Winter January, 2006

Community Education in Karst at the Geological Alumni Society GeoPark, University of South Florida

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Available at: https://works.bepress.com/lee_florea/19/
ABSTRACT

For the past 20 years, a tract of undeveloped land at the University of South Florida in Tampa has served as a facility for education and research into mantled karst landscapes, the hydrology of the Surficial and Upper Floridan Aquifers, and geophysical methods used to study sinkholes. For the past four years, the Geological Alumni Society at the University of South Florida has used the GeoPark site for annual expositions of geological field techniques. Efforts over the past few years to develop the site into a community education site have borne fruit: the site now boasts three large limestone boulders of Floridan Aquifer material, several sinkholes, a mulched, shaded trail with educational signs, and many permanent monitoring wells in the Surficial and Upper Floridan Aquifers. A recent community education grant funded by the Southwest Florida Water Management District provided the resources to develop the series of educational signs. Today the GeoPark is an official part of the University’s green-space corridor.

AWARENESS OF KARST IN SOUTH FLORIDA

The Tampa Bay metropolitan area (Fig. 1) is built upon a mantled karst terrain and relies heavily upon water withdrawn from the underlying Upper Floridan Aquifer, a karstic aquifer partially confined by the siliciclastic Hawthorn Group. The Upper Floridan Aquifer is one of the most productive karst aquifers in the world, and one of the aquifers most pressured by population growth and pollution concerns. Our understanding of the interaction between the surface landscape and the underlying aquifer structure is limited, because classical fluvio-karst features, such as sinkholes, have subdued expression at the surface. Some are even undetectable without using subsurface methods.

Nevertheless, the effects of karst processes are far from invisible here. Reports of intermittent – and sometimes spectacular – sinkhole collapse in the area make it apparent that sinkholes are an active part of the karst system underlying the Tampa Bay area, including the University of South Florida (USF). In fact, sinkhole-collapse and subsidence caused more than 100 million dollars in structural damage in Florida in 1997 (Smith, 1997). Damage estimates increase every year in part due to the expanding urban sprawl. Reflecting this trend are engineering and consulting companies established solely for evaluation and intervention of sinkhole-collapse damage. This direct threat to personal property drives a high level of public interest in the Tampa Bay area about sinkhole processes.

Many employees of Tampa Bay-area engineering and consulting companies, as well as many in local water-resources agencies, are active in the alumni society of the Department of Geology at USF. This award-winning and nationally recognized alumni society (Rodriguez et al., 2002) was the driving force for establishing the campus GeoPark, which is growing into a community education facility. The GeoPark is a project with many contributors, including people from the Southwest Florida Water Management District (SWFWMD), Florida Geological Survey (FGS), Florida Department of Environmental Protection, United States Geological Survey, as well as students, faculty, and administration of USF.

ESTABLISHING THE GEO PARK

In 2001, the USF Geology Alumni Society was looking for a site at which to host an exposition of field equipment and techniques. They settled on the picturesque lot behind the science building (Fig. 2). This site had been used by USF geology professors Mark Stewart and Sam Upchurch (now with SDII Global, Inc.) as an outdoor laboratory. Since the early 1980s Stewart and Upchurch have supervised dozens of students working in the karst of west-central Florida. In particular, two MS theses covered the geology of the GeoPark site: Diane Bloomberg’s study on the anatomy of sinkhole structures revealed by using cone-penetrometer exploration, and John Parker’s thesis on the hydrogeology of the sinkhole structures on site (Bloomberg, 1987; Parker, 1992).

Green, shady, and planted with Florida-friendly vegetation, the GeoPark site lies within the medical campus of USF, adjacent to the Shriners Hospital for Children, the American Cancer Society Hope Lodge associated with the Moffit Cancer Center, and the University Diagnostic Center. The USF Botanical Gardens, advertised in tourist guides to area attractions and visited by many people from off campus, is situated directly to the west of the site. Both the Botanical Gardens and the GeoPark site lie within a swath of green space running west-to-east across the square-mile campus.

The president of the Geology Alumni Society and the chair of the Department of Geology met with the director of facilities and planning of USF to propose that the site be designated as a resource for on-campus geological teaching and research. Following that initial meeting, our site was officially labeled the "Geology Alumni Society GeoPark." In 2004, our GeoPark was granted permanent recognition as part of the university’s Master Plan and included specifically in the cross-campus greenway.

The GeoPark gained a physical presence in the fall of 2002 when a five-ton boulder of the Ocala Limestone was delivered to the site. It was donated by Crystal River Quarries and transported by several members of FGS and SWFWMD. This boulder and two others (donated in 2005) comprise a monolithic centerpiece for the GeoPark and allow visi-
tors to examine the "porosity" of the Upper Floridan Aquifer (Fig. 2). The boulders and sinkholes are fringed by a set of mulched trails constructed by a group of alumni, faculty, and students in the Winter of 2003.

**KARST WITHIN THE USF GEOPARK**

Situated within the Gulf Coast Lowlands of Florida, the Tampa Bay area typically has very low relief (<15m) and a shallow water table. The Upper Floridan Aquifer is a highly permeable sequence of Tertiary carbonates, ranging from Eocene to Oligocene in age and including the Ocala and Suwannee Limestones. The siliciclastic units of the Miocene Hawthorn Formation and the weathering residuum of the Tampa Limestone partially confine the Upper Floridan Aquifer. Quaternary deposition of siliciclastics during periods of high sea level and eolian activity created a veneer of very fine, very well sorted sand on the Miocene strata. These Quaternary sediments comprise the Surficial Aquifer System and subdue the surface expression of karst features in the area.

The number and types of sinkhole-collapse features in Florida depends upon the thickness of the Hawthorn Group. The campus of the University of South Florida is within a region characterized by active cover-collapse sinkholes. The insoluble residue of the Tampa Limestone and other fine-grained clays of the Hawthorn Group form a stiff clay cap over the underlying carbonates. This cap is competent enough to bridge small cavities, but the clays collapse into larger cavities, which stop upward through the overlying sands as they trickle or fall into the cavity. Much like sand in an hourglass, the surficial sediments drain through the breach in the semi-confining layer, and a depression forms at the surface. The process ranges from imperceptible (cover-subidence) to sudden and even catastrophic (cover-collapse).

Geophysical studies at the USF GeoPark demonstrate that the density of depressions on the surface of the semi-confining layer is on the order of one feature per 625 m² (25 x 25 m) of land surface (Parker, 1992). That’s around 256 depressions for an area the size of a city block! The fact that only two topographic depressions are visible on the surface highlights the need for detailed subsurface investigation in mantled-karst terrain. In forty years of operation, the USF campus has experienced more than thirty cover-collapse sinkhole events. Just using these rough numbers, we see that the frequency of cover-collapse sinkhole events can be on the order of one per square mile per year in sinkhole-prone areas. One cover-collapse feature at well 4A in the GeoPark has experienced episodic collapse three times since 1980.

Because of the presence of the density of mantled-sinkhole structures and the downward hydraulic gradient, lateral flow within the Surficial Aquifer System is limited. At the USF GeoPark, and probably in much of the Tampa Bay region, shallow groundwater flows only a few tens of meters until it either discharges into a surface water body or finds a sinkhole structure, through which it then recharges the Upper Floridan Aquifer (Stewart and Parker, 1992).

By far, the greatest volume of recharge to the Upper Floridan Aquifer at the USF GeoPark occurs through sinkhole structures and not through the semi-confining layer itself. In the 12,000-m² GeoPark site, estimates indicate that the sinkhole structures that breach the semi-confining layer contribute 16 m³/day of recharge; in contrast, about an estimated 1 m³/day is estimated to leak through the semi-confining layer (Stewart and Parker, 1992). While sinkhole structures cover less than 1% of the land surface, they contribute 95% of the recharge to the underlying Upper Floridan Aquifer.

**PRESENT AND FUTURE USE**

Each year since 2001 exhibitors and demonstrators at the annual Geology Alumni Society Equipment Expo have installed more monitoring wells and run geophysical surveys in the GeoPark. Typically more than a hundred geologists and environmental scientists from the community attend these events. In addition, the GeoPark hosted the North American Environmental Field Conference and Exposition once in 2004, and will again in 2006. The demonstrations at these exhibitions contribute to the extensive data already compiled on the geology and hydrogeology of the site. In fact, the GeoPark may be one of the best characterized karst locations in the Tampa Bay area.

During the rest of the year, faculty and graduate students from a variety of departments use the GeoPark as a demonstration facility for a variety of lecture and laboratory courses including hydrogeology, geophysics, and geomorphology, as well as biology and ecology. Undergraduate students use the site during practice and application courses in hydrogeology, and they create maps of the water table as part of USF’s field camp.

In the Fall of 2004, USF geology professors Sarah Kruse and Chuck Connor focused on the GeoPark for the applied part of their environmental geophysics course. As part of the course requirements, the students conducted group research projects in the GeoPark using all the geophysical techniques covered in the course. The results of these group projects were compiled and presented as a poster at the American Geophysical Union Meeting in 2005.

Non-scientific use of the GeoPark facility continues. Students are often seen reading a book or taking a nap amongst the boulders. Visitors from the nearby medical facilities use the site as an outdoor refuge.

**EDUCATIONAL MATERIAL**

In 2003, Len Vacher, Mark Stewart, and Mark Rains applied for and were awarded a SWFWMD Community Education Grant...
to develop professional-quality educational signs for the GeoPark site. These grants are designed to support efforts to "actively engage adults in water-related issues pertaining to conservation, protection and preservation." Funded by the SWFWMD’s individual groundwater Basin Boards, the program is intended to help communities get involved in water protection by promoting activities and education.

Vacher, Stewart, and Rains assembled a team of alumni from the environmental community, students, and others to plan and create the signs. The team designed and produced five signs: "The Hillsborough River Basin," "The Floridan Aquifer," "Sinkholes," "Sources of Contamination," and "The Botanical Gardens – GeoPark Connection." Each sign highlights a different feature of the GeoPark and the surrounding karst landscape. The material for the signs was assimilated from written material, diagrams, and data from several sources.

- The "Hillsborough River Basin" sign orient visitors within the river basin using a collage of aerial photos of the Hillsborough River Basin from the USGS Terraserver (http://terraserver-usa.com) with the basin boundaries and streams (available as ArcGIS shapefiles from the SWFWMD website (http://www.swfwmd.state.fl.us/data/) overlain onto it (Fig. 1). The sign calls attention to the SWFWMD and its watershed management activities, pointing out other community education resources in the basin.

- The "Floridan Aquifer" sign stands in front of the three boulders of aquifer rock. It explains the concept of an aquifer and includes a simplified cross-sectional view of the Florida platform (Fig. 3). The development of cavernous porosity in karst rocks is also explained. The Floridan Aquifer diagram was simplified from the geological map of Florida (Scott et al., 2001).

- The "Sinkholes" sign overlooks the larger of the sinkholes. One box on this sign includes descriptions of sinkhole types and a map of distribution of sinkhole types in Florida (Fig. 4). Another box has a description of techniques used to study them and cross-sections through the sinkhole. Much of the material on this sign was provided by the USGS (Tihansky, 1999).

- The "Groundwater Contamination" sign emphasizes the connectivity of the aquifer to the surface with a block diagram and lists potential sources of contamination. The Florida Department of Environmental Protection contributed information on the potential sources of contamination and regulations.

- The "Botanical Gardens-GeoPark Connection" sign directs visitors from the Botanical Gardens to the GeoPark. This sign presents an overview of the project and a description of the GeoPark.

**FUTURE PLANS AND CONCLUSIONS**

The GeoPark is truly a community effort involving members of the water-resources and geological communities of the Tampa Bay area. It is an excellent example of an on-campus resource and a physical focal point of karst studies at the University of South Florida. The Geology Alumni Society and the Department of Geology plan for the GeoPark to evolve into an on-campus community education facility. They envisage that, in time, the GeoPark will be the destination of self-guided, environmental tours starting from the nearby Botanical Gardens and a quiet, educational respite within our busy campus.

**ACKNOWLEDGEMENTS**

The authors would like to thank our advisor Len Vacher and department chair Chuck Connor for encouraging us to publish this article. We thank our hydrology professors Len Vacher, Mark Stewart, and Mark Rains for their commitment to establishing the GeoPark as a community resource; USF alumni Bob Bretnall, Eileen Rodriguez, Tom Scott, Ann Tihansky, Dave DeWitt, and KT Moran for their many contributions to the GeoPark phenomenon; the Hillsborough River Basin Board of SWFWMD for funding the educational signs; USF student Don Seale for installing the signs; Chuck Connor, Bob Brinkmann, and Rick Oches, Chairs of Geology, Geography, and Environmental Science and Policy, respectively, and Jim Garey and Sandy Schneider, Associate Deans of the College of Arts and Sciences for their administrative support and encouragement.

**REFERENCES**


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**Sinkhole Types and Locations**

**Solution Sinkholes**
- Limestone, if any, sediment cover
- Mainly solution sinkholes

**Cover-Subsidence Sinkholes**
- Sandy sediment cover, 60-60 meters thick
- Mainly cover-subsidence sinkholes

**Cover-Collapse Sinkholes**
- Sandy, clay-rich sediment cover, 5-60 meters thick
- Mainly cover-collapse sinkholes

**Figure 4:** Panel from the "Sinkholes" sign detailing the types of sinkholes and their distribution within the SWFWMD. Material on this panel is from USGS (Tihansky, 1999).