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CORE DRILLING AND ANALYSIS: CITY OF SARASOTA, DOWNTOWN WELL FIELD
(revised)

by

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Introduction

The Florida Geological Survey (FGS), in cooperation with the U.S. Geological Survey (USGS) and the city of Sarasota, drilled and analyzed a deep core hole located at the Sarasota Downtown Well Field (SDWF). The investigation focused on the Neogene and Paleogene lithostratigraphy and the Floridan aquifer system. The corehole was drilled into the top of the Middle Eocene Avon Park Formation and terminated at a total depth of 1101 feet below land surface (bls). The core obtained in this study is cataloged as well W-16999 and is stored in the FGS core repository. Funding was provided by the Florida Geological Survey and the City of Sarasota.

The SDWF draws water from both the intermediate and Floridan aquifer systems. The intermediate aquifer system and confining units consist of Neogene and Paleogene Hawthorn Group sediments. The Floridan aquifer system is composed of latest Paleogene sediments of the Hawthorn Group, and Paleogene sediments of the Suwannee and Ocala Limestones and the Avon Park Formation.

The corehole site is located within the City of Sarasota at the SDWF (SE, SE, SW, section 18, Township 36 S, Range 18 E, elevation 18 feet), northwest of the intersection of 10th St. and Orange Ave (Figure 1). The well was drilled utilizing the FGS Failing 1500 drill rig. Core samples were collected from the land surface to 1101 feet bls. A four-inch diameter monitor well was constructed after coring was completed. The FGS installed casing from the land surface to 353 feet bls and plugged the corehole with neat cement from 590 to 1101 feet bls creating a monitor zone from 353 to 590 feet.

A lithologic description for the core (Appendix 1) was generated by R.C.Green utilizing a binocular microscope. The description was recorded in the standard FGS format and entered into the FGS data base via WELL LOG DATA SYSTEM software (Geosys Inc., 1992). A stratigraphic column was also generated from the lithologic log.

Structure

The broad Florida Platform extends southward from the North American continent, separating the Gulf of Mexico from the Atlantic Ocean. The exposed portion of the platform forms the peninsula of Florida, with the present-day western coast of peninsular Florida lying approximately on the axis of the Florida Platform. Sarasota County, located in the southwestern portion of the Florida peninsula, lies near the center of the southern half of the platform. The main structural features that affected Cenozoic deposition in the study area include the Sarasota Arch, South Florida Basin, Ocala Platform and Okeechobee Basin. The Sarasota Arch and the South

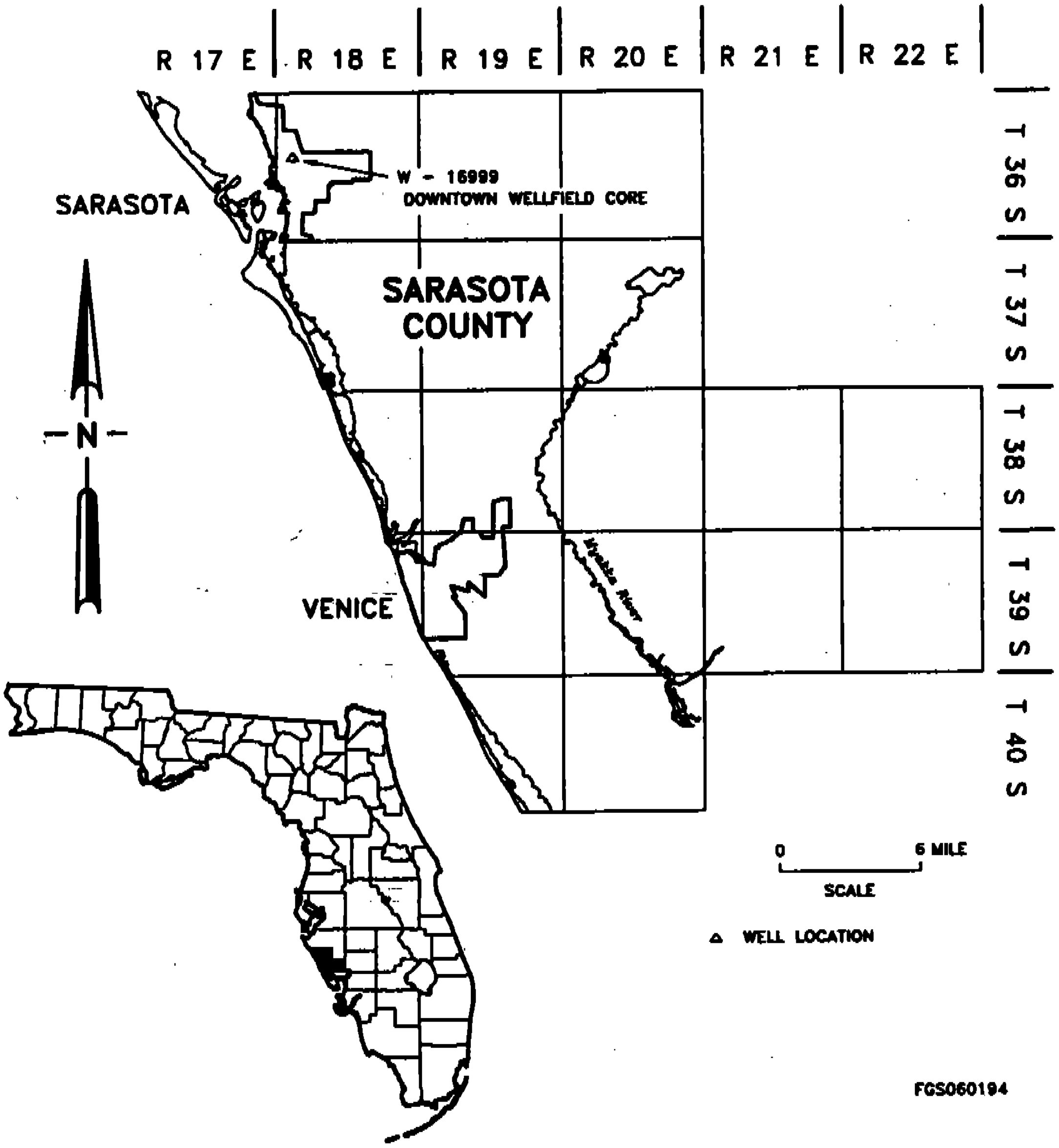


Figure 1. Location Map

Florida Basin influenced deposition during the Paleogene, while the Ocala Platform and the Okeechobee Basin affected deposition during the Neogene. Subsurface investigations in southwestern Florida have encountered complex geologic conditions in the Paleogene and Neogene section. Some researchers have delineated faults disrupting the strata, complicating the lithostratigraphic and hydrostratigraphic interpretations (Sproul et al., 1972; Hutchinson, 1991). Other investigators recognized folding in seismic reflection surveys run parallel to the coastline and up the Caloosahatchee River (Missimer and Gardner, 1976). This has led to speculation that deep-seated faulting was responsible for near- surface structures. Interesting new data acquired during recent seismic surveys off the southwestern coast of the state have revealed that the reflectors in the mid-Eocene section are essentially flat lying, while reflectors in the Mio-Pliocene section appear folded (Missimer, personal communication, 1993). Evans and Hine (1988) discussed the existence of a number of small basins, erosional features and deltas. Samples from wells penetrating these features can provide a very confusing picture of the stratigraphy. The very limited information obtained from well cuttings has led to complex interpretations that include significant faulting (Sproul et al., 1972).

Lithostratigraphy

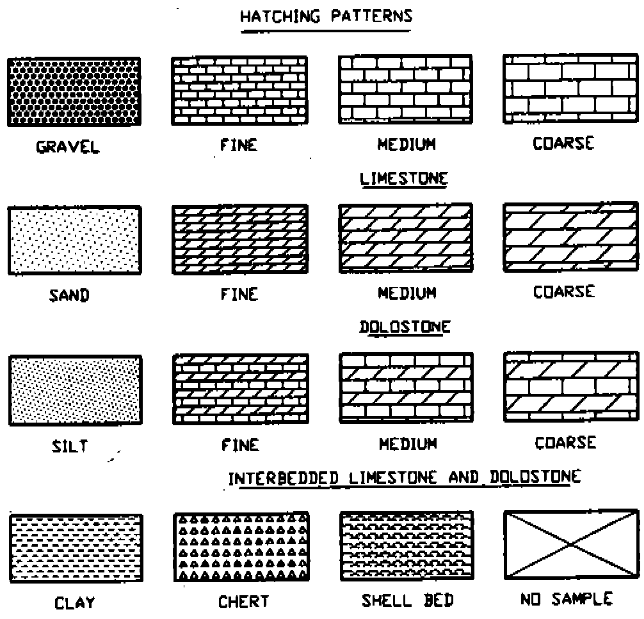
This investigation focused on the lithostratigraphy of the Neogene and Paleogene section in the SDWF corehole drilled for this study (FGS W-16999). This core penetrated the top of the Middle Eocene Avon Park Formation at 1028.5 feet bls.

The Avon Park Formation in this core consists of interbedded limestones and dolostones (Figures 2 and 3). The dolostones are grayish brown to dark yellowish brown, fine grained, well indurated, variably porous and recrystallized. Benthic foraminifera, echinoids and fossil molds are the most common fossils present. Limestones present are very light orange, fine- to medium-grained, moderately- to well-indurated packstones. Fossils present are similar to those in the dolostones. Both lithologies may contain small quantities of organic material. The Avon Park is overlain by the Ocala Limestone. The contact in the northern portion of the peninsula is unconformable, however, in southern Florida the contact may be conformable.

The Upper Eocene Ocala Limestone occurs from 781 to 1028.5 feet bls in the SDWF core. The Ocala consists primarily of limestone (781-961 feet) with a limited amount of dolostone (961-1028.5 feet). The limestones are very light orange, microcrystalline- to medium-grained, fossiliferous, moderately indurated grainstones and packstones with calcilutite matrix. Fossils consist primarily of benthic foraminifera, bryozoans, echinoids and mollusks. Dolostones are grayish brown, fine grained, well indurated, highly recrystallized, sucrosic and may contain trace quantities of organic material. Fossils and fossil molds are common, primarily species of the large benthic foraminifers Operculinoides, Nummulites, and Lepidocyclina. The Ocala Limestone in this core and others in the area, appears to be gradationally overlain by the Suwannee Limestone.

The Lower Oligocene Suwannee Limestone occurs from 549 to 781 feet bls in the SDWF core. The limestones encountered are white to very light orange,

EXPLANATION



COMMENTS

M	MICRITE	T	SILT
S	SAND	C	CLAY
P	PHOSPHATE GRAVEL	Sh	SHELL
p	PHOSPHATE SAND	D	DOLOSTONE
O	ORGANICS	L	LIMESTONE
R	SPAR	H	HEAVY MINERALS
I	IRON STAIN	NO SPL	NO SAMPLE
Q	QUARTZ	G	GYPSUM
A	ANHYDRITE	Py	PYRITE
Ch	CHERT		

FGS060294

Figure 2. Stratigraphic column legend

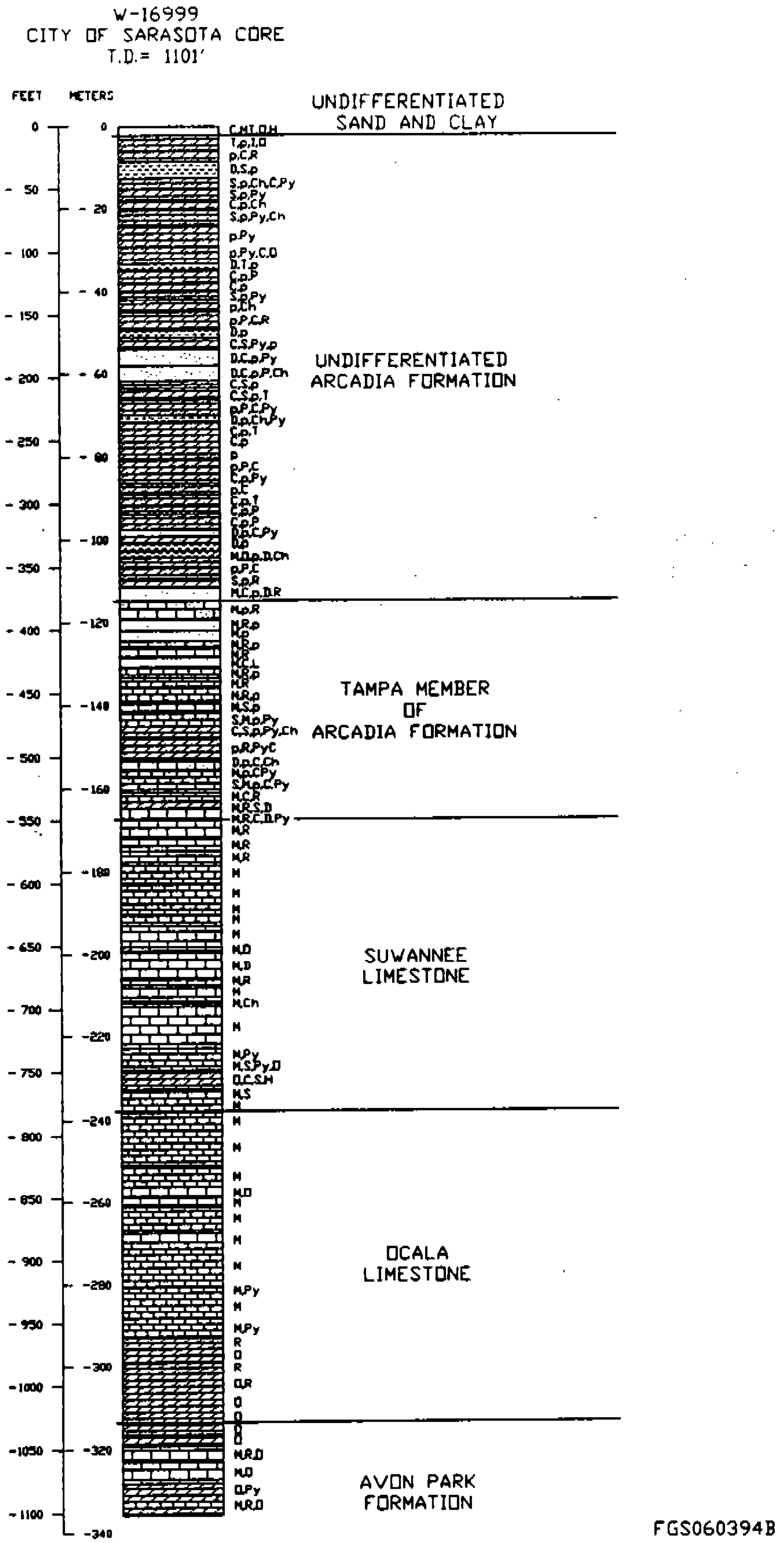


Figure 3. Stratigraphic column of W-16999

predominantly moderately- to well-indurated, fine- to medium-grained, fossiliferous packstones to grainstones. Matrix material consists of calcilutite and to a lesser extent, sparry calcite. Foraminifera, including characteristic miliolid forms are the most common faunal constituent followed by mollusk fragments and molds.

The Suwannee Limestone is overlain by the Arcadia Formation of the Hawthorn Group. The contact in some areas of the state appears to be disconformable while in other areas it appears to be gradational and conformable. The unconformity is often difficult to recognize due to similarities in lithologies between the top of the Suwannee Limestone and the basal Tampa Member or undifferentiated Arcadia Formation. The occasional difficulty in recognizing the disconformity spawned the humorous term "Suwa-Tampa-Haw" to describe the unit. This difficulty is predominantly related to lithologic descriptions and formational picks made from well cuttings. Close examination of high-quality core samples often allows the unconformity to be recognized.

The Hawthorn Group, in the SDWF core, consists of the Arcadia Formation with its component Tampa Member (Scott, 1988). The Arcadia Formation is found from 6.8 feet to 548.5 feet bls. The Tampa Member is found from 376-548.5 feet bls. The upper Hawthorn Group Peace River Formation is absent due to erosion. The absence of the Peace River Formation in this core is not unusual for this area (Scott, 1988).

The Lower Oligocene to Middle Miocene undifferentiated Arcadia Formation contains a wide variety of lithologies. In general, carbonates dominate the section with siliciclastic beds being less abundant (Figures 2 and 3). Dolostone tends to dominate the carbonate lithologies of the Arcadia Formation in this region. Limestone becomes more common within this section to the south and southeast.

Dolostones in the core are generally yellowish gray, light olive gray and white, moderately- to well-indurated, fine- or very fine-grained, quartz sandy and clayey. Phosphate is ubiquitous in these sediments, although economic concentrations are not present. The concentration of phosphate particles varies considerably, from less than one to more than 20 percent of the sample, generally varying from approximately three to 10 percent.

The Upper Oligocene to Lower Miocene Tampa Member of the Arcadia Formation was identified in the SDWF core from 376 to 548.5 feet bls. The Tampa Member consists predominantly of light- to yellowish-gray, slightly- to non-phosphatic, quartz sandy and occasionally clayey limestones. Dolostones are found from 475 to 501 and from 537.5 to 540 feet bls in this core. These dolostones are light gray to yellowish gray, predominantly very fine-grained, and moderately- to well-indurated. The Tampa Member is fossiliferous, with mollusk fragments and molds, benthic foraminifera and corals being common.

One of the units of primary interest in this study is the Venice clay member (Joyner and Sutcliffe, 1976), an informal unit originally identified as a lower member of the Tamiami Formation. Upon investigating the Carlton Reserve core (W-16782) (Campbell, et al., 1993), characteristic Arcadia Formation sediments were found superimposed on the clays referred to the Venice clay member. The implication is that either the Arcadia sediments were reworked locally during the Pliocene and redeposited on the Venice clay member, or the Venice clay member is part of the

Arcadia Formation. Microfossils recovered from the Venice clay member in the USGS Walton core, suggested an Early to Middle Miocene age (L. Edwards, USGS, personal communication, 1992) which is compatible with the age range of the Arcadia Formation. Following this lead, the Venice clay member has been recognized in the Arcadia Formation in other cores on file at the FGS. Scott (1992) suggested the informal placement of the Venice clay member in the Arcadia Formation based on the subjacent and suprajacent lithologies and preliminary fossil evidence.

The Venice clay member is recognized in the SDWF core, occurring between 19 and 41.3 feet bls, and is generally, a variably dolomitic, gray-green clay with minor amounts of quartz sand and silt. Phosphate is rarely present in identifiable quantities. It becomes more silty (quartz and/or dolomite) toward the upper and lower contacts. Fossils were not noted in the Venice clay member, although microfossils are present in the unit in other cores.

Sediments immediately above and below the Venice clay member may be very clayey "dolosilts." These beds are not included in the Venice clay member as defined in this report. The SDWF core reveals that a thin (five feet) carbonate bed occurs between two clay units that make up the Venice clay member, which is included in the unit. It is possible that, upon further study, the clay- and dolomite-rich zones that overlie or underlie the Venice clay member may be included in the informal unit.

The gamma-ray signature of the Venice clay member consists of a zone of low gamma-ray intensity falling between two zones of more intense gamma-ray activity. The overall pattern of gamma-ray activity surrounding the Venice clay member is quite characteristic of the Arcadia Formation in southwestern peninsular Florida (Scott, 1988).

The erosional disconformity forming the upper surface of the Hawthorn Group cuts across a variety of units depending on the location within southwest Florida. In the Tampa area, most of the Arcadia Formation is missing leaving the Tampa Member at or near the surface. The Hawthorn Group sediments thicken to the south as the axis of the platform dips in that direction, forming a more complete section.

A thin Pleistocene section (0-6.8 feet bls) overlies the eroded surface of the Arcadia Formation. These materials consist of light gray and olive gray, medium-grained quartz sands with minor clay and calcilutite matrix and some weathered shells.

Paleontology

A paleontological reconnaissance based on calcareous nannofossils and diatoms was conducted by FGS paleontologists. Unfortunately, the samples are virtually barren of both nannofossils and diatoms. There are no indications that these microfossils were previously present. Analysis for dinoflagellates was not conducted.

Hydrostratigraphy

The potable water resources in the Sarasota area are contained primarily in the intermediate aquifer system, with limited quantities coming from the surficial aquifer system. The Floridan aquifer system underlies the entire area but does not contain potable water.

The Floridan aquifer system consists of the carbonates of the Avon Park

Formation, Ocala Limestone, Suwannee Limestone and the lower portion of the Tampa Member of the Arcadia Formation. The top of the Floridan aquifer system occurs at approximately 507 feet bls in the lower portion of the Tampa Member (Barr, personal communication, 1994). The Floridan aquifer system in the Sarasota area is used principally for irrigation, to supply saline water for reverse osmosis desalinization and the injection of waste water.

The Arcadia Formation comprises the entire intermediate aquifer system and confining unit in this portion of Sarasota County. There are two major permeable zones and several confining zones recognized in the intermediate aquifer system in this area (Barr, personal communication, 1994). The Venice clay forms part of the upper confining zone in the SDWF core. The intermediate aquifer system extends from approximately seven feet bls to 507 feet bls.

The surficial aquifer system is poorly developed in this core. It consists of a seven foot thickness of undifferentiated sands disconformably overlying the Arcadia Formation.

Hydraulic Conductivity

Falling head permeameters (Figure 4) were utilized to measure the hydraulic conductivity of 26 core samples. Thirteen sample intervals were analyzed for both vertical and horizontal hydraulic conductivity. One-inch diameter core plugs were taken adjacent to the vertical permeability samples to determine horizontal hydraulic conductivity. The following procedure is summarized from FGS permeability lab procedures.

Indurated core samples were prepared for hydraulic conductivity testing by cutting the sample on a trim saw and encasing the sample in an epoxy resin within a larger diameter plastic tube. Liquid rubber and wax were placed on the ends of the core sample to ensure that the liquid resin did not block the ends of the sample during pouring and curing. After the epoxy hardened, the wax and liquid rubber layers were removed to allow fluid flow through the core. Rubber-ring gaskets were then placed on each end of the plastic tube containing the sample and the entire assembly was clamped in the permeameter. The assembled permeameter is placed on a stand and connected to a buret filled with de-ionized water to a level simulating one meter of hydraulic head. The stopcock on the buret is opened and the permeameter is monitored until flow has been achieved through the sample, at which time the stopcock is closed and the buret refilled. The fluid level is measured from the upper drain port to the top of the buret fluid level. This figure is recorded as the initial head. The time is noted and the stopcock opened. After sufficient head drop (usually 10 centimeters or more) the stopcock is closed and the time is recorded as the end of the test. Tests are conducted in triplicate except where saturation is not achieved. Samples that do not reach saturation after 31 days are removed. After testing of a sample is complete, the hydraulic conductivity is calculated by PERMCAL (software by Jon Arthur, FGS).

Ten samples (6 horizontal, 4 vertical) did not saturate during the test period

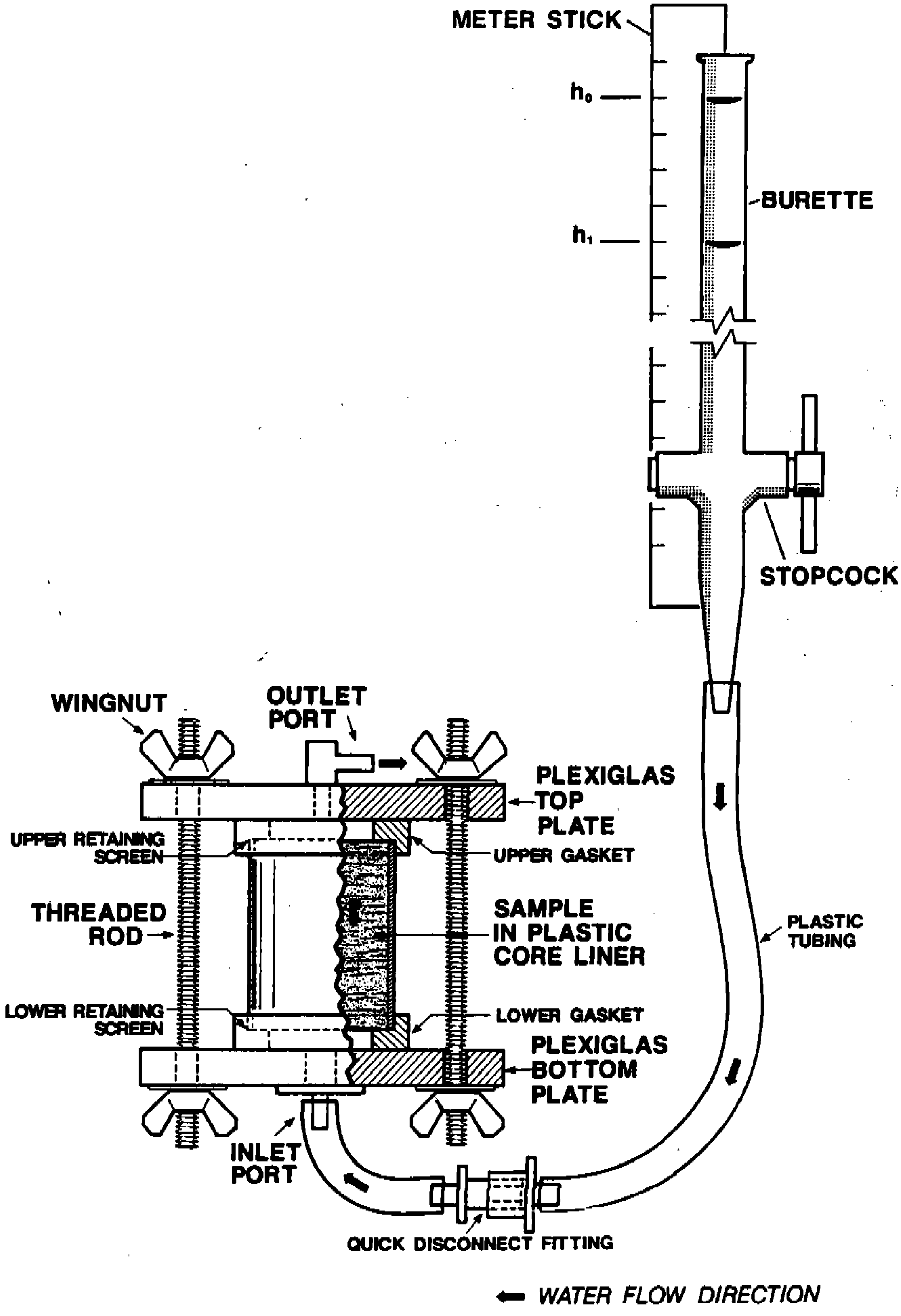


Figure 2: Falling head permeameter (Green, et al., 1989).

(over 31 days in each case). Hydraulic conductivity of these samples should be considered only in a qualitative sense and are best described as having very low permeability. One sample (316 feet bls) was destroyed by slaking while saturating.

The range of average hydraulic conductivities determined for those samples which did flow is from 1.65E-03 to 3.80E-09 centimeters/second (4.69E+00 to 1.08E-05 feet/day). In general, vertical hydraulic conductivity was less than the horizontal, although there were exceptions. For three of the sample intervals (316, 465 and 1095 feet bls), neither sample achieved saturation. Hydraulic conductivity data is presented in Tables 1-3.

Effective porosity

The samples cut for vertical hydraulic conductivity were also utilized for effective porosity determination. Samples were rinsed in distilled water after being cut on a trim saw, then oven dried at 50°C. When dry, the samples were removed and allowed to cool and equilibrate with the lab air, then were weighed. Following weighing, each sample was placed in distilled water and allowed to saturate overnight. Samples were then removed from the water, lightly blotted and immediately weighed. Following weighing, the saturated sample was placed in a beaker with a known volume of water to determine the saturated sample volume. Porosity was then calculated.

In order to obtain a porosity figure for the 316 foot sample which was destroyed by slaking, a second method was utilized. The shape volume of the dried sample was obtained by averaging several measurements of the core diameter and core height. The sample was then saturated in a known volume of distilled water in a graduated cylinder. Sample porosity was calculated utilizing the difference between the shape volume of the sample and the increase in volume (known volume of water and saturated sample) to get volume of pore spaces, which is then converted to percent porosity. To ensure that the results of this process are comparable to the previous method, several samples were run with both methods. Although the second process is less precise, the porosity values obtained are similar to the previous method. Effective porosity of the selected samples ranges from over 32 percent to less than one percent (Table 4).

Acknowledgments

A number of people provided assistance with different aspects of this project. Alex Howell prepared microfossil samples and conducted hydraulic conductivity analyses. Frank Rupert examined microfossil samples. Jon Arthur, Jim Balsillie, Joel Duncan, Ron Hoenstine, Steve Spencer and Frank Rupert of the FGS edited the text.

Table 1

Vertical Hydraulic Conductivity Analysis of Selected Samples: Downtown Wellfield Core (W-16999)

Depth (Ft)		Hydraulic Conductivity (K) cm/s ft/day		cm/s ft/day
	Run 1	Run 2	Run 3	Mean (K)
316	Sample destroyed by slaking during saturation.			
465	Sample did not reach saturation after 31 days. Hydraulic conductivity can best be described as very low.			
495	9.22E-08	1.13E-07	8.64E-08	9.72E-08
	2.62E-04	3.20E-04	2.45E-04	2.76E-04
756	Sample did not reach saturation after 31 days. Hydraulic conductivity can best be described as very low.			
779	5.12E-06	3.96E-06	3.09E-06	4.05E-06
	1.45E-02	1.12E-02	8.76E-02	1.15E-02
807	Sample did not reach saturation after 31 days. Hydraulic conductivity can best be described as very low.			
847	Sample did not reach saturation after 31 days. Hydraulic conductivity can best be described as very low.			
895	5.18E-06	4.94E-06	4.49E-06	4.87E-06
	1.47E-02	1.40E-02	1.27E-02	1.38E-02
953	4.00E-09	4.00E-09	3.40E-09	3.80E-09
	1.13E-05	1.13E-05	9.65E-06	1.08E-05
980.5	1.66E-03	1.70E-03	1.60E-03	1.65E-03
	4.72E+00	4.81E+00	4.53E+00	4.69E+00
1025	2.76E-07	3.01E-07	3.28E-07	3.02E-07
	7.82E-04	8.55E-04	9.29E-04	8.55E-04
1035	4.39E-05	5.01E-05	3.59E-05	4.33E-05
	1.25E-01	1.42E-01	1.02E-01	1.23E-01
1095	Sample did not reach saturation after 31 days. Hydraulic conductivity can best be described as very low.			

Table 2

Lateral Hydraulic Conductivity Analysis of Selected Samples: Downtown Wellfield Core (W-16999)

Depth (Ft)		Hydraulic Conductivity (K)		
		cm/s ft/day		cm/s ft/day
	Run 1	Run 2	Run 3	Mean (K)
316	Sample did not reach saturation after 31 days. Hydraulic conductivity can best be described as very low.			
465	Sample did not reach saturation after 31 days. Hydraulic conductivity can best be described as very low.			
495	4.24E-07	3.26E-07	1.80E-07	3.10E-07
	1.20E-03	9.23E-04	5.11E-04	8.79E-04
756	2.80E-03	2.68E-03	2.79E-03	2.76E-03
	7.95E+00	7.60E+00	7.90E+00	7.82E+00
779	1.53E-05	1.69E-05	8.10E-06	1.34E-05
	4.33E-02	4.79E-02	2.30E-02	3.81E-02
807	6.46E-06	6.72E-06	8.97E-06	7.38E-06
	1.83E-02	1.90E-02	2.54E-02	2.09E-02
847	4.16E-05	3.81E-05	6.78E-05	4.92E-05
	1.18E-01	1.08E-01	1.92E-01	1.39E-01
895	2.43E-04	2.44E-04	2.30E-04	2.39E-04
	6.90E-01	6.91E-01	6.52E-01	6.78E-01
953	Sample did not reach saturation after 31 days. Hydraulic conductivity can best be described as very low.			
980.5	6.10E-07	4.12E-07	1.15E-06	7.24E-07
	1.73E-03	1.17E-03	3.26E-03	2.05E-03
1025	2.09E-03	3.80E-03	3.63E-03	3.18E-03
	5.93E+00	1.08E+01	1.03E+01	9.00E+00
1035	Sample did not reach saturation after 31 days. Hydraulic conductivity can best be described as very low.			
1095	Sample did not reach saturation after 31 days. Hydraulic conductivity can best be described as very low.			

Table 3

Hydraulic Conductivity: Comparison of Lateral and Vertical Conductivity

Depth (Ft)	Mean Hydraulic Conductivity Vertical cm/s, ft/day	Horizontal cm/s, ft/day
316	Sample destroyed by slaking	Sample did not saturate
465	Sample did not saturate	Sample did not saturate
495	9.72E-08, 2.76E-04	3.10E-07, 8.79E-04
756	Sample did not saturate	2.76E-03, 7.82E+00
779	4.05E-06, 1.15E-02	1.34E-05, 3.81E-02
807	Sample did not saturate	7.38E-06, 2.09E-02
847	Sample did not saturate	4.92E-05, 1.39E-01
895	4.87E-06, 1.38E-02	2.39E-04, 6.78E-01
953	3.80E-09, 1.08E-05	Sample did not saturate
980.5	1.65E-03, 4.69E+00	7.24E-07, 2.05E-03
1025	3.02E-07, 8.55E-04	3.18E-03, 9.00E+00
1035	4.33E-05, 1.23E-01	Sample did not saturate
1095	Sample did not saturate	Sample did not saturate

Table 4

Effective Porosity of Selected Samples: Downtown Wellfield Core (W-16999)

Depth (Ft)	Porosity (%)	Depth (Ft)	Porosity %
316*	32.5	895	30.6
465	12.2	953	17.7
495	23.0	980.5	12.6
756	9.4	1025	9.3
779	19.7	1035	8.8
807	29.8	1095	0.8
847	31.2		

*Original sample destroyed by slaking during saturation; porosity figure determined by alternate method described in text.

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