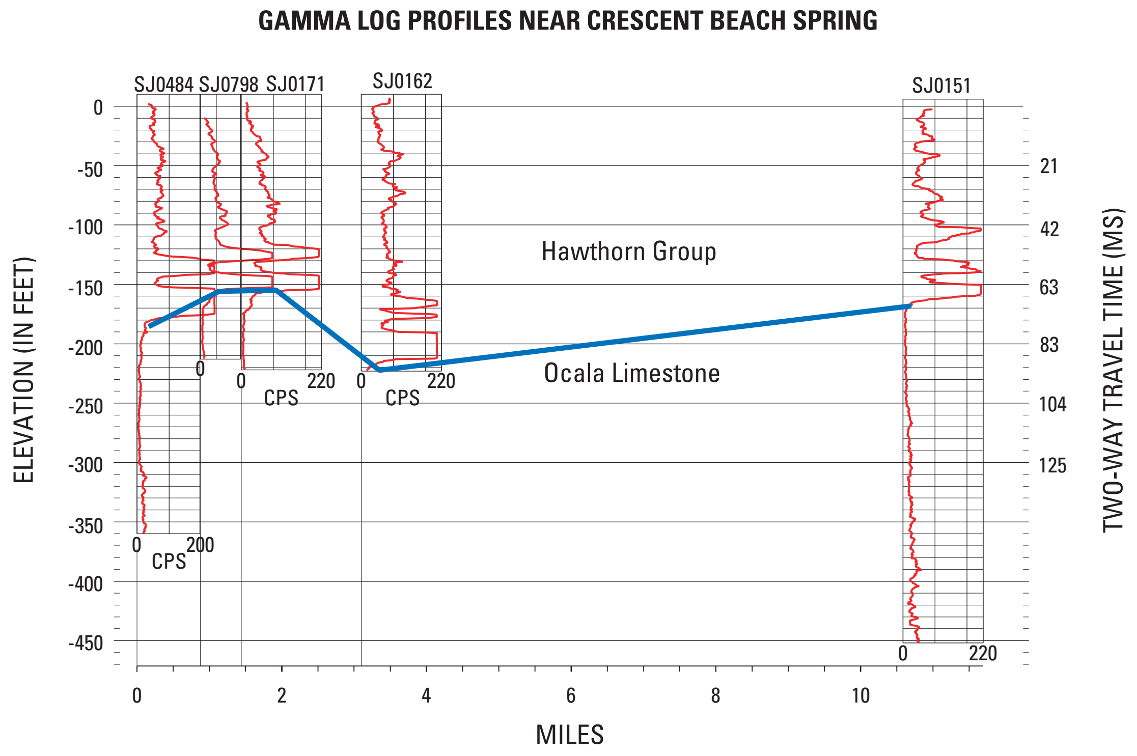
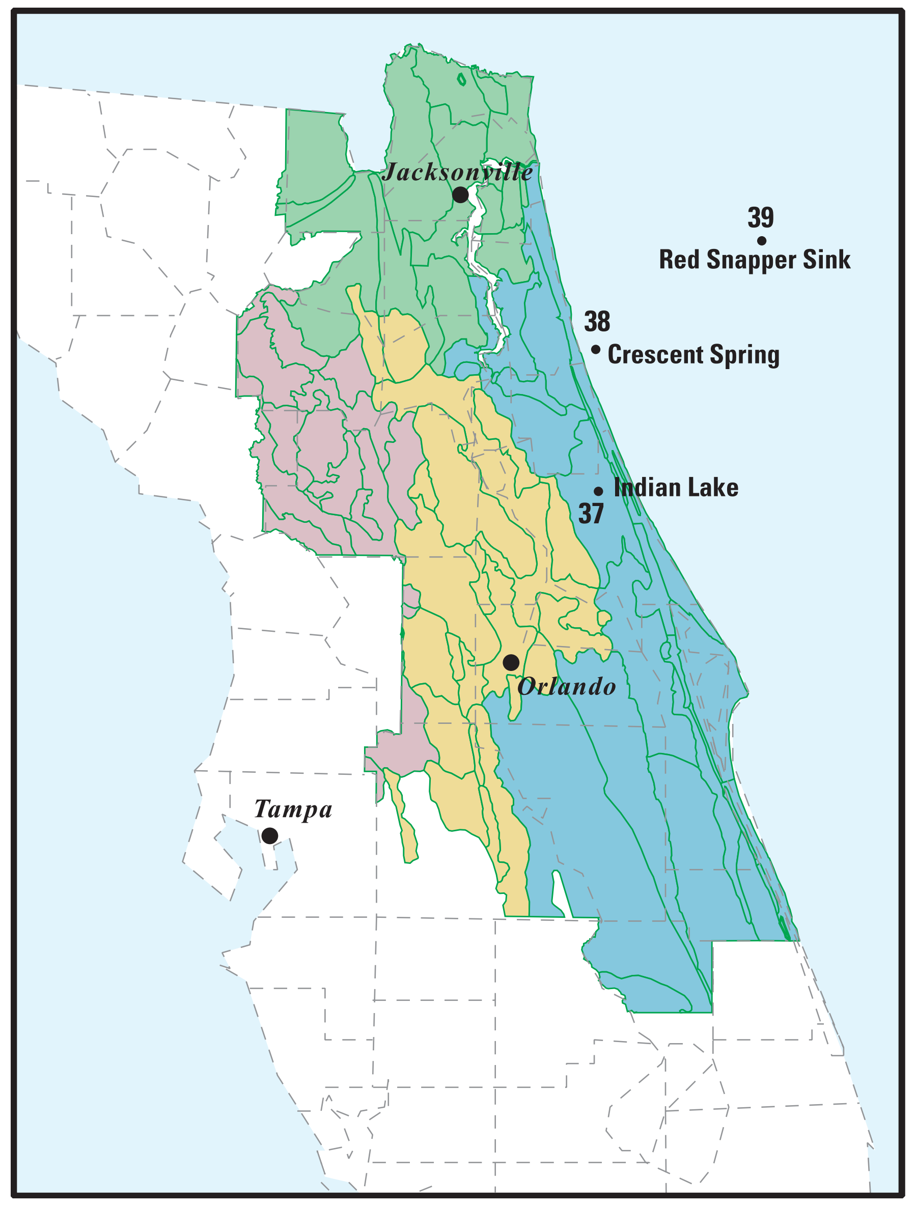
# INDEX MAP AND GAMMA LOG

## CROSS-SECTIONS, SECTION H



Location of Crescent Beach Spring and Indian Lake, right (Hillshade not available). Gamma log profile onshore adjacent to Crescent Spring above.

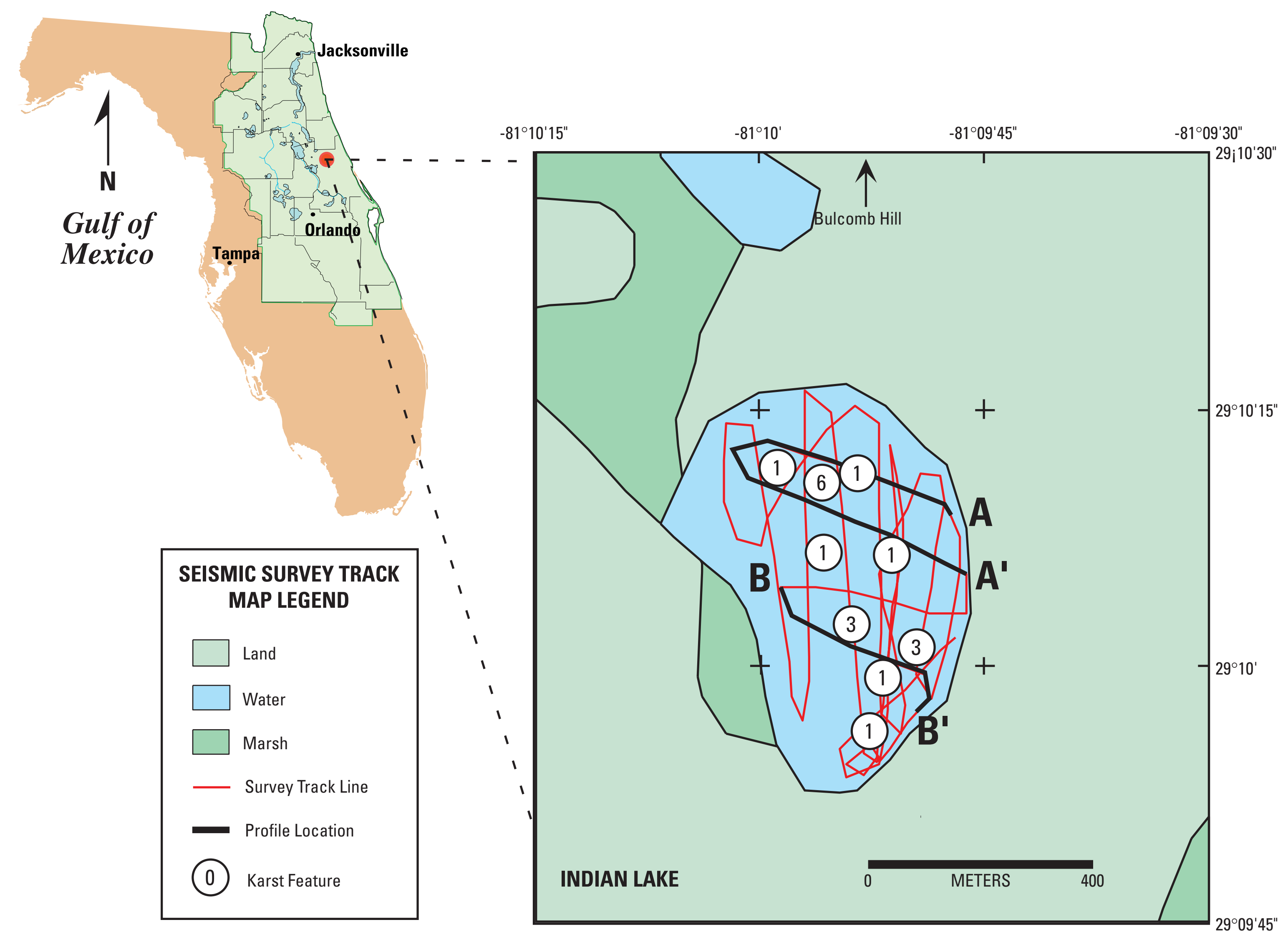


**LEGEND**

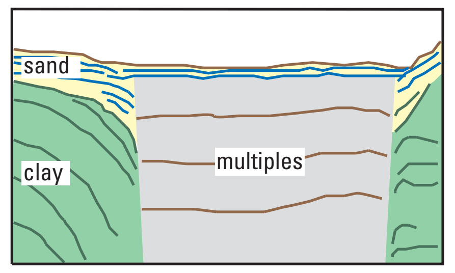
| | | page # |
|---|---|---|
| 🟩 | Physiographic Province Boundary | |
| — — | Counties | |
| 37 | Indian Lake | 43 |
| 38 | Crescent Spring | 44 |
| 39 | Red Snapper Sink | |

# INDIAN LAKE

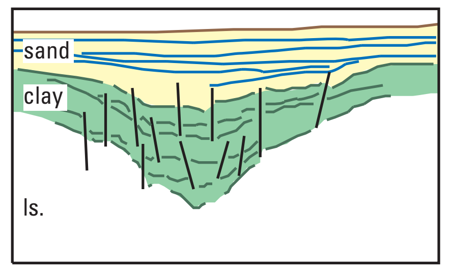
## VOLUSIA COUNTY, FLORIDA



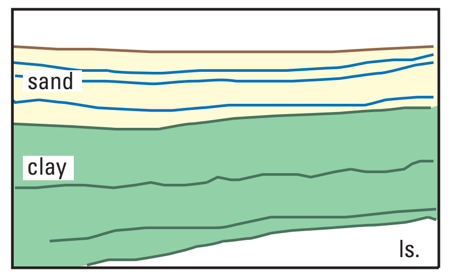
### EXPLANATION



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



3. Baselevel sinkhole—with near-surface disturbance.



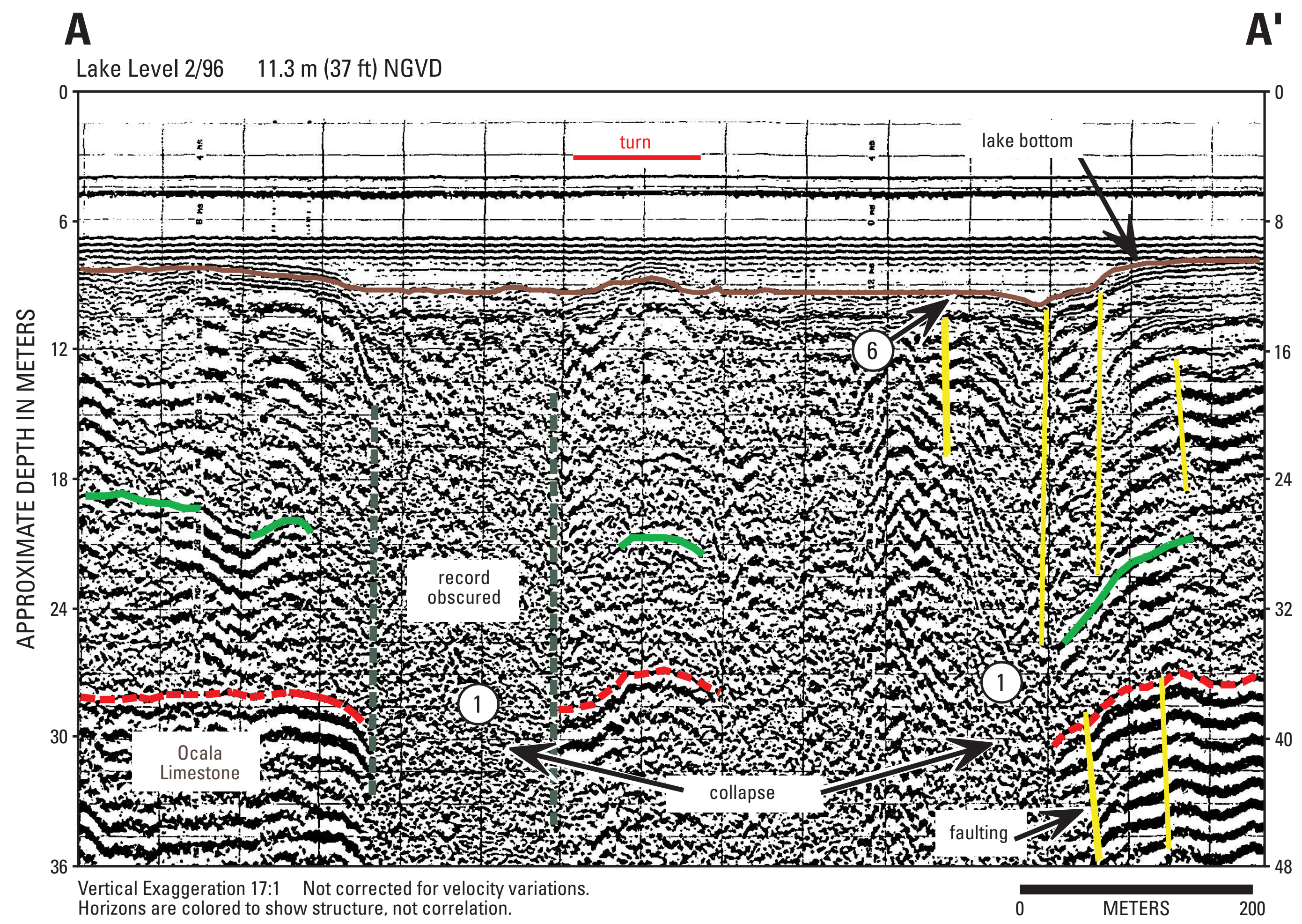
6. Intact subsurface—minimal karst development.

### INTRODUCTION

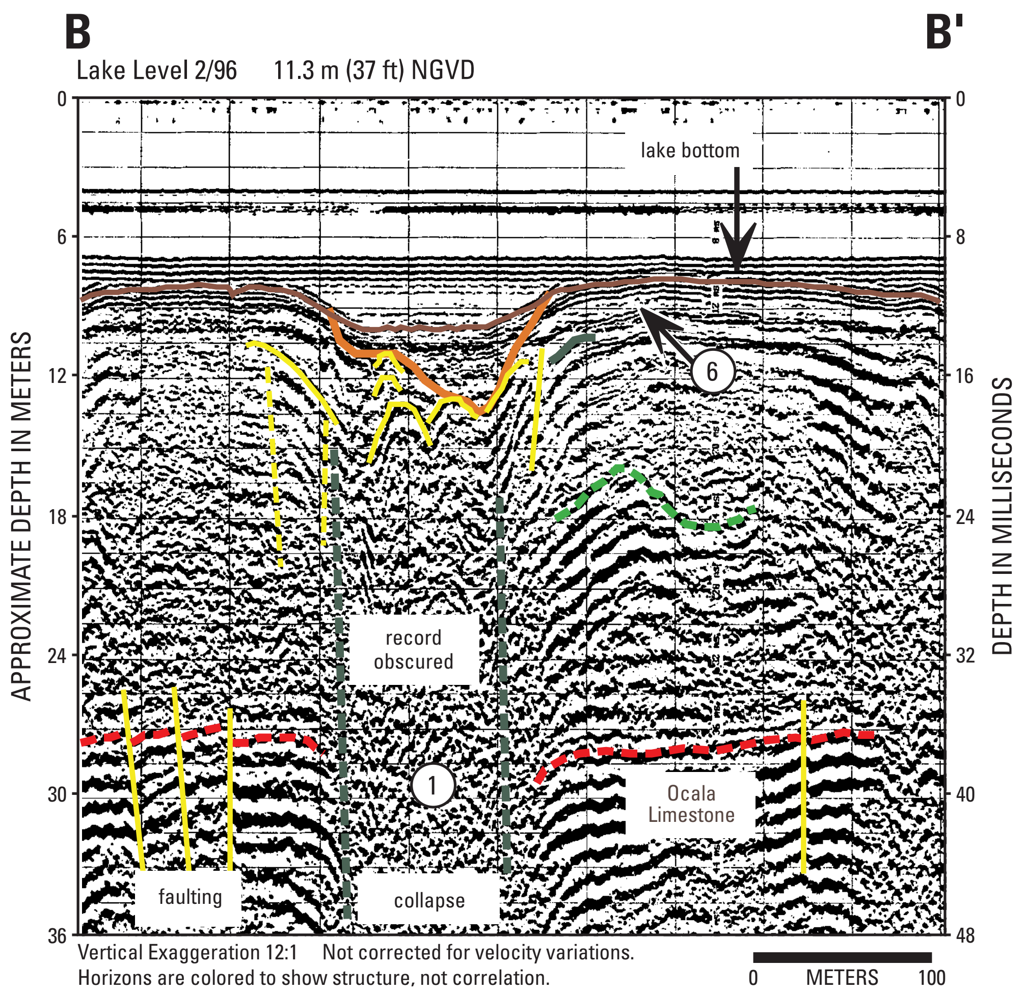
Indian Lake is located in north central Volusia County. The lake is situated along Rima Ridge of the Volusia Ridge Sets, in the Eastern Flatwoods District. Lake level at the time of the seismic survey was 11.3 m (37 ft) NGVD. Indian Lake has an oblong shape with a perimeter of 6 km (4 mi) and a surface area of 2.2 sq km. Rima Ridge is bordered on either side by Tiger Bay and Bennet Swamps. Bumcomb Hill is situated to the north of the lake.

### SUBSURFACE CHARACTERIZATION

Indian Lake is characterized by two areas of subsidence within the lake. These areas are shown in the map to the lower left. Seismic profiles A-A' and B-B' are oblique cross-sections across the two depressions. Seismic profile A-A' shows a bi-directional view of the larger of the two subsidence areas, as the survey trackline turns and crosses the depression twice. The profile shows a strong reflective horizon (red) about 28 m (92 ft) below lake level (9 m, 29.5 ft above NGVD). This horizon is interpreted to be the top of the Ocala Limestone, as correlated elsewhere in the study area with gamma-log profiles. There appears to be an area of collapse within the Ocala, approximately 150 m (492 ft) wide, that has caused a concomitant subsidence in the overlying structure. Seismic profile B-B' shows a smaller subsidence in the southern part of the lake. Some structure such as collapse-related faulting is better visualized in this record. Because of the lack of visible features within the collapsed areas, these profiles show characteristics similar to a type 1 interpretation as shown in the explanation (left). In the uppermost part of the profiles, a relatively transparent signal characteristic of organic debris and sands (type 6) appear to be infilling the depressions. Contour plots of the lake bottom and lower horizon, digitized from the seismic profiles, are shown to the lower left. The cross section C-C' was generated from the digitized surfaces.



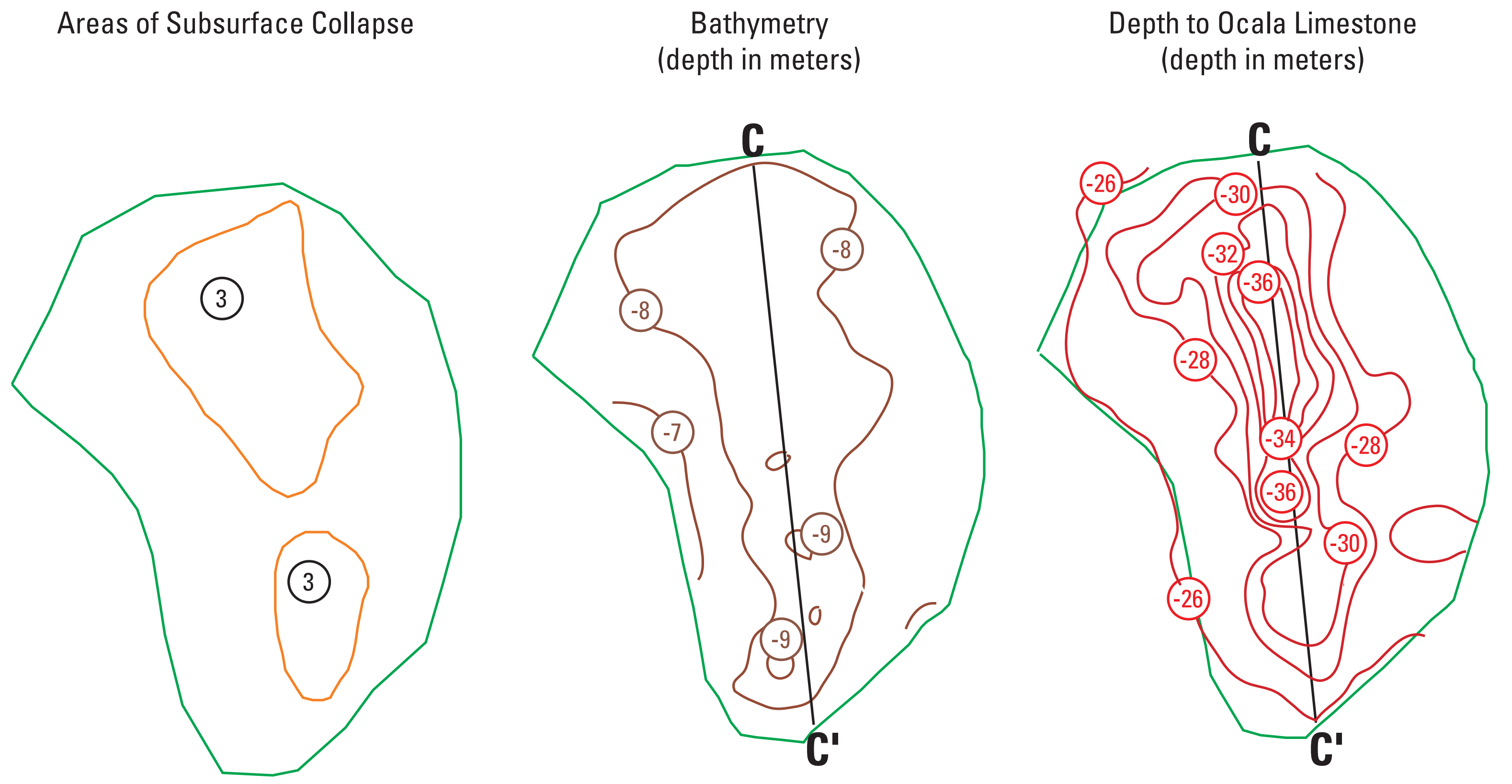
Vertical Exaggeration 17:1 Not corrected for velocity variations.
Horizons are colored to show structure, not correlation.



Vertical Exaggeration 12:1 Not corrected for velocity variations.
Horizons are colored to show structure, not correlation.

H

### LAKES KEENE & SMOKEHOUSE DISTRIBUTION OF FEATURES (noted from seismic profiles)

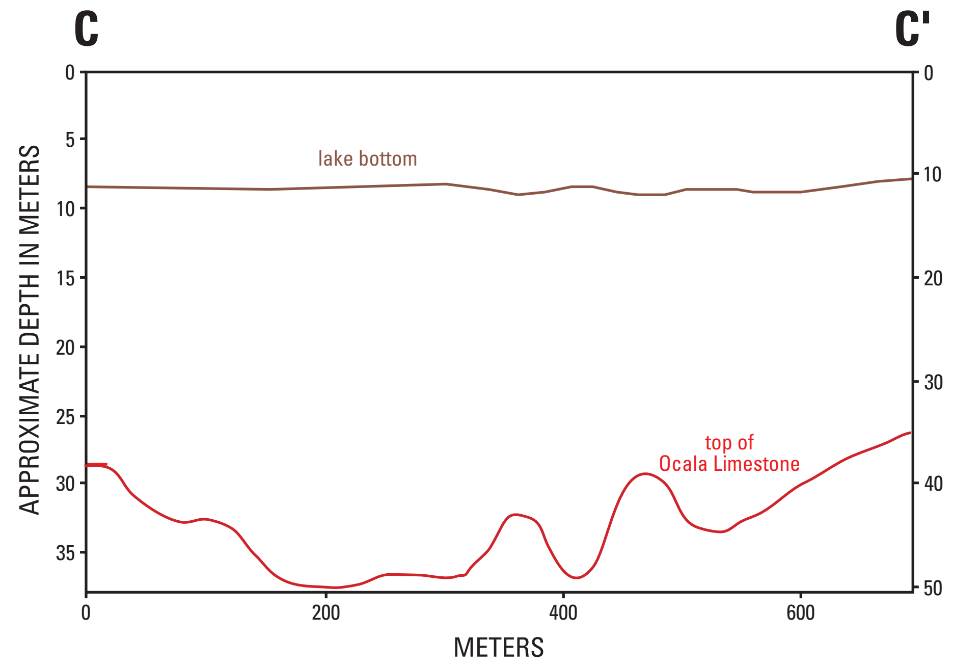


Areas of Subsurface Collapse

Bathymetry (depth in meters)

Depth to Ocala Limestone (depth in meters)

### SUBSURFACE PROFILE ACROSS INDIAN LAKE



Location of profile shown in above figures.

**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
U.S. Geological Survey
St.. Petersburg, Florida 33701

[2] St. Johns River Water
Management District
Palatka, Florida 32178

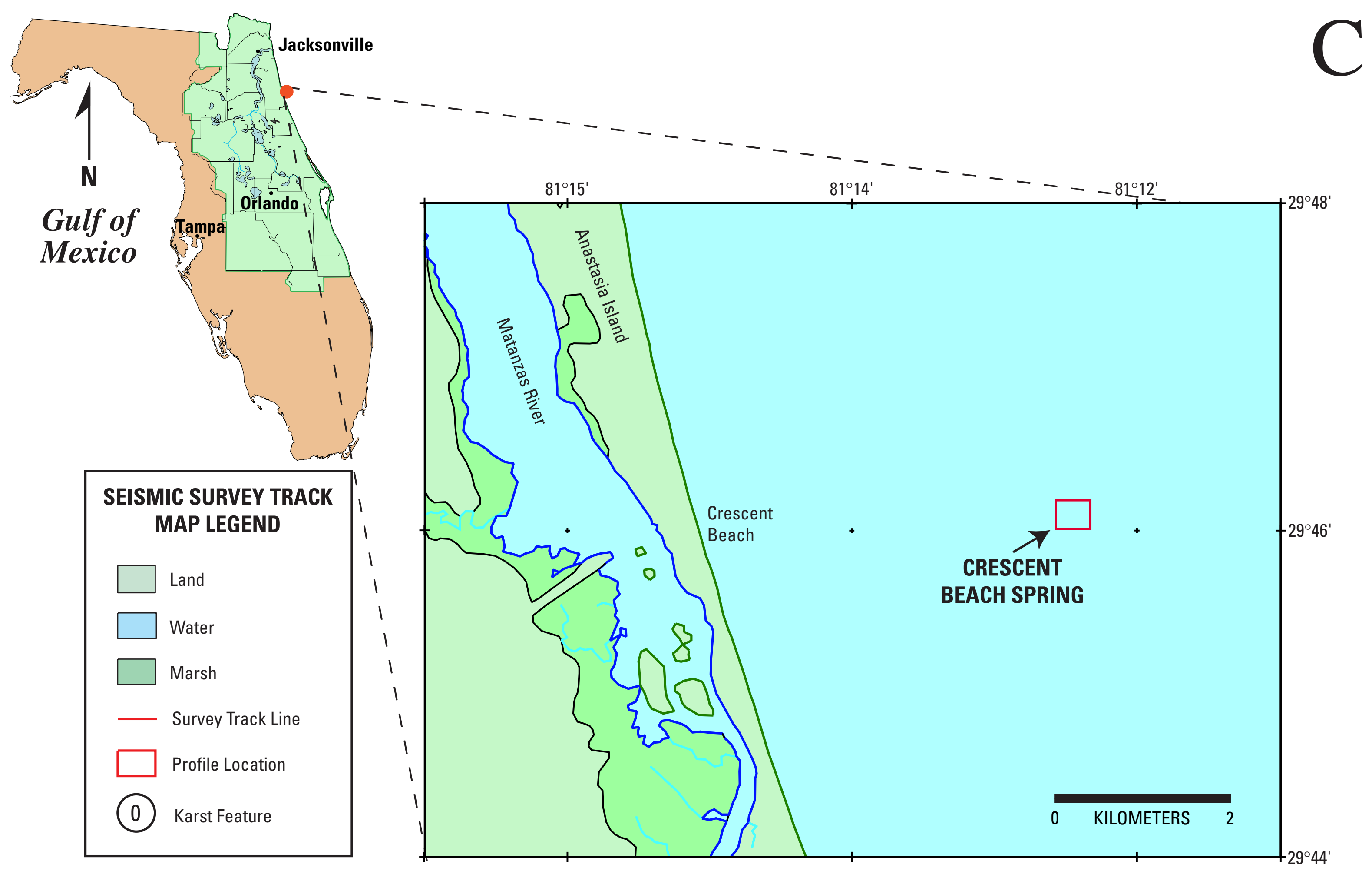
The use of trade, product and firm names used in this publication are for descriptive purposes only and in no way imply endorsement by the U.S. Government.

The U.S. Geological Survey, in cooperation with the St. Johns River Water Management District, prepares this information “as is” for its own purposes and this information may not be suitable for other purposes. This map has not been reviewed for conformity with U.S. Geological Survey editorial standards.

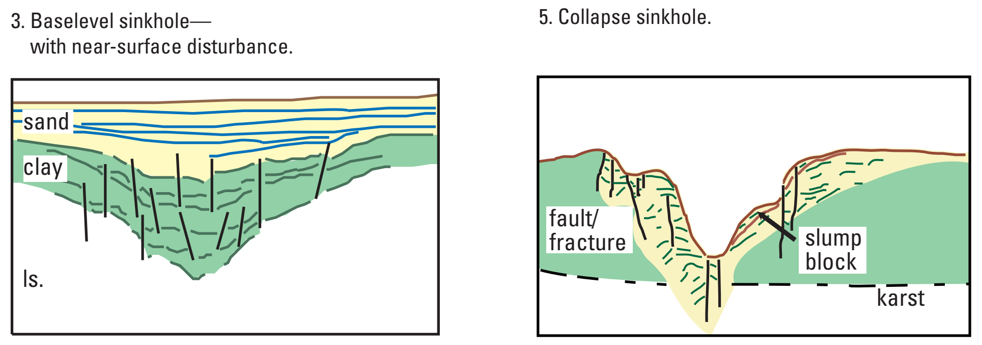
This sheet is Section H page 43 of Open-File Report #00-180 prepared by the U.S. Geological Survey Center for Coastal Geology and the St. Johns River Water Management District. For a detailed description of methods, site locations, explanation of regional geology, physiography, karst development and karst features identified by seismic profiling, refer to pages 1 through 7.

# CRESCENT BEACH SPRING

## ATLANTIC COAST, FLORIDA

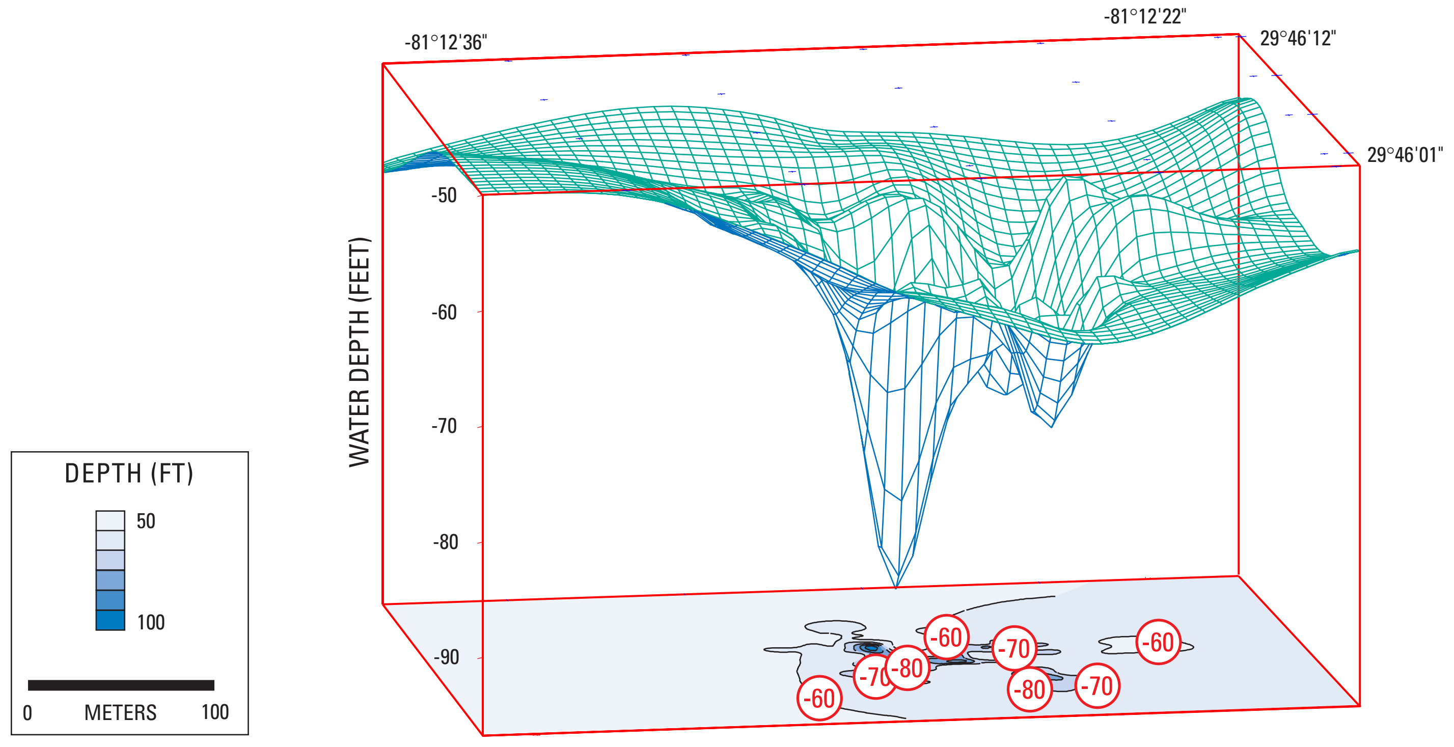


EXPLANATION


3. Baselevel sinkhole—with near-surface disturbance.

5. Collapse sinkhole.

3-D MODEL OF BATHYMETRY AT CRESCENT BEACH SINK



### Introduction

The submarine spring near Crescent Beach, St. Johns County, is approximately 4 km (2.5 mi) offshore in 18 m (59 ft) of water in the Atlantic Ocean. The spring is a major discharge point for water from the Floridan aquifer and is evident on seismic profiles to be a spring vent rather than a collapse-type sinkhole. The profiles show a vent area of approximately 90 to 150 m (300-500 ft) in diameter (example profiles A-A' and B-B') and a depth of over 35 m (115 ft) below sea level. NOAA/NOS navigation chart number 11486 lists a water depth of 43 m (140 ft) at the base of the vent. Brooks (1961), conducted a detailed survey of the "sink" using SCUBA, with a maximum recorded depth by diving of 40 m (132 ft). Brooks described the base of the sink to be comprised of secondary craters up to 4 m (12 ft) across. He noted that spring water discharge is from the bottom of these secondary craters. The spring water rises to the sea surface as density driven boils, at the surface these boils can be seen for some distance from the spring. In the seismic profiles, the velocity contrast between the fresher water discharging into the seawater produces reflectors that can be used to define the discharge plume.

In 1923, the U.S. Coast and Geodetic Survey obtained water samples from three areas in the spring that indicate the source water has a chloride content between 7090 mg/l and 7680 mg/l. These values are similar to those of the Floridan aquifer obtained from a well about six kilometers onshore to the west (Brooks, 1981). In 1995 water samples were collected from the spring by USGS staff to determine chlorides and age of the water using isotopes. The Chloride value from samples that isolated the discharge from the seawater was 3630 mg/l and the age based on Carbon-14 techniques was 10500 years (Toth, 1999).

### Subsurface Characterization

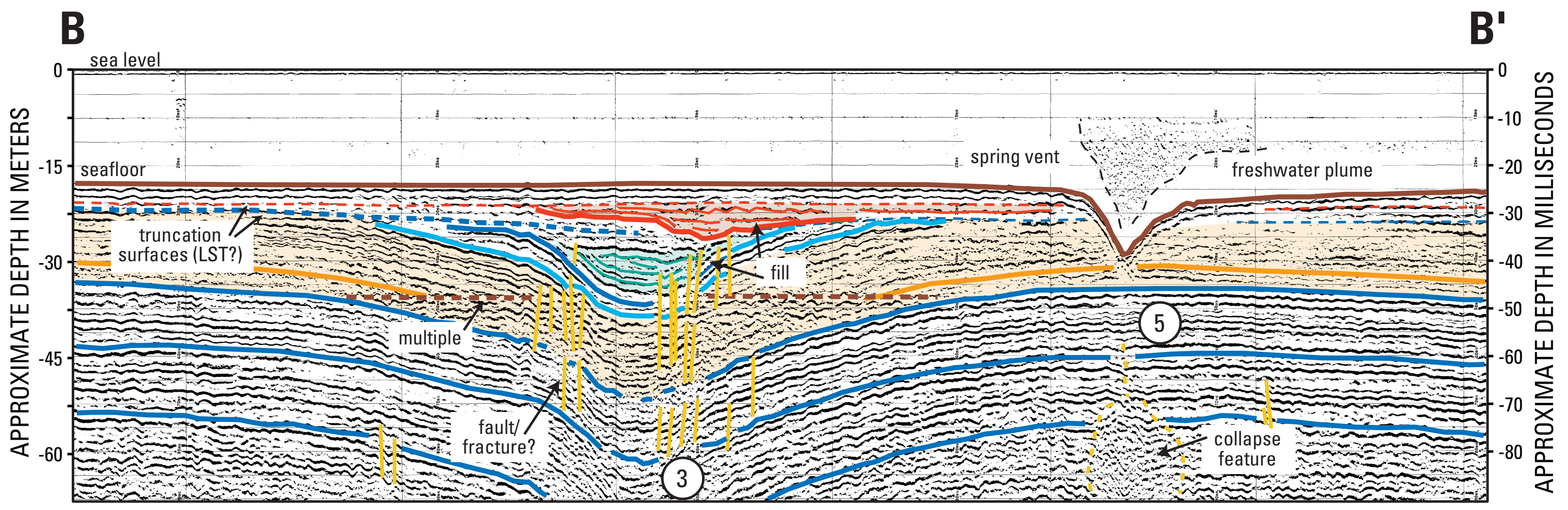
Numerous transects across Crescent Beach spring were conducted in 1994 to acquire HRSP of the subsurface. Two examples of the profiles are shown as A-A' and B-B'. Unfortunately the navigational fixes attached to the digital seismic data have been lost, so horizontal scale of the profiles and their geographic location cannot be determined at this time. Another survey of the sink using Side-Scan Sonar, HRSP and a fathometer were done in 1998.

The seismic profiles (A-A' and B-B') show numerous strong, parallel reflectors from about 30 m (98 ft) to 60 m (197 ft) below sea level. Gamma log profiles (Index Map Section H, page 42), interpreted from Gamma counts acquired from inland wells drilled within eight kilometers of the spring show numerous peaks in gamma counts at the base of the Hawthorn Group. These peaks are at similar depths to the strong reflectors in the seismic profiles. The package of reflectors highlighted by an orange background (A-A' and B-B') exhibits a slightly more "noisy" characteristic than adjoining reflectors and may represent different lithologic or stratigraphic parameters. The series may correlate with the higher frequency Gamma count peaks seen in Gamma log profiles SJ0798 and SJ0171 between -21 m (-70 ft) and -30 m (-100 ft). Below 60 m (197 ft) the strong reflectors diminish in the seismic profile (not shown). This change in acoustic return may represent the top of the Ocala Limestone. In the gamma profiles this surface is indicated by a blue line and ranges from an elevation of -53 m NGVD (71 ms or -170 ft) at SJ0151 to -69 m NGVD (92 ms or -220 ft) at SJ0162. Though there is insufficient data to confirm the identity of one reflecting horizon as the top of the Ocala Limestone, it is most likely around 70 ms (53 m, 174 ft) on the seismic data.

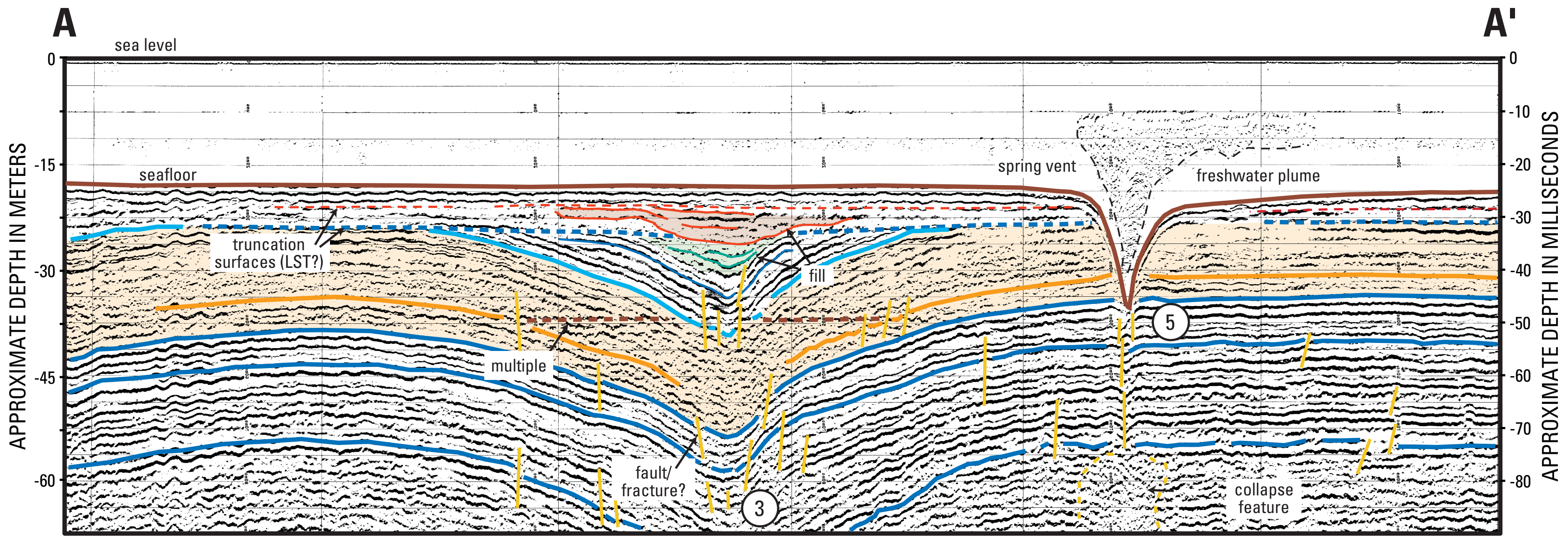
What is readily apparent in the HRSP examples is the very large (~1 km) subsidence feature evidenced by the downwarped reflectors within the Hawthorn Group. Discontinuities in the horizontal reflectors (yellow vertical lines) may represent stress fracturing associated with the downwarping. Meisburger and Field (1976) identify this large subsidence feature as a pronounced fold. Popenoe and others (1984) identified the top of the Eocene on the downward flexure of the fold to be between -47 m (-150 ft) in the undisturbed section to about -75 m (-240 ft) msl at the deepest part. Karst-related dissolution at depth and subsequent near-surface subsidence might be another explanation, rather than a structural fold. The area highlighted by a green background (A-A' and B-B') appears to contain offlap and cross-bedded reflectors that may represent fill when the depression was exposed.

The downwarped reflectors of the Hawthorn Group are truncated at about 22 m depth, shown by the blue dashed line in the example profiles. This surface, and a second one near surface (red dashed line), may represent erosional surfaces related to sea level low stands. The area highlighted by a red background shows a second depression with offlap- and cross-bedded fill. This feature may represent an area of resumed subsidence following the first sea level cycle. It may also be an incised fluvial channel with fill occupying the topographic low created by the original subsidence event. These sequences of truncation surfaces and fill may be remnants of the last two sea level cycles, the parallel reflectors overlying these sequences being the most recent marine deposition.

At the sea floor the spring vent appears to be independent of the large subsurface subsidence feature. Although their relationship at depth is not resolvable from the seismic profiles, their formation is probably a manifestation of major dissolution (mega-void) within the underlying limestone. The vent incises the most recent marine sequence, which suggests that the vent is recent. The north (left) flank of the sink is higher in elevation than the south flank (profile B-B'). Sediment removal from the vent may be accumulating on the prevailing down-current side of the vent. Another possibility is that the vent may occupy a fault line, with the southern flank being a down dropped block. Popenoe and others (1984) mapped numerous downward flexures and fractures traces along the northeast coast of Florida. The reflections within the Hawthorn Group show some minor displacement. There is some definite discontinuity in the reflectors below the sink (profile B-B') which could represent the breach within the Hawthorn and the migration pathway for the freshwater discharge. At depth in the seismic profiles the signal does appear to be slightly more chaotic than the neighboring acoustic return (outlined with yellow dashed line). This effect could be from noise in the signal caused by the sink itself, or it could be a zone of recrystallization or more advanced karst development within the Ocala Limestone. Removal of limestone by dissolution may have created a cavity and caused subsequent roof collapse and fill of the void. Increased dissolution within the Ocala Limestone would be the cause and effect of the fluid-migration pathway related to the spring vent and freshwater discharge at the sea floor.



Horizontal scale, vertical exaggeration not available



Horizontal scale, verticle exaggeration not available

**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
U.S. Geological Survey
St.. Petersburg, Florida 33701

[2] St. Johns River Water
Management District
Palatka, Florida 32178

The use of trade, product and firm names used in this publication are for descriptive purposes only and in no way imply endorsement by the U.S. Government.

The U.S. Geological Survey, in cooperation with the St. Johns River Water Management District, prepares this information "as is" for its own purposes and this information may not be suitable for other purposes. This map has not been reviewed for conformity with U.S. Geological Survey editorial standards.

This sheet is Section H page 44 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.

# SUMMARY, ACKNOWLEDGEMENTS AND REFERENCES

## SUMMARY

This atlas is the product of an investigation of lakes and rivers in north central Florida, a cooperative effort by the St. Johns River Water Management District and the U.S. Geological Survey. The objectives of the study were to: 1.) identify evidence of breaches or discontinuities of the confining units between surficial water bodies and the Floridan aquifer, and; 2.) identify diagnostic features, structure and geomorphology of the lakes and rivers within the region.

The shallow subsurface of north central Florida is characterized as a mature karst (limestone) overlain by an overburden of clays, silts and sands that act as an impermeable layer between surficial waters and the Floridan aquifer. Breaches through this layer allow recharge or discharge of waters to or from the Floridan aquifer. The development of breaches are influenced by various physical parameters, including the thickness and lithologic composition of the overburden, the maturity of karst development and depth to the potentiometric surface of the aquifer. Knowledge of these parameters and identifying the location and magnitude of the breaches is important in understanding the interaction between the surface waters and the aquifer.

The nature of the breaches within the overburden and dissolution in the underlying limestone take on various dimensions. Subsidence of the overburden due to dissolution at depth forms sinkholes that create large discontinuities within the impermeable layer. Smaller discontinuities include faulting and fracturing within the overburden that provide conduits for water movement, which over time develop solution pipes. With continued water movement and karst development these features reach stages of maturity that may include infilling and/or reactivation. Buried subsidence and dissolution features may not have a surface expression since recent fluvial deposition post-dates subsidence activity. However, the subsurface features may still provide conduits for water movement to and from the aquifer and reactivation is a possibility.

Subsurface geologic characterization beneath the lakes and rivers was determined by High Resolution Seismic Profiling (HRSP). The acoustic profiles provide images of karst features such as subsidence and collapse structures and related fracturing, faulting and dissolution pipes. These features may produce breaches within the confining layer or define subsurface discontinuities that provide a pathway for communication between surface waters and the aquifer. The physical parameters that produce these features, such as thickness of overburden, can also be inferred from HRSP with support from interpretations of gamma-log profiles obtained from water wells in the vicinity. Previous knowledge of geomorphology and regional geology further supports the HRSP and gamma-log interpretations. Compilation of HRSP from across north central Florida shows that certain karst-related features re-occur from lake to lake. By identifying these features, as well as comparing the subsurface physical parameters between lakes, the potential for interaction between surface and groundwater can be determined.

## ACKNOWLEDGEMENTS

The authors would like to express their thanks to the Governing Board of the St. Johns River Water Management District (SJRWMD), and Douglas A. Munch (SJRWMD), for their continuing support of high resolution seismic reflection studies within the District. We also want to thank individual property owners for the generous use of their facilities and personal knowledge of the lakes. Finally we would like to recognize Dana Wiese (USGS), Shane Dossat (SJRWMD), Micah Weltmer (USGS), Cherie Hulsman-Reid (USGS), Laura Lacy (USGS) and Tracy Enright (USGS) for their technical support; and the reviewers for their comments and suggestions.

### A

Arrington, D. V., and Lindquist, R. C.
1987, *Thickly Mantled Karst of the Interlachen, Florida Area:* in Beck, B. F., and Wilson, W. L. (editors), Karst Hydrogeology, Engineering and Environmental Impacts of Karst, 2, p. 31-39.

### B

Bates, E. R.
1973, *Detection of Subsurface Cavities:* U.S. Army Engineer Waterways Experiment Station Miscellaneous Paper no. S-73-40, 83 p.

Beck, B. F.
1988, *Environmental and Engineering Effects of Sinkholes—The Processes Behind the Problems:* Environmental Geology and Water Science, v. 12, no. 2, p. 71-78.

Beck, B. F. and Sayed, S.
1991, *The Sinkhole Hazard in Pinellas County: A Geologic Summary for Planning Purposes:* Florida Sinkhole Research Institute Report, no. 90-91-1, 140 p.

Boniol, D., Williams, M. and Munch, D.
1993, *Mapping Recharge to the Floridan Aquifer Using a Geographical Information System:* St. Johns River Water Management District Technical Publication SJ93-5, 41 p.

Brainard, D.
1982, *When the Earth Caves In:* Testing World, March, p. 15.

Brooks, H. K., and Merrit, J. M.
1981, *Guide to the Physiographic Divisions of Florida:* Florida Cooperative Extension Service Institute of Food and Agricultural Sciences, University of Florida, Gainesville. 1 map 150x105 cm and text 16 p.

Brooks, H. K.
1961, *The Submarine Spring Off Crescent Beach, Florida.* Quarterly Journal of Florida Academy of Science, 24 (2), p. 122-134.

### C

Clark,W. E., Musgrove, R. H., Menke, C. G. and Cagle, J. W., Jr.
1964, *Water Resources of Alachua, Bradford, Clay and Union Counties, Florida.* Florida Geological Survey, report Inv. 35.

Cooke, C. W.
1945, *Geology of Florida:* Florida Geological Survey Bulletin, v. 29, 339 p.

Culshaw, M. G. and Waltham, A. C.
1987, *Natural and Artificial Cavities as Ground Engineering Hazards.* Quarterly Journal of Engineering Geology, vol. 20, pp139-150.

### D

Dall, W. H. and Harris, G. D.
1892, *Correlation Papers: Neocene:* U.S. Geological Survey Bulletin, v. 84, 334 p.

Davis, J. B.
1996, *Geological and Karstic Features That May Impact the Surface Water to Ground Water Interactions at Orange Lake, Alachua County, Florida.* Masters Thesis, University of Florida, Gainesville, Florida, 125p.

### F

Federal Emergency Management Agency
1997, *Multihazard:* Identification and Risk Assessment, 359 p.

Ford, D. C., and Williams, P. W.
1992, *Karst Geomorphology and Hydrology:* Chapman & Hall publishers, New York, 601p.

### G

Gams, I.
1978, *The Polje: The Problems of Its Definition:* Z. Geomorph, v. 22, p. 170-181.

### H

Haller, B. and Hoyer, M.
1992, *Water Discharge From Orange Lake Towards the Heagy Boat Ramp:* University of Florida IFAS Center for Aquatic Plants Report to the St. Johns River Water Management District, 3 p.

Hine, A.C.
1997, *Structural and Paleoceanographic Evolution of the Margins of the Florida Platform:* in: Randazzo, A.F. and Jones, D.S. (eds.), The Geology of Florida, University Press of Florida, p. 169-195.

Hirsch, J. D.
1998, *Characterization of Hydraulic Seepage Within Brooklyn Lake, Keystone Heights, Florida.* Masters Thesis, University of Florida, Gainesville, Florida, 165 p.

### J

Jessen, E.
1972, *Land Use in the Orange Lake Area of Central Florida:* University of Florida, Gainesville, Florida, M.A. Thesis, 386 p.

Johnson, R.A.
1986, *Shallow Stratigraphic Core Tests on File at the Florida Geological Survey:* Florida Geological Survey Information Circular No. 103, 431 p.

### K

Kindinger, J.L., Davis, J.B., and Flocks, J.G.
(1998), *Geologic Controls on the Formation of Lakes in North-Central Florida:* Modern and Ancient Lake Systems, Utah Geological Association Guidebook 26, 22 p.

Kindinger, J. L., Davis, J. B., Flocks, J. G. and Tihansky, A. B.
1996, *High-Resolution Single-Channel Seismic Reflection Surveys of selected Lakes and Peace River, Florida:* USGS Advanced Workshop on Integrated Uses of Geophysics in Hydrology and Geology, Golden, CO, unpaginated.

Kindinger, J. L., Davis, J. B., and Flocks, J. G.
1994, *High-Resolution Single-Channel Seismic Reflection Surveys of Orange Lake and Other Selected Sites of Northern Florida:* U S Geological Survey Open-File Report 94-616, 48 p.

Kindinger, J. L., Davis, J. B., and Flocks, J. G.
1999, *Geology and Evolution of Lakes in North-Central Florida:* Environmental Geology, v. 38:4, p. 301-321.

### L

Lane, E.
1986, *Karst in Florida.* Florida Geological Survey, Special Report no. 29, 100 p.

Lane, E.
1994, *Florida's Geological History and Geological Resources.* Florida Geological Survey, Special Publication 35, 64 p.

Lane, E., and Hornstine, R. W.
1991, *Environmental Geology and Hydrogeology of the Ocala Area, Florida.* Florida Geological Survey, Special Publication 31, 71 p.

Locker, S. D., Brooks, G. R. and Doyle, L. J.
1988, *Results of a Seismic Reflection Investigation and Hydrographic Implications for Lake Apopka, Florida:* University of South Florida, St. Petersburg, Florida, Final Report to St. Johns River Water Management District, 39 p.

### M

Mallinson, D. J., Compton J., and Hodell D.
1994, *Isotope Chronostratigraphy, Lithostratigraphy, and Sequence Stratigraphy of the Miocene Hawthorn Group of Northeastern Florida:* Implications for eustacy and 13 C: Journal of Sedimentary Research 864:392-407.

McCann, D. M., Baria, R., Jackson, P. D., Culshaw, M. G., Green, A. S. P., Suddaby, D. L. and Hallam, J. R.
1982, *The Use of Geophysical Methods in the Detection of Natural Cavities, Mine Shafts, and Anomalous Ground Conditions:* British Geological Survey Engineering Geology Unit Report, no. 82/5, 272 p.

# REFERENCES

### M

McCann, D. M., Jackson, P. D. and Culshaw, M. G.
1987, *The Use of Geophysical Surveying Methods in the Detection of Natural Cavities and Mine Shafts:* Quarterly Journal of Engineering Geology, v. 20, p. 59-73.

Meisburger, E. P. and Field, M. E.
1976, *Neogene Sediments of Atlantic Inner Continental Shelf Off Northern Florida:* American Association of Petroleum Geologists Bulletin, v. 60, p. 2019-2037.

Miller, J. A.
1986, *Hydrogeologic Framework of the Floridan Aquifer System in Florida and in Parts of Georgia, Alabama and South Carolina*, U.S. Geological Survey Professional Paper 1403-B, 91 p., 2. pl.

Missimer, T. M. and Gardner, R. A.
1976, *High-Resolution Seismic Profiling for Mapping Shallow Aquifers in Lee County, Florida.* U. S. Geological Survey, Water Resources Investigation, no. 76-45, 30 p.

### O

Opdyke, N. D., Spangler, D. P., Smith, D. L., Jones, D. S. and Lindquist, R. C.
1984, *Origin of the Epeirogenic Uplift of Pliocene-Pleistocene Beach Ridges in Florida and Development of Florida Karst:* Geology 12:226-28.

Owen, T. E.
1983, *Detection and Mapping of Tunnels and Caves: in A. A. Fitch (ed.),* Developments in Geophysical Exploration Methods, Amsterdam, Elsevier, p. 161-258.

### P

Pirkle, E. C. and Brooks, H. K.
1959a, *The Hawthorn and Alachua Formations of Alachua County, Florida:* Quarterly Journal of Florida Academy of Science, p.197-239.

Pirkle, E. C. and Brooks, H. K.
1959b, *Origin and Hydrology of Orange Lake, Santa Fe Lake and Levys Prairie Lakes of North-Central Peninsular Florida:* Journal of Geology, v. 67, no. 3, p. 302-317.

Popenoe, P., Kohout, F. A. and Manheim, F. T.
1984, *Seismic-Reflection Studies of Sinkholes and Limestone Dissolution Features on the Northeast Florida Shelf: in B. F. Beck (ed.), Sinkhole: Their Geology, Engineering, and Environmental Impact- Proceedings of the First Multidisciplinary Conference on Sinkholes,* Orlando, Florida, p.43-57.

### R

Randazzo, A. F.
1972, *Petrography of the Suwannee Limestone.* Florida Geological Survey Bulletin no. 54, 2:1-13.

Randazzo, A. F. and Jones, D. S.
1997, *The Geology of Florida.* University Press of Florida, Gainesville, Florida, 327 p.

Randazzo, A. F. and Zachos, L. G.
1984, *Classification and Description of Dolomite Fabric of Rocks from the Floridan Aquifer, U.S.A.* Sedimentary Geology 37:151-62.

Ripp, B.J. and Baker, J.P.
1997, *Urbanization in Karst Sinkhole Terrain – A St. Louis Perspective:* in: Beck, B.F. and Stephenson, J.B., (eds.), The Engineering Geology and Hydrogeology of Karst Terrains, A.A. Balkema, Rotterdam, 516 p.

Robison, P. C., Ware, C., Hall, G. B. and Hupalo, R. B.
1994, *Water Management Alternatives and Their Effects on Lake Levels and Wetlands in the Orange Creek Basin, Lower Ocklawaha River, Northeast Florida:* St. Johns River Water Management District Technical Publication SJ94, 154 p.

Rowland, L. O.
1957, *Florida Watersheds Under Public Law 566:* Quarterly Journal Florida Academy of Sciences, v. 20, p. 114-120.

Rutledge, A.T.
1982, *Hydrology of the Floridan Aquifer in Northwest Volusia County, Florida:* USGS Water Resources Investigations Open File Report 82-108, 116 p.

### S

Sacks, L. A., Lee, T. M. and Tihansky, A. B.
1991, *Hydrogeologic Setting and Preliminary Data Analysis for the Hydrologic Budget Assessment of Lake Barco, an Acidic Seepage Lake in Putnam, County, Florida:* U.S. Geological Survey Water Resources Investigations Report, no. 91-4180.

Schmidt, W.
1997, *Geomorphology and Physiography of Florida:* in: Randazzo, A.F. and Jones, D.S. (eds.), The Geology of Florida, University Press of Florida, p. 169-195.

Scott, T. M.
1988, *The Lithostratigraphy of the Hawthorn Group (Miocene) of Florida:* Florida Geological Survey Bulletin, 59, 148 p.

Scott, T. M.
1992, *A Geological Overview of Florida:* Florida Geological Survey Open File Report, no. 50, 78 p.

Smith, T.J.
1997, *Sinkhole Damage Investigation for the Insurance Industry in West-Central Florida:* in: Beck, B.F. and Stephenson, J.B., (eds.), The Engineering Geology and Hydrogeology of Karst Terrains, A.A. Balkema, Rotterdam, 516 p.

Snyder, S. W., Evans, M. W., Hine, A. C. and Compton, J. S.
1989, *Seismic Expression of Solution Collapse Features from the Florida Platform:* in; Beck, B.F. (ed.), Proceedings of the Third Multidisciplinary Conference on Sinkholes, St. Petersburg Beach, Florida, v. p. 281-297.

Spechler, R. and Wilson, W. A.
1992, *Letter to Barbara Vergara:* St. Johns River Water Management District September 2, 1992, 4 p.

Subsurface Detection and Investigations, Inc,
1992, *High Resolution Seismic Profiling in Selected Lakes in the St. Johns River Water Management District:* Final Report to the St. Johns River Water Management District, xp.

### T

Toth, David J.
In press, *Water Quality and Stable Radioactive Isotope Concentrations from Selected Springs in the St. Johns River Water Management District:* SJRWMD Tech. Pub.

### U

U. S. Geological Survey
1985, *Types, Features and Occurrence of Sinkholes in the Karst of West-Central Florida.* U. S. Geological Survey Water Resources Investigation no. 85-4126, p. 55-59.

### W

Waltham, A. C.
1989, *Ground Subsidence:* London, Blackie, 202 p.

Wiener, Jacky M.
1982, *Geologic Modeling in the Lake Wauberg-Chacala Pond Vicinity Utilizing Seismic Refraction Techniques.* University of Florida M.S. thesis. 94 p.

White, W. A.
1970, *The Geomorphology of the Florida Peninsula: Florida Bureau of Geology,* Geological Bulletin 51, 165 p.

Williams, K. E., Nichol, D. and Randazzo, A. F.
1977, *The Geology of the Western Part of Alachua County, Florida:* University of Florida, Gainesville, Florida, Bureau of Geology Report of Investigations, no. 85, 98p.