The Mural Limestone of Arizona: An Outcrop Analog for the Aptian-Albian Patch-Reef Reservoirs of the Maverick Basin, Texas

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EXTENDED ABSTRACT

Outcrop analogs provide an excellent opportunity to understand facies geometry of carbonate reservoirs; subsurface data, including well logs and seismic data, commonly lack the resolution necessary for characterizing laterally heterogeneous systems such as reef complexes and adjacent facies. The Mural Limestone, located in the Mule Mountains at the Grassy Hill and Paul Spur reef localities in southeastern Arizona (Fig. 1A), provides an exceptional outcrop analog for productive reservoirs in the Albian Glen Rose patch-reef play of the Maverick Basin. This study documents the detailed facies architecture and sequence stratigraphic setting of the Paul Spur reef and its associated shelf facies using standard field techniques, surface mapping with real-time kinematic global positioning system (RTK GPS), and digital outcrop characterization using ground-based LIDAR (light detection and ranging).

The Mural Limestone is exposed in a number of folds and east-dipping fault blocks in the Mule Mountains and at the Paul Spur locality of southeastern Arizona, to the northeast and southeast of Bisbee, Arizona, respectively. The Mural Limestone represents a remnant of a south-facing distally-steepened carbonate ramp that prograded into the Chihuahua Trough during the Cretaceous; exposures of coalesced patch reefs representing a low-relief ramp crest are located in Sonora, Mexico (Warzeski, 1983). T he Mural Limestone is divided into two lithostratigraphic members with time-transgressive boundaries above and below: the lower member is comprised of 90 to 160 m (270 to 480 ft) of transgressive intercalated carbonates, siltstones, and shales, and the upper member is comprised of 50 to 75 m (150 to 225 ft) transgressive and regressive massive buildup-bearing and bedded carbonates. Biostratigraphic studies in Arizona and geochronologic studies in Sonora, Mexico, indicate that the Mural Limestone is time-equivalent to the Pine Island Shale member of the Pearsall Formation (Scott, 1987) and the lower Glen Rose Formation (Warzeski, 1987; Gonzalez-Leon et al., 2007) in Central Texas (Fig. 1B). An important aspect of the Aptian-Albian sequence architecture in Arizona that is currently missing from published literature is the recognition and description of the cycle- or parasequence-level depositional history of the patch reefs and associated shelf facies.

In the outcrops at the Paul Spur locality, Mural facies consist of a 10 to 35 m (30 to 105 ft) thick patch reef with four distinct reef communities: *Microsolena*-microbial framestone (Fig. 2A), *Actinastrea*-algal boundstone (Fig. 2B), branching coral-skeletal rudstone (Fig. 2C), and caprinid-requienid-floatstone (Fig. 2D). Reef-flank facies consist of coral rudist rudstone debris and backreef *Orbitolina*-skeletal grainstone shoals (Fig. 2E). Echinoid-*Orbitolina*-mollusk wackestone (Fig. 2F) represents the deeper, low-energy inter-reef or deep subtidal environment. At least three aggradational to retrogradational high-frequency sequences of reef growth are evident. Retrogradational stacking is consistent with that of time-equivalent Lower Glen Rose patch reefs in the

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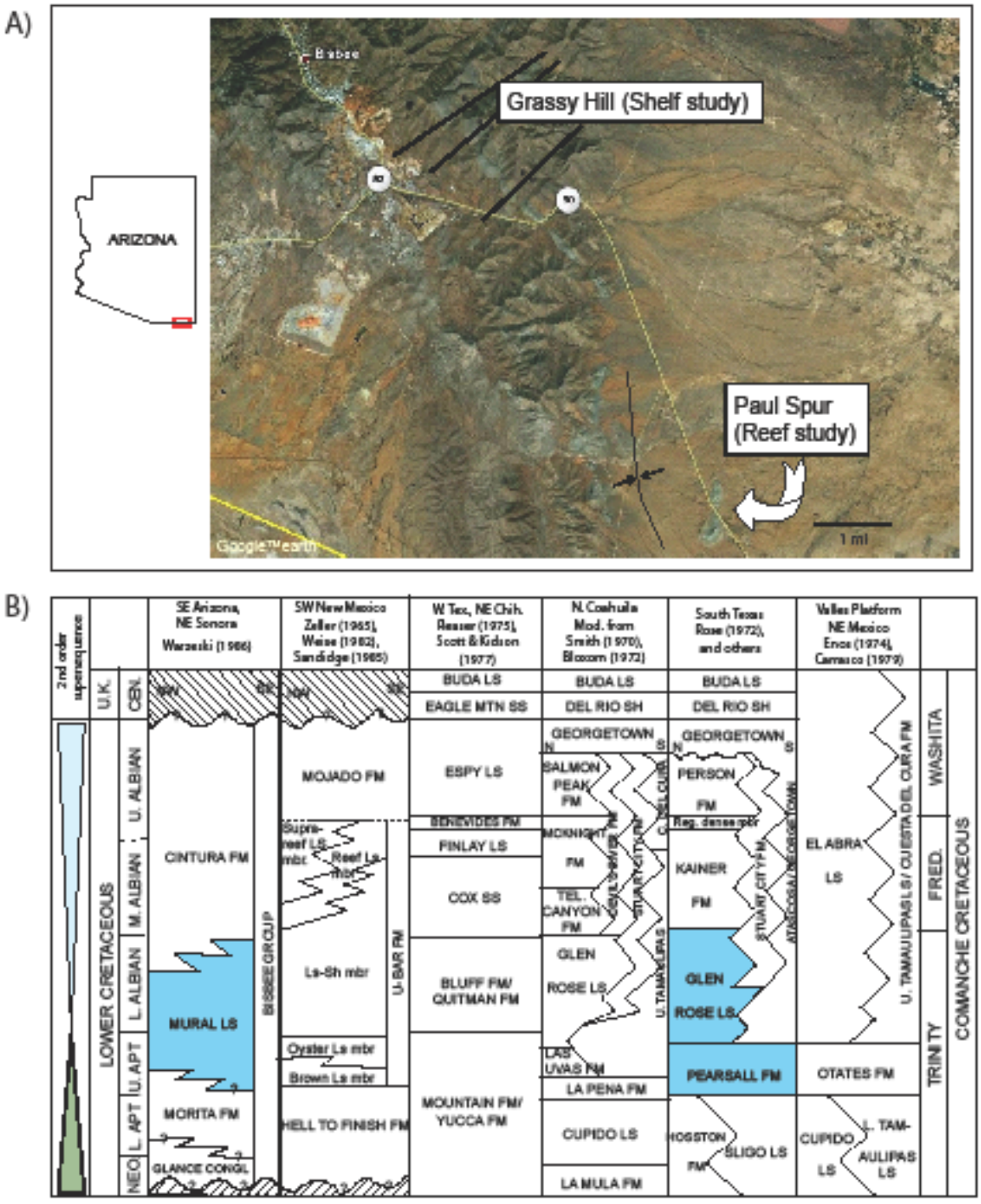

Figure 1. (A) Study area showing location of Paul Spur patch reef, and (B) Stratigraphic column, after Warzeski (1983) showing Aptian-Albian stratigraphy of the Mural Limestone in southeastern Arizona (this study), New Mexico, northern Mexico, and southern Texas.

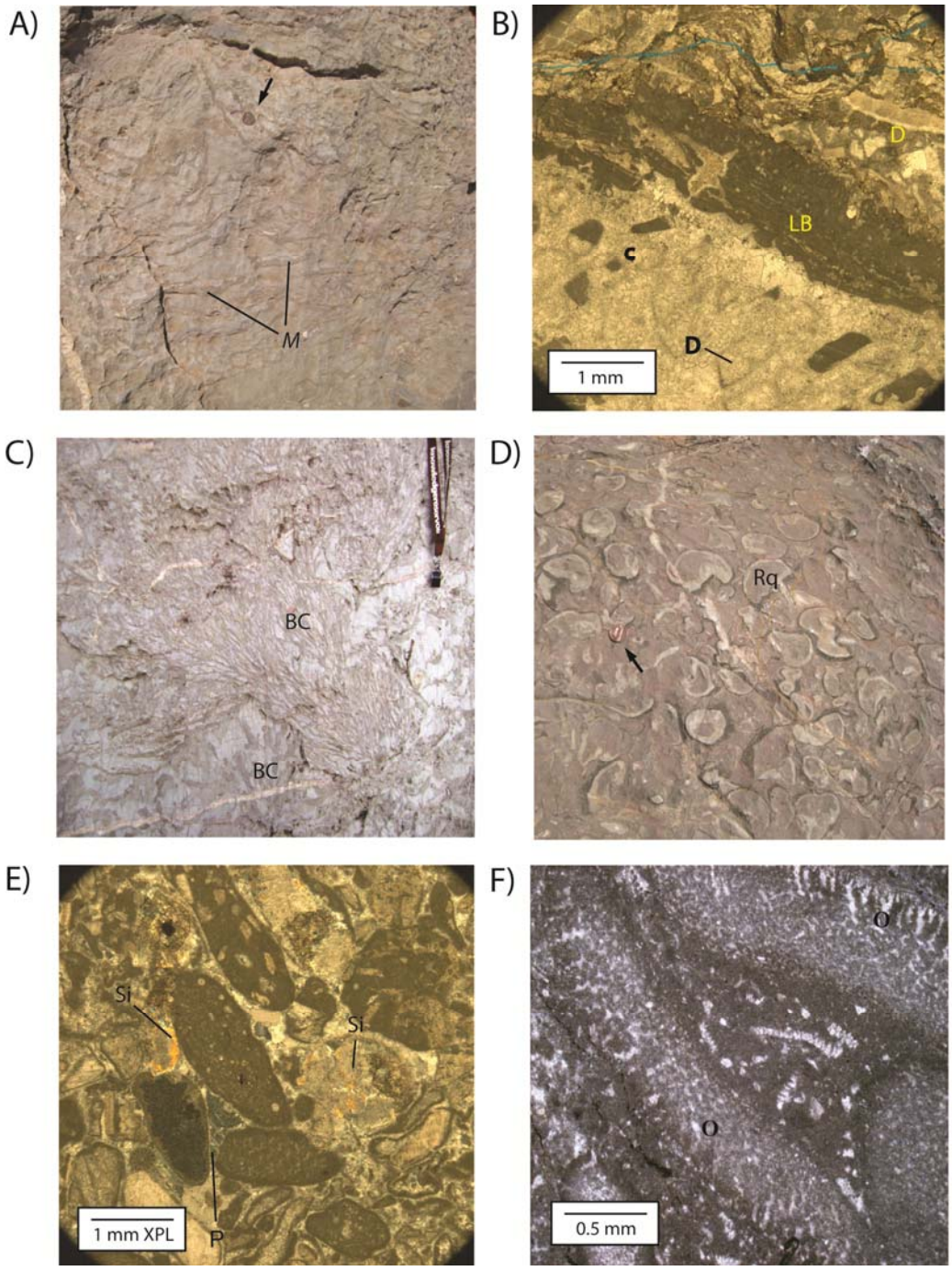

Figure 2. Photomicrographs of Paul Spur patch reef facies. (A) *Microsolena* (M)-microbial framestone; (B) *Actinastrea*-algal boundstone with corals (c) encrusted with *Lithocodium* (LB)—note late dolomite rhombs (D); (C) Branching coral (BC)-skeletal rudstone; (D) Caprinid-requienid (Rq) floatstone in wackestone to mud-dominated packstone matrix; (E) Silicified (Si) *Orbitolina*-skeletal grainstone showing poorly developed rim cements and primary porosity (P) occluded by a later generation of calcite cement; and (F) Mollusk-echinoid-*Orbitolina* (O) wackestone. 1 mm = 0.039 in. XPL = crossed polar. Arrows in (A) and (D) point to coin for scale.

Maverick Basin of Texas, which suggests a eustatic driver for stratigraphic architecture along the Bisbee/Comanche shelf. Reef diversification in HFS 3 may indicate that a combination of more oxygenated waters, low nutrient levels, low siliciclastic influx, or improved water circulation influenced reef evolution and stratigraphy. Reef and backreef shoal facies exhibit poor porosity and permeability in outcrop. Petrographic analysis of backreef grainstones shows that primary and secondary porosity may have been present based on the lack of well-developed marine rim cements and presence of silica, respectively (Fig. 2F).

Small mud-dominated coral-algal buildups (~5 m or 15 ft thick) and tabular biostromes (up to 1.5 m or 7 ft thick) consisting of caprinid-requienid floatstones are common in the bedded shelf carbonates at the Grassy Hill locality in the Mule Mountains, 10 km (6 mi) landward of the Paul Spur reef. Buildups in this area are flanked by noncyclic but well-bedded skeletal mud- and grain-dominated packstones. Localized discontinuous skeletal grainstones are associated with these buildups and contain no visible porosity. Two high-frequency sequences were identified; sequence boundaries were picked on top of thin beds of miliolid wackestone, which are the shallowest water facies in the study area.

New insights from this study show that extensive grain-rich reservoir-prone facies are dominant on the leeward side of mud-rich reef buildups, which suggests that the backreef shoal facies may be a more suitable reservoir target than reefal rims as suggested for the Maverick Basin.

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