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Megaporosity and Permeability of *Thalassinoides*-Dominated Ichnofabrics in the Cretaceous Karst-Carbonate Edwards-Trinity Aquifer System, Texas

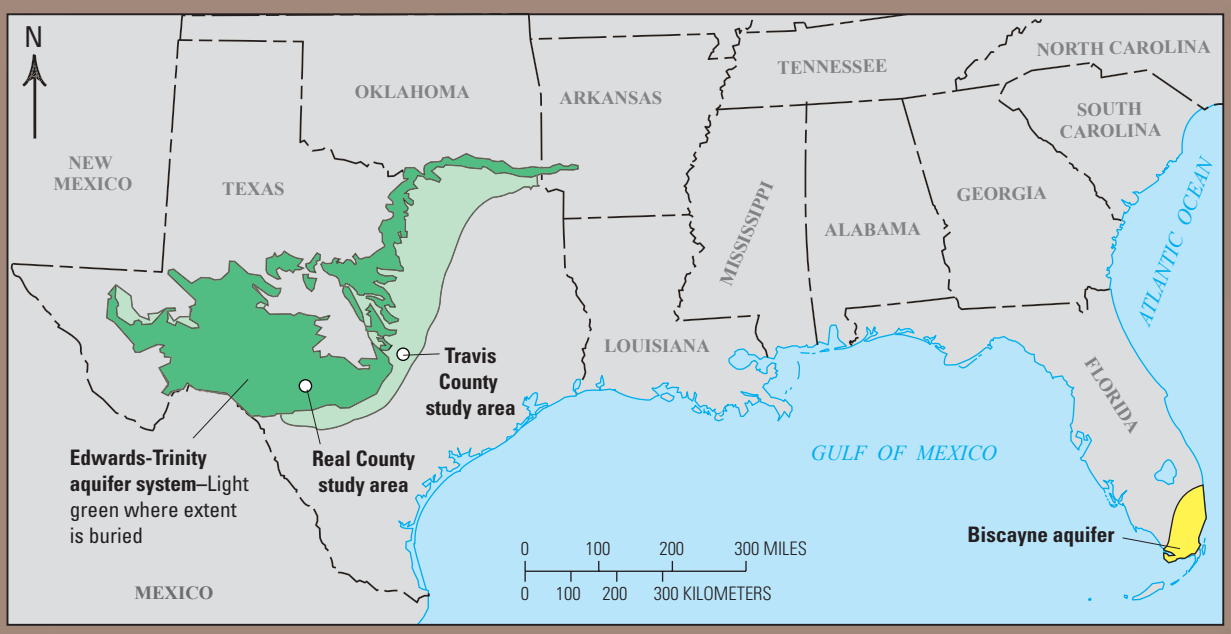

Figure 1. Map showing two case study areas in central Texas. Modified from Cunningham and others (in press).

Current research has demonstrated that trace fossils and their related ichnofabrics can have a critical impact on the fluid-flow properties of hydrocarbon reservoirs and groundwater aquifers. Most petroleum-associated research has used ichnofabrics to support the definition of depositional environments and reservoir quality, and has concentrated on siliciclastic reservoir characterization and, to a lesser degree, carbonate reservoir characterization (for example, Gerard and Bromley, 2008; Knaust, 2009). The use of ichnology in aquifer characterization has almost entirely been overlooked by the hydrologic community because the dynamic reservoir-characterization approach has not caught on with hydrologists and so hydrology is lagging behind reservoir engineering in this area (de Marsily and others, 2005). The objective of this research is to show that (1) ichnofabric analysis can offer a productive methodology for purposes of carbonate aquifer characterization, and (2) a clear relation can exist between ichnofabrics and groundwater flow in carbonate aquifers.

Case Studies in Real and Travis Counties, Central Texas

Research at two study areas in Real and Travis Counties, central Texas (fig. 1), demonstrates a relation between ichnofabrics, megaporosity (Choquette and Pray, 1970), and permeability where *Thalassinoides*-dominated ichnofabrics occur within the unsaturated part of the karst-carbonate Edwards-Trinity aquifer system (figs. 2 and 3). The research centers on the influence of thalassinidean or thalassinid-like crustacean-produced ichnofabrics (Goldring and others, 2007) on carbonate aquifer characteristics. Results show evidence of concentrated paleogroundwater flow through stratiform, touching-vug, megaporous flow zones linked to secondary fabric-selective intraburrow and interburrow megaporosity within *Thalassinoides*-dominated ichnofabrics. At both sites (fig.1), megaporous bioturbation is within Cretaceous carbonate strata representative of a restricted shallow-marine, platform-interior

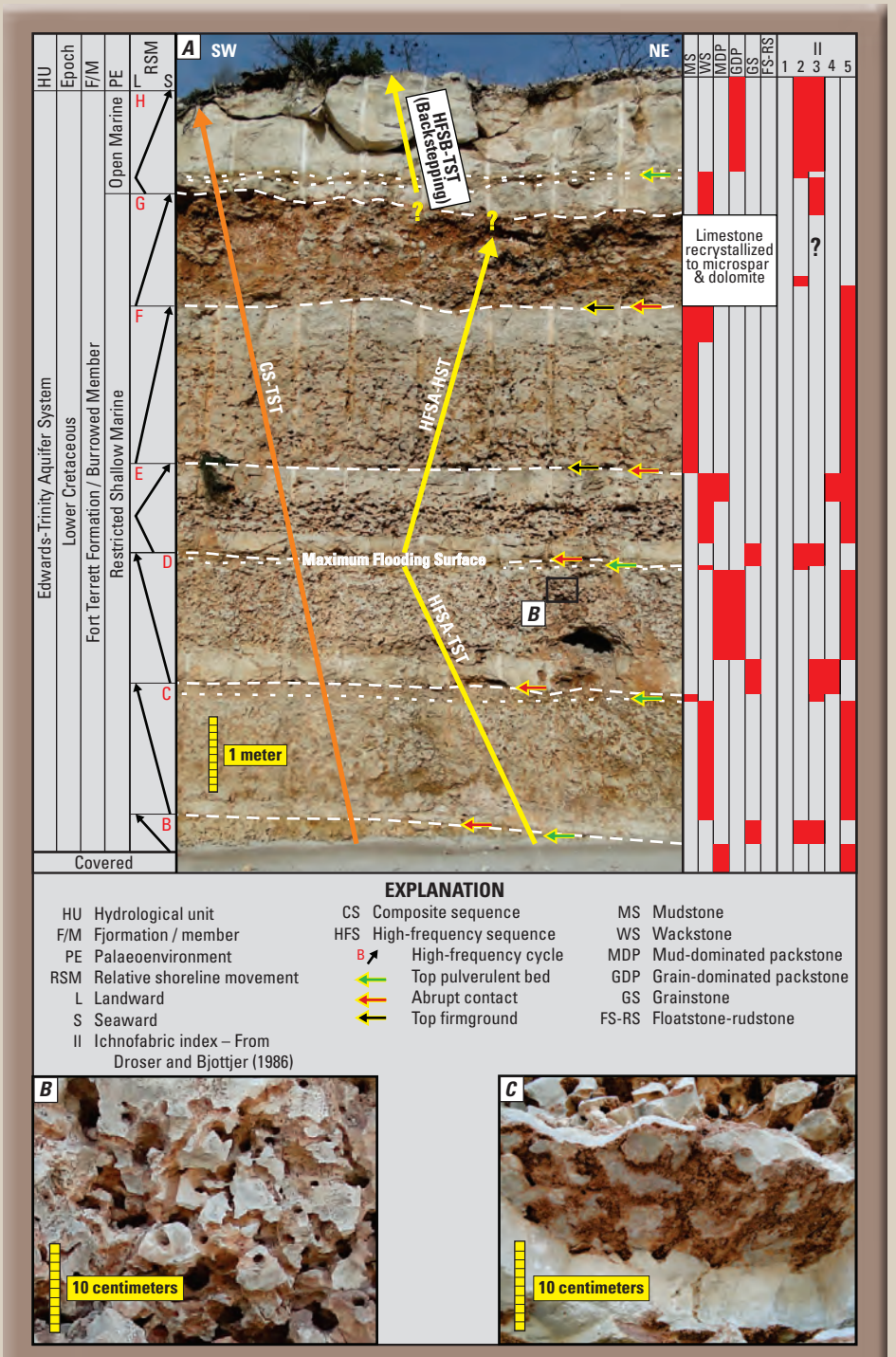

Figure 2. Roadcut in the Burrowed Member of the Fort Terrett Formation, Real County, Texas. Sample LTX-4 (fig. 4) was collected here. *(A)* Photomap annotated with geology and hydrostratigraphy, *(B) Thalassinoides*-related intraburrow megaporosity within high-frequency cycle D, and *(C) Thalssinoides*-related intraburrow megaporosity along bedding plane in high-frequency cycle E. Modified from Cunningham and others (in press).

paleoenvironment. Lattice Boltzmann calculated intrinsic permeabilities for intraburrow and interburrow megaporosity, represented in whole-core-scale computer renderings made from X-ray computed tomography scans, are 5.6 x 10^6 and 1.8 x 10^6 Darcies, respectively (fig. 4). The Cretaceous megaporous, maximum *Thalassinoides* ichnofabrics have similar intrinsic permeability values as compared to intraburrow and interburrow megaporosity related to *Ophiomorpha*-dominated ichnofabrics in Pleistocene shallow-marine platform carbonates of the Biscayne aquifer in southern Florida (Cunningham and others, 2009; Cunningham and Sukop, 2011) (figs. 1 and 2). Highly permeable *Thalassinoides*-dominated ichnofabrics, where present, could play an important role in groundwater movement in saturated parts of the Edwards-Trinity aquifer system as suggested by Barker and Ardis (1996), and thus, improve the water supply for urban and agricultural areas.

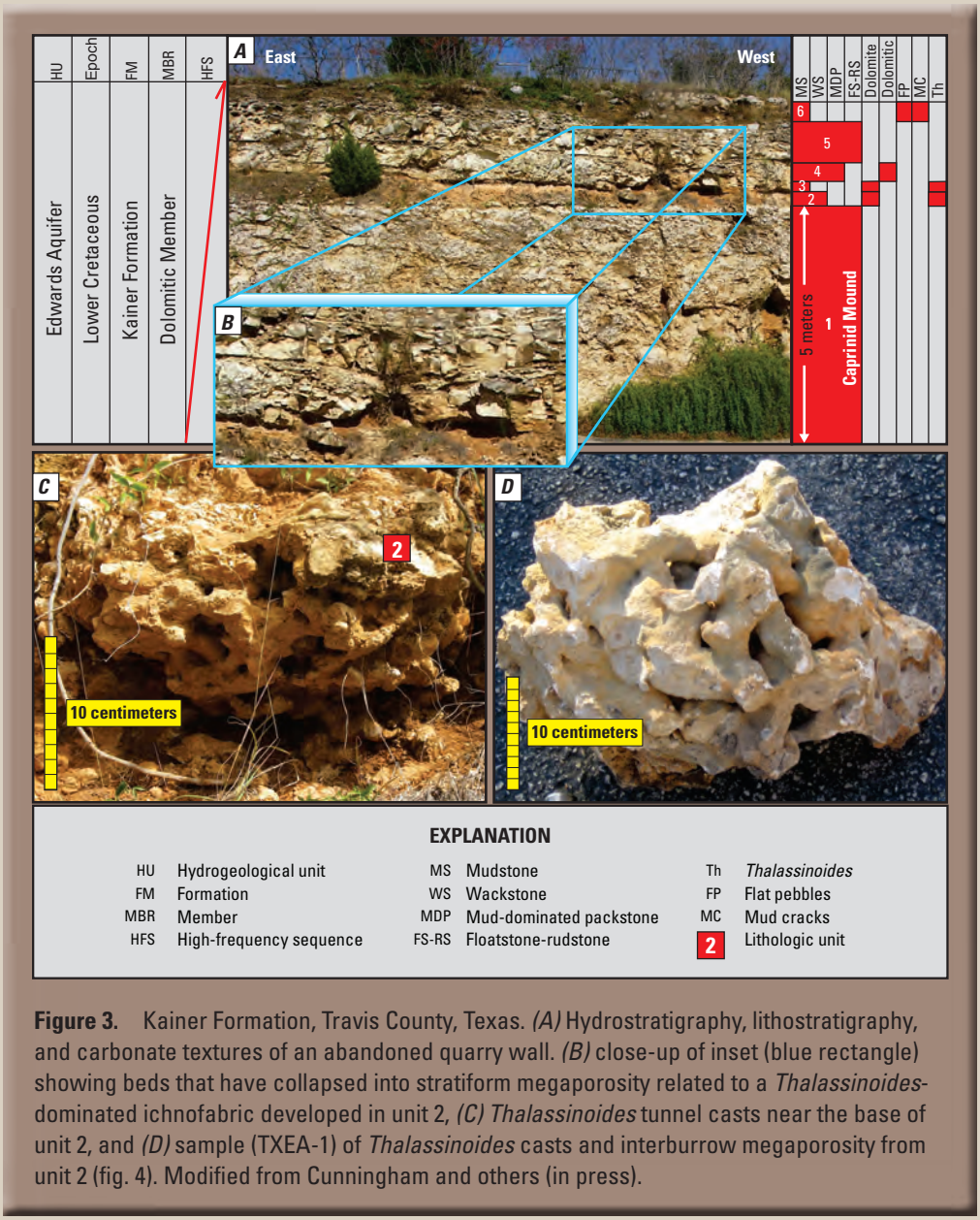

Figure 3. Kainer Formation, Travis County, Texas. *(A)* Hydrostratigraphy, lithostratigraphy, and carbonate textures of an abandoned quarry wall. *(B)* close-up of inset (blue rectangle) showing beds that have collapsed into stratiform megaporosity related to a *Thalassinoides*-dominated ichnofabric developed in unit 2, *(C) Thalassinoides* tunnel casts near the base of unit 2, and *(D)* sample (TXEA-1) of *Thalassinoides* casts and interburrow megaporosity from unit 2 (fig. 4). Modified from Cunningham and others (in press).

In the Cretaceous examples, fabric-selective dissolution in and around carbonate ichnofabrics related to *Thalassinoides*-dominated *Cruziana* ichnofacies are shown to have a marked impact on karst development of (1) highly permeable stratiform megaporosity; (2) caves, which commonly conform to upper and lower stratal boundaries in high-frequency cycles; and (3) solution collapse structures. The stratiform networks of extremely permeable megaporosity can be mapped and, as such, represented in groundwater flow and transport computer simulations. Comparative analyses between Cretaceous and Pleistocene carbonate aquifers emphasize that the past (Mesozoic) can be the key to the Pleistocene. The two studies provide corroborating illustrations of the impact that ichnofabrics can have on groundwater flow in shallow-marine, carbonate platform aquifers. These analogues offer excellent examples for refining conceptualization of groundwater flow in the Pleistocene carbonates of the Biscayne aquifer for use in assessing and predicting change associated with implementation of restoration plans for the Greater Everglades in southern Florida.

Acknowledgments

The U.S. Geological Survey Priority Ecosystems Science Program provided major funding for comparisons of the Biscayne aquifer and Edward-Trinity aquifer system. Bill Ward (deceased), Rene Barker (Texas State University), Nico Hauwert (Austin Watershed Protection Department), Scott Hiers (Austin Watershed Protection Department), and Al Broun (Hays Trinity Groundwater Conservation District) provided insight into Texas geology. X-ray CT scans were conducted at High-Resolution X-Ray CT Facility at the University of Texas.

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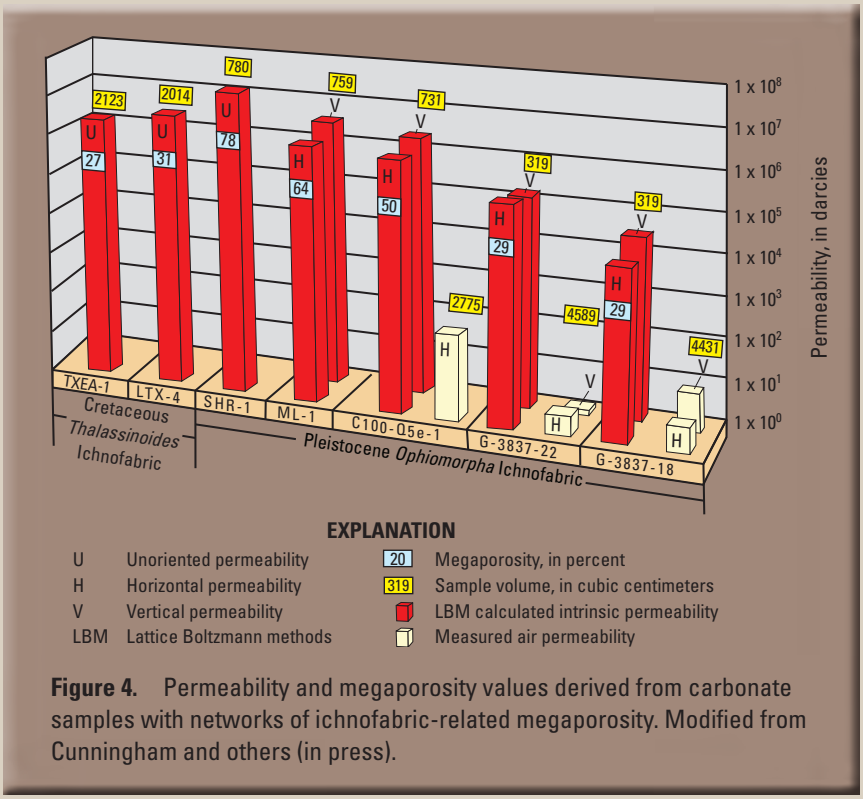

Figure 4. Permeability and megaporosity values derived from carbonate samples with networks of ichnofabric-related megaporosity. Modified from Cunningham and others (in press).

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