U.S. Geological Survey
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Miami, FL 33178
October 28, 2002

Michael Fies
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Fies,

The report, Sequence-stratigraphic analysis of the ROMP 29A test corehole and its relation to carbonate porosity and regional transmissivity trends in the Floridan aquifer system, Highlands County, Florida by William C. Ward, Michael A. Wacker, Kevin J. Cunningham, Janine I. Carlson and Robert A. Renken, is provided to the U.S. Army Corps of Engineers to complete the requirements for Tasks 1 through 3 of Work Order #3 under the Memorandum of Agreement between the USGS and the Department of the Army dated 11/29/99.

You may access copies of the document, tables, and various appendices at our ftp web site address, flmiasr004.er.usgs.gov (or 144.47.26.4) and by logging in as 'anonymous', user ID as the password and changing to the pub/Miami/ROMP29A directory. Please copy all files to your home directory.

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Sincerely,

Robert A. Renken

Hydrologist

Sequence-stratigraphic analysis of the ROMP 29A test corehole and its relation to carbonate porosity and regional transmissivity in the Floridan aquifer system, Highlands County, Florida

By William C. Ward, Michael A. Wacker, Kevin J. Cunningham, Janine I. Carlson, *and* Robert A. Renken

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U. S. GEOLOGICAL SURVEY

Open File Report 02-XXXX

Tallahassee, Florida
2002

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CONVERSION FACTORS, ACRONYMS, ABBREVIATIONS, AND VERTICAL DATUM ACRONYMS AND ABBREVIATIONS

Multiply	By	To obtain
inch	25.4	centimeter
foot	0.3048	meter
foot per day	0.3048	meter per day
mile	1.609	kilometer
gallon per day	0.003785	cubic meter per day
Mgal/d (million gallons per day)	0.04381	cubic meter per second

Acronyms

SWFWMD	Southwest Florida Water Management District
ASR	Aquifer storage and recovery
JPEG	Joint Photographic Experts Group
USGS	United States Geological Survey
ROMP	Regional Observation and Monitoring Program
PVC	Polyvinyl chloride
MFS	Maximum flooding surface
SB	Sequence boundary
HFS	High-frequency sequence
HFC	High-frequency cycle
HFCS	High-frequency cycle sets
CD	Cored depth
TD	Total depth
GDP	Grain-dominated packstone
MDP	Mud-dominated packstone
CERP	Comprehensive Everglades Restoration Plan

Abreviations

in	inch
ft	foot
ft^2/d	square feet per day
gpd/ft	gallons per day per foot
LAT	Latitude
LONG	Longitude
my	million years
m	meter
cm/1,000 yr	centimeter per one thousand years

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929), a geodetic datum derived from a general adjustment of the first-order levels nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Sequence-stratigraphic analysis of the ROMP 29A test corehole and its relation to carbonate porosity and regional transmissivity in the Floridan aquifer system, Highlands County, Florida

By William C. Ward[1], Michael A. Wacker[2], Kevin J. Cunningham[2], Janine I. Carlson[3], *and* Robert A. Renken[2]

ABSTRACT

The ROMP 29A test corehole penetrated several lithologic units ranging in age from middle Eocene to Miocene; including the Avon Park Formation, Ocala Limestone, Suwannee Limestone, and the Hawthorn Group. The portion of the Avon Park Formation penetrated in the ROMP 29A test corehole comprises one composite depositional sequence. The composite depositional sequence is composed of at least 5 high-frequency depositional sequences. The high-frequency depositional sequences contain high-frequency cycle sets that are an amalgamation of vertically stacked high-frequency cycles. Three types of high-frequency cycles have been identified in the Avon Park Formation: peritidal, subtidal and deeper subtidal high-frequency cycles.

Vertical distribution of carbonate diffuse flow zones within the Avon Park Formation are heterogeneous with no porous interval more than a few tens of feet thick, with most much thinner. The volumetric arrangement of the diffuse flow zones shows that a majority occurs in the transgressive systems tract of the composite depositional

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sequence of the Avon Park Formation as compared to the highstand systems tract. While the porous and permeable layers may not be thick, extensive lateral continuity of some intervals may exist because of deposition on a flat-lying, low-relief ramp. There is a thick interval of thin vuggy zones and open faults that form thin conduit flow zones mixed with relatively thicker carbonate diffuse flow zones between a depth of 1070 and 1244 ft below ground level or the bottom of the test corehole. This interval is the most transmissive portion of the Avon Park Formation penetrated in the ROMP 29A test corehole and is included in the transgressive systems tract of the composite sequence.

Three lower-order depositional sequences can be defined in the Ocala Limestone of Romp 29A test corehole. Deposited within deeper-subtidal depositional cycles, no zone of enhanced porosity and permeability is expected in the Ocala Limestone; accordingly the Ocala is considered to be a semiconfining unit. Only a thin erosional remnant of shallow-marine Suwannee Limestone overlies the Ocala Limestone and permeability appears to be low as moldic porosity is poorly connected.

Geophysical log and aquifer test data collected in Highlands County and elsewhere were compared to assess relationships between geology, hydrogeology and transmissivity. Open-hole digital borehole images of the Floridan aquifer were quantified and used to improve delineation of zones of preferential flows. Unfortunately, most aquifer tests have been conducted in wells having open-hole intervals that range from 250 to 1200 ft thick, making comparison of discrete flow zones and assessment of their regional continuity difficult. However, regional transmissivity patterns could be evaluated by assigning open-hole intervals to generalized rock-stratigraphic units and hydrogeologic units. On the basis of a preliminary analysis of aquifer test data, there appears to be a spatial relation among wells that penetrate water-bearing rocks having relatively high and low transmissivity. Transmissivity in an ‘upper zone’ that comprises rocks within the Lower Hawthorn, Suwannee Limestone and Ocala Formation is generally less than 10,000 ft^2/day in areas located south of a line that extends from northern St. Lucie, Okeechobee, eastern Polk, DeSoto, and southern Sarasota Counties. Limited data have been compiled for a ‘lower zone’ water-bearing unit that includes the Avon Park Formation; accordingly, transmissivity patterns can not yet be regionally assessed.

INTRODUCTION

The analysis of existing core samples represents an early-phase task authorized by the Comprehensive Everglades Restoration Plan (CERP) Regional ASR Project Management Team. This effort may provide insight into the thickness and stratigraphic distribution of zones of transmissivity within the Upper Floridan Aquifer. In addition, there is a need to develop a better understanding of representative Upper Floridan aquifer lithology in the Lake Okeechobee area. The correlation of rock properties and borehole geophysical log data in one specific well can serve as a comparative guide to the geology in nearby non-cored wells. More than 2,500 ft of cored rock samples were obtained from the Florida Geological Survey’s Core Repository in Tallahassee, FL and Southwest Florida Water Management District. Three continuously cored wells from Southwest Florida Water Management District’s Regional Observation and Monitoring Well Program (ROMP) having sufficient length and interval in the Lake Okeechobee area were considered for the evaluation (ROMP 14, ROMP 28, and ROMP 29A) (fig. 1). An

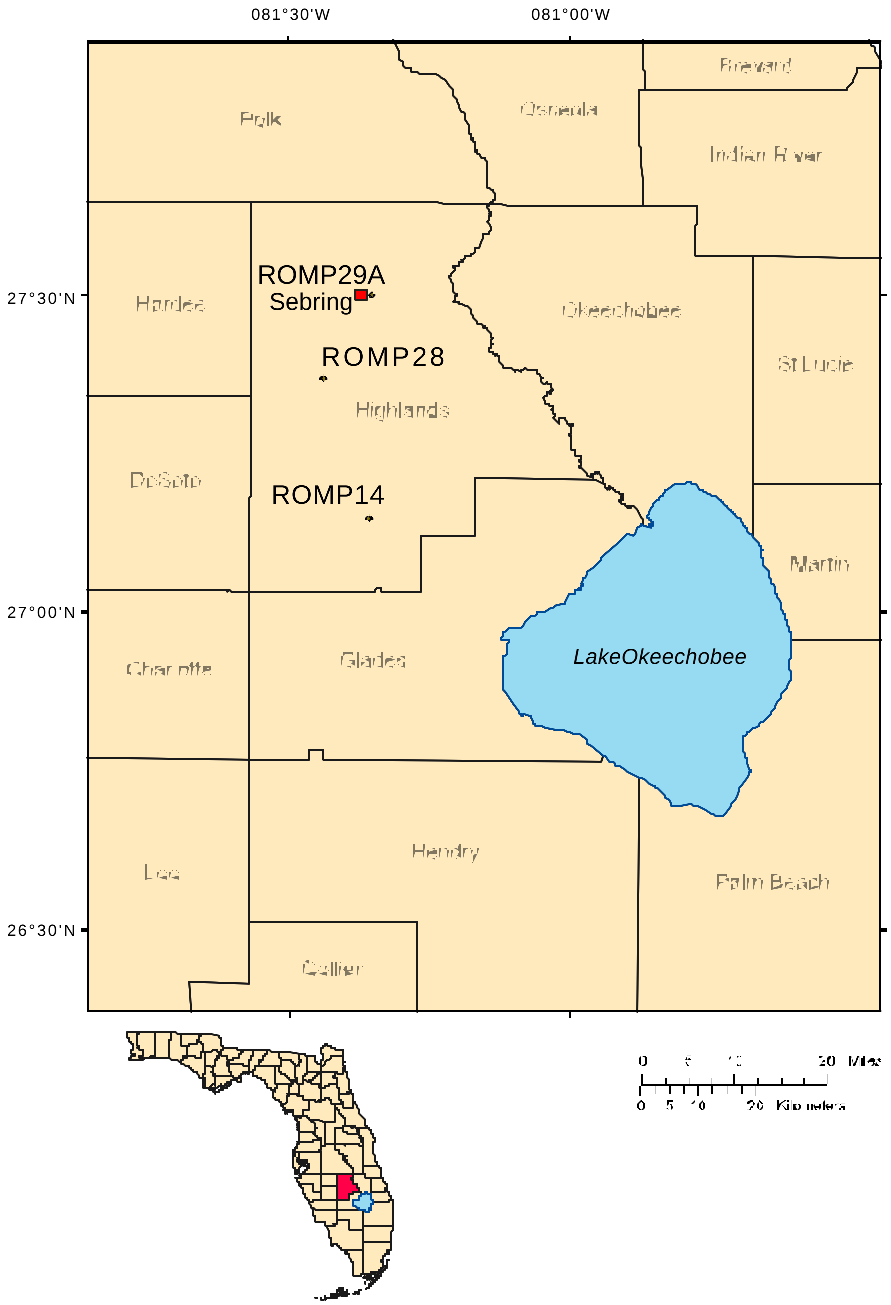

Figure 1. Location of Southwest Florida Water Management District's Regional Observation and Monitoring Program (ROMP) cored test wells in Highlands County, Florida included in this study.

evaluation of unslabbed core samples of all three wells was conducted; the ROMP 29A well, located near Sebring, Florida was determined to be best suited for this analysis. Although not described in this document, a cursory comparison of the ROMP 29A, ROMP 28, and ROMP 14 cored wells was conducted to assess wider continuity and well to well correlation of selected rock unit intervals.

Purpose and Scope

The purpose of this report is to describe and interpret the lithology and sequence stratigraphy of part of the upper Floridan aquifer penetrated by ROMP 29A test corehole. This report provides a detailed description of the upper Avon Park Formation of Middle Eocene Age (the lowermost 475 ft), Ocala and Suwannee Limestones. Attention was given to the vertical distribution and thickness of porous and permeable zones and their relationship to a sequence-stratigraphic framework established from this core. Geophysical log and aquifer test data collected in Highlands County and elsewhere were compared to assess relationships between geology, hydrogeology and transmissivity.

Lithologic descriptions are based on examination of 834 ft of slabbed core and 59 petrographic thin sections and include petrologic and microfaunal analyses to determine the mineralogy, geologic age, and paleoenvironments of deposition. X-ray defraction of six samples was also made to aid in the determination of mineralogy. Detailed lithologic logs of the slabbed core were produced as the final product of the detailed description. Each log includes descriptions of the following features: lithology, color, texture, porosity, exposure surfaces, depositional features, bedding thickness, fossils and assignment to formational units. Percent vuggy porosity was estimated by a new method for the quantification of vuggy porosity using digital borehole images (Cunningham and others, in press). The borehole image and percent vuggy porosity are included on each log sheet. The core also was photographed inside the core boxes and the developed photographs digitized in a JPEG format.

Location of Study Area

The city of Sebring is located northern Highlands County, south-central Florida, approximately 40 mi northwest of Lake Okeechobee (fig. 1). The ROMP 29A test well is located east of Sebring (fig. 1) on Highlands County School Board Property located near the intersection of Tangerine Avenue and School Street. The geographic coordinates of the ROMP 29A test well are 27° 30' 00" N latitude and 081° 25' 19" W longitude at a surface elevation of 125 ft above sea level.

Acknowledgments

Numerous individuals and governmental agencies provided technical contributions and other assistance. Especially important was the assistance from Richard Lee (SWFWMD) in providing the ROMP 29A core, geophysical logs, and access to the well site. Bruce Ward, of Earthworks, Inc, provided technical assistance to William Ward. Don McNeill of the Division of Marine Geology and Geophysics at the University of Miami's Rosenstiel's School of Marine and Atmospheric Science prepared and analyzed the X-ray diffraction samples. Core samples were slabbed and prepared by Jared Lutz at the Earth Sciences Department of Florida International University. Dominicke Merle provided assistance with preparation of this report.

WELL CONSTRUCTION

Test well ROMP 29A was drilled as a temporary exploratory test corehole to provide geologic and hydrologic information necessary for the establishment of three permanent monitor wells in the surficial and intermediate aquifer systems, and the upper Floridian aquifer. During the drilling process continuous core samples were collected as well as other geologic and hydrologic data. The total depth cored was 1,244 ft below land surface.

Drilling and Casing Procedures

Initially the well was drilled to 40 ft with a 21-in borehole and completed with 16-in inner diameter schedule 40 PVC casing grouted with 5-percent bentonite cement. A 14 ¾-in borehole was then drilled from 40 to 250 ft below surface. This corehole was lined with 10-in inner diameter schedule 40 PVC casing from the surface to a depth of 250 ft and grouted with 5-percent bentonite cement. A 9 7/8-in corehole was drilled to 494 ft and lined from the surface with 6-in inner diameter schedule 40 PVC casing, also grouted with 5-percent bentonite cement. Finally, a temporary 4-in inner diameter casing was installed from the surface to 496 ft and the well was then cored to 1,244 ft.

Coring and Geophysical Data Collection

Test corehole ROMP 29A was cored continuously from land surface to 1,244 ft using a 5-ft long core barrel. Core samples were retrieved, measured, described, and placed in cardboard boxes for preservation and storage at the Southwest Florida Water Management District office in Brooksville, Florida. Each core box contains approximately ten ft of core. Core recovery ranged from poor to excellent with an overall recovery of about 70 percent.

Caliper, natural gamma, and resistivity logs were collected and provided by the Southwest Florida Water Management District. A digital optical borehole image of the well below 730 ft was collected by the USGS using a Mount Sopris Instrument Company ALT OBI-40™ Optical Televiewer[4].

GEOLOGIC DESCRIPTION

The ROMP 29A test corehole penetrated poorly consolidated to consolidated carbonate and some clastic rocks ranging in age from middle Eocene to Pliocene: Avon Park Formation, Ocala Limestone, Suwannee Limestone, and the Hawthorn Group (fig. 2). Core description is limited to the Avon Park Formation, Ocala Limestone, and Suwannee Limestone. The Hawthorn Group is generally included as part of the intermediate confining unit which overlies the Floridian aquifer (fig. 2). The emphasis of this report is a detailed description of the upper Floridian aquifer; detailed descriptions of the intermediate confining unit are not included in the body of this report. However, a description of the Hawthorn Group below 412 ft is provided in the detailed lithologic logs (Appendix 2).

General Stratigraphy and Depositional Setting

The stratigraphic section described in the Romp 29A test corehole is carbonate rock of Middle Eocene to Oligocene age that includes, from oldest to youngest, the Avon

[4] Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

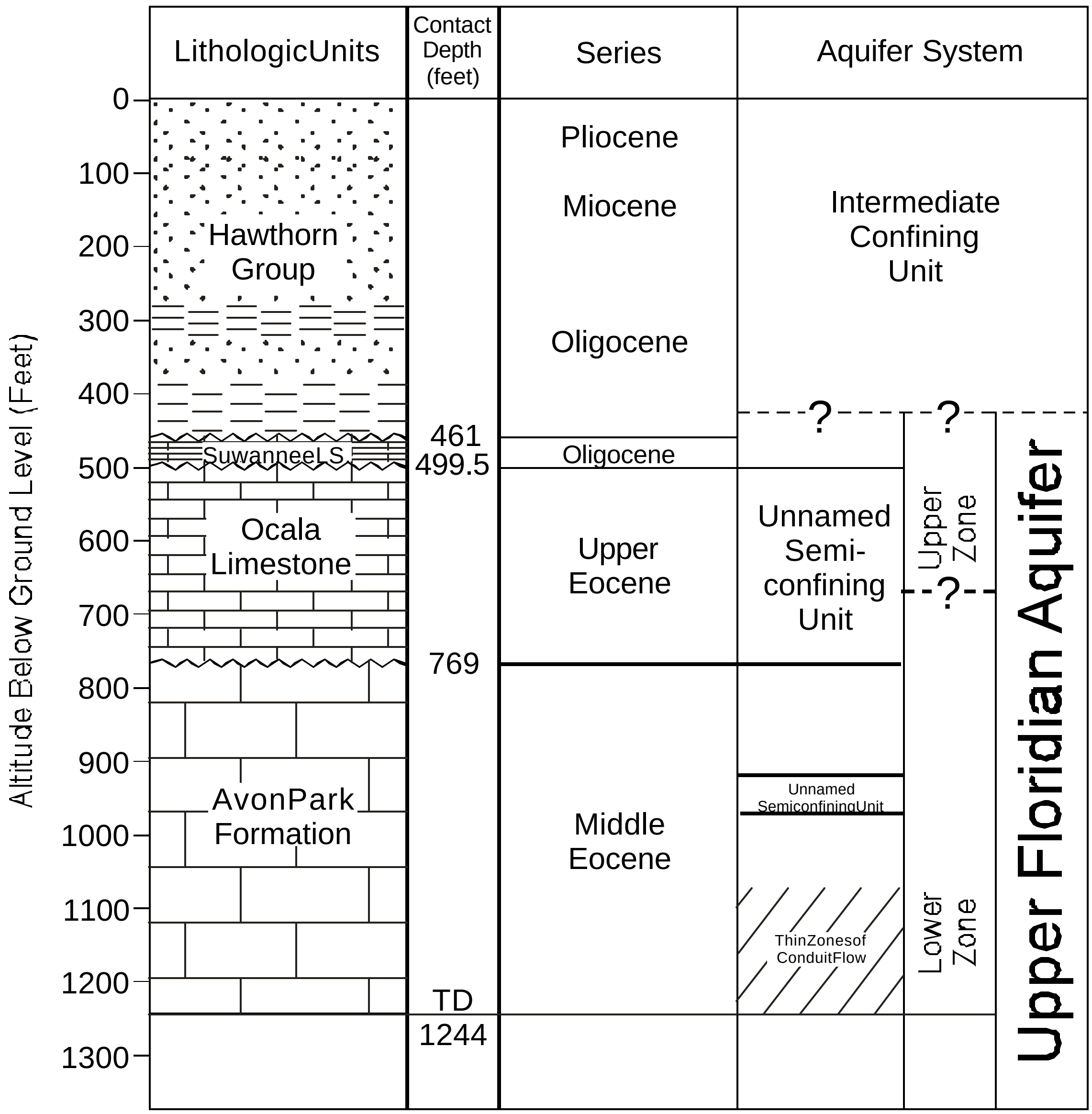

Figure2.StratigraphiccolumnoftheupperFloridianaquiferpenetratedbyROMP29Atestcoreholein HighlandsCounty,Florida.

Park Formation, Ocala Limestone, and Suwannee Limestone Formations. The younger siliciclastic rocks are part of the Hawthorn Group (fig.2).

The shallow-marine limestones and dolomites of the Avon Park Formation were deposited mostly on the inner part of a broad flat-lying carbonate ramp that sloped gently toward the Gulf of Mexico during the Eocene. The fine-grained carbonates of the Ocala Limestone of central Florida were deposited on the mid- to outer-ramp in water depths generally below storm wave base. The Suwannee Limestone represents a return to shallow-marine conditions in central Florida during the early Oligocene. The Hawthorn Group is composed of shallow-marine to non-marine coastal and deltaic sandstone and mudstone, which prograded out over the older carbonate platform during the late Oligocene and Pliocene.

Avon Park Formation

Twelve lithofacies were identified for the Avon Park Formation (Table 1). The vertical distribution of rock types is highly cyclic; consequently, there is considerable vertical heterogeneity of porosity and permeability within the Avon Park Formation. There are few thick intervals of any one lithofacies as shown in the detailed lithologic logs in Appendix 2.

Depositional Sequences and Sequence Stratigraphy

The vertical distribution of lithofacies within the Avon Park Formation inner ramp shows that its depositional setting in south-central Florida changed repeatedly over brief periods. Short-term, low-amplitude changes in relative sea level are recorded by a multitude of high-frequency depositional cycles. These high-frequency cycles (HFC) are the fundamental depositional units that characterize the Avon Park Formation.

The HFC of the Avon Park Formation can be grouped into high-frequency sets reflecting high-frequency fluctuations of relative sea level on a lower order. These HFC sets may be termed high-frequency sequences (HFS). Figure 3 shows the nomenclature that is commonly applied to the various orders of depositional cyclicity in carbonate rocks.

The lithofacies contained in the HFCs record three major depositional settings that predominated during the buildup of the carbonate rocks of the Avon Park Formation: 1) pertidal, 2) open-shelf shallow-subtidal, and 3) open-shelf deeper-subtidal. Table 2 illustrates the common types of HFCs deposited in these three general depositional settings. The successive shifting of these depositional settings through time was closely related to relative sea-level changes recorded by the HFSs. Another order of depositional cyclicity was identified in part of the cored interval of Avon Park Formation. This is an order lower than the HFC and higher than the HFS. This order of cyclicity is called high-frequency cycle set (HFCS)(figs. 3 and 4). The overall large-scale vertical changes in lithology of the Avon Park Formation are evidence of a still lower order of relative-sea-level change, reflected in development of a single composite sequence (figs. 3 and 4). The hierarchical scheme of sequence stratigraphy made from the ROMP 29A test corehole is considered to be tentative (fig.4). The stratigraphic sections in several other wells located in southern Florida need to be evaluated to determine which cycles and sequences defined herein are regionally significant. Excellent correlation of many lithologic units in the Avon Park Formation in ROMP 29A test corehole and the slightly

Tectono-eustatic/ Eustatic cycle order	Sequence stratigraphic unit	Duration (my)	Relative sea level Amplitude (m)	Relative sea level Rise/Fall Rate (cm/1,000 yr)
First		>100		< 1
Second	Supersequence	10 - 100	50 - 100	1 - 3
Third	Depostional sequence, Composite Sequence	1 - 10	50 -100	1 - 10
Fourth	High-Frequency Sequence, Parasequence, High-Frequency Cycle Set	0.1 - 1	1 - 150	40 -500
Fifth	Parasequence, High-Frequency Cycle	0.01 - 0.1	1 - 150	60 - 700

Figure 3. Terminology of stratigraphic cycle hierarchies and orders of cyclicity (modified from Kerans and Tinker, 1997).

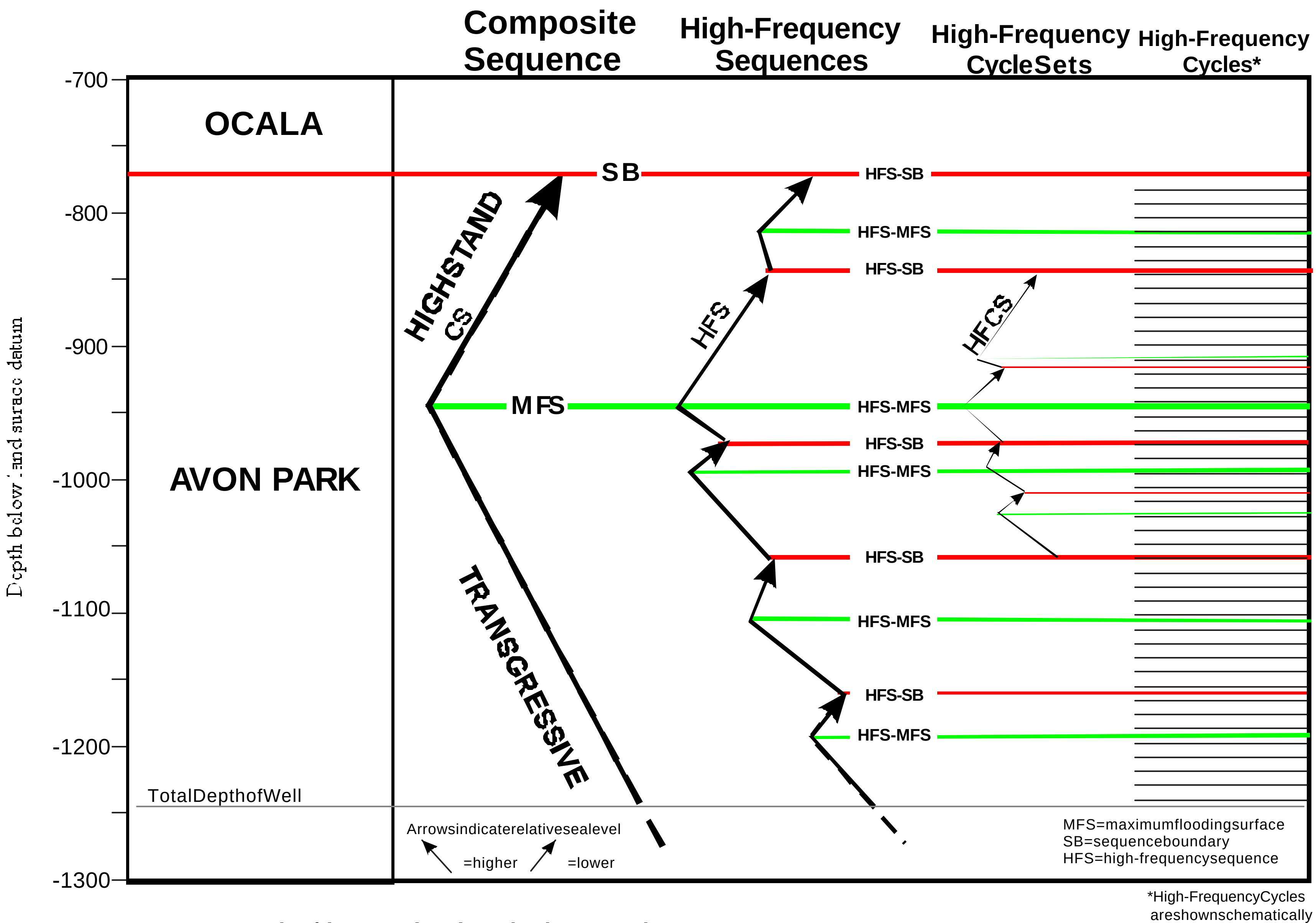

Figure4. Hierarchyof depositional cycleswithintheAvonParkFormation.

downdip ROMP 28 test corehole suggests that at least the proposed intermediate-order cycles proposed may have semi-regional significance.

Relationship of Porosity to Sequence Stratigraphy

There are several correlations between the proposed sequence-stratigraphic framework shown in Figure 4 and the vertical distribution of porous and permeable rocks of the Avon Park Formation in the ROMP 29A test corehole. These relationships are shown in Figure 5.

Most intervals of grainstone and grain-dominated packstone (i.e., rocks likely to have intergranular porosity and relatively high matrix permeability) are in the transgressive portions of the HFS and HFCS. The vertical distribution of grainstone alone shows an even closer tie to the transgressive sequences (not illustrated here). The transgressive portion of the lower-order depositional sequence (CS, fig. 4) is dominated by transgressive parts of the HFS and HFCS. Conversely, the high-stand or progradational part of the CS is dominated by progradational segments of the HFS and HFCS (fig. 4). This explains why the lower transgressive part of the Avon Park Formation section cored in the ROMP 29A test corehole has more grainy limestones than the upper highstand part (Fig. 5). It is likely that carbonate accumulations deposited during transgressive phases may be more laterally extensive than layers deposited during progradation, because progradation produces more laterally discontinuous geometric configurations in depositional environments.

The maximum-flooding surface (MFS) of the depositional sequence (i.e., the record of the maximum landward advance of the sea during Avon Park Formation deposition) is within an interval of deeper-subtidal planktic-foram wackestone. This fine-

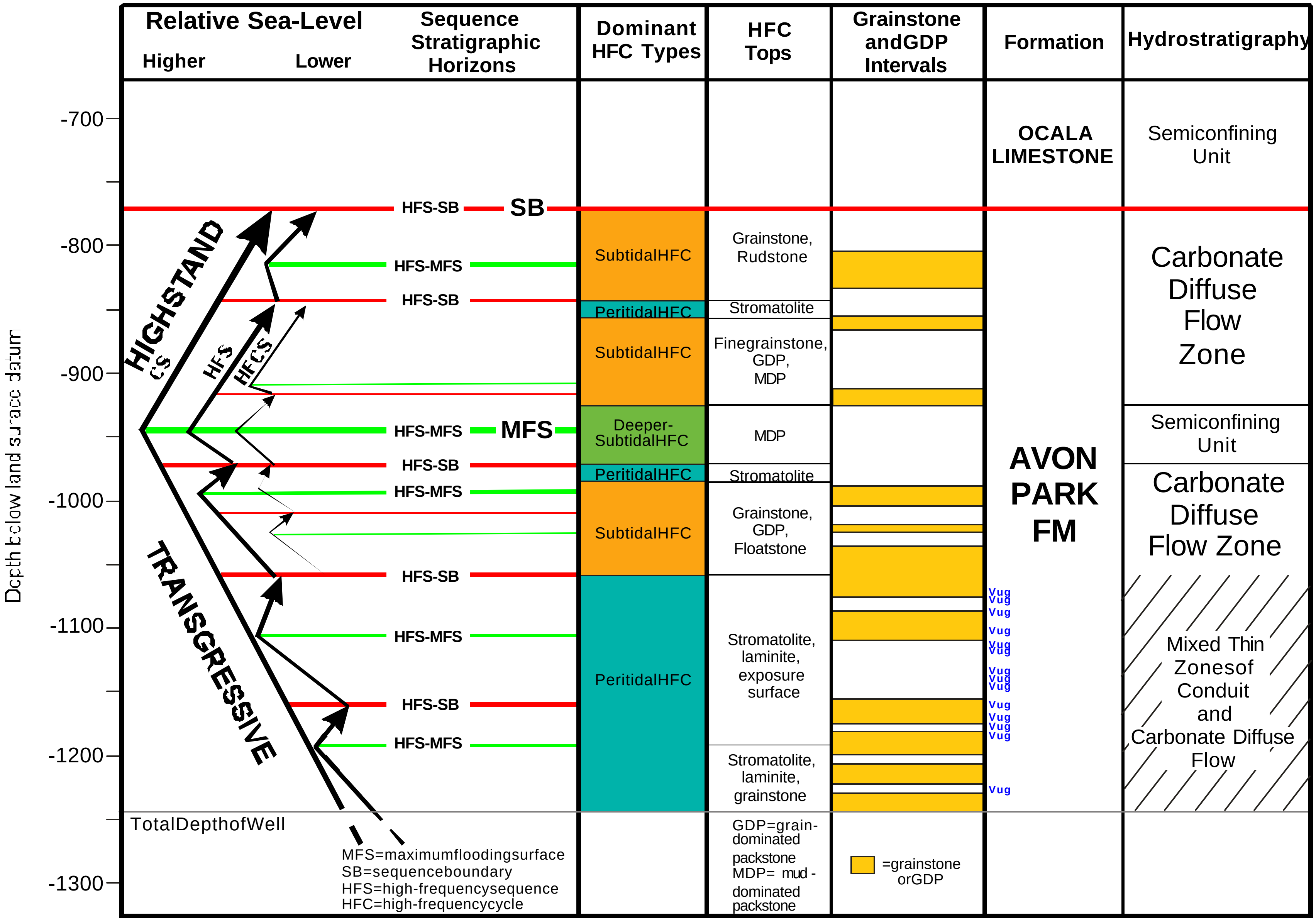

Figure5.Relationofproposedsequence-stratigraphic frameworktovertical distributionof majorpackagesofhig h-frequencycyclesand to intervalsof grainstone/grain-dominatedpackstone.

grained unit probably is an aquitard that separates porous zones in the upper Avon Park Formation from those in the middle and lower Avon Park Formation (fig. 5).

The 1070-1185-ft interval in the ROMP 29A test corehole has numerous large vugs (fig. 5 and Appendix 2). This vuggy zone is in the upper part of the thick interval of peritidal/shallow-subtidal HFCs (fig. 5), which largely corresponds to a transgressive portion of shallower-water HFSs. The peritidal HFCs contain some evidence of tidal-flat or supra-tidal-flat evaporites, such as thin solution breccias, fractures, and molds of gypsum crystals. These thin evaporite layers probably dissolved during early burial, and provided porous and permeable zones of enhanced groundwater flow, thus promoting post-burial dissolution and creating the vuggy interval.

The lower interval between 1082 ft and TD has several fractures with mineralized striations or slickenlines on both surfaces. The mineralized slickenlines are comprised of a darker material than the host rock and are easily identified on the digital borehole image. The sense of motion on the slickenlines is oblique to the fault dip, but lack steps or other kinematic indicators to determine if the dominant motion is normal or reverse. Measurable dips range from 33 to 60 degrees and there is no pattern to the dip direction. The faults formed in the wackestones and packstones and not in any of the dolomitized layers and are possibly related to dissolution of evaporites. These faults, along with the fractured dolomites found near the base of the core, large dissolution cavities, and vugs in the 1070-1185-ft interval indicate increased permeability below 1070 ft.

Porosity and Diagenesis

The ROMP 29A test corehole penetrated the upper 18 ft of a pervasively dolomitized zone of the lower Avon Park Formation between 1226 and 1244 ft. This vuggy and fractured section probably has relatively high porosity and permeability. The overlying part of the Avon Park Formation, however, has only scattered thin zones of finer-crystalline dolomite with relatively low porosity and permeability. Most of the core from the Avon Park Formation shows little alteration of the depositional fabric by post-burial diagenesis. Apparently in this area of the carbonate ramp, sediments of Avon Park Formation were buried without being subjected to a substantial influx of fresh water. Porosity of 30 to 40 percent is still preserved in many grainstones and grain-dominated packstones as well as in mud-dominated packstone and wackestone. Even intraskeletal porosity in many foraminifers is preserved. However, matrix permeability is high only in the grainy limestones (Budd, 2001).

Except in the coarse-dolomitized intervals and the vuggy zones, secondary porosity is not as important to fluid flow as is the preserved intergranular porosity. There is minor fossil-moldic porosity in the generally foraminifer-rich limestones of the Avon Park Formation, but only a few thin layers rich in mollusks have extensive moldic porosity. In echinoid-rich grainstones, intergranular porosity is occluded by coarse syntaxial cement.

The zone of large vugs between 1070 and 1244 ft in the lower part of the cored interval of Avon Park Formation shows evidence of a late-stage invasion of dolomitizing ground water (brines?). A narrow dense zone around many vugs was dolomitized and large fibrous crystals of dolomite and anhydrite grew in the vugs. It appears that this late-stage diagenesis created a dense, poorly permeable zone around many of the vugs. If so, this might affect fluid flow in the vuggy interval.

Ocala Limestone

The Ocala Limestone penetrated by ROMP 29A test corehole is a 270-ft section of poorly consolidated carbonate-mud-rich limestone of Late Eocene age. In south-central Florida the Ocala Limestone probably was deposited in a mid- to outer-ramp setting, generally below normal wave base. Wave- or current-winnowed grainy limestones, therefore, are absent in the Ocala Limestone in this well. Even so, cyclic vertical heterogeneity in lithology is characteristic (Appendix 2).

The two predominant lithofacies are 1) soft, large-benthic-foram (*Nummulites* and/or *Lepidocyclina)* wackestone; and 2) poorly indurated, large-benthic-foram mud-dominated packstone. In addition, there are a few intervals of floatstone and mud-dominated rudstone composed of abundant *Lepidocyclina* foraminifers several centimeters in diameter. Another less common lithofacies is mixed-skeletal wackestone with few or no large foraminifers. Other fossils in these lithofacies include planktic foraminifers, small benthic foraminifers, thin-shelled bivalves, echinoids, bryozoans, ostracodes, and planktic crinoids.

Depositional Sequences and Sequence Stratigraphy

The Ocala Limestone of this region is composed of deeper-subtidal depositional cycles of at least two orders of frequency. Loizeaux (1995) and Budd (2001) traced three lower-frequency depositional sequences within the Ocala Limestone across west-central Florida as far east as the Romp 28 test corehole. Without the regional correlations, other packaging of Ocala Limestone lithofacies might well be made in the southeastern reaches of their areas of study. Loizeaux (1995) designates these major coarsening- and shallowing-upward depositional units as third-order sequences.

Using nearby Romp 28 test corehole for comparison, three lower-order depositional sequences (fig. 3) also can be defined in the Ocala Limestone of Romp 29A test corehole:

1) The lower depositional sequence overlying the unconformity at the top of the Avon Park Formation is 90 ft of predominantly large-benthic-foram wackestone between 679 and 769 ft. Most of the lower 55 ft is well laminated with alternating layers of light-gray and darker-gray *Nummulites* wackestone. Above this is non-bedded (presumably highly bioturbated) *Lepidocyclina-Nummulites* wackestone coarsening upward to *Lepidocyclina-Nummulites* mud-dominated packstone and topped with 8 ft of large *Lepidocyclina* floatstone and thin rudstone.

2) The middle sequence is 93 ft of *Lepidocyclina* wackestone with thin *Lepidocyclina* mud-dominated packstone.

3) The upper sequence between 499.5 and 585 ft is mostly mixed-skeletal wackestone with minor mud-dominated packstone and a 1.5 ft layer of *Lepidocyclina* floatstone at 541.5 ft. The upper boundary is a regional unconformity at the top of the Ocala Limestone.

Within each "third-order" sequence, Loizeaux (1995) tentatively defined two to three higher-order coarsening-upward depositional cycles. Typically, the high-frequency depositional cycles are 15 to 50 ft thick and consist of large-foram wackestone overlain by large-foram mud-dominated packstone. Using Loizeaux's criteria, the lower Ocala sequence in the Romp 29A test corehole tentatively could be divided into three higher-frequency units; the middle, into five; and the upper, into three. The meaning of textural changes in a mid- to outer-ramp large-foram buildup is problematic. In addition, it is uncertain how these subaqueous higher-order cycles relate to various high-order cycles as defined in shallow-water limestones.

Relationship of Porosity and Permeability to Sequence Stratigraphy

The Ocala Limestone in the vicinity of the Romp 29A test corehole is composed entirely of carbonate-mud-rich rocks. Much of the original high matrix porosity, however, is preserved. Porosity values typically range from 30 to 40 percent (Loizeaux, 1995). By contrast, matrix permeability and vertical hydraulic conductivity are low in the mud-dominated lithofacies of the Ocala Limestone of west-central Florida (Loizeaux, 1995; Budd, 2001).

For this area of deeper-subtidal depositional cycles, no zones of enhanced porosity and permeability are expected in the Ocala Limestone, regardless of place in the depositional system tracts. The Ocala Limestone is considered a semiconfining unit (figs. 2 and 5)

Suwannee Limestone

In the area where the Romp 29A test corehole was drilled, only a thin erosional remnant of shallow-marine Suwannee Limestone overlies the unconformity at the top of the Ocala Limestone. In the Romp 29A test corehole, the basal unit of Suwannee is a 21-ft interval of white, slightly silty, mollusk floatstone and mud-dominated rudstone. Molds of whole bivalves and gastropods are abundant, and echinoid fragments are common. Moldic porosity is high, but permeability probably is low because the molds do not appear to be well connected.

Abruptly overlying the basal unit is a 17-ft coarsening-upward sequence, passing upward from silty and sandy skeletal mud-dominated packstone to silty and sandy skeletal grain-dominated packstone and then into silty and sandy miliolid-echinoid grainstone. Molds of gastropods and bivalves are common at the top of this depositional cycle. The intergranular porosity of the grainstone estimated in thin section is only 10 to 15 percent, because much of the pore space is occluded by syntaxial echinoid overgrowths.

At the top of this thin remnant of Suwannee are irregular vertical cavities infiltrated by Hawthorn silt. This surface probably is microkarst produced during subaerial exposure, which followed extensive erosion of the Suwannee Limestone and preceded deposition of the shallow-marine silt and sand of the basal Hawthorn Group.

Depositional Sequences

Only portions of two high-frequency depositional sequences are preserved in the Suwannee Limestone in the vicinity of the Romp 29A test corehole (fig. 3). This fragmentary stratigraphic record precludes any meaningful analysis of the sequence stratigraphy.

QUANTIFICATION OF VUGGY POROSITY FROM DIGITAL BOREHOLE IMAGES

Vuggy porosity is visible “pore space that is within grains or crystals or that is significantly larger than the grains or crystals; that is, pore space that is not interparticle” (Lucia, 1995). Intraparticle pores, particle molds, fenestrals, channels, vugs, and caverns of Choquette and Pray (1970) are included in this definition. Identification of vugs and fractures by geophysical logging is normally accomplished, in the absence of image logs, by combining and interpreting several logs, including: sonic, dipmeter, laterolog and induction, density, spontaneous potential, caliper, and natural gamma-ray spectrometry (Crary et al., 1987). Identifications of vugs and fractures using these logs are challenging and interpretive in the absence of a borehole-wall image. Visual interpretations of digital borehole images are the most reliable and practical method of identifying vuggy porosity in the limestone of the Floridan aquifer. Electronic images of borehole walls are being used to quantify vuggy porosity (Hickey, 1993; Newberry et al., 1996; Hurley et al., 1998; 1999) in petroleum reservoirs and fracture porosity in aquifers (Williams and Johnson, 2000). Quantification of digital borehole images is an important new technology that can improve delineation of zones of preferential flow and was used successfully to quantify digital borehole images of the Pleistocene Biscayne aquifer (Cunningham and others, in press). This approach has also been successfully applied to the Upper Floridan aquifer.

Digital borehole image logs were run in the ROMP 29A test corehole while filled with clear fresh water using the Mount Sopris OBI-40™ Optical Borehole Image logging tool. Mount Sopris has designed the OBI-40 logging tool for clear-water borehole environments to monitor, process, and record optical images of borehole walls in digital format for geological and geotechnical analysis. Quantification of vuggy porosity in borehole images of limestone and dolomite carbonate aquifers is a three-step process using Baker Atlas's RECALL™ software[5]. This process includes measurement of the

[5] Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

proportion of vugs in images of slabbed whole-core samples, identification of potential vuggy porosity in borehole images, and calibration of the core-sample values to the results from borehole-images.

For purposes of this investigation and due to time and funding contraints, digital borehole images were not calibrated with whole-core samples. Threshold values similar to those identified in core-calibrated Pleistocene carbonates of south Florida were used to calculate vuggy porosity (Cunningham and others, in press). Accordingly, the synthetic porosity log provides only an estimate of vuggy porosity. However, the synthetic vuggy porosity log can be used to compare changes in porosity within the entire open-hole optically logged interval.

REGIONAL DISTRIBUTION OF TRANSMISSIVITY IN THE NORTHERN LAKE OKEECHOBEE AREA

Transmissivities optimum for injection and recovery in successful ASR in south Florida are reported to range from values as low as 5,000 to 7,000 ft^2/day to an upper limit of 30,000 to 50,000 ft^2/day (R.S. Reese, 2001, p. 40; T.M. Missimer, 2001, verbal communication). Therefore, maps showing the spatial distribution of transmissivity within likely water-bearing storage zones could help direct CERP regional ASR well siting activities. A number of different elements are reported to influence the distribution of transmissivity in the Floridan aquifer system (Miller, 1986). Properties that influence the regional distribution of transmissivity in the Floridan aquifer system include the original lithologic character of the carbonate rock, carbonate depositional patterns, subsequent diagenesis including dolomitization, widening of fractures and joints by dissolution, and other types of karstification.

Estimates of transmissivity for the Upper Floridan aquifer were limited to data obtained from the Southwest Florida Water Management District (SWFWMD) or from the literature (Shaw and Trost, 1984), and derived by the analysis of aquifer test data. Whereas transmissivity estimates derived by Shaw and Trost (1984) have been estimated using the Theis analytical equation, transmissivity estimates obtained from the SWFWMD were estimated using a variety of analytical methods including Theis (1935), Cooper and Jacob (1946), Jacob (1946) for confined aquifers. Hantush and Jacob (1955) and Walton (1962) were used for semiconfined, leaky hydrologic conditions. The thicknesses of open-hole aquifer-test intervals varied widely ranging from as little as 1 ft to as much as 2100 ft (fig. 6). However, large open-hole thickness in most wells prohibits hydraulic evaluation or direct comparison of discrete flow zones within the stratigraphic section. For example, most transmissivity estimates are based on open-hole intervals that range between 250 and 1000 ft thick (fig. 6).

The reader should consider this analysis as preliminary as it provides an incomplete regional depiction of transmissivity patterns within the Upper Floridan aquifer. Other data that may be available in the literature or contained within the files of the U.S. Geological Survey, South Florida Water Management District, or private consultants were not compiled or synthesized as part of this effort.

For purposes of this analysis, the Upper Floridan aquifer was separated into ‘upper’ and ‘lower’ zones depending on the thickness and vertical position of the open-hole interval. The ‘upper zone’ is considered to be representative of open-hole conditions

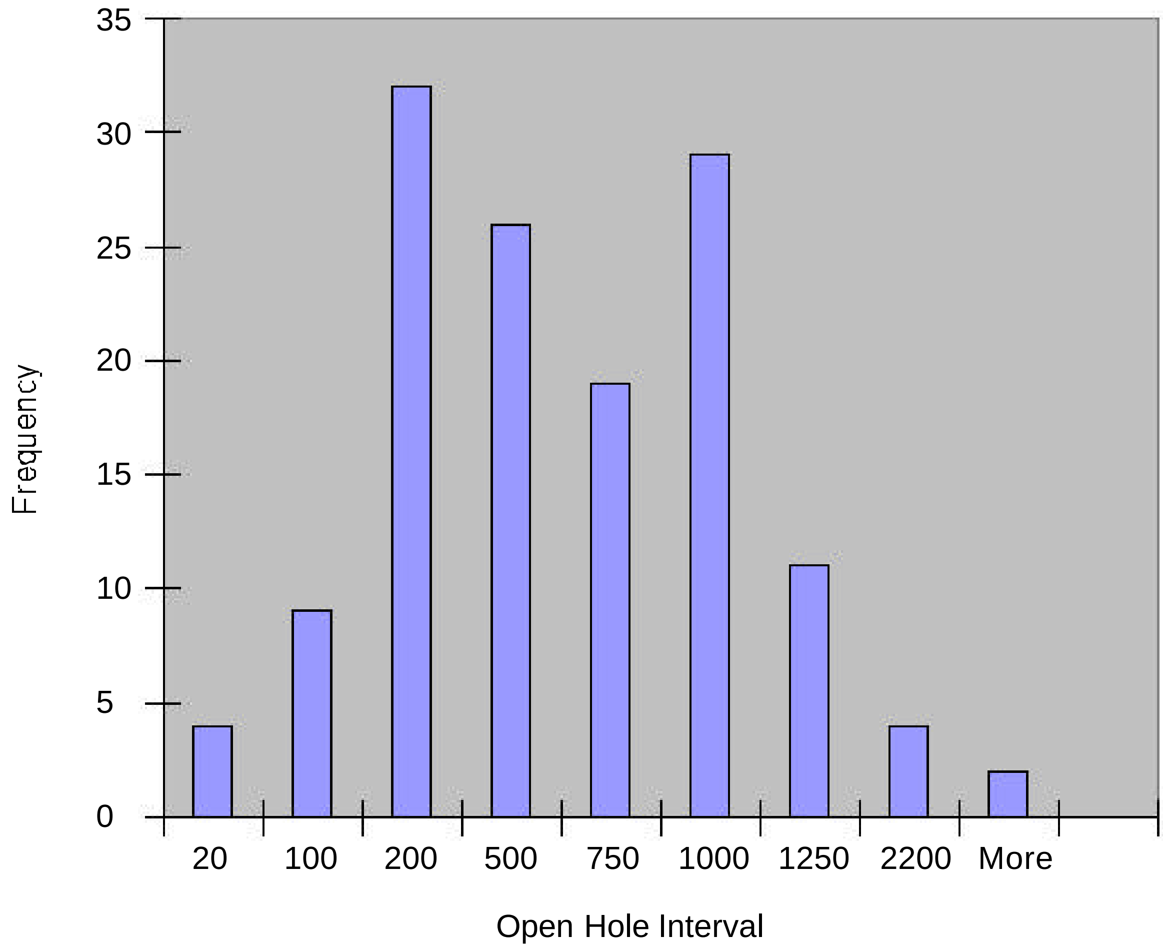

Figure6. Histogram showingfrequencyofthelengthofopen-holeinterval,infeet.

contained within the lower part of the Hawthorn Group, Suwannee Limestone, and Ocala Limestone and is considered, at least in part, correlative with the ‘upper zone’ defined in figure 2. The ‘lower zone’ includes open-hole wells assigned the Ocala Limestone and Avon Park Formation and considered partly equivalent to the ‘lower zone’ of figure 2. This arbitrary division into ‘upper’ and ‘lower’ zones is partly based on comparison of major hydrogeologic units identified in the ROMP 29A test corehole (fig. 2) and a cursory correlative examination of the nearby ROMP 28 test corehole (fig. 1). The areal extent of hydrogeologic zones continuity has not been verified. However, the assignment of hydraulic data into these two zones north of Lake Okeechobee does appear to provide information regarding the distribution of regional transmissivity.

Geologic maps have been used to tentatively assign aquifer-test data to specific geologic or hydrogeologic units by comparing reported open-hole depth intervals with structure contour maps available in the literature (Miller, 1986). The reader is cautioned that a more detailed analysis is required, both in terms of re-evaluating the assignment of open-hole intervals to ‘upper’ or ‘lower’ water-bearing zones defined herein (fig. 2), and an inherent need to synthesize hydraulic data encompassing a wider areal extent. In addition, open-hole intervals that represent the combined transmissivity of both ‘upper’ and ‘lower’ zones were not included in this analysis; it was not possible to apportion transmissivity into ‘upper’ and ‘lower’ zones.

On the basis of a preliminary analysis of data, a spatial relation among groups of relatively high and low transmissivity values within the ‘upper zone’ is evident. For the most part, transmissivity of the ‘upper zone’ is less than 10,000 ft^2/day in areas located south of a line that extends from northern St. Lucie, Okeechobee, eastern Polk, DeSoto, and southern Sarasota Counties (fig. 7). Hydraulic data compiled for the lower zone (Ocala Limestone and Avon Park Formation) is much less extensive in terms of its distribution; therefore, regional differences or spatial patterns are more difficult to recognize. In any case, transmissivity of the ‘lower’ zone appears to be less than 10,000 ft^2/day in much of Highlands County (fig. 8).

CONCLUSIONS

The ROMP 29A exploratory well, near Sebring, FL, was continuously cored to a depth of 1244 ft and geophysically logged by the Southwest Florida Water Management District; digital optical borehole image data were collected as part of this study in the open-hole interval extending from 730 to 1240 ft below land surface. Digital borehole images were quantified and used to improve delineation of zones of preferential flows. ROMP 29A penetrated rocks ranging in age from Eocene to Pliocene age, including (in ascending order) the Avon Park Formation, Ocala Limestone, Suwannee Limestone and Hawthorn Group.

The vertical distribution and thicknesses of porous and permeable layers within the Avon Park limestone in south-central Florida is heterogeneous. No porous interval is more than a few tens of feet thick, with most found to be much thinner. Though the layers of porous limestones may not be thick, there may be extensive lateral and predictable continuity of some porous intervals because of deposition on a flat-lying, low relief ramp. There is good preservation of intergranular porosity in many Avon Park grainstones and grain-dominated packstones. At least three orders of cyclicity are recorded in the core. The vertical distribution of texture and continuity is strongly related

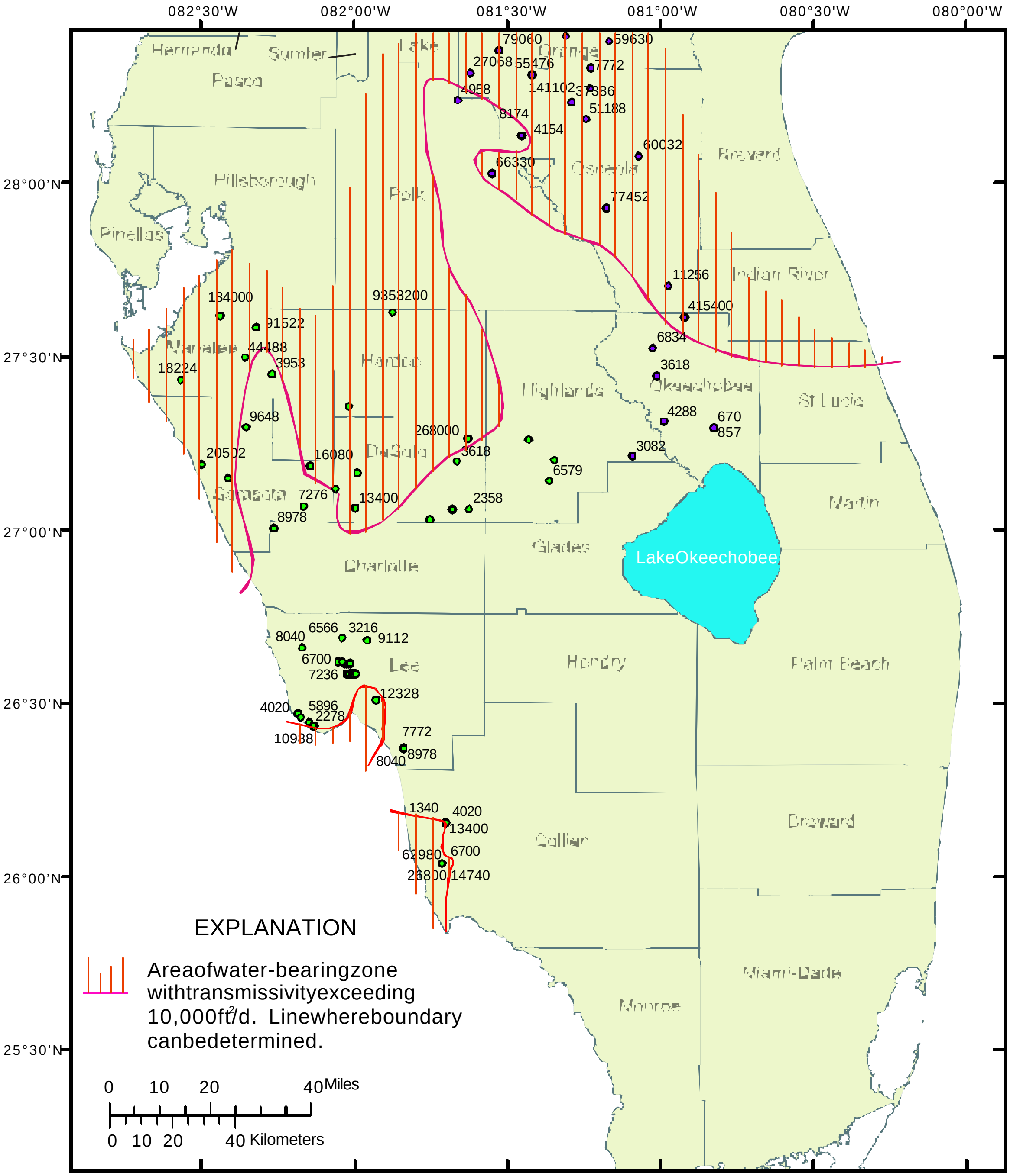

Figure 7. Regional distribution of transmissivity of the Upper Floridian aquifer's "upper zone" (lower part of the Hawthorn Group, Suwannee Limestone, and Ocala Limestone equivalent).

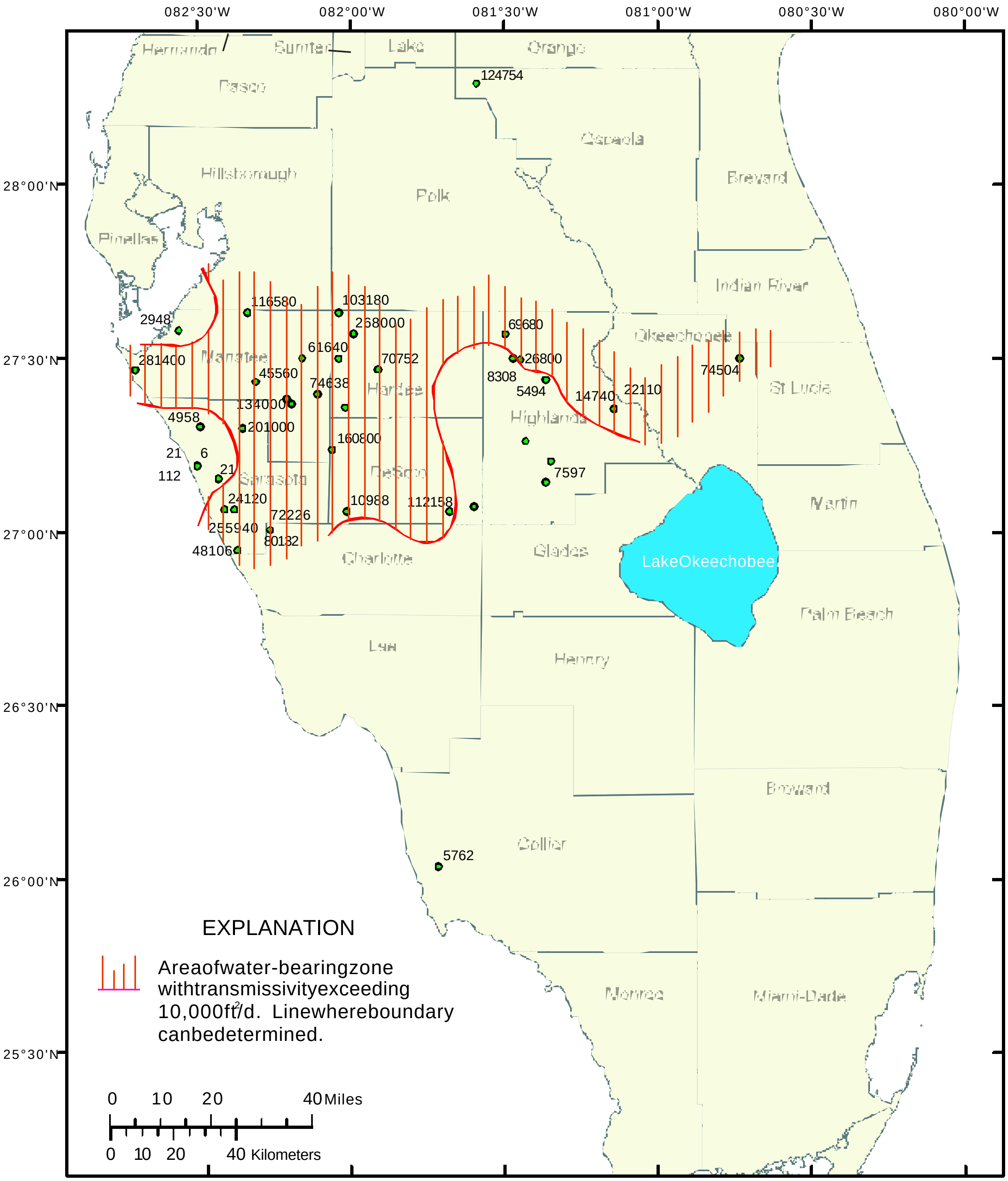

Figure8.Regionaldistributionoftransmissivityofthe UpperFloridianaquifer's "lower zone" (Ocala Limestone andAvonParkFormationequivalent).

to the sequence stratigraphy of the Avon Park Formation. Porous grainstones were preferentially deposited during transgressive phases of at least three orders of depositional cyclicity, except during deposition in deeper water. A thick interval of thin vuggy zones and open faults form thin conduit flow zones mixed with relatively thicker carbonate diffuse flow zones at depths of 1070 and 1244 ft below land surface. This interval, included in the transgressive systems tract of the composite sequence, represents the most transmissive portion of the Avon Park Formation penetrated in the ROMP 29A test corehole.

The Ocala Limestone, considered to be a semi-confining unit, contains three lower-order depositional sequences in the Romp 29A test corehole. Deposited within deeper-subtidal depositional cycles, no zones of enhanced porosity and permeability are expected in the Ocala Limestone. The thin erosional remnant of the shallow-marine Suwannee Limestone overlies the Ocala Limestone and permeability appears to be comparatively low as moldic porosity is poorly connected.

Rocks that comprise the Lower Hawthorn Group, Suwannee Limestone, and Ocala Limestone form the permeable 'upper zone' and rocks of the lower Ocala Formation and Avon Park Formation comprise a permeable 'lower zone'. On the basis of a preliminary analysis of transmissivity estimates for wells located north of Lake Okeechobee, spatial relations among groups of relatively high and low transmissivity values within the 'upper zone' are evident. Upper zone transmissivity is generally less than 10,000 ft^2/day in areas located south of a line that extends from northern St. Lucie, Okeechobee, eastern Polk, DeSoto, and southern Sarasota Counties. Transmissivity patterns within the Avon Park Formation's 'lower zone' can not be regionally assessed as insufficient data of wide areal extent have been compiled.

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Table 1. Depositional Lithofacies

AVON PARK FORMATION

Lithofacies	Composition	Interpretation
Benthic-foram wackestone/ mud-dominated packstone	Carbonate-muddy limestone dominated by benthic foraminifers, most commonly miliolds. Other common constituents: *Dictyoconus*, *Fabularia*, ostracodes, mollusks, pellets and peloids. Generally low and highly variable porosity: moldic, vuggy, microcrystalline, and intraskeletal.	Low-energy inner shelf. Shallow subtidal to intertidal.
Benthic-foram grain-dominated packstone/ grainstone	Grainy limestone dominated by benthic foraminifers, most commonly miliolids. Other common constituents: *Dictyoconus*, *Fabularia*, Shallow subtidal to ostracodes, mollusks, and intraclasts. Generally good porosity (10-25% estimated in thin section): intergranular, intraskeletal, moldic, and vuggy.	High-energy inner shelf. Shallow subtidal to intertidal.
Skeletal wackestone/ mud-dominated packstone	Carbonate-muddy limestone with echinoids, mollusks, and mixtures of benthic and planktic foraminifers. Generally low and highly variable porosity: moldic, vuggy, microcrystalline, and intraskeletal.	Low-energy open shelf. Shallow subtidal.
Skeletal grain-dominated packstone/grainstone	Grainy limestone with benthic foraminifers, echinoids, mollusks, peloids, and intraclasts. Generally good porosity (10-25% estimated in thin section): intergranular, intraskeletal, moldic, and vuggy.	High-energy open shelf. Shallow subtidal.
Skeletal floatstone/rudstone	Coarse-grained equivalent of skeletal wackestone/MDP and GDP/ grainstone rich in gravel-size mollusks and/or echinoids. Variable porosity (low in echinoid-rich layers): intergranular, intraskeletal, moldic (especially in mollusk-rich layers) and vuggy.	Shallow subtidal.
Planktic-foram wackestone/ mud-dominated packstone	Carbonate-muddy limestone with abundant planktic foraminifers, ostracodes, echinoids and pellets. Porosity low: microcrystalline,	Open shelf. Deeper subtidal

	moldic, vuggy, intraskeletal.	
Stromatolite	Wavy laminated carbonate mudstone, fine packstone, or fine grainstone with thin irregular organic-rich laminae. Constituents: pellets, ostracodes, and benthic foraminifers. Porosity highly variable, up to estimated 20% in grainy laminae: moldic, fenestral, vuggy, intergranular, minor fracture.	Restricted inner shelf. Intertidal to supratidal.
Laminite	Laminated carbonate mudstone and/or wackestone. Poorly fossil-iferous. Ostracodes and benthic foraminifers. Pellets. Generally very low porosity: fenestral, fracture, moldic.	Restricted inner shelf. Low-energy tidal flats.
Intraclastic floatstone/rudstone	In situ carbonate conglomerate composed of gravel-size fragments of limestone and dolomite. Porosity highly variable depending on amount of matrix: intergranular, fracture, moldic.	
Rip-up-clast breccia	Intraclast floatstone/rudstone composed of mostly angular fragments of laminite, stromatolite, or other carbonate rock types.	Mostly shallow inner shelf. Ocassional surges of wave energy. Peritidal & shallow subtidal.
Collapse breccia	Intraclast floatstone/rudstone composed of rounded to angular fragments of various limestone rock types. Some with cave cements.	Zones of post-depositional Mostly associated with large vugs or caves. Others associated with dissolutin of evaporites in tidal-flats.
Caliche	Carbonate mudstone with clotty microstructure, circumgranular cracking, and fitted clasts. Poorly to non-fossiliferous. Very low porosity: fracture and vuggy. Commonly hard and dense.	Subaerial exposure.

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Table 2. High-Frequency Cycles

AVON PARK FORMATION

General Depositional Setting	Typical High-Frequency Cycle Type
Peritidal: very shallow subtidal, intertidal, and supratidal.	Peritidal HFC: Less than 1 ft to a few ft thick (15-ft maximum). Mostly fining-upward sequences. Mostly benthic-foram wackestone/mud-dominated packstone (MDP) or benthic-foram grain-dominated packstone (GDP)/grainstone at the base to stromatolite or laminite at the top. A few cycles capped by exposure surfaces (caliche and microkarst).
Subtidal: open-shelf shallow subtidal.	Subtidal HFC: From 1 to 10 ft thick. Mostly coarsening upward. From skeletal wackestone/MDP or skeletal GDP at the base to GDP or grainstone at the top. Some crossbedding at the top. Some burrowing in the lower part.
Deeper subtidal: open-shelf generally below wave base.	Deeper-Subtidal HFC: From 10 to 20 ft thick (definition of these HFCs is locally difficult). From planktic-foram wackestone at the base to MDP at the top. Well-preserved laminations in some places. Other zones highly burrowed.

Table 3. Hydraulic data for selected wells (Southwest Florida Water Management District)

Well NAME	LAT	LONG	County	Dia. (in)	CD (ft)	TD (ft)	Open Hole Interval (ft)	Aquifer	Zone Tested	Type of Test	Transmissivity (gpd/ft) or [ft2/d]
LM-1914	263100	815444	Lee	6				L. Haw.		APT	92,000
LM-3249	264147	820119	Lee	12	500	735	235	L. Haw.		APT	49,000
LM-3273	264128	815631	Lee	12		800	800	L. Haw.		APT	24,000
LM-1622	264003	820859	Lee	16	365	963	598	L. Haw.		APT	60,000
LM-2213	263738	820200	Lee	10	360	863	503	L. Haw.		APT	54,000
LM-3513	262838	820943	Lee	16	616	682	66	L. Haw.		APT	13,600
LM-944	262753	820910	Lee	10	440	608	168	L. Haw.		APT	15,600
LM-944	262753	820910	Lee	10	440	608	168	L. Haw.		APT	17,600
LM-2464	262707	820732	Lee	4	665	905	240	L. Haw.		APT	17,000
LM-987	262625	820641	Lee	12	660	774	114	L. Haw.		APT	30,000
LM-988	262624	820639	Lee	4	660	775	115	L. Haw.		APT	82,000
LM-988	262624	820639	Lee	4	660	775	115	L. Haw.		APT	88,000
LM-988	262624	820639	Lee	4	660	775	115	L. Haw.	660-715	APT	83,000
LM-988	262624	820639	Lee	4	660	775	115	L. Haw.	660-715	APT	82,000
LM-2041	262243	814921	Lee	4	350	620	270	L. Haw.		APT	58,000
LM-1980	262242	814918	Lee	8	350	660	310	L. Haw.		APT	
LM-1980	262242	814918	Lee	8	350	660	310	L. Haw.		APT	
LM-1980	262242	814918	Lee	8	350	660	310	L. Haw.		APT	67,000
LM-1980	262242	814918	Lee	8	350	660	310	L. Haw.		APT	58,000
LM-2424	263720	820049	Lee	12	599	764	165	L. Haw.		APT	
LM-2425	263720	820028	Lee	12	599	742	143	L. Haw.		APT	18,000
LM-2426	263720	820015	Lee	12	590	765	175	L. Haw.		APT	63,500
LM-2427	263720	820002	Lee	12	520	702	182	L. Haw.		APT	
LM-2428	263722	815947	Lee	12	20	782	762	L. Haw.		APT	
LM-2417	263532	820020	Lee	12	450	707	257	L. Haw.		APT	
LM-2418	263532	820007	Lee	12	440	700	260	L. Haw.		APT	
LM-2419	263533	815948	Lee	12	495	722	227	L. Haw.		APT	
LM-2420	263533	815918	Lee	12	490	710	220	L. Haw.		APT	
LM-2421	263533	815904	Lee	12	508	720	212	L. Haw.		APT	
LM-2422	263533	815849	Lee	12	510	720	210	L. Haw.		APT	
LM-2423	263533	815835	Lee	12	515	642	127	L. Haw.		APT	
LM-1527	262624	820639	Lee	4	750	770	20	SUW	760-775	APT	98,000
LM-1527	262624	820639	Lee	4	750	770	20	SUW	760-775	APT	79,000
LM-1527	262624	820639	Lee	4	750	770	20	SUW	760-775	APT	82,000
LM-3508	264124	815631	Lee	6	785	1100	315	SUW		APT	68,000

LM-2213	263738	820200	Lee	10	360	863	503	SUW		APT	50,000
LM-2221	263740	820157	Lee	4	360	863	503	L. HAW/ SUW		APT	104,000
LM-2464	262707	820732	Lee	4	665	905	240	SUW		APT	32,880
LM-987	262625	820641	Lee	12	660	774	114	SUW		APT	44,000
LM-2221	263740	820157	Lee	4	360	863	503				104,000
CO-2080	260249	814145	Collier	12	360	1608	1248	Haw.	465-530	Packer	200,000 est.
CO-2080	260249	814145	Collier	12	360	1608	1248	L. Haw.	680-760	Packer	
CO-2081	260952	814107	Collier	12	318	1616	1298	L. Haw.	630-720	Packer	10,000
CO-2080	260249	814145	Collier	12	360	1608	1248	SUW	930-1020	Packer	50,000 est.
CO-2081	260952	814107	Collier	12	318	1616	1298	SUW	945-1000	Packer	30,000
CO-2080	260249	814145	Collier	12	360	1608	1248	Ocala	1180-1220	Packer	
CO-2081	260952	814107	Collier	12	318	1616	1298	L. SUW/Ocala	1250-1616	Packer	100,000
CO-2080	260249	814145	Collier	12	360	1608	1248	Avon Pk.	1345-1606	Packer	43,000 est.
N. Port Deep Inj. Well (148)	270043	821442	Charlotte		560	1100	540	SUW	560-1100	Packer	67,000
N. Port Deep Inj. Well (148)	270043	821442	Charlotte		560	1600	1040	SUW/Ocala/ Avon Park	560-1600	Packer	539,000
N. Port Deep Inj. Well (148)	270043	821442	Charlotte		1100	2000	900	Avon Park	1100-2000	Packer	1,122,000
N. Port Deep Inj. Well (148)	270043	821442	Charlotte		1100	3200	2100	Avon Park	1100-3200	Packer	1,910,000
Cecil Webb Romp 5 (163)	265645	814828	Charlotte	12	720	970	250	SUW	720-970	APT	19,522
Amax (126)	271439	820253	De Soto	24	280	1550	1270	Ocala/Avon Park		APT	1,200,000
Tropical River Groves (127)	271628	813714	De Soto	12	175	1340	1165	SUW/Ocala		APT	2,000,000
Wilson (128)	271405	814532	De Soto				0	Floridan		APT	6,300,000
ROMP 9.5	270737	820250	De Soto	12(505-800)	800	801	1	SUW	505-801	APT	[4,870 ft2/d]
Prairie Creek ROMP 12	270228	814432	De Soto	22(710-1100)	1100	1133	33	SUW	725-909	APT	[7,060 ft2/d]
Tippen Bay ROMP 13	270419	813658	De Soto	6	674	786	112	SUW	671-786	APT	17,600
Long Island Marsh ROMP 15	271233	813922	De Soto	10	576	880	304	SUW/Ocala			27,000
Horse Creek ROMP 17	271028	815835	De Soto	6(395-1430)	1430	1430	0	SUW	670-780	APT	[7,000 ft2/d]
Peace River Well 0414-5847 (140)	270402	815956	De Soto		124	1072	948	Avon Park		APT	82,000
Fort Ogden Test Site 15 (141)	270417	815901	De Soto	20	160	1090	930	SUW/Ocala		APT	100,000
DeSoto Land & Cattle (142)	270413	814009	De Soto	12		1600	1600	SUW/Ocala/ Avon Park		APT	880,000
Sunpure Groves Well 201 (144)	270502	813410	De Soto	8	688	1154	466				990,000
Sunpure Groves Well 101 (146)	270314	813413	De Soto	10	638	1547	909				2,250,000
North Grove PW-1 (145)	270501	813520	De Soto	12	650	1544	894	Suw/Ocala/Avon Park		APT	837,000
CF Industries (101)	273446	815851	Hardee	20	514	1175	661	Avon Park	950-1175	APT	2,000,000

USSAC-S Rockland Mine (102)	273817	815201	Hardee	24	400	1050	650	Ocala	700-1050	APT	69,800,000
Mississippi Chemical (109)	273024	820145	Hardee	10	700	1100	400	Ocala/Avon Park	750-1100	APT	1,000,000
Estech (100)	273818	820149	Hardee	14	950	1320	370	Ocala/Avon Park		APT	770,000
CF Industries (101)	273446	815851	Hardee				0	Avon Park	1500-1702	APT	1,400
Farmland Industries FIF-1 (111)	272841	815403	Hardee	18	472	1400	928	Ocala/Avon Park	1000-1400	APT	528,000
Lily ROMP 25	272159	820025	Hardee	12(300-676)	676	1911	1235	SUW	305-675	APT	[6820 ft2/d]
Lily ROMP 25	272159	820025	Hardee	12(960-1785)	1785	1911	126	Avon Park	970-1785	APT	[286,000 ft2/d]
FPC Avon Park	273446	812925	Highlands	12	425	1492	1067	Ocala/Avon Park		APT	520,000
Sebring	273028	812630	Highlands	8	520	1400	880	Ocala/Avon Park		APT	200,000
Tropical River Grove Test Site (129)	271623	812528	Highlands	12	397	1317	920	SUW/Ocala/ Avon Park		APT	6,900,000
Consolidated Tomoca (130)	271252	812030	Highlands	10	682	1682	1000	SUW/Ocala/ Avon Park		APT	420,000
Hicoria ROMP 14 (Well no. 2) (164)	270915	812130	Highlands	8	650	730	80	SUW		APT	49,100
Hicoria ROMP 14 (Well no. 1) (164)	270915	812130	Highlands	10	1003	1670	667	Avon Park		APT	56,698
Oneco ROMP TR 7-2 (114)	272615	823301	Manatee	12	358	700	342	Suw.	358-700	APT	136,000
Waterbury-Kibler ROMP 33 (117)	272728	821526	Manatee	12	404	750	346	Suw.		APT	29,505
Rubonia ROMP TR 8-1 (95)	273459	823246	Manatee	8	462	1260	798	Suw./Ocala/ Avon Park		APT	22,000
Hecht Ranch (97)	273726	822533	Manatee		200	900	700	Suw./Ocala		APT	1,000,000
L-3 Farms (99)	273531	821833	Manatee		503	1264	761	SUW/Ocala		APT	683,000
Rutland Ranch Test Site 4 (106)	273018	822036	Manatee		200	1050	850	SUW/Ocala		APT	332,000
Beker (108)	273030	820845	Manatee	12	750	1225	475	Ocala/Avon Park		APT	460,000
FP&L-Willow (98)	273815	821930	Manatee	12	346	1568	1222	SUW/Ocala/ Avon Park		APT	870,000
Elsberry Farms Test Site 5 (118)	272616	821742	Manatee	12	250	1250	1000	SUW/Ocala/ Avon Park		APT	340,000
4-Corner Mines Well CB-8 (119)	272324	821140	Manatee		522	1200	678	SUW/Ocala/ Avon Park		APT	1,950,000
Long Creek Farm (121)	272414	820546	Manatee	8	632	1405	773	Avon Park		APT	557,000
Myakka City Pacific Tomato (125)	272233	821044	Manatee	16	600	1500	900	SUW/Ocala/ Avon Park		APT	1,000,000
Bradenton WWTD Injection Well (113)	272800	824102	Manatee	24	1067	1659	592	Avon Park		APT	2,100,000
Utopia ROMP 22 (124)	271813	822013	Sarasota	6	409	635	226	SUW	400-635	APT	72,000

Utopia Romp 22 (124)	271813	822013	Sarasota	12	940	1685	745	Avon park	1200-1660	APT	1,500,000
Osprey ROMP 20 (131)	271138	822845	Sarasota	12	500	840	340	SUW		APT	153,000
Osprey ROMP 20 (131)	271138	822845	Sarasota	6	500	1480	980	Avon park	1220-1405	APT	160
Geronimo ROMP TR 5-7 (133)	270921	822342	Sarasota	6	510	700	190	SUW		APT	99,500
Murdock N.W. ROMP 18 (135)	271135	820748	Sarasota	10	57	880	823	SUW/Ocala	670-890	APT	120,000
Atlantic Utilities Test Well (123)	271825	822821	Sarasota		1480	1902	422	Avon Park		APT	37,000
Knight Trail Pk. Exp. Well (132)	270929	822436	Sarasota		1599	1915	316	Avon Park		APT	2,244,000
Osprey ROMP 20 (134)	271137	822845	Sarasota	6	500	1480	980	Avon Park	1220-1305	APT	160
Osprey ROMP 20 (134)	271137	822845	Sarasota	6	500	1480	980	Avon Park	1300-1405	APT	49
Osprey ROMP 20 (134)	271137	822845	Sarasota	6	500	1480	980	Avon Park	1430-1480	APT	840
Venice Gardens DIW (138)	270415	822332	Sarasota		1388	1705	317	Avon Park		APT	180,000
Plantation DITW (139)	270414	822138	Sarasota		1102	1605	503	Ocala/Avon Park		APT	501,200
Englewood IW-1 (147)	265712	822057	Sarasota		1040	1600	560	Ocala/Avon Park		APT	359,000
Englewood IW-1 (147)	265712	822057	Sarasota		1040	1800	760	Ocala/Avon Park		APT	598,000
Northport ROMP 9 (MW-5) (152)	270434	820856	Sarasota	12	545	860	315	SUW	545-860	APT	54,300

Table 4. Hydraulic data for selected wells (Shaw and Trost, 1984)

Well #	Date Pumped	Lat	Long	County	Casing Dia. (in)	CD (ft.)	Total depth/depth of well (ft.)	Aquifer	Type of Test	Estimated Transmissivity (gpd/ft)	Transmissivity (ft2_d)
HIF-1	3/9/1982	271335	810520	Highlands	6	450*	640	Floridan aquifer	single well	23,000	
OKF-13	3/23/1982	273043	804400	Okeechobee	10	600*		Floridan aquifer	single well	556,000	
OKF-15	4/7/1982	271934	805913	Okeechobee	8	375	1600	Floridan aquifer	single well	32,000	
OKF-18	11/28/1979	272726	810039	Okeechobee	8	255	1015	Floridan aquifer	single well	27,000	
OKF-34	11/28/1979	273217	810126	Okeechobee	10	276	1143	Floridan aquifer	single well	51,000	
OKF-54	11/29/1979	273740	805512	Okeechobee	12	260	973	Floridan aquifer	single well	3,100,000	
0SF-2	12/5/1979	281802	813516	Osceola	10	85		Floridan aquifer	single well	931,000	
0SF-11	7/8/1979	280905	812701	Osceola	6	134	398	Floridan aquifer	single well	31,000	4,154
0SF-11	12/5/1979	280905	812701	Osceola	6	134	398	Floridan aquifer	single well	61,000	8,174
0SF-26	6/12/1978	281159	811428	Osceola	10	322	622	Floridan aquifer	single well	382,000	51,188
0SF-31	3/7/1979	281719	811340	Osceola	8	239	474	Floridan aquifer	single well	181,000	24,254
0SF-42	11/29/1979	274307	805824	Osceola	6	218	767	Floridan aquifer	single well	84,000	11,256
0SF-44	11/27/1979	281456	811717	Osceola	8	481	614	Floridan aquifer	single well	279,000	37,386
POF-2	8/1/1979	281511	813931	Polk	6	358	447	Floridan aquifer	single well	37,000	4,958
POF-4	12/1/1979	280229	813252	Polk	8	146	453	Floridan aquifer	single well	495,000	66,330
POF-7	4/21/1982	275805	813219	Polk	3				single well	15,000	2,010
HIF-39	6/9/1982	272158	810827	Highlands	10	370	1332	Floridan aquifer	single well	165,000	22,110
HIF-39	6/9/1982	272158	810827	Highlands	10	370	1332	Floridan aquifer	single well	110,000	14,740
HIF-41	*no data*	272655	812132	Highlands	16	420	1205	Floridan aquifer	single well	41,000	5,494
OKF-26	*no data*	271830	804935	Okeechobee	12	625	825	Floridan aquifer	single well	6,400	858
OKF-27	*no data*	271830	804935	Okeechobee	12	477	725	Floridan aquifer	single well	5,000	670
ORF-43	10/31/1980	282622	811828	Orange	12	211	500	Floridan aquifer	single well	243,000	32,562
OSF-9	10/11/1969	281937	812459	Osceola	16	283	1195	Floridan aquifer	single well	414,000	55,476
OSF-10	8/27/1969	281937	812501	Osceola	16	278	458	Floridan aquifer	single well	1,053,000	141,102
OSF-25	*no data*	281955	813707	Osceola	6	99	300	Floridan aquifer	single well	202,000	27,068
OSF-27	*no data*	282051	811332	Osceola	6	373	463	Floridan aquifer	single well	58,000	7,772
OSF-54	5/4/1982	275634	811027	Osceola	10	249	869	Floridan aquifer	single well	578,000	77,452
OSF-55	11/7/1982	280533	810410	Osceola	13	354	891	Floridan aquifer	single well	448,000	60,032
W-2859	*no data*	812800	273040	Highlands	14	464	1400	Floridan aquifer	single well	62,000	8,308
A		283343	812227	Orange					multiple well	5,000,000	670,000
B		282531	810957	Orange	4	226	300	Floridan aquifer	multiple well	445,000	59,630
C		282352	813132	Orange	12	237	910	Floridan aquifer	multiple well	590,000	79,060
D		283100	812200	Orange	12	88	350	Floridan aquifer	multiple well	455,000	60,970