

Utilizing Stable Isotopes (^2H , ^{18}O) to Better Identify Different Water Types of the Floridan Aquifer System in Southwest Florida

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ABSTRACT

Stable isotopes (^2H , ^{18}O) were used to complement inorganic data to define different water masses within the Floridan aquifer system (FAS). In southwestern Florida, the FAS is separated into three hydrostratigraphic units, the upper Floridan aquifer, middle-confining unit, and the lower Floridan aquifer. This paper better defines the hydrogeologic framework, using stable isotopes to identify different groundwaters contained within the FAS and identifies recharge sources and interaction between the two aquifers.

INTRODUCTION

The stable isotope, and inorganic (major cation and anion) data were obtained from eight multi-zone FAS test wells owned by the South Florida Water Management District (SFWMD) and eight multi-zone FAS monitor wells operated by various Utilities for a total of 42 samples. The location of these FAS wells are shown on Figure 1. Samples were collected at various depth intervals within the FAS. They were collected during packer tests within the open borehole or from completed multi-zone monitor wells.

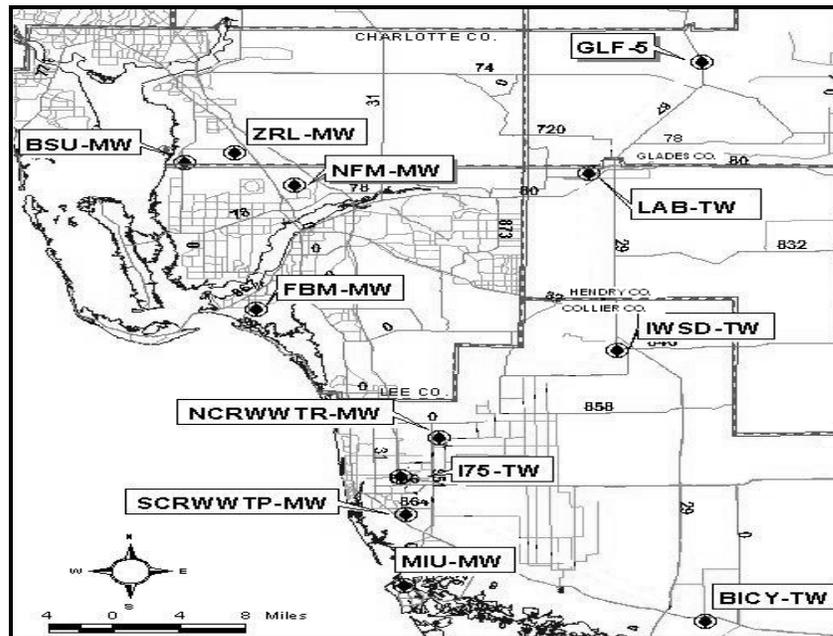


Figure 1. Site Map with Well Locations

HYDROGEOLOGY

Three major aquifer systems underlie Southwest Florida: the Surficial Aquifer System (SAS), the Intermediate Aquifer System (IAS), and the Floridan Aquifer System (FAS). These aquifer systems are composed of multiple, discrete aquifers separated by low permeability “confining” units that occur throughout this Tertiary/Quaternary age sequence. The aquifers occurring in the

FAS are the focus of this study. Figure 2 shows a generalized hydrologic cross-section from northwest to southeast across south Florida.

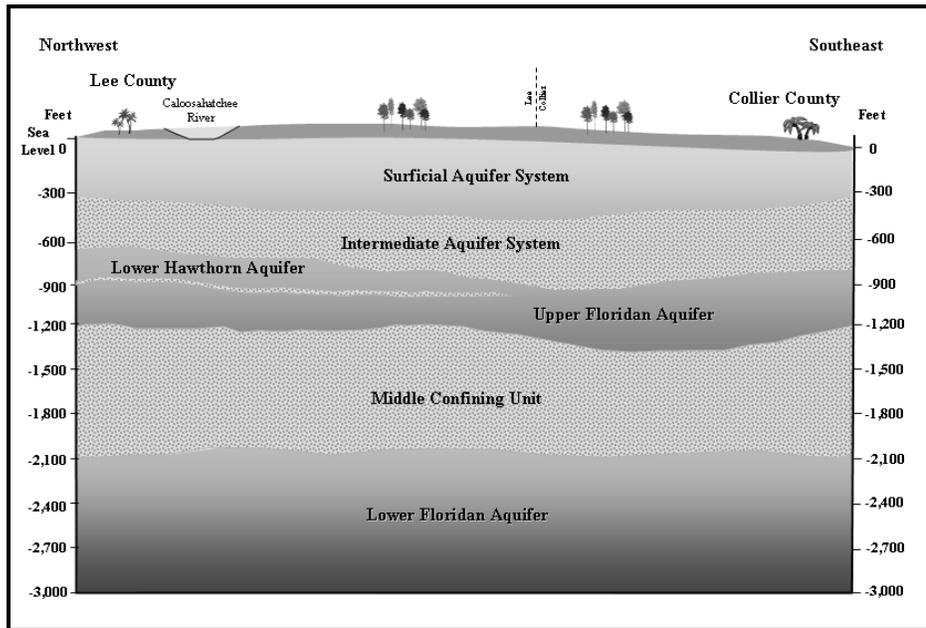


Figure 2. Generalized Hydrologic Cross-section of Southwest Florida

The FAS in the study area is separated into three hydrostratigraphic units, Upper Floridan aquifer (UFA), middle confining unit (MCU), and Lower Floridan aquifer (LFA). These units are composed predominately of limestone with dolomitic limestone and dolomite. The UFA chiefly consists of permeable zones in the lower Hawthorn Group and Suwannee Limestone (Reese, 1998). The middle-confining unit consists of low permeable dolomitic zones in the Ocala Limestone and upper part of the Avon Park Formation (Reese, 1998 and Bennett, 2001). The LFA consists of permeable dolostones in the lower part of the Avon Park Formation, Oldsmar Formation, and the upper part of the Cedar Keys Formation (Meyer, 1989 and Bennett, 2001).

INORGANIC CHEMISTRY AND STABLE ISOTOPES

More than 90% of the dissolved constituents in groundwater can be attributed to eight ions: sodium (Na^+), calcium (Ca^{2+}), potassium (K^+), magnesium (Mg^{2+}), sulfate (SO_4^{2-}), chlorine (Cl^-), bicarbonate (HCO_3^-), and carbonate (CO_3^{2-}) (Fetter, 2001). The differences in inorganic composition of the ground water can be classified into hydrochemical facies which are a function of the lithology, solution kinetics, and flow patterns of the aquifer system (Fetter, 2001). Inorganic and stable isotopic data were used to identify different water masses and the dominant recharge source of the groundwater within the hydrologic units of the FAS.

Deuterium (^2H) and oxygen-18 (^{18}O) are two stable isotopes commonly used in hydrologic studies to complement and better define groundwater systems. These stable isotopes do not undergo radioactive decay, but because of the difference in mass between the more common isotopes of their respective elements, protium (^1H) and oxygen-16 (^{16}O), they react differently with other atoms and molecules as they move through the hydrologic system (Swancar and Hutchinson, 1992). The higher mass of ^2H and ^{18}O causes them to bond more tightly in molecules (including water), thus requiring more energy to break the bonds when these molecules participate in chemical reactions. Consequently, these two isotopes become enriched during the chemical reactions (Swancar and

Hutchinson, 1992). These data can therefore be particularly useful because they provide additional criteria linking water chemistry with mineral mass transfer, which can ultimately be used to better understand the geochemical processes and ground water interactions within the FAS.

RESULTS

The results from the inorganic analyses indicate that Na^+ and Cl^- are the dominant ions and along with total dissolved solids (TDS) concentrations increase with depth. The inorganic data tend to group together near the right apex when plotted on a Piper Trilinear Diagram which suggests that seawater is the dominant recharge source for the FAS in coastal portion of southwestern Florida using the method developed by Frazee (1985).

Scatter plots of ^2H and ^{18}O (Figure 3) indicate two different types of water within the FAS; this is consistent with findings from previous studies (Meyer, 1989; Swancar and Hutchinson, 1992, Bennett m, 2001). The ^2H and ^{18}O values from LFA waters plot close to 0.0 per mil concentration, which is similar to the standard mean ocean water standard of present day ocean water. The isotopically heavier waters within the LFA suggest inland migration of ocean water. The UFA values are isotopically lighter than ocean water (more negative values). These values parallel the Global Meteoric Water Line (GMWL), which suggest the source of the water in the UFA is precipitation from recharge areas north of the study area. The stable isotope composition of the MCU is distributed more or less evenly among isotopically light and heavy values that fall along the GMWL. This suggests potential interactions between the upper and lower Floridan aquifers, within the middle-confining unit via the presence of vertical fractures, cracks or fissures.

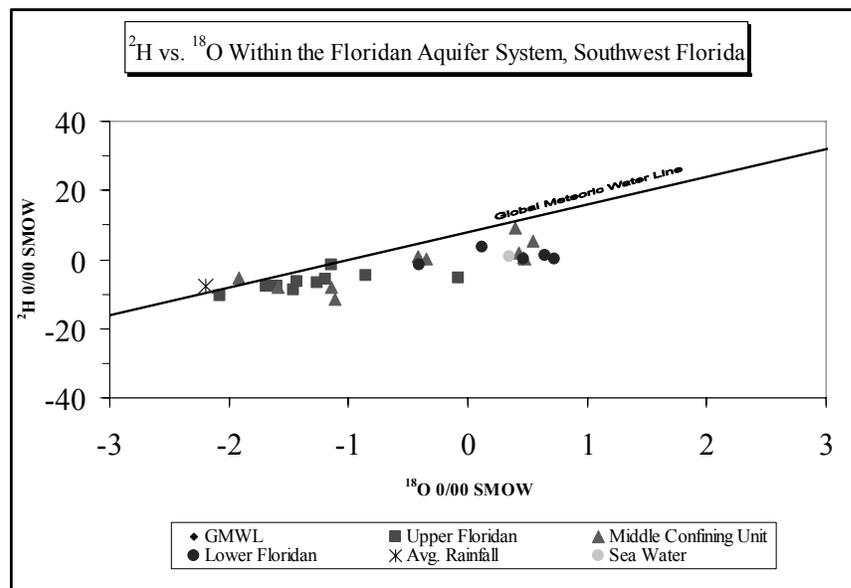


Figure 3. Floridan Aquifer System ^2H vs ^{18}O stable isotope compositions plotted with the GMWL.

CONCLUSIONS

Inorganic constituents and stable isotopes were used to identify different water masses in the FAS. The inorganic data identified sodium and chloride as the dominant ions and that the concentration of these ions including TDS increased with depth. The ^2H and ^{18}O plots suggests two distinct water masses within the FAS and suggest groundwater interaction in some parts of this region between the upper and lower Floridan aquifers. In time, we may have an even better

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understanding of the complexity and interaction of the hydrologic unit of the FAS in southwest Florida as research continues by state and local agencies.

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