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PS Processes, Patterns and Petrophysical Heterogeneity of Grainstone Shoals at Ocean Cay, Western Great Bahama Bank*

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Abstract

Holocene and Pleistocene carbonate shoals at Ocean Cay, Bahamas, provide key evidence to comprehend patterns, processes and petrophysics of grainstone deposits. High-resolution remote sensing data, acoustic Doppler measurements, sub-bottom profiles, sedimentological and petrophysical analyses elucidate various factors in the deposition of a shoal complex and assess how much the sedimentary fabric and early diagenesis influence the petrophysical characteristics of such deposits.

The Holocene Cat Cay ooid shoal and the Ocean Cay tidal deltas collectively form a 1-3 km wide, 35 km long sand belt. Controls on their distribution, preservation and modification are the antecedent Pleistocene topography, bathymetry, and hydrodynamics. The Cat Cay ooid shoal is situated platformward of a bedrock ridge but high-resolution seismic data reveal a flat Pleistocene surface underneath the laterally continuous Cat Cay shoal. This finding challenges assumptions of previous studies that an antecedent high is needed for ooid shoal initiation. South of Ocean Cay, skeletal-rich tidal deltas form over a slightly shallower and irregular Pleistocene surface than the surface north of Ocean Cay. Hydrodynamic data indicate that the modern shoal geometry is primarily a product of fair-weather current conditions. In particular, tidal flows form and modify bars creating sinuous and parabolic forms. Flow velocities

up to 100 cm sec-1 inside tidal channels and inlets control the spatial distribution of grain size and sorting by remobilizing and mixing skeletal grains, peloids and ooids. Lobes that protrude from the shoal have been interpreted as storm generated spillover lobes but they are produced by focused flow in shallow channels across the shoal.

The underlying Pleistocene at Ocean Cay shows a similar facies architecture as the Holocene shoals with bars, channels, and stabilized areas. Cross-bedded and bioturbated grainstone facies exhibit petrophysical heterogeneity. Porosity and permeability are high (up to 47% and 11,500 mD, respectively). Early diagenesis modifies pore geometry, reducing permeability. This study integrates modern and ancient systems to offer a better understanding of the controls on morphology, architecture, and petrophysics of grainstone shoals of shallow carbonate platforms.