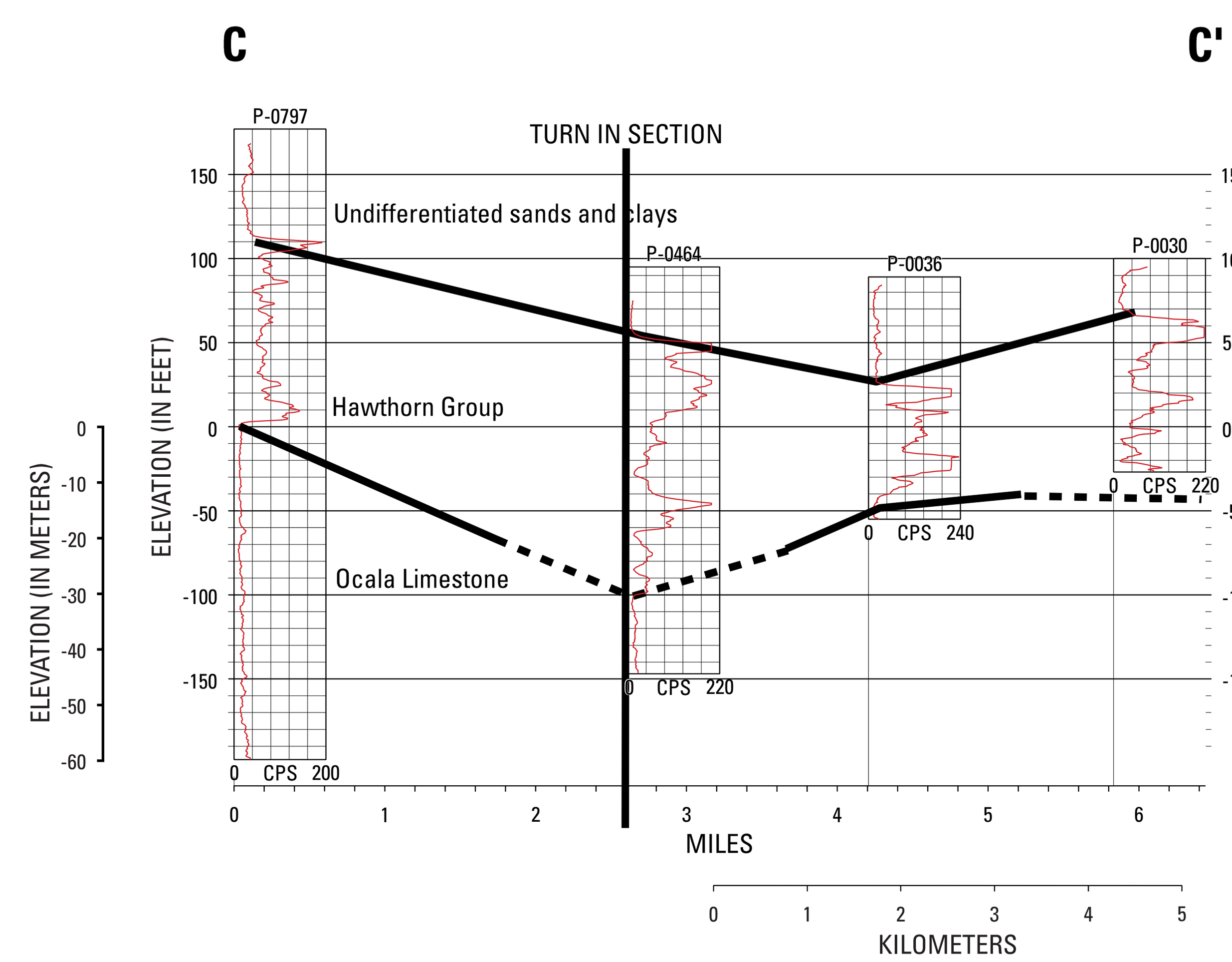
A

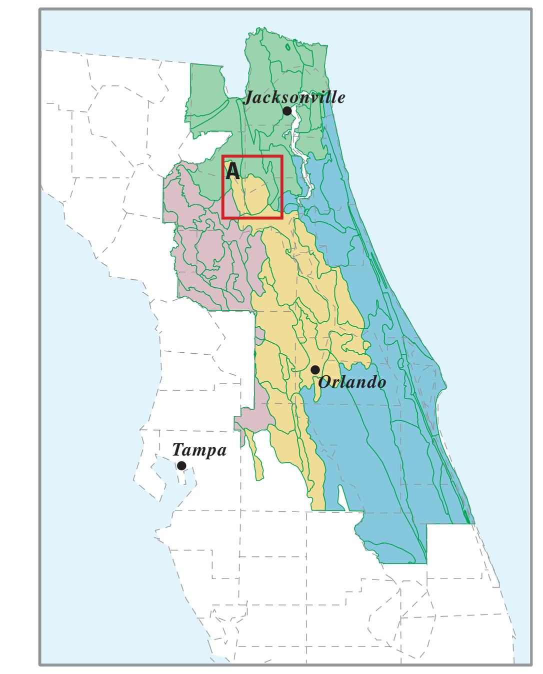
INDEX MAP AND GAMMA LOG

CROSS-SECTIONS, SECTION A

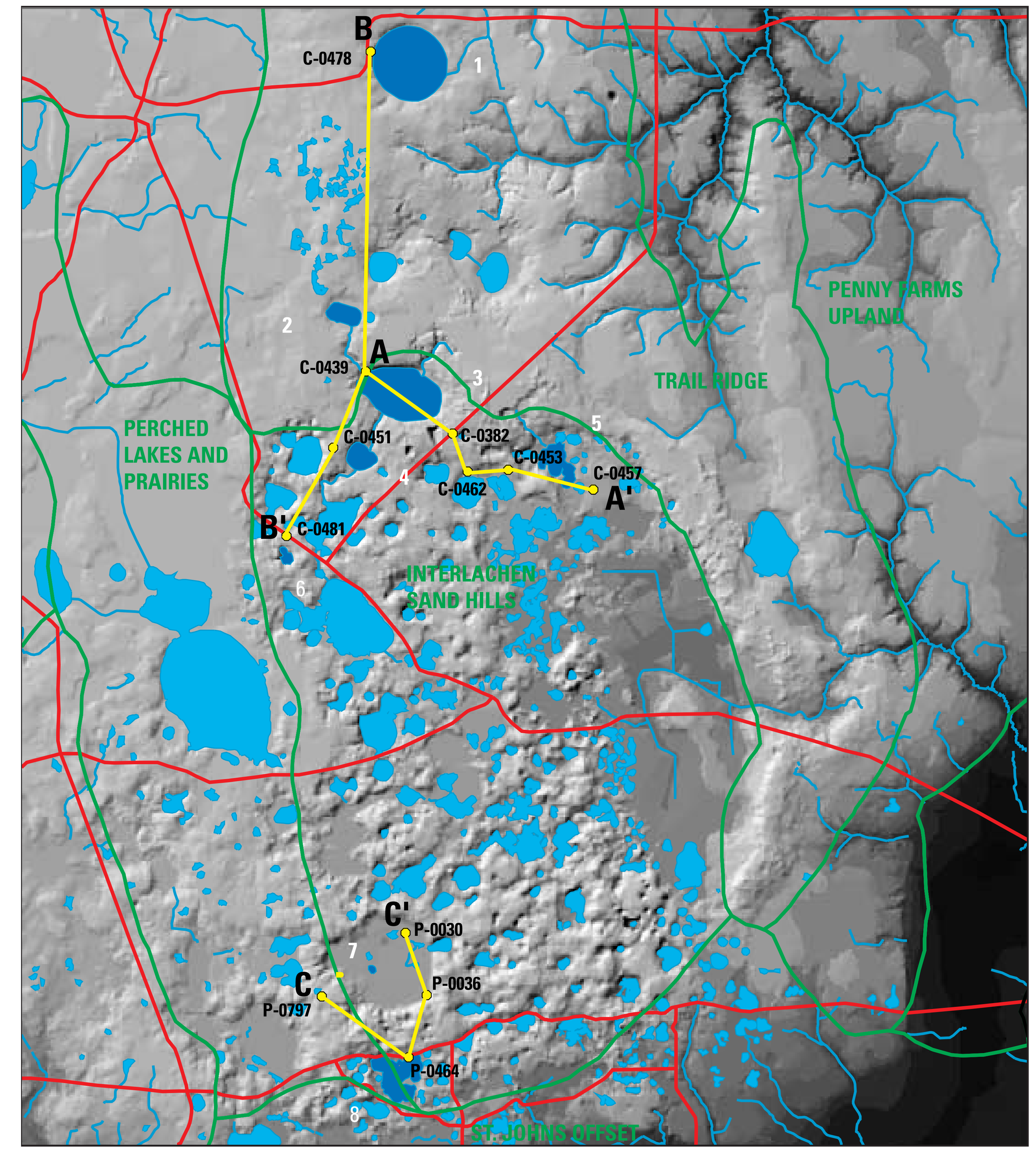








Location of survey area right (red square). Shaded relief map below showing physiographic regions, and location of wells and gamma log cross-section. Gamma Log cross-sections (left) show geologic contacts for correlation to seismic sections.



LEGEND

- Wells, Cross-Sections
- Streams/Rivers
- Major Roads
- Physiographic Province Boundary
- Lakes
- Lakes in Atlas

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1	Kingsley Lake	9
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6	Paradise Lake	
7	Levys Prairie	
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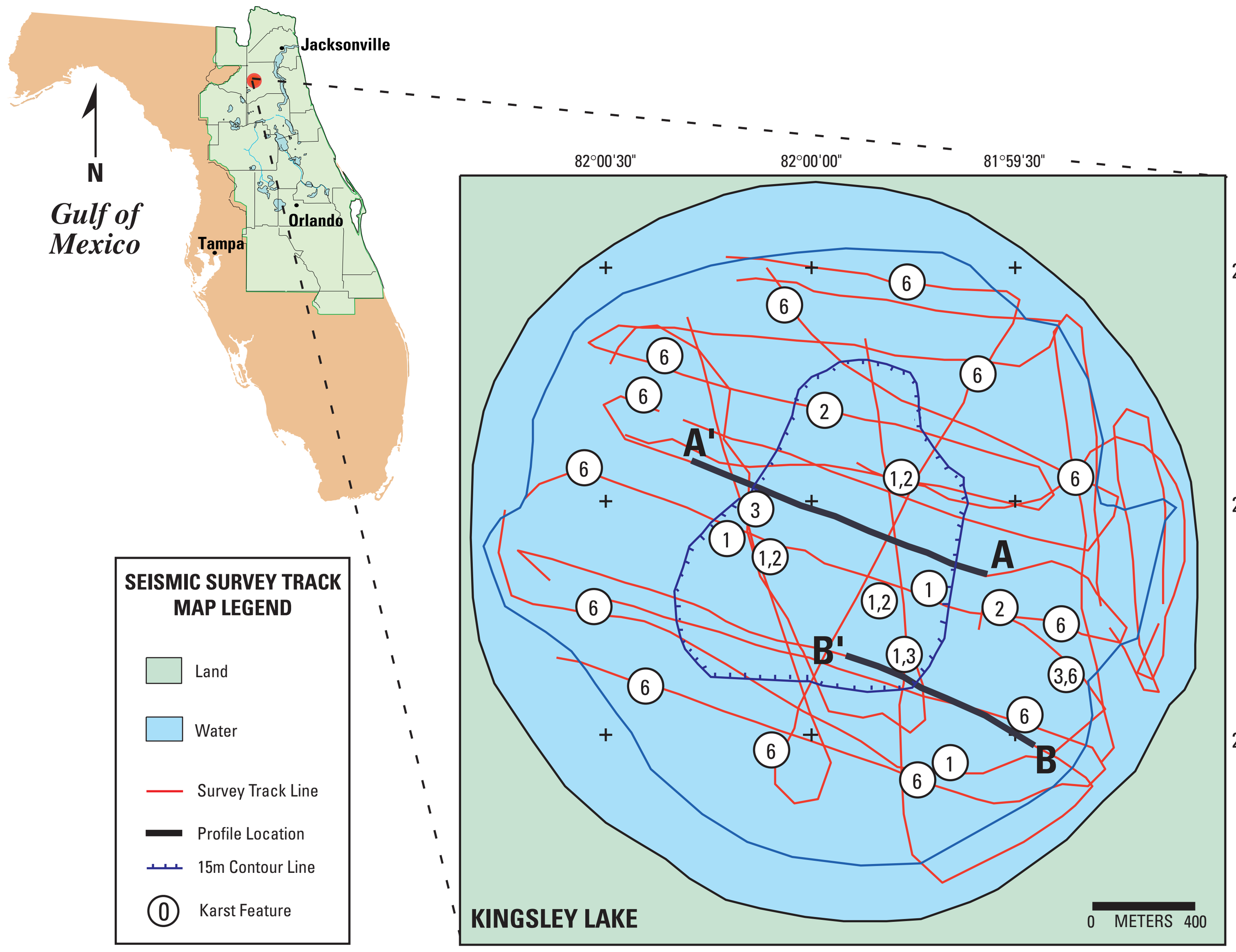
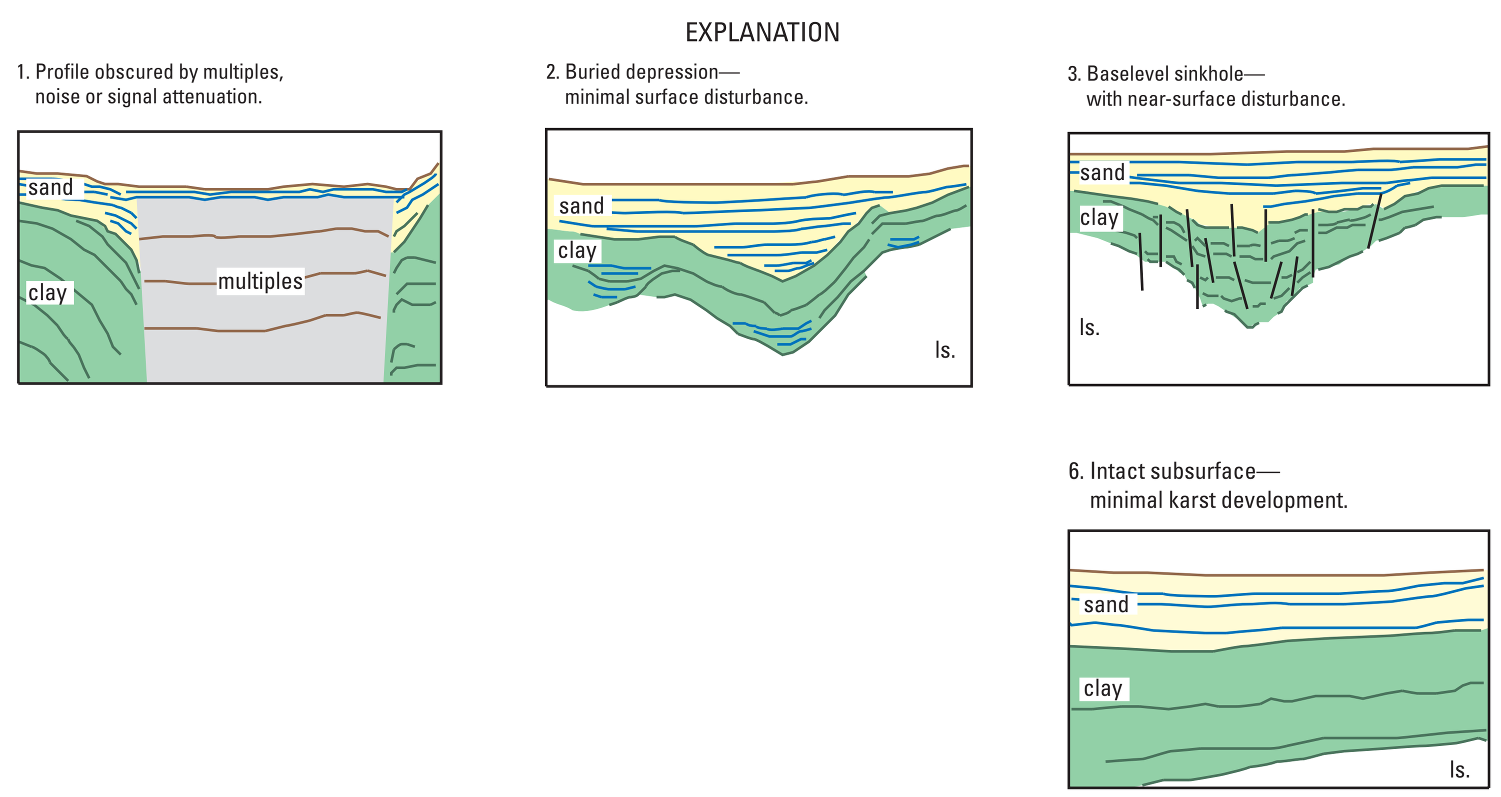
1 0 1 MILES   1 0 1 KILOMETERS

KINGSLEY LAKE
CLAY COUNTY, FLORIDA





Introduction

Kingsley Lake is a circular lake centered at approximately latitude 29°57'54"N and longitude 82°W in west-central Clay County, Florida. The lake is located within the Trail Ridge area of Sea Island District. Kingsley Lake is flanked on the west by the Trail Ridge deposits and is underlain and surrounded by Citronelle sediments (Clark, 1964) that consist of a relatively thick section of unconsolidated to semi-consolidated quartz sands, clayey sands, and gravels. The Trail Ridge sands are above an elevation of 45 m (149 ft) and are mined commercially for heavy minerals used in paints and abrasives. These sediments are unconsolidated and completely saturated, this enhances the filling process when sinkholes collapse or sediment is washed into the lakes by surface runoff. Generally the sands are seismically transparent but clay stringers or cementation may provide reflecting horizons.

Lake level at the time of the seismic survey was 54 m (176 ft) NGVD. This circular lake is approximately 3.2 km in diameter with a perimeter of 12.8 km and surface area of 5.6 km^2. The deepest part (40 ms, ~30 m) of the lake southeast is of the center where a large, steep-sided, collapse sinkhole is located. Otherwise, the lake is shallow around the shoreline, gradually deepening to 6 m (see Survey Track Map). Towards the center of the lake the bottom slope steepens and increases in depth from 6 to 15 m (see Survey Track Map).

Subsurface Characterization

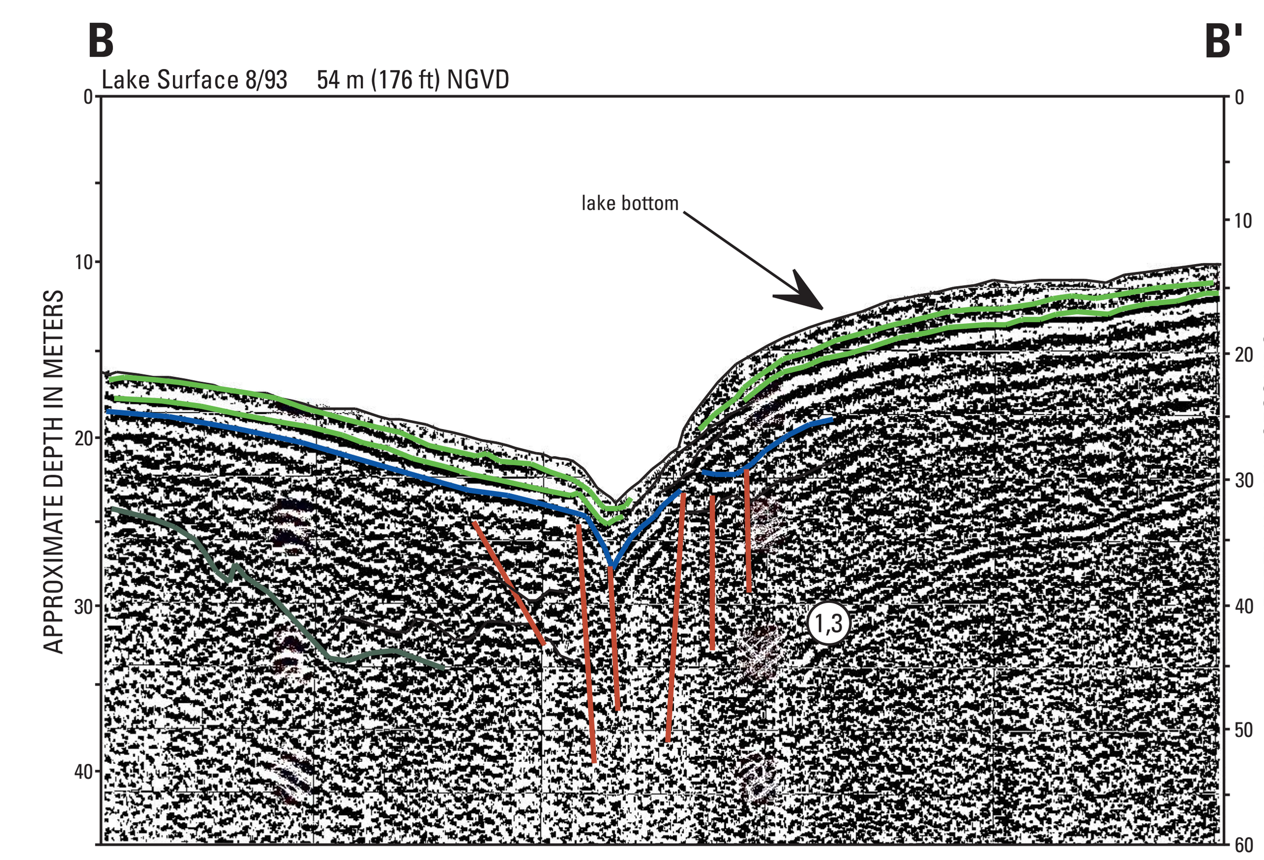
Profile A-A' illustrates the strata in and around the primary sinkhole within the lake. An abrupt change in the lake bottom slope can be seen on the flanks of the sinkhole. This is a filled, collapse-sinkhole with steep flanks overlain by offlapping fill and slumps. The fill is acoustically transparent with few low-amplitude reflections discernible. This is to be expected since the source of the fill is primarily clean quartz sands brought in from the adjacent Trail Ridge deposits. Plotted on the Kingsley Lake survey trackline map are the karst features identified from seismic profiles; Types 1, 2, 3, and 6 karst features were found. Features 1 and 2 represent the primary sinkhole surrounded by Type 6 undistrubed depostional layers.

The Type 1, 3 feature seen in Profile B-B' appears to be a secondary collapse feature that occurred after the formation of the main doline shown in Profile A-A'. Unlike the main doline, this feature is not completely filled with sediment. The data does not indicate that the feature extends through the surficial and Hawthorn Group sediments into the Floridan aquifer (>95 m).

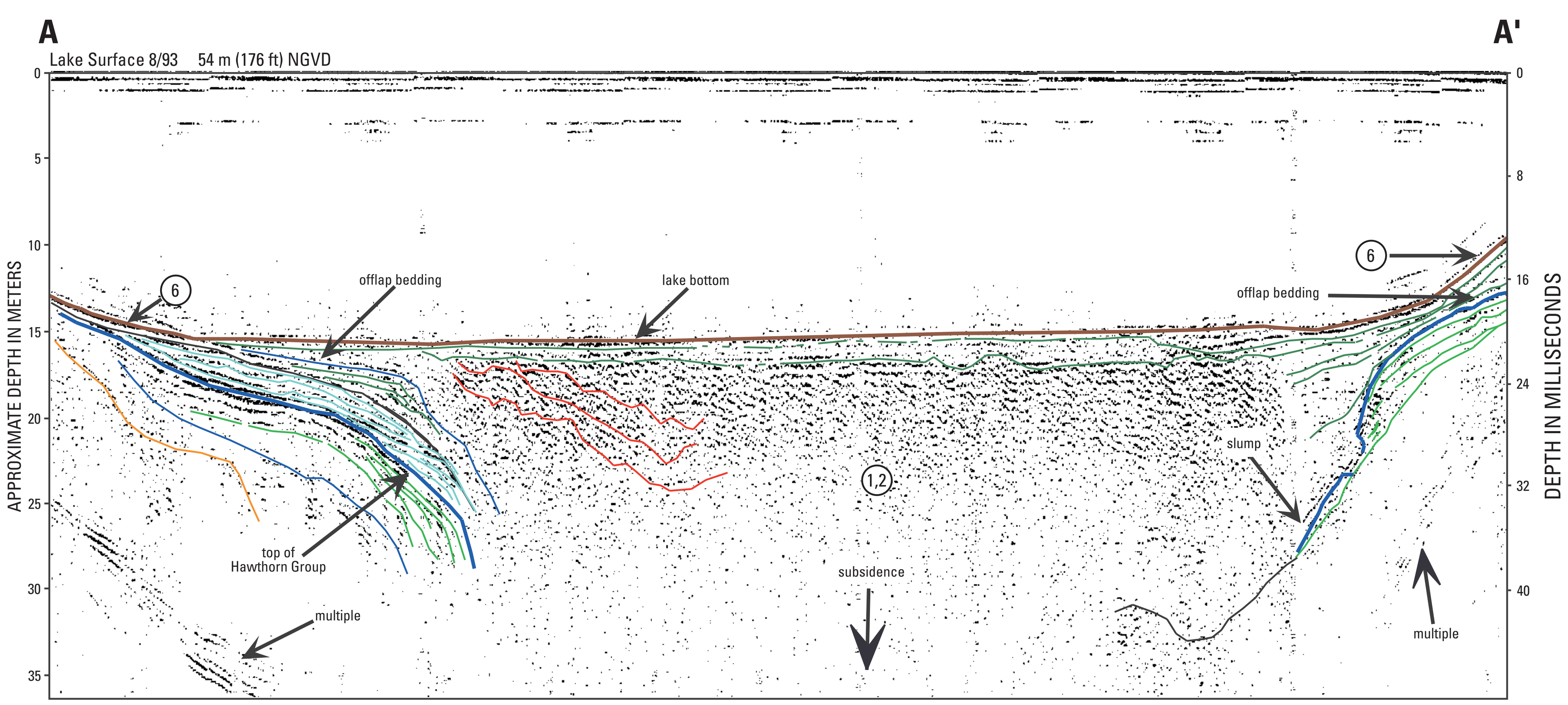
There is only limited borehole data available to correlate the seismic data. Interpolating from the nearest borehole C-0478 (Index Map A, page 8) the top of the Hawthorn Group is seen along the shallow flanks of the lake at approximately 10 ms. In Profile A-A' the top of the Hawthorn Group is shown to be steeply dipping towards the center of Lake Kingsley due to the sinkhole collapse. It is estimated that the top of the Floridan aquifer should be seen in the data at approximately 150 ms. None of the profiles contained data that was resolvable at that depth however.

Processes that control lake development are:
1) karstification or dissolution of the underlying limestone, and 2) the collapse, subsidence, or slumping of overburden to form sinkholes. Initial lake formation is directly related to the karst topography of the underlying host limestone. Lake size and shape are a factor of the thickness of overburden and size of the collapse or subsidence and/or clustering of depressions allowing for lake development. Lake development passes through progressive sequence stages to maturity.

Kingsley Lake is in a late transitional phase (middle age) - the sinkhole becomes plugged as the voids within the collapse fill with sediment. No evidence of active subsidence was located within Kingsley Lake (Profile A-A') though minor, isolated, small scale, subsidence type features were found Profile B-B'). The sediment plug within this main sinkhole is relatively smooth and less disturbed compared to the smaller but active subsidence features of Orange Lake.



Vertical Exaggeration 15.2:1 Not corrected for velocity variations. Horizons are colored to show structure, not correlation. Modified from Kindinger and others, 1996.



Vertical Exaggeration 15:1 Not corrected for velocity variations. Horizons are colored to show structure, not correlation. Modified from Kindinger and others, 1996.

Subsurface Characterizations of Selected Water Bodies in the St. Johns River Water Management District, Northeast Florida

Jack L. Kindinger[1], Jeffrey B. Davis[2], and James G. Flocks[1]
2000

[1] Center for Coastal Geology and Regional Marine Studies
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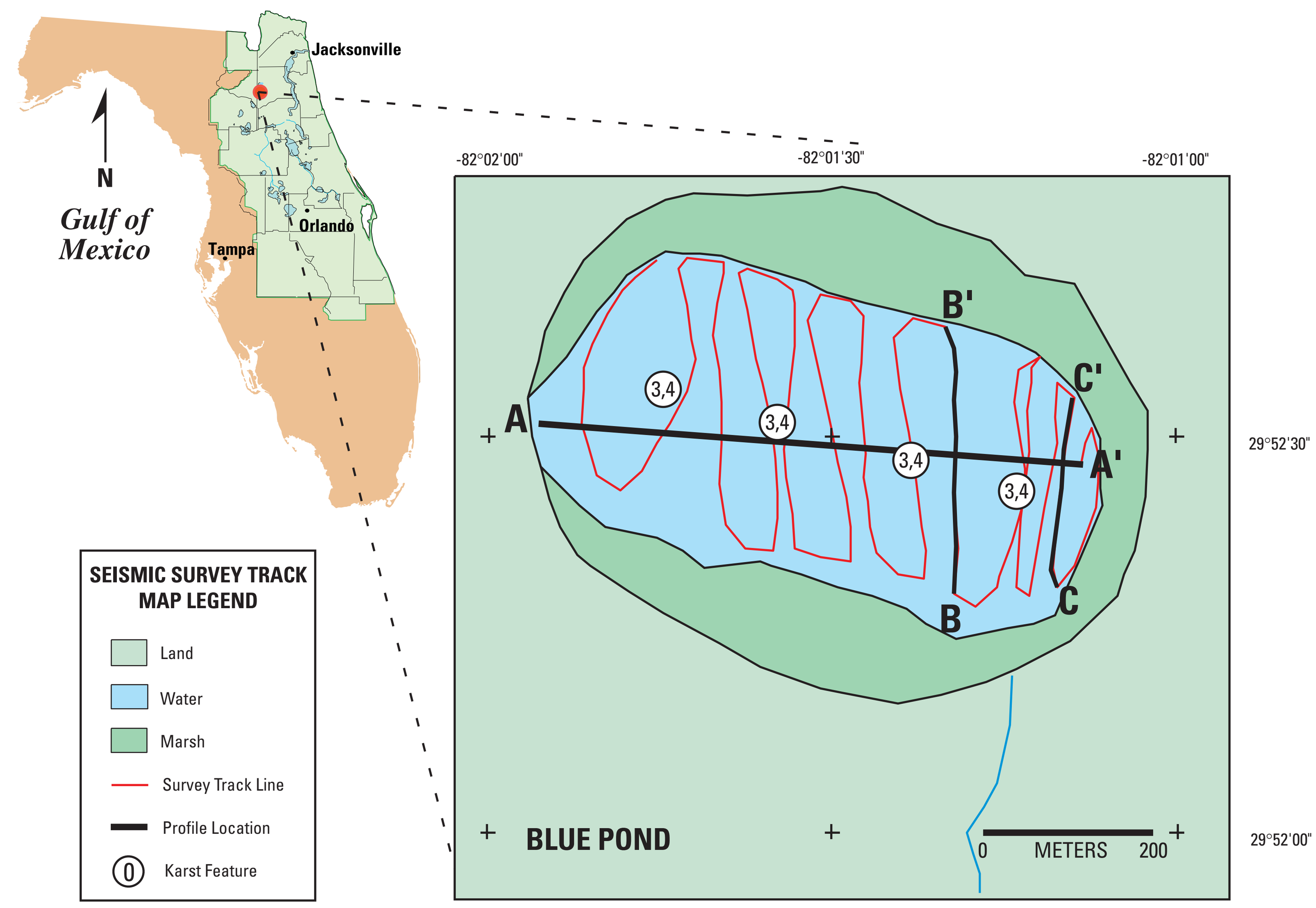
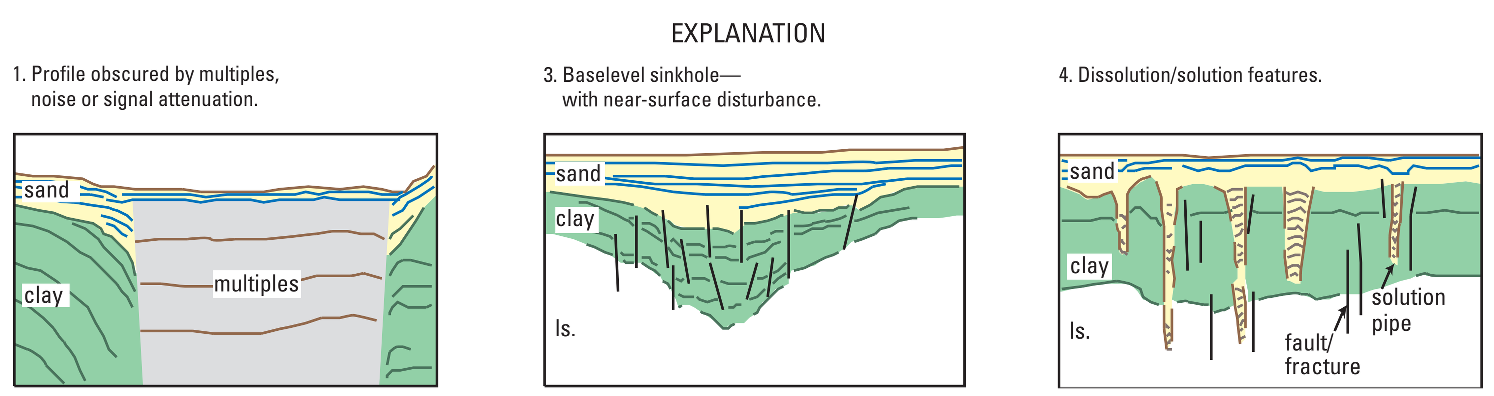
Palatka, Florida 32178

This sheet is Section A page 9 of Open-File Report #00-180 prepared by the U.S. Geological Survey Center for Coastal Geology and the St. Johns River Water Management District. For a detailed description of methods, site locations, explanation of regional geology, physiography, karst development and karst features identified by seismic profiling, refer to pages 1 through 7.

BLUE POND
CLAY COUNTY, FLORIDA



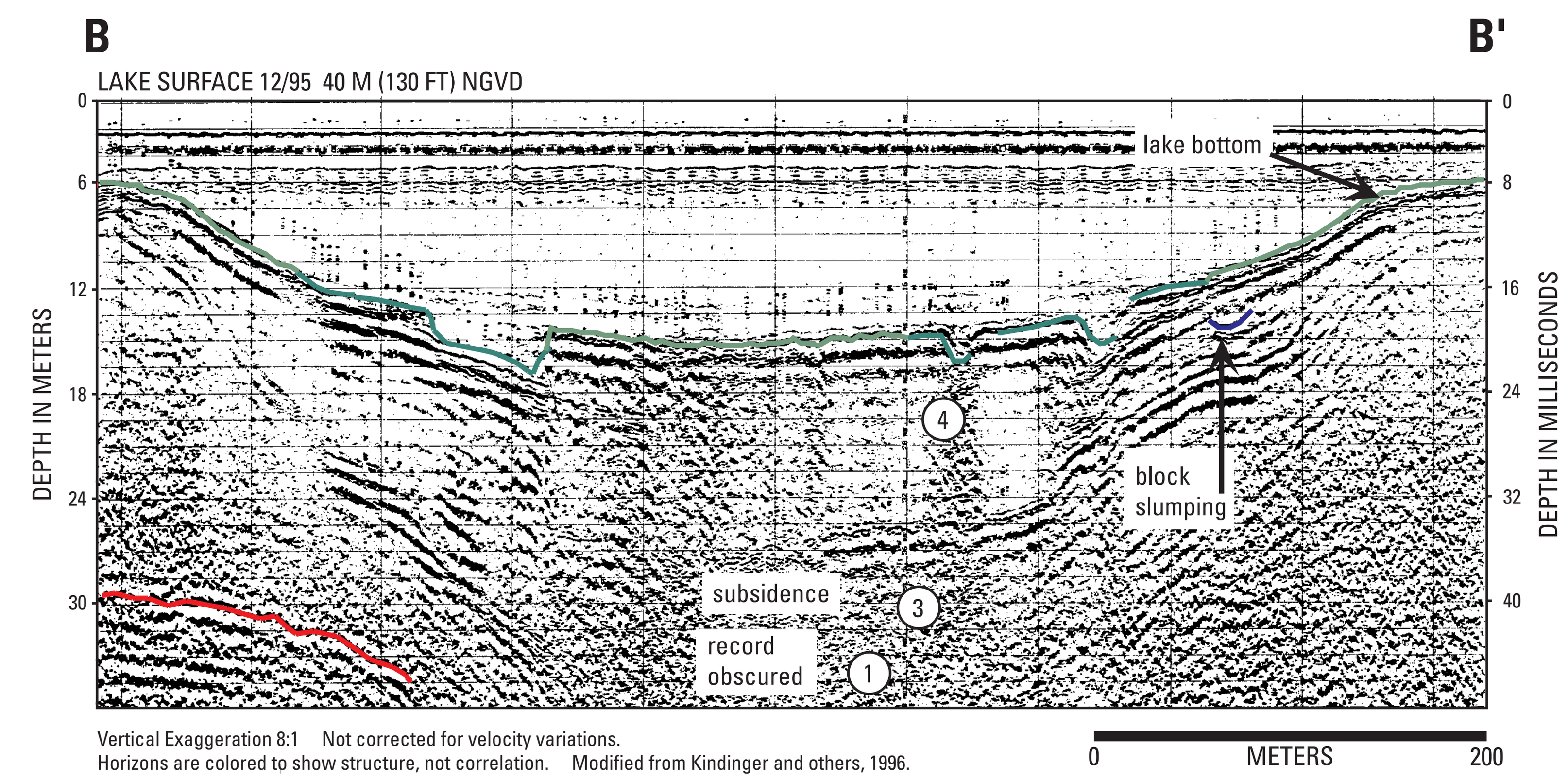


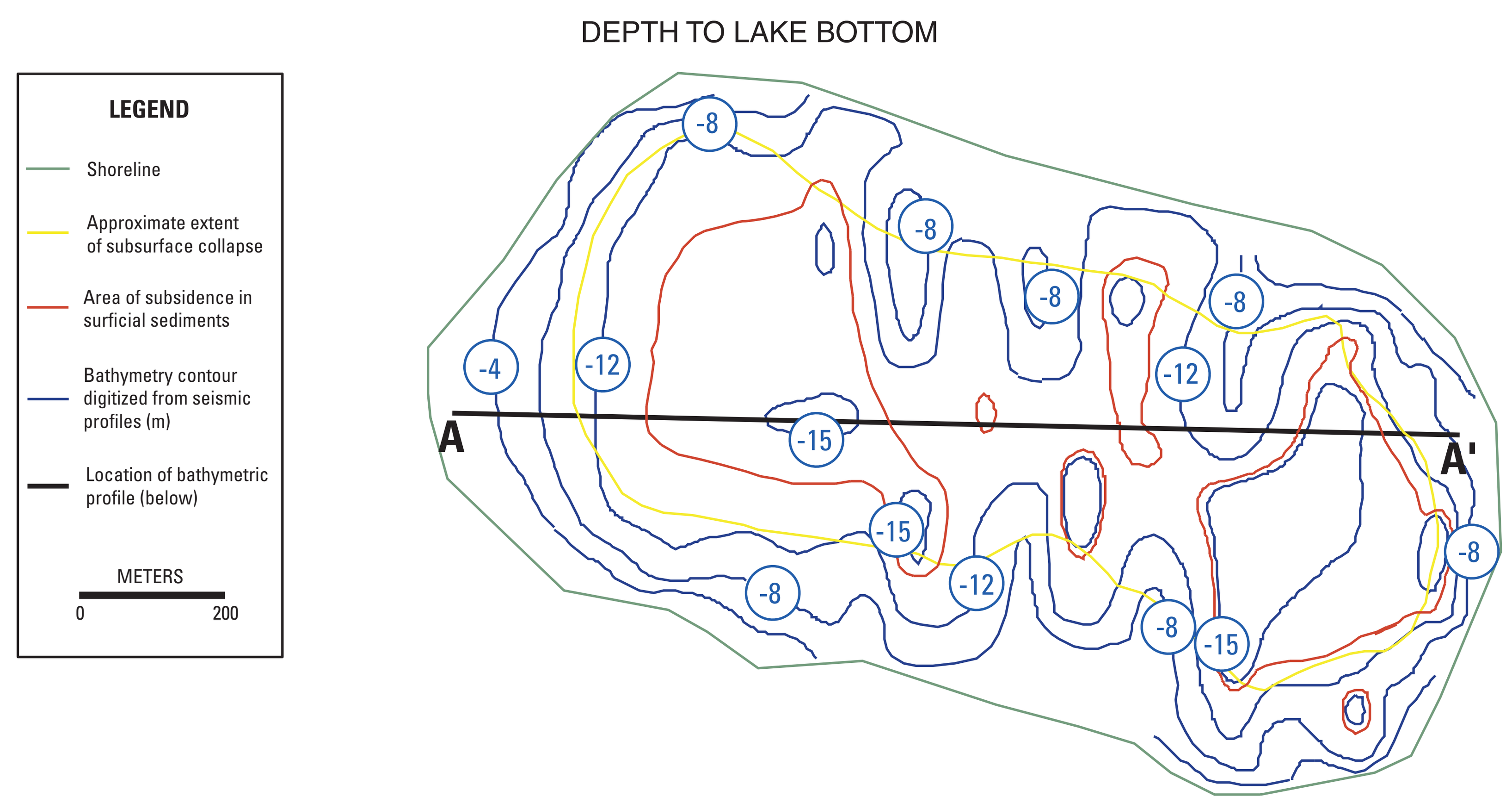
Introduction

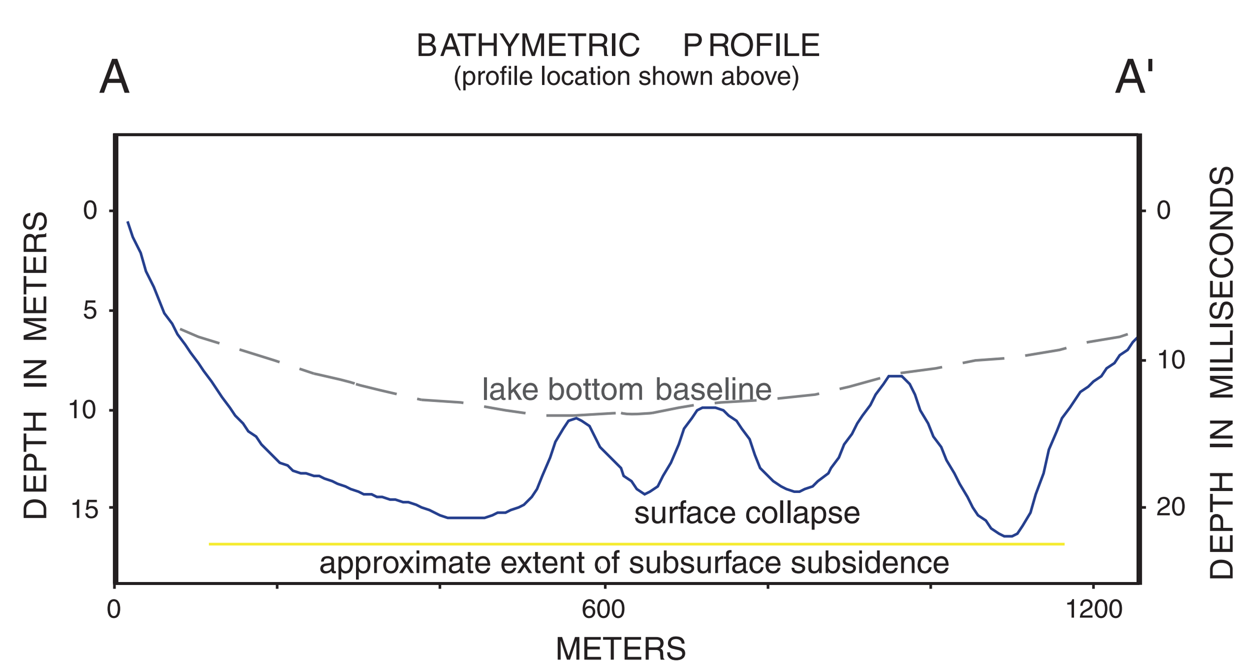
Blue Pond is located in western Clay County. The lake borders on the Volusia Ridge Sets of the Eastern Flatwood District and the Interlachen Sand Hills of the Central Lakes District. Lake level at the time of the seismic survey was about 40 m (130 ft) NGVD. Blue Pond is oval shaped, approximately 750 x 350 meters with a perimeter of 4.6 km and a surface area of 1.3 km^2. Average water depth during the survey was about 9 m (30 ft). Blue Pond is connected surficially to Sand Hill Lake to the south.

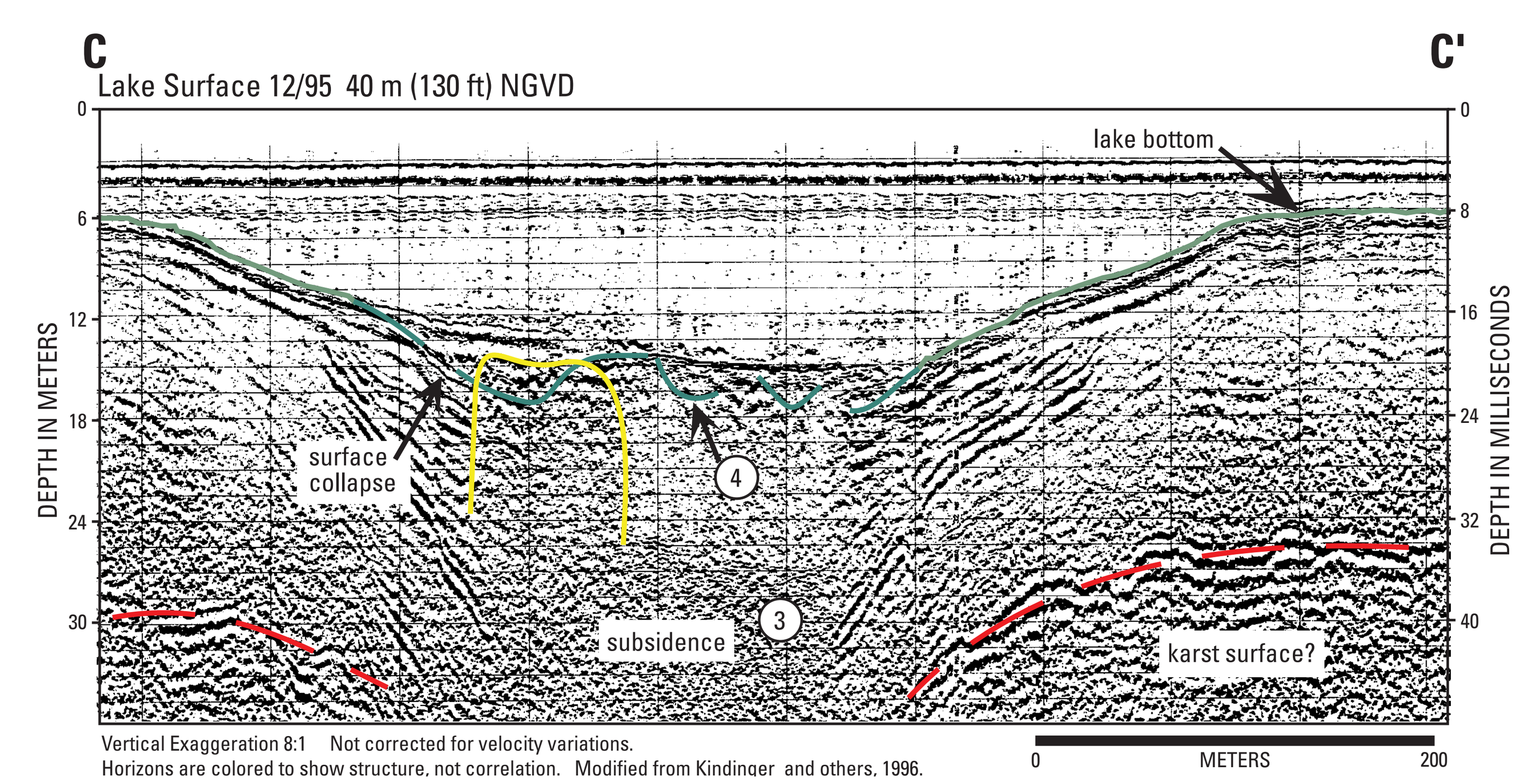
Geologic Characterization

Blue Pond appears to be a single large depression, (see seismic profiles B-B' and C-C'). Many lakes surveyed in this area all appear to have this characteristic (i.e. single basin, single sink), whereas others occur as a complex of depressions. The steep sides of these lakes infer they are young and in the active subsidence or collapse phase (Kindinger and others, 1998). At depth, a strong subsurface reflective horizon at about 30 m below lake level (C-C') is interpreted to be the karst surface. However, interpretations of gamma log profiles to the south put the top of the Ocala Limestone at nearly 60 meters below the lake surface. Johnson (1986) a report that the top of the Marks Head Formation at this depth in a well approximately 4.8 km (3 miles) north of the lake. The Marks Head Formation is part of the Hawthorn Group and is characterized as interbedded dolomite, sand and clay. This horizon is collapsed throughout most of the lake as shown in yellow in the bathymetry map below. The subsurface collapse has created general surface subsidence, as well as slumping of the overburden into the depression (B-B'). Smaller areas of surface collapse are evident at the lake bottom (green line, C-C'). The smaller collapse structures may be a result of accommodation during subsidence, or solution features created by water movement. These surface breaches probably provide pathways for aquifer recharge from the surface waters. The areas of surface collapse have been mapped in red in the contour plot (A-A'). The profile below the contour plot (A-A') shows the relationship between the lake bottom, the surface features and the subsurface collapse. Most of the profiles from the survey are obscured by acoustic noise, which masks returns from structure within the depression. The noise and multiples appear to be related to the shape of the seismic lake which produces ringing in the acoustic return. This signature is relatively common (Type 1) and can be compared with similar seismic returns seen in other lakes in the study area.









Subsurface Characterizations of Selected Water Bodies in the St. Johns River Water Management District, Northeast Florida

Jack L. Kindinger[1], Jeffrey B. Davis[2], and James G. Flocks[1]
2000

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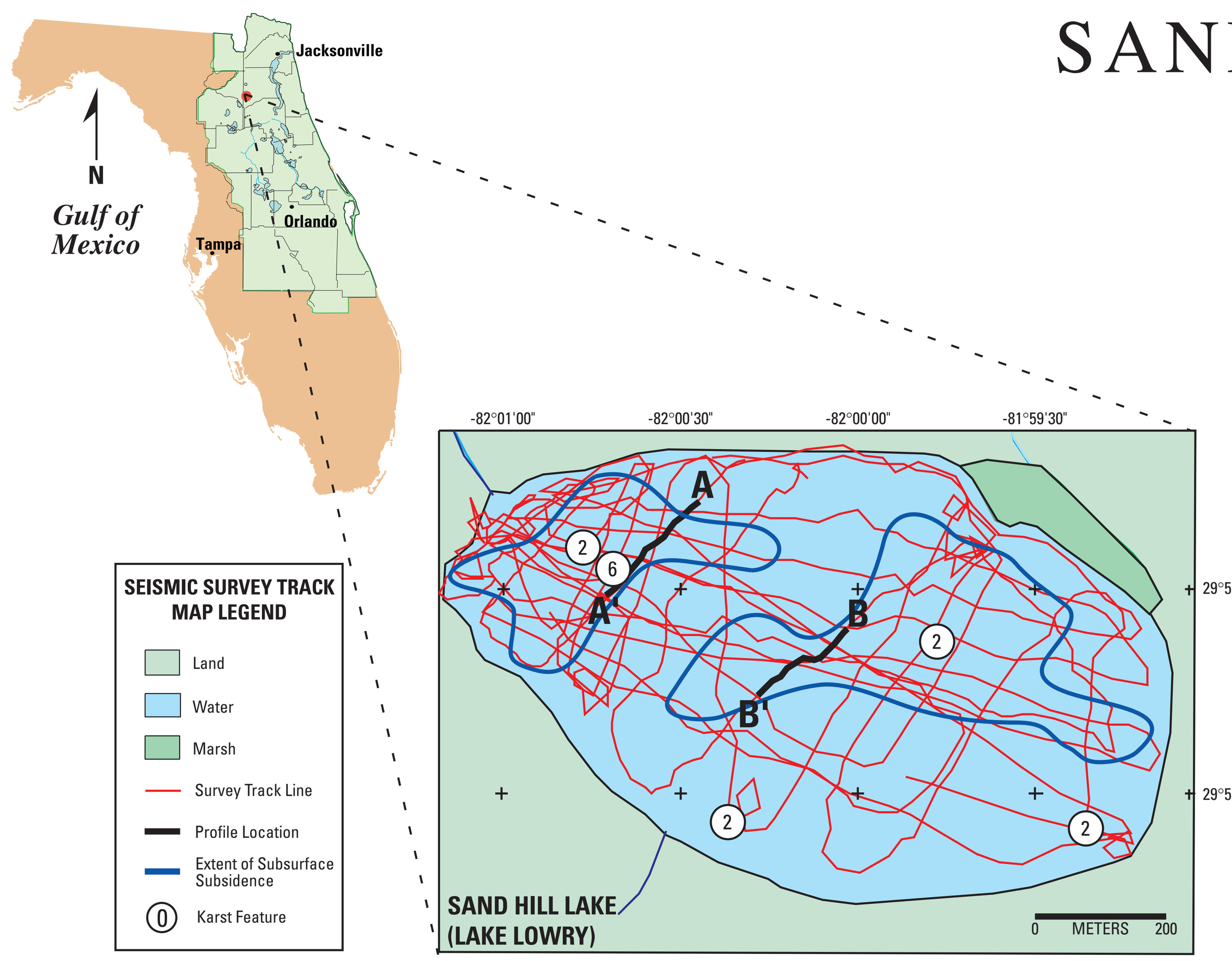
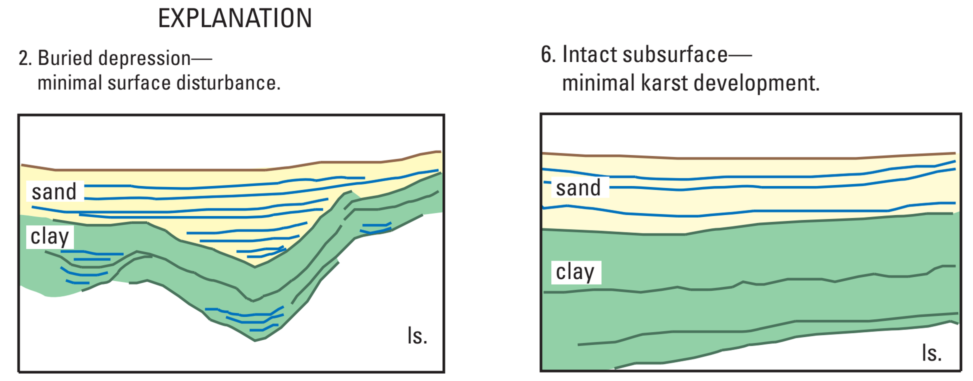
SAND HILL LAKE (LAKE LOWRY)

CLAY COUNTY, FLORIDA



EXPLANATION



Introduction

Sand Hill Lake (also known as Lake Lowry), located in Clay County (approximate latitude 29°50'22"N and longitude 81°0'12"), is a semicircular lake (about 2 by 3 km) with a 32.5 km perimeter and area of 7.6 km2 (See Survey Track Map). This lake, unlike Kingsley Lake (page 9), has buried and implied active subsidence features (Type 2). Like many of the lakes formed by sinkholes, Lake Lowery has a relatively shallow bottom (2-5 meters) from the shore toward the center of the lake and a central part eight to ten meters deep.

Similar to Lakes Magnolia and Kingsley, Lowry is flanked on the west by the Trail Ridge deposits. The lake is underlain and surrounded by Citronella sediments (Clark, 1964), which consist of a relatively thick section of unconsolidated to semi-consolidated quartz sands, clayey sands, and gravels. The sediments are unconsolidated and completely saturated, this enhances the filling process when sinkholes collapse or sediment is washed into the lakes by surface runoff. Generally the sands are seismically transparent but clay stringers or cementation may provide reflecting horizons.

Subsurface Characterization

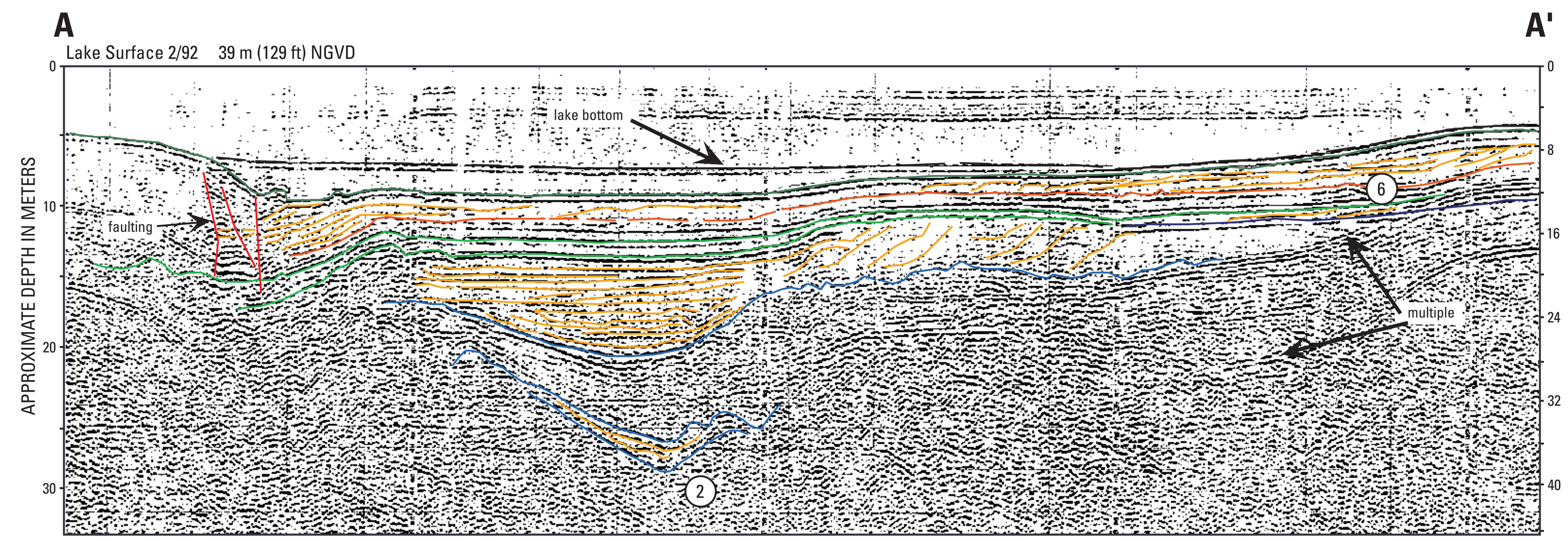
Subsidence features observed from profiles show two areas identified as large (1000 m) subsidence sinkholes (See Survey Track Map). One forms the northwest section of the lake and the other is in the southeast area. Profile A-A' illustrates a large combined subsidence feature that includes buried and active subsidence (Type 2). This cross section shows a variety of depositional fills including cross bedding and onlapping fill. Also found in each profile (Profiles A-A', B-B') is the characteristic pattern of fill and subsidence that indicates rapid subsidence activity and hiatus with slow deposition of sediment. Each of the sinkholes may have developed independently and coalesced over time. Lake Lowry has many of the same characteristic cover-subsidence characteristics found in Orange Lake, but they are much larger.

A ground water well located on the northwest shore of Lake Lowry is used to monitor the Floridan aquifer, indentified as well C-0439 on Cross Section A-A' (Index Map A, page 8). The natural gamma log of the well indicates the top of the Floridan aquifer is at -57 feet NGVD or approximately 80 ms on the seismic data. The majority of resolvable data on the seismic profile is above 20 ms and so it cannot be determined if the entire confining unit is breached.

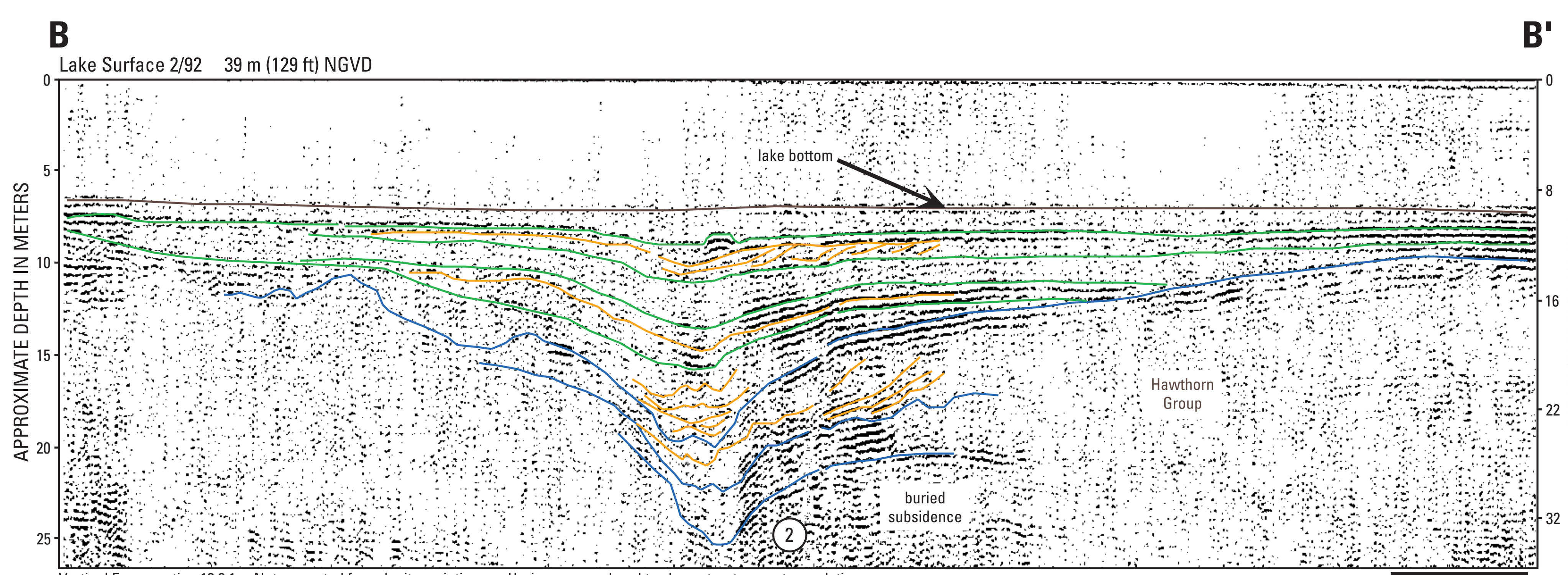
The mechanical processes that result in lake development are a slumping or subsidence of underlying clastics or carbonates, and a clustering of sinkholes. Two factors that effect lake formation are karst development in host limestone and thickness of unconsolidated overburden (the confining unit). If the host limestone is highly karstic then the probability of collapse is greater than in areas of less karst. Thickness of overburden is the other controlling factor. A slight surface depression will form over a collapse in an area with a thick unconsolidated overburden (ten's to 100 m). As the unconsolidated material fills the depression left by solution, there is little or no accommodation space for lake formation. A larger surface depression will form if the same collapse were to occur with two meters of overburden, thereby creating accommodation space for lake formation.

Sinkhole lakes can be delineated into a progressive sequence of lake formation based on geomorphic types (Sinkhole Evolution, page 5). The progression begins with the initial collapse, forming a sinkhole. The depression may be open or, if a portion of the depression is below the water table, it may be filled with water. As sediments are washed into the depression, the sinkhole becomes plugged. The process continues until the sinkhole is buried.

Lake Lowry is in the transitional phase (middle age), when the lake becomes partially or completely plugged, the lake begins to develop a shallower and flatter bottom. During this phase the plug may be flushed into the karst (faults, fractures, and/or solution pipes), allowing the sinkhole to reactivate and revert to an active subsidence phase, described above as subsidence activity and hiatus with slow sediment depostion (Profile A-A' and B-B'). This may occur several times until sediment accumulates faster than dissolution of the underlying limestone.



Vertical Exaggeration 9.5:1 Not corrected for velocity variations. Horizons are colored to show structure, not correlation.
Modified from Kindinger and others, 1998.



Vertical Exaggeration 13.3:1 Not corrected for velocity variations. Horizons are colored to show structure, not correlation.
Modified from Kindinger and others, 1998.

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2000

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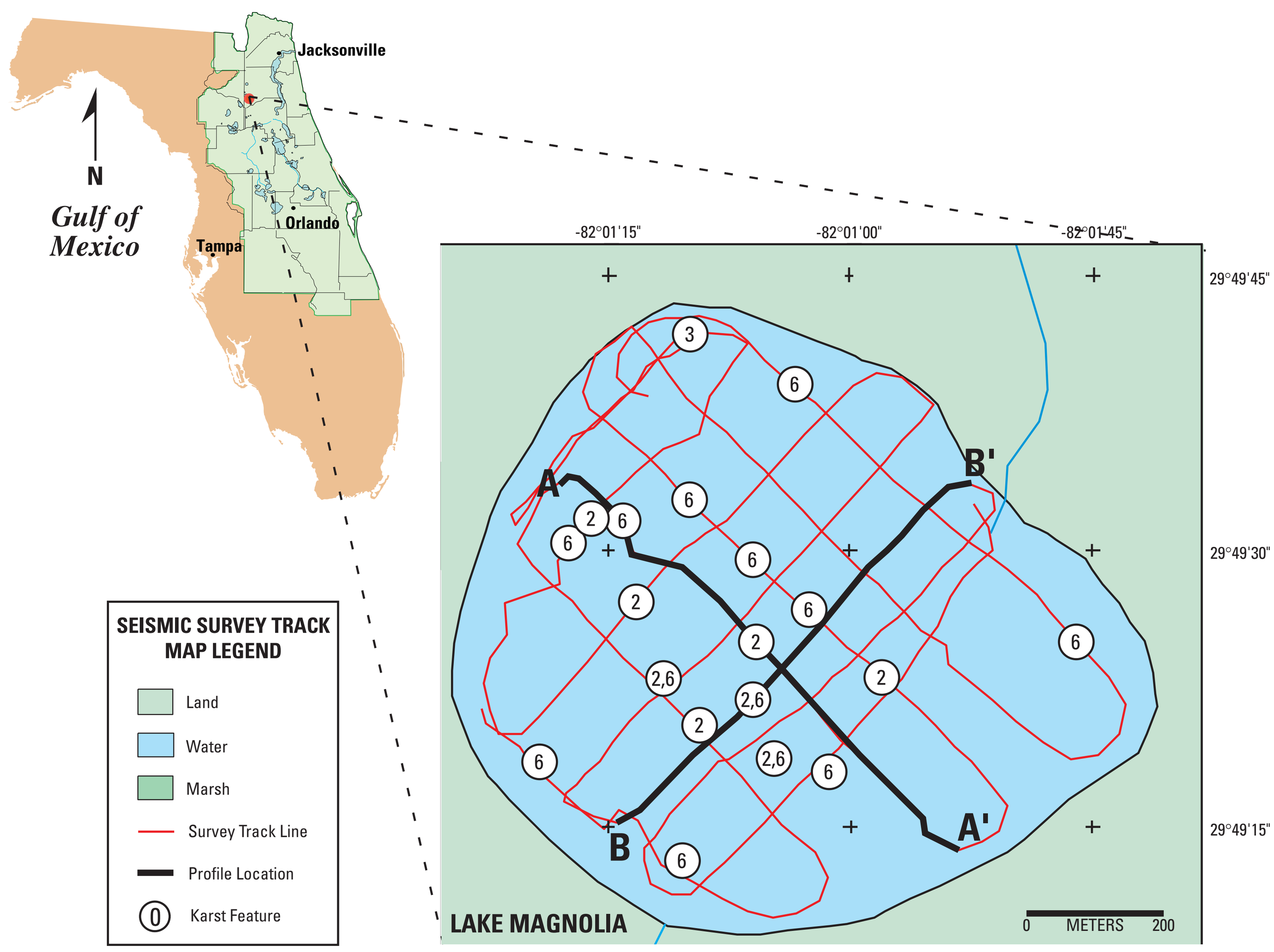
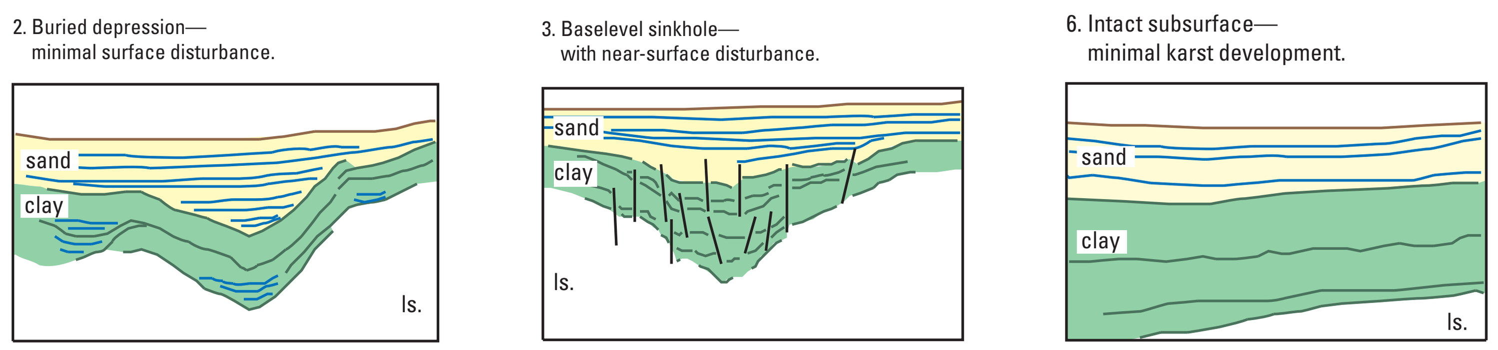
LAKE MAGNOLIA
CLAY COUNTY, FLORIDA



EXPLANATION



Introduction

Lake Magnolia is on the southwest boundary of Clay County, Florida and is located in the Interlachen Sand Hills of the Central Lakes District. Lake level at the time of the seismic survey was 38 m (125 ft) NGVD. Lake Magnolia is oval shaped approximately 1.1 x 0.9 km with a perimeter of 3.2 km and surface area 0.8 km2. Average water depth during the survey was 6 to 7 m (19 to 23 ft). The lake is bordered by woodlands. Lake Magnolia is flanked on the west by the Trail Ridge deposits with Citronella deposits elsewhere. The lake is underlain by Citronella sediments (Clark, 1964) which consist of a relatively thick section of unconsolidated to semi-consolidated quartz sands, clayey sands, and gravels. The Trail Ridge sands are above an elevation of 45 m (149 ft) and are mined commercially for heavy minerals used in paints and abrasives. The sediments are unconsolidated and completely saturated, this enhances the filling process when sinkholes collapse or sediment is washed into the lakes by surface runoff. Generally the sands are seismically transparent but clay stringers or cementation may provide reflecting horizons.

Subsurface Characterization

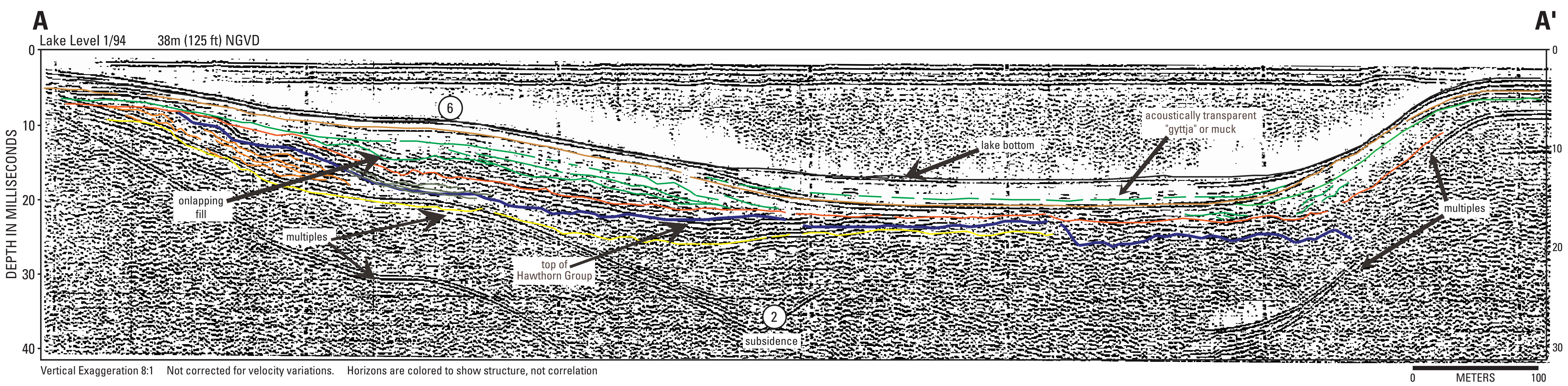
Profile A-A' shows the basic character of Lake Magnolia, which appears to be comprised of a single depression. The characteristics of this lake are very similar to Kingsley Lake, Blue Pond and several other lakes in the region. The subbottom was disturbed during the subsidence then covered and infilled similar to Types 2 and 6 karst features described on page 6. In the northwestern corner of the lake is a buried block that has rotated and slumped into the sink (Type 3 karst feature).

The main depression is continuous across the lake in both of the predominant traverse directions. Profile A-A' from Lake Magnolia shows a singular subsidence that is shallow nearshore with onlapping fill on the northwest flank. The central portion of the lake has an undisturbed surficial layer that is acoustically transparent and is possibly composed of high-organic sediments termed "gyttja". The undisturbed nature of the surficial sediments implies that there has been little to no recent subsidence. In this case, as the sink became plugged, the lake developed a shallower and flatter bottom due to the infilling associated with runoff and eolian processes.

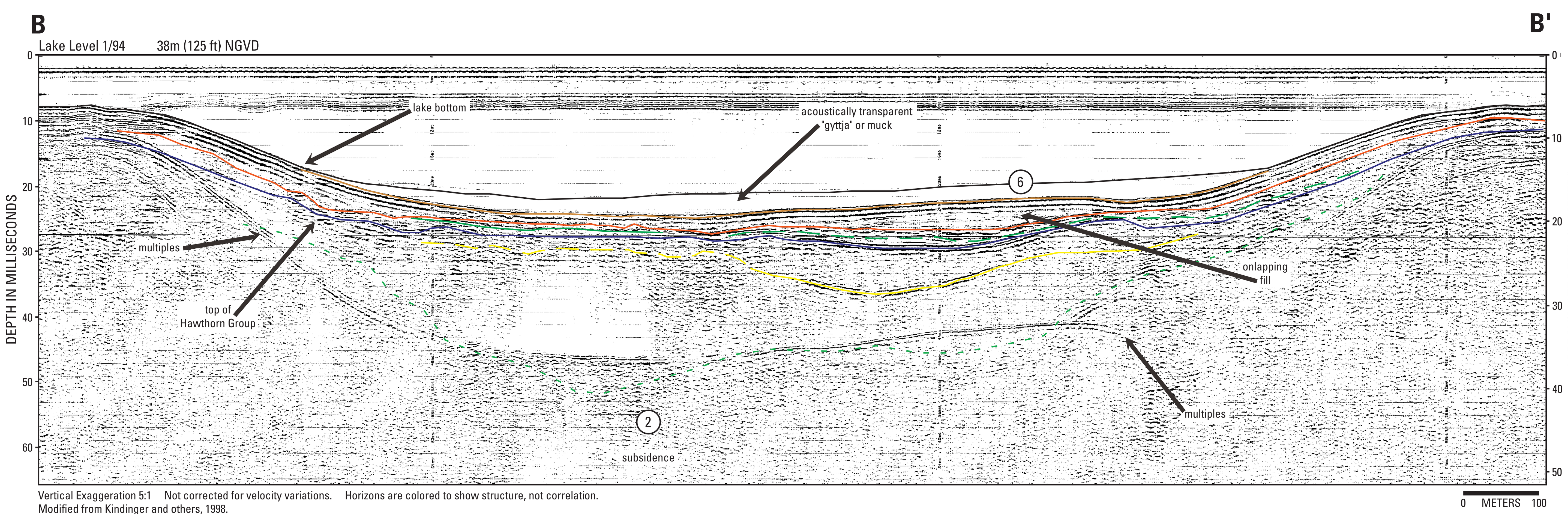
Correlation of gamma logs from the boreholes to contacts seen in the seismic records is tenuous. Log C-0451 is from a well approximately 1 km west of Lake Magnolia and Log C-0439 is from a well located on the northwest shore of Sand Hill Lake (Section A, page 11). The units identified from the gamma logs are the clay confining units of the Hawthorn Group and the top of the Ocala Limestone. The blue horizon in Profile A-A' has been interpreted as a reflection near the top of the Hawthorn Group.

Sinkhole lakes can be delineated into a progressive sequence of lake formation based on geomorphic types (page 5). The progression begins with the initial collapse, forming a sinkhole. The depression may be open or, if a portion of the depression is below the water table, it may be filled with water. As sediments are washed into the depression, the sinkhole becomes plugged. The process continues until the sinkhole is buried.

Lake Magnolia is used as the type description for transitional phase or middle-age lakes. When the lake becomes partially or completely plugged, the lake begins to develop a shallower and flatter bottom. During this phase, the plug may be flushed into the karst (fractures and solution pipes), allowing the sinkhole to reactivate and revert to an active subsidence phase. This may occur several times until sediment accumulates faster than dissolution of the underlying limestone.



Vertical Exaggeration 8:1 Not corrected for velocity variations. Horizons are colored to show structure, not correlation



Vertical Exaggeration 5:1 Not corrected for velocity variations. Horizons are colored to show structure, not correlation.
Modified from Kindinger and others, 1998.

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Jack L. Kindinger[1], Jeffrey B. Davis[2], and James G. Flocks[1]
2000

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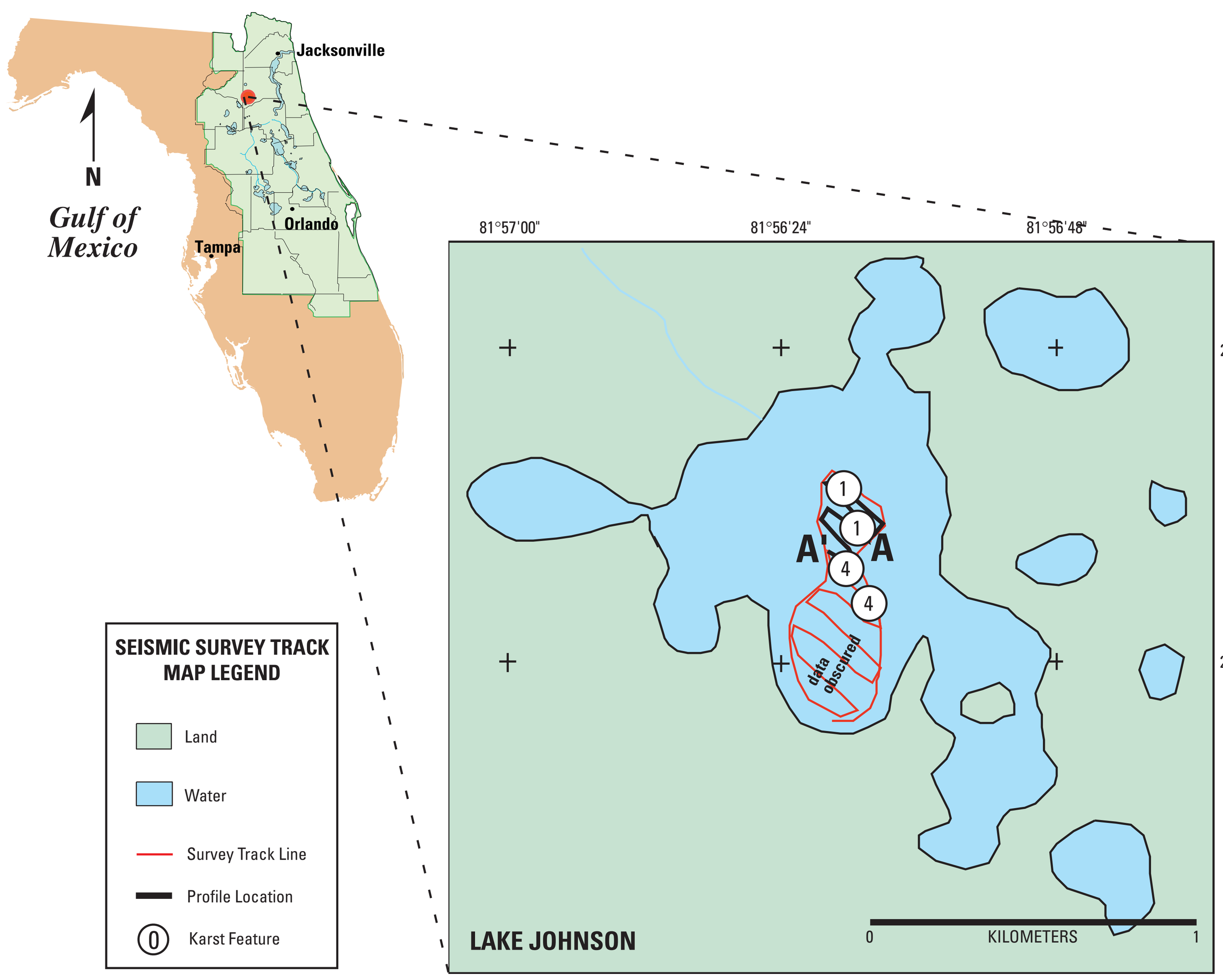
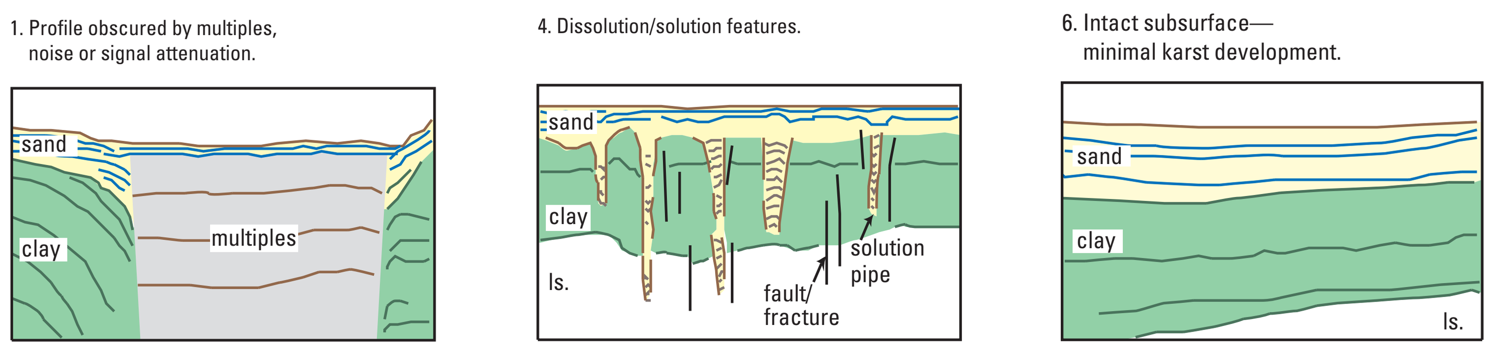
LAKE JOHNSON
CLAY COUNTY, FLORIDA



EXPLANATION



Introduction

Lake Johnson lies within the Central Lake District physiographic province. It is within the Interlachen Sand Hills subdistrict. The lake is adjacent to the Trail Ridge Sands which is a paleodune ridge that extends north into Georgia. This region includes the largest number of cover collapse sinkholes and provides direct recharge to the underlying Floridan aquifer system. Vegetation that includes longleaf pine and turkey oak is prevalent. Internal drainage through the sinkhole lakes has limited the formation of streams except during periods of high rainfall.

The surficial sands provide storage for rainfall and recharge to the lakes during high water-table conditions. The potentiometric surface of the Floridan aquifer is lower than the lake so a continual downward gradient exists and provides the mechanism for recharge. Pathways for recharge exist where the thick clay and sandy clay units within the Hawthorn Group are breached by collapse sinkholes.

The unique physiography of the region can be seen in the hillshade view presented on Index Map A, page 8. The landscape is dotted with lakes that are incised into the surrounding sand hills. Large, flat bottom prairies, such as Levys Prairie in the southwest section of the Interlachen Sand Hills, attest to the erosional process of internal drainage into sinkholes. There is only a poorly developed surface water drainage system in the sand hills. A well developed drainage can be seen in the northeast section of Index Map A, page 8 in the Penny Farms Uplands. This is related to the thicker section of Hawthorn Group and the lack of sinkhole development.

The irregular shape of Lake Johnson gives it a perimeter of over 10 km, with an area of only 2 km2. Lake level at the time of the survey was 29 m (95 ft) NGVD. Gold Head Branch flows into Lake Johnson from the northwest and there is no surface water outflow points.

Subsurface Characterization

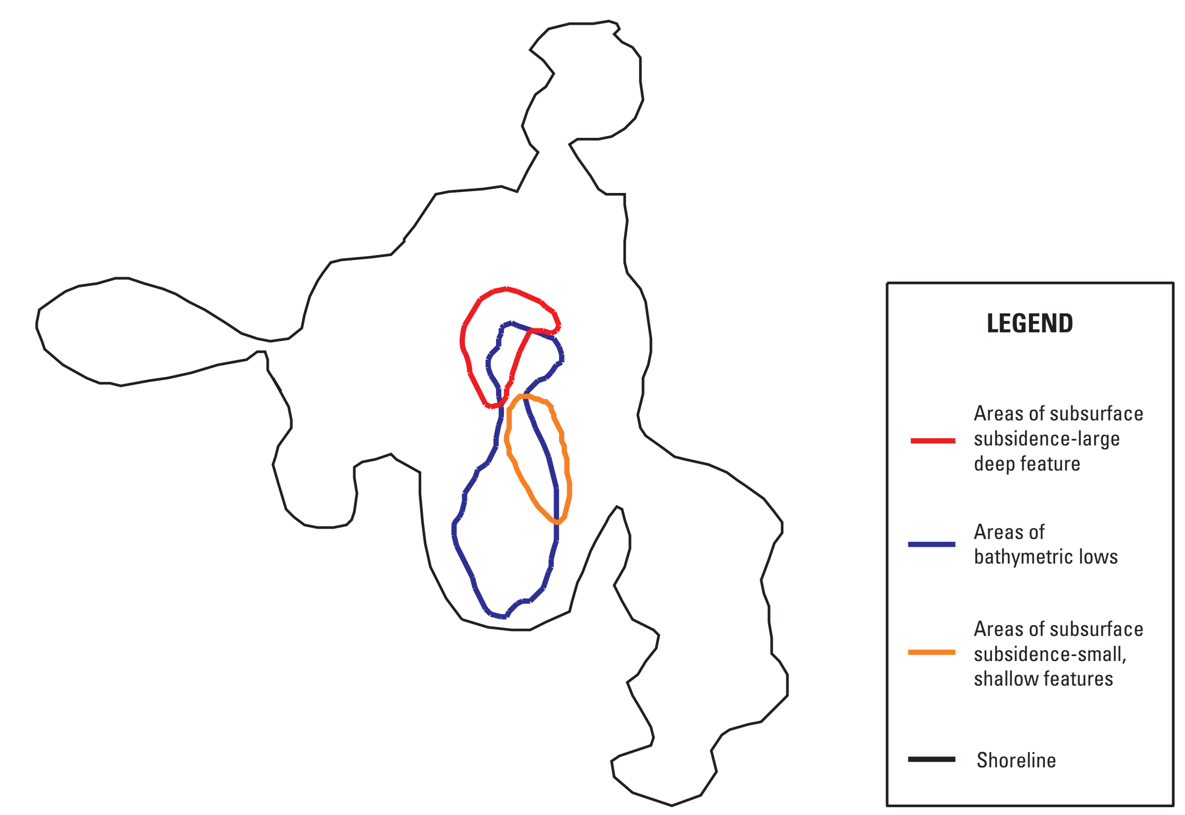
The geologic units present at Lake Johnson are typical of northeast Florida stratigraphy. The surface material consists of Plio-Pleistocene sand hills. The lakes within these hills define the surficial aquifer system of the region. The natural gamma logs from two wells south of Lake Johnson (Index Map A, page 8, wells C-0453 & C-0457) indicate that these sands are present above +28.1 m (90 ft) NGVD on the western side below Lake Johnson and may be missing or only a few feet thick on the eastern section of the lake.

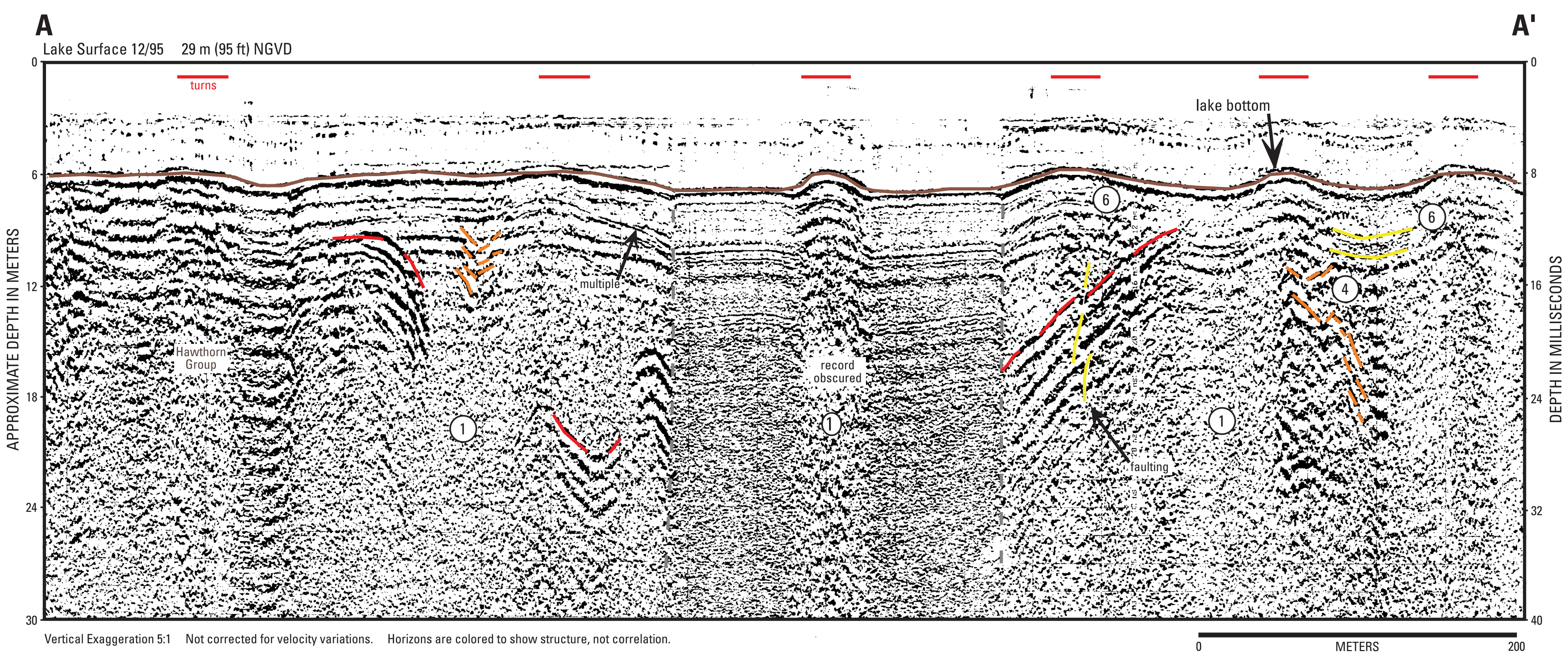
Below the sands, the clay and sandy clay of the Hawthorn Formation can be identified in the gamma logs by the sequence of high peaks between +28.1 m (90 ft) and -21.8 m (-70 ft) NGVD in well C-0453. Most of the imagable area of the seismic profiles is within the Hawthorn Formation. Below -21.8 m (-70 ft), the Eocene carbonates of the Ocala Limestone are identified by the extremely low counts (less than 20 counts per second) on the natural gamma logs. These depths are below the imagable areas of the seismic profiles.

Acoustic data from Lake Johnson is generally poor due in part to a strong lake bottom multiple, signal attenuation and technical difficulties. Parallel, horizontal reflectors are present above 12 ms (8.7 m below lake surface) that may represent in situ and transported Plio-Pleistocene sands (Type 6 feature, seismic profile). Below 12 ms, only "windows" of interpretable data are present. Sections of the data can be resolved to approximately 32 ms (10 m). High angle reflectors suggest collapse of material into a large sink (Type 1 feature, seismic profile) and smaller, concave reflectors that suggest subsidence into smaller sinks or dissolution pipes (Type 4 feature, seismic profile).

Lake Johnson appears to have formed by the coalescing of many collapse sinkholes. After the initial collapse of an individual sinkhole, the sides have eroded into the central portion of the sink, flattening the banks and filling the center. A very steep-sided, deep sink is located near the entrance of the adjacent Gold Head Branch State Park and may represent the younger stages of this process. The area where the seismic profiles were run is relatively flat bottomed and shallow, indicating a more mature feature. Flow into Lake Johnson with no outflow indicates direct recharge to the aquifer.

DISTRIBUTION OF FEATURES
(noted from seismic profiles)





Vertical Exaggeration 5:1 Not corrected for velocity variations. Horizons are colored to show structure, not correlation.

Subsurface Characterizations of Selected Water Bodies in the St. Johns River Water Management District, Northeast Florida

Jack L. Kindinger[1], Jeffrey B. Davis[2], and James G. Flocks[1]
2000

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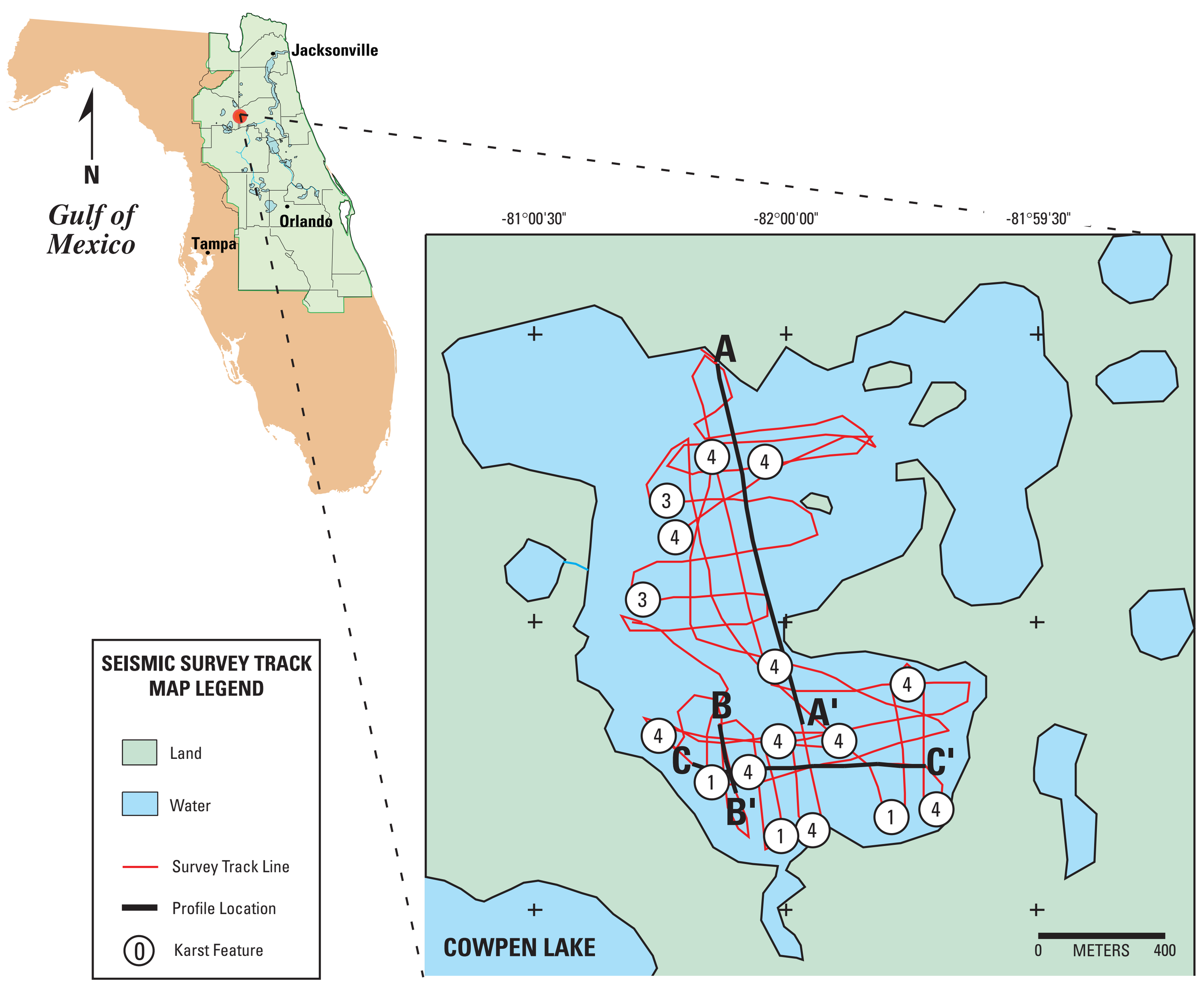
This sheet is Section A page 13 of Open-File Report #00-180 prepared by the U.S. Geological Survey Center for Coastal Geology and the St. Johns River Water Management District. For a detailed description of methods, site locations, explanation of regional geology, physiography, karst development and karst features identified by seismic profiling, refer to pages 1 through 7.

COWPEN LAKE

CLAY COUNTY, FLORIDA



Introduction

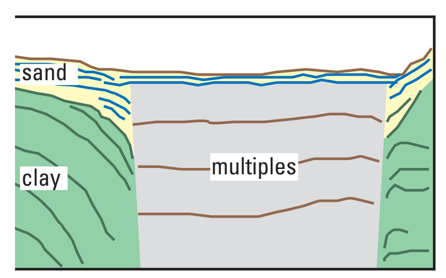
Cowpen Lake is located in western Putnam County, Florida. The lake is located within the Interlachen Sand Hills of the Central Lakes District. The area around the lake is dominated by many small lakes and marshland, particularly Levys Prairie to the north. The lakes and prairies in this region occupy dissolution valleys, where sinkholes coalesce to form small, irregular-shaped lakes. Cowpen's shoreline is very irregular, with a perimeter of 11.5 km and a surface area of 2.8 sq km. Lake level in March of 1995 was 26 m (85 ft) NGVD.

Subsurface Characterization

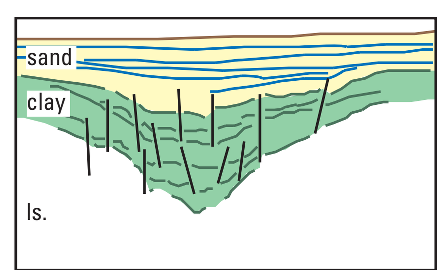
The acoustic signal in Cowpen Lake as a whole is relatively weak. This is shown in the example profiles (A-A', B-B' and C-C'). Factors which contribute to a noisy or weak acoustical return in the lakes of this study area include proximity of hardbottom (limestone) to the sediment surface, accumulation of organic debris on the lake bottom, shallow water depths and proximity, steepness and irregularity of the shoreline. In Cowpen Lake, the nearby and irregular shoreline could create interference (noise) in the signal, and the marshy area in which it resides could produce organic-rich surficial sediments which dampen the return. As a result, little can be seen in the seismic profiles below about 10-12 m. The lake bottom shows an undulating surface marked by localized subsidence less than tens of meters in width. Accumulations of material is imaged near surface in the bathymetric lows (red lines, profiles B-B' and C-C'). This could represent fill from the surrounding sand hills. In the subsurface, high frequency reflectors occasionally can be seen (orange dashed lines, profiles A-A' and B-B'). These may represent dissolution-type features or disturbed bedding and could indicate breaches in the overburden. The contact between the top of the Hawthorn Group and overlying undifferentiated fill is interpolated to be around 12 m (39 ft) below lake level (see Section A, Index Map). This contact is difficult to detect in the seismic profile because of the signal noise and multiples, but the disturbed bedding at depth would indicate breaches in the confining Hawthorn Group. The top of the Ocala Limestone is estimated to be around 20-30 m (67-98 ft) below lake level (~0 ft NGVD), but is obscured in the profiles. Solution of the limestone at depth could produce dissolution type features which transport material downwards and can create the smaller subsidence areas seen at the surface.

EXPLANATION

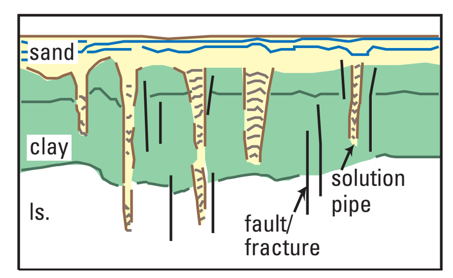
1. Profile obscured by multiples, noise or signal attenuation.

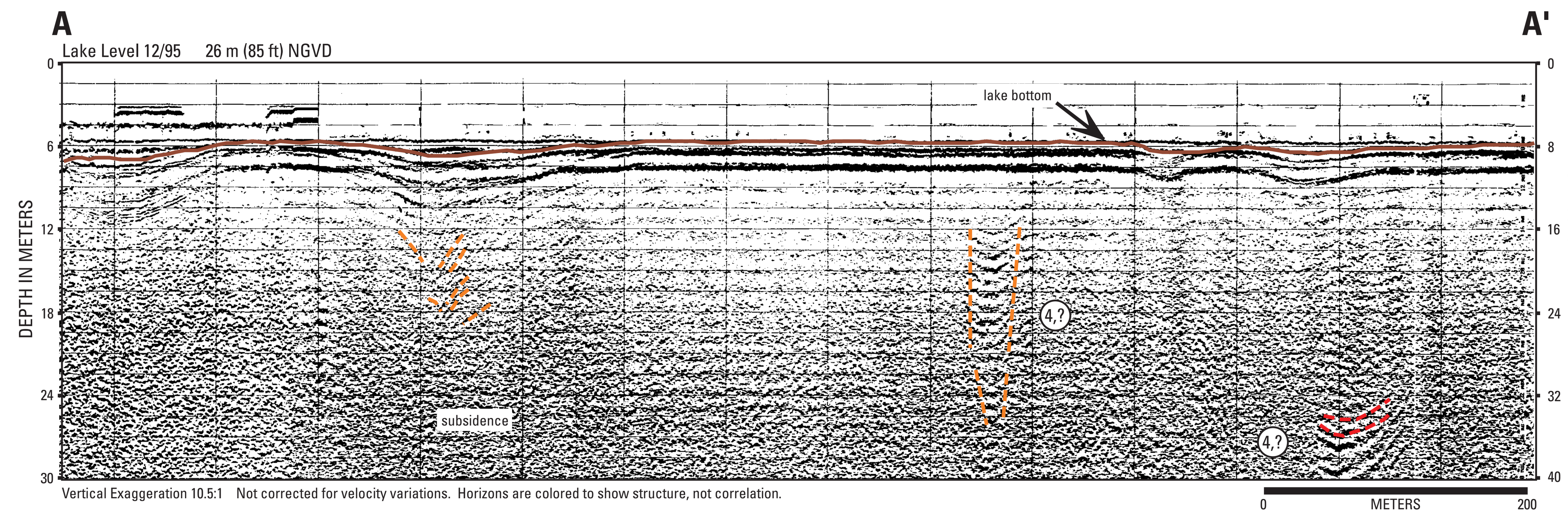


3. Baselevel sinkhole— with near-surface disturbance.

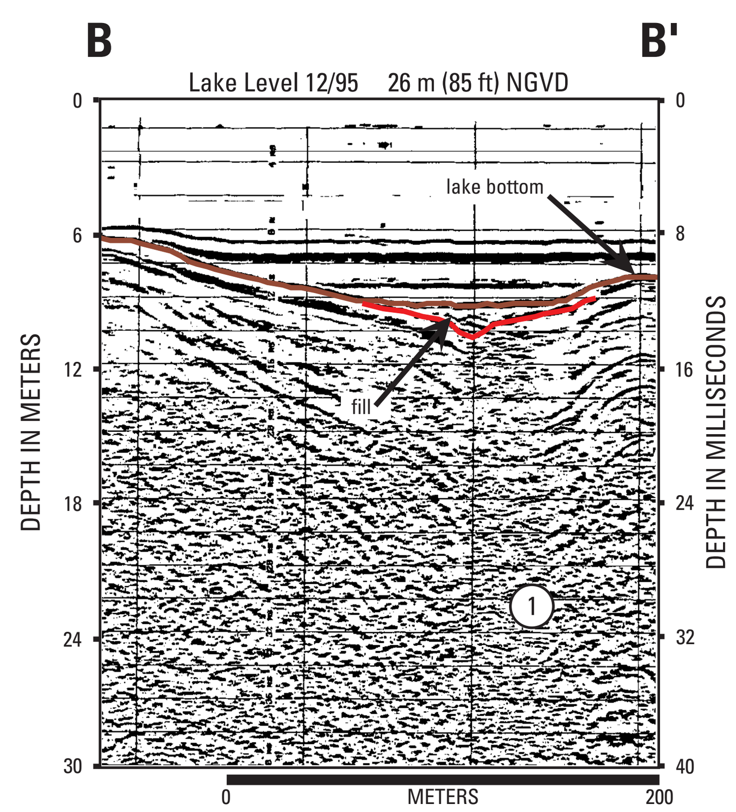


4. Dissolution/solution features.





Vertical Exaggeration 10.5:1 Not corrected for velocity variations. Horizons are colored to show structure, not correlation.



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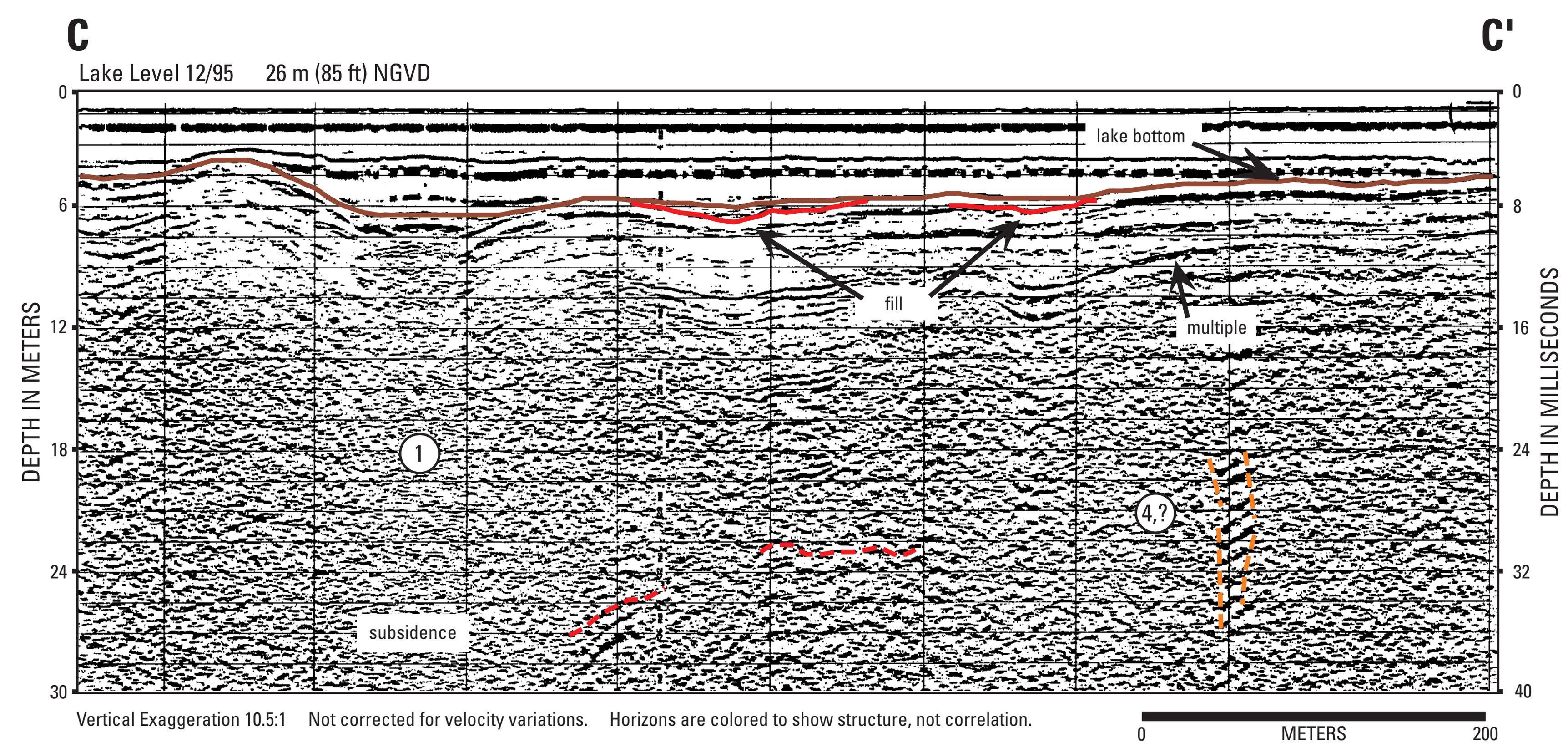

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