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Textural and stratigraphic controls on fractured dolomite in a carbonate aquifer system, Ocala limestone, west-central Florida

Stephanie B. Gaswirth [a,b], David A. Budd [a,*], Brian R. Crawford [b]

[a] Department of Geological Sciences, University of Colorado, 399 UCB, Boulder, CO 80309-0399, United States
[b] Exxonmobil Upstream Research Company, Houston, TX 77252-2189, United States

Abstract

The Late Eocene Ocala Limestone is part of the Upper Floridan Aquifer, and in west-central Florida the Ocala forms a subregional semi-confining unit that separates underlying and overlying highly transmissive zones. In portions of the same area, the lower half of the Ocala is dolomitized and fractures are observed in cores. Where present, the fractures should locally enhance the hydraulic conductivity of the dolomite and could enhance vertical leakage through the semi-confining Ocala interval.

Triaxial strength tests and Brazilian Disc tensile tests were conducted on a suite of 2.5-cm diameter dolomite core plugs from five boreholes. Samples were texturally subdivided on the basis of degree of induration into three general categories: friable sucrosic dolomite with high porosity, moderately indurated dolomite with intermediate porosity, and tightly indurated dolomite with low porosity. Results indicate elevated cohesion magnitude and tensile strength as the degree of induration increases and secondarily as abundance of moldic porosity decreases. Sucrosic and moderately indurated dolomites are most likely to fracture due to their low cohesion strength, followed by tightly indurated dolomites with high moldic porosity. Tightly indurated dolomite with little or no moldic porosity is the least likely to fracture.

Degree of dolomite induration is a function of the lime precursor's depositional fabric. Thus, combining strength data with known stratigraphic patterns in depositional textures allows for prediction of mechanical units and fractured horizons in the Ocala dolomites, and provides insight into regions of potentially increased hydraulic conductivity.

Keywords: Dolomites; Fractures; Tensile strength; Floridan aquifer; Ocala group

1. Introduction

The Floridan Aquifer System (Fig. 1) is the largest carbonate aquifer in the United States and is a major source of groundwater for the southeastern U.S. (Johnston and Bush, 1988). Increases in municipal water use, saltwater intrusion, and wastewater discharge in the Floridan Aquifer System have prompted concerns regarding freshwater availability in coastal west-central Florida. This concern has resulted in feasibility studies of aquifer storage and recovery (Reese, 2002) and analysis of vertical encroachment of the underlying saline water (e.g., Hutchinson and Trommer, 1992). Hundreds of tests are performed annually in west-central Florida to determine the hydraulic properties and understand the behavior of the Upper Floridan Aquifer (UFA), especially in the dolomite intervals (Hutchinson and Trommer, 1992).

Flow in the dolomite intervals of the confined portion of the UFA has been attributed to very permeable sucrosic dolomites (Budd and Vacher, 2004), and to fractured dolomites of varied matrix porosities and

* Corresponding author. Tel.: +1 303 492 3988; fax: +1 303 492 2606.
E-mail address: budd@colorado.edu (D.A. Budd).

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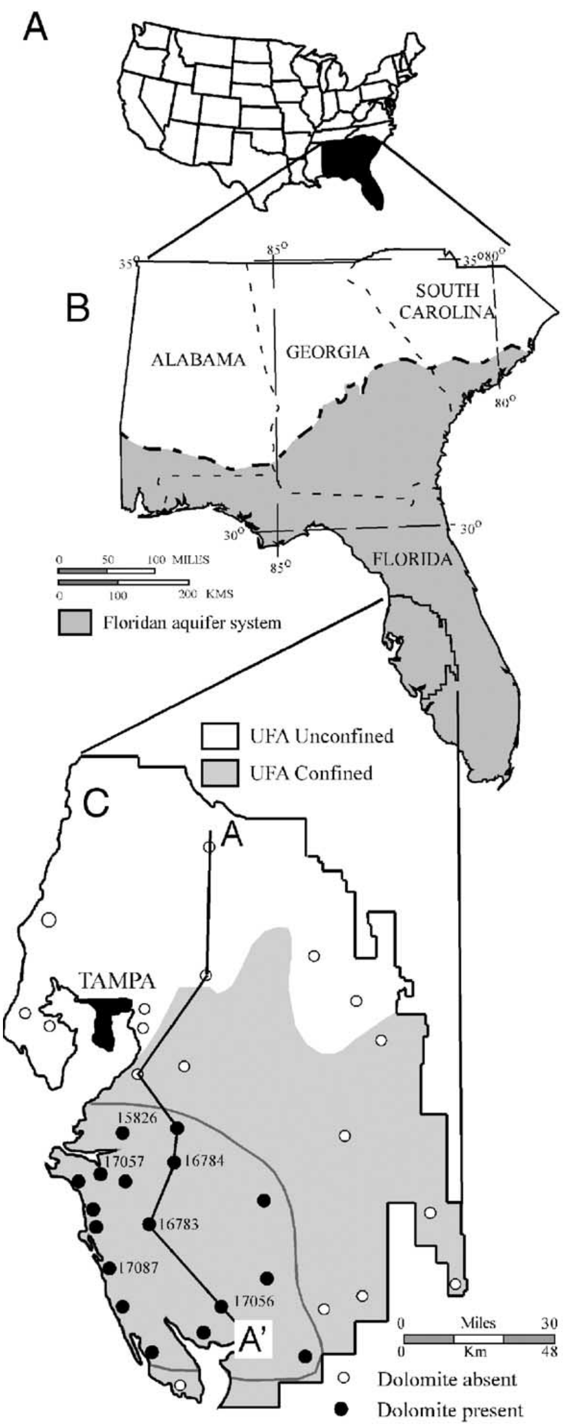

Fig. 1. A) Location and B) extent of the Floridan Aquifer System in the southeastern United States (modified from Miller, 1986). C) Location of the study area in west-central Florida. Dolomite extent in the Ocala Limestones, based on its presence or absence in cores throughout the entire unit, is outlined by the dark gray line. The dolomite body is restricted to the confined portion of the Upper Floridan Aquifer (UFA). Section A–A′ is shown in Fig. 3.

permeabilities (Safko and Hickey, 1992; Duerr, 1995; Maliva et al., 2002). Within the aquifer, fractures (joints) are more common in dolostones than limestones (Safko and Hickey, 1992). These widely dispersed, interconnected fractures provide pathways for horizontal flow to (production) and from (injection) wells, as well as pathways for vertical migration of saline waters or injected wastewater (Duerr, 1995). Therefore, an understanding of where these fractures form in dolomite bodies is crucial, and will assist in the prediction of fracture formation throughout the aquifer.

In more general terms, heterogeneity in facies and diagenetic textures leads to heterogeneity in the strength of sedimentary rocks, which in turn is related to the formation of fractures. Therefore, the presence of lithologic and facies heterogeneity, which is common in carbonate rocks, makes understanding carbonate aquifer behavior a significant challenge for both hydrogeologists and sedimentologists. Hydrogeologists recognize that sedimentologic and stratigraphic models provide a method of incorporating geologic variability into models of fluid flow, however less attention has been focused on the sedimentologic and stratigraphic controls on fracture patterns (Muldoon et al., 2001).

The Ocala Limestone, which is the focus of this study, is part of the UFA (Fig. 2). Dolomites in the Ocala are restricted to an area of ~5000 km^2 that is concentrated along the modern west-central coastline of Florida (Fig. 3). These dolomites include sucrosic dolomites with high porosity and indurated dolomites with low porosity. They are thus well suited to determine the

AGE		STRATIGRAPHIC UNIT	HYDROGEOLOGIC UNIT
Miocene		Hawthorn Group	Upper Confining Aquifer
Lower Oligocene		Suwannee Limestone	Upper Floridan Aquifer
Eocene	Late	OCALA LIMESTONE	← *subregional confining unit*
	Middle	Avon Park Formation	Middle Confining Unit
	Early	Oldsmar Formation	Lower Floridan Aquifer
Paleocene		Cedar Keys Formation	Lower Confining Unit

Fig. 2. Hydrogeologic stratigraphy of the Floridan Aquifer System. The Ocala limestone is highlighted and the distribution of dolomite within it is shown schematically.