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Cylindrical Mega-Voids in Quaternary Aeolianites, Little Exuma Island, The Bahamas: Georadar Response

Ilya Val Buynevich

H. Allen Curran
Smith College, acurran@smith.edu

Bosiljka Glumac
Smith College, bglumac@smith.edu

Michael Savarese
Florida Gulf Coast University

Lisa Park Boush
University of Connecticut - Storrs

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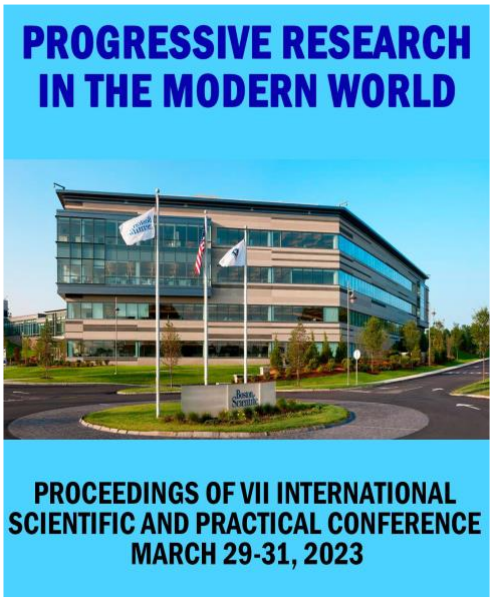

Buynevich Ilya Val
PhD, Associate Professor
Curran H. Allen
PhD, Professor
Glumac Bosiljka
PhD, Professor
Smith College, Northampton, USA
Savarese Michael
PhD, Professor
Florida Gulf Coast University, Ft. Myers, USA
Park Boush Lisa
PhD, Professor
University of Connecticut, Storrs, USA

Introduction: In addition to karst features, tropical carbonates contain a wide range of smaller cylindrical voids ("pipes") attributed to bioturbation, tree molds, or dissolution, among others [1-3]. During geophysical investigation of the Little Exuma Island, The Bahamas (Fig. 1), several sites with enigmatic voids were investigated using a high-frequency ground-penetrating radar (GPR) imaging.

The aim of the paper is to assess the feasibility of GPR to detect voids within lithified Holocene calcarenites of the Hannah Bay Member (Rice Bay Formation; Fig. 2).

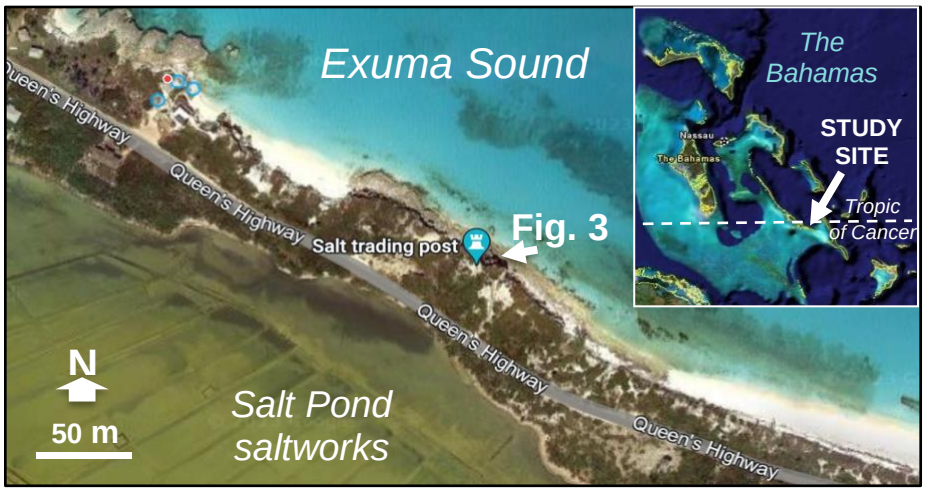

Figure 1. Location of the Salt Beacon study site along the coastal cliff separating Salt Pond saltworks from the Exuma Sound, Little Exuma Island, The Bahamas (see inset for location).

Methodology: This study was part of field research in January 2013 at several sites on Little Exuma Island. Geophysical surveys were collected using a digital 800 MHz MALÅ GPR system. The cliff-top grid included eight profiles along the cliff brink and shore-normal sections (#1103-1110; total length: 98.4 m) in the vicinity of the Salt Beacon (Fig. 1). Geolocation was provided by a hand-held GPS unit and there was minimal topographic variation along survey lines. Signal velocities of 12 cm/ns were used for unsaturated limestone, with air-filled void velocities assumed to reach the maximum of 30 cm/ns. Standard post-processing with RadExplorer was applied to 2D images (B-scans; see recent georadar studies for signal processing [4]).

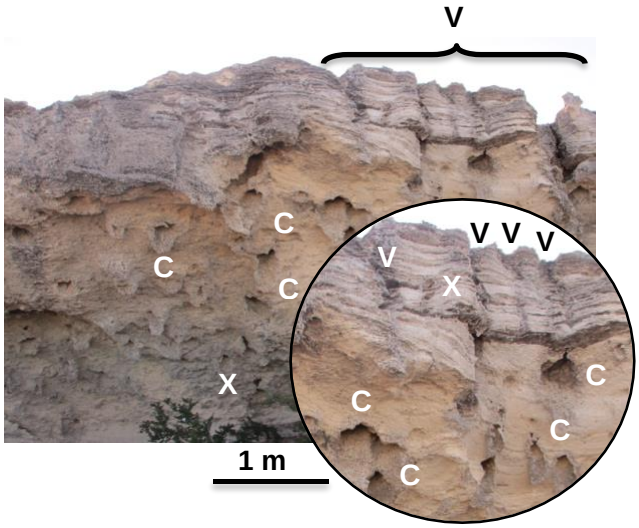

Figure 2. Aeolianite cliffs with cross-bedded sections (X), vertical "pipes" (voids – V), and their cross-sectional expressions (C) in weathered sections located just west of the geophysical study site.

Results and Summary: Geophysical images collected along the brink of the cliff (Fig. 3A) clearly show vertical "striping" (width ~20-30 cm) produced by lateral amplitude variations and attenuation (Fig. 3B). Although near-vertical features often result in signal scattering [5], the ability to image them directly (most minimally filled) facilitates the accurate interpretation of the observed subsurface response. Some vestiges of aeolian cross-bedding (Figs. 2 and 3A) are also visible (see "X" in Fig. 3B). This example is one of the first attempts to image such features, which are similar to dissolution voids [3], at high resolution and complements recent success in visualizing subsurface expressions of bioturbation structures [4] and buried palm trees [5] on several islands of the Bahamian archipelago.

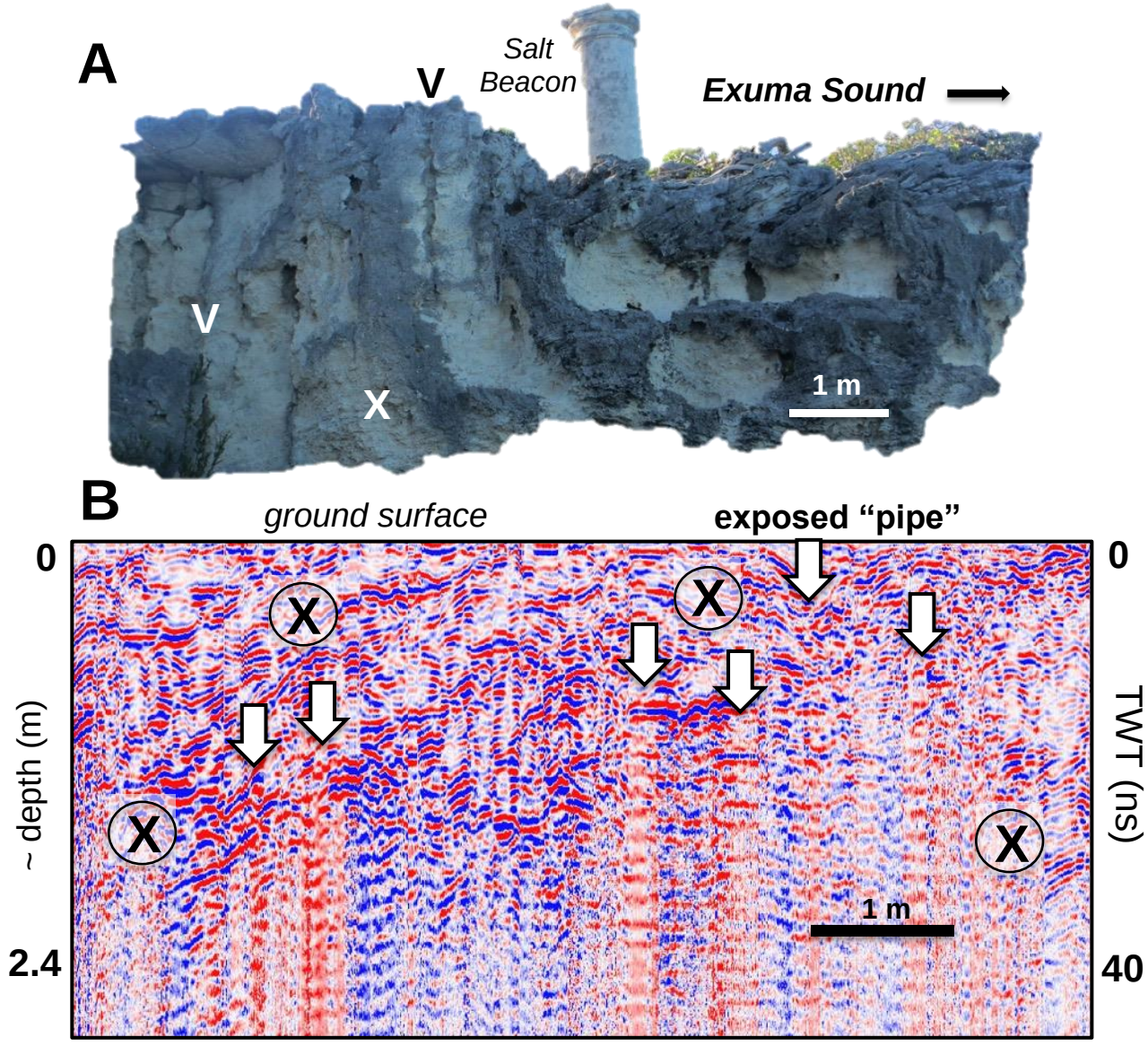

Figure 3. A) Salt Beacon cliffs (looking west) with exposed vertical voids (V); B) Radargram (#1110) reveals a vertical pattern of amplitude anomalies (arrows) below complex cross-bedded facies (X). See Fig. 1 for location. TWT – two-way travel time (nanoseconds).

Our study demonstrates the viability of GPR in detecting and resolving vertical voids in lithified carbonate sequences, even in coastal areas adjacent to saline influence (groundwater, salt spray). Whereas individual geophysical signatures of sub-vertical anomalies are by themselves not sufficient to establish their origin, spatial mapping and 3D visualization will eventually lead to a more accurate interpretation of these ubiquitous features and their discovery at other sites.

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