Reservoir Characterization of Microbial Reef Reservoirs at Little Cedar Creek Field, Conecuh County, Alabama

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Abstract. Little Cedar Creek Field (LCCF) in Conecuh County, Alabama is the largest Smackover field discovered in the northern U.S. Gulf Coast in the last three decades. It is now the most productive field in the State of Alabama. The LCCF gives an opportunity to identify the characteristics of microbial (thrombolite) developments in shallow water deposits and differentiate it from the nearby reef reservoirs which grow directly on Paleozoic basement paleohighs. Previous studies from this area have indicated that Jurassic microbial buildups are associated with Paleozoic basement paleohighs. In contrast, microbial buildups at LCCF apparently developed in shallow subtidal environment without the influence of basement rockgrounds.

The objective of this project is to examine the microbial reef reservoirs at Little Cedar Creek in order to identify any relationship between depositional fabric type and reservoir quality distribution. Furthermore this study compares these nearshore thrombolite facies to microbial fabric types identified at Appleton and Vocation fields, Alabama and will focus on the types of Jurassic microbial developments in this field and the poor reservoir rock fabric types identified in other fields and characterized as lagoon, and subtidal facies.

This study will improve the understanding of Upper Jurassic Smackover microbial development, its lithologic fabrics and controls on reservoir quality. The results will improve the exploration strategy to find other stratigraphic microbial carbonate reservoirs worldwide. Examining the controls on reservoir quality distribution at LCCF will provide new insights into this unique and prolific petroleum reservoir facies

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1. Introduction

Little Cedar Creek Field, Conecuh County, Alabama, has proven to be one of the largest hydrocarbon discoveries in the northeastern U.S. Gulf Coast in the last three decades. Microbial reef fabrics of the Upper Jurassic (Oxfordian) Smackover Formation are identified as a major producing unit in this field. Thickness of the Smackover microbial section in the Little Cedar Creek Field ranges from 0 to 115 feet.

Baria et al. (1982), Parcell (2000), Llinas (2004) Mancini et al. (2004), and Mancini et al. (2006) have recognized that microbial buildups are a major hydrocarbon reservoir in many fields in the eastern Gulf Coastal Plain. A common exploration strategy for microbial reservoirs developed from earlier analyses of Alabama oils fields, including Vocation Field, Monroe Co., and Appleton Field, Escambia Co. was to associate Smackover reefs with paleotopographic Paleozoic basement highs directly overlying crystalline rock and Jurassic Louann salt structures in eastern Gulf Coastal Plain. However with the development of Little Cedar Creek Field, geologists recognized that significantly large microbial reefs also developed within updip, nearshore, shallow to subtidal environments with no apparent underlying structural control.

The purpose of this study is to examine the relationships between reservoir quality (porosity and permeability) and microbial fabric and growth form at Little Cedar Creek Field. This study compares and contrasts these relationships to microbial reservoirs in the other fields in Eastern Gulf Cost.

2. Experiment, Results, Discussion, and Significance

The Smackover Formation does not outcrop in Alabama; therefore, data were derived from well logs and cores available from the Alabama Geological Survey core repository in Tuscaloosa, AL. Examination include analysis of well logs from 42 wells, description of core from five wells, and thin section analysis.

Examining the Little Cedar Creek field is achieved in two phases. During the first phase available subsurface wireline well data were collected to correlate units in the different well locations and achieve an overall understanding of the distribution of major units and facies patterns. Those well logs and subsequent core information was integrated in the computer program 'GeoPlus Petra'.

In the second phase of the project, core analysis and sample collection was done from the available cores in Alabama Geological Survey at University of Alabama, Tuscaloosa. From the collected samples thin

sections were prepared for representative lithofacies. Detailed measurements of lithology, fossil content, microbial fabric and growth form were done based on the collected porosity permeability data and from thin sections of available core samples.

Heydari and Baria (2005) provided a preliminary lithofacies description from cores in Little Cedar Creek Field. Mancini et al. (2006) later identified six Smackover lithofacies in the field. All facies were interpreted to form in shallow water (less than 10 feet) within 3 miles of the paleoshoreline. In stratigraphic descending order the facies are (1) peritidal lime mudstone to wackestone, (2) shallow subtidal nearshore grainstone to wackestone, (3) deep subtidal lime mudstone, (4) subtidal microbially-influenced lime mudstone to packstone and (5) subtidal peloidal thrombolite boundstone, and transgressive subtidal lime mudstone.

From the analysis of the well data, all these five zones are fully developed and present in the LCCF. When compared to the previous studies, the principal difference in this field is, dolomitization is less in the lower microbial packstone and thrombolite boundstone. This field is oriented northeast to southwest and the thickness of the Smackover section increase to the southwest. It also gets thicker towards south while thinning towards north, makes Smackover section is the LCCF wedge shape and pinch out at the northern boundary. Thrombolite boundstone section also follows the same trend. After the analysis of porosity and permeability, the mean permeability range between 150-350 and mean porosity values vary from 10-25 in the southwest part of the field. In the northern portion of the field mean porosity and permeability values are extremely low. When comparing the microbial fabric type of southwest part of the field to the rest of the field, it proves to be characterized by highly interconnected secondary and vuggy porosity with moderate dolomitization. In the low permeability zones the microbial section is not fully developed and the vertical interconnectivity is controlled by centimeter scale laminations. Especially in the northeast part of the field highly porous microbial layers are separated by muddy limestone layer, which makes this part low in porosity and much lower in permeability. These two fabric types are respectively similar in properties of the Type II reticulate thrombolite and Type I layered thrombolite classified by Parcell, 2002.

3. Conclusions

Smackover formation in the Little Cedar Creek field has unique features than the other Smackover fields. Microbial section in this field is sits on top of the mudstone layer instead of crystalline basement rocks. Also these are not associated with paleohighs either. The reservoir associated with this formation in Little Cedar Creek is a stratigraphic trap and the wedge shape of the field towards north indicates that Smackover section pinches out to the north from Little Cedar Creek field. Reservoir characteristics of this field also controlled by the fabric types associated with the microbial section. The high porosity and permeability part of the field has the most developed and vertically and horizontally interconnected microbial buildups and the lower porosity and permeability zone has lesser developed microbial section with higher porous microbial section separated by lime mudstone layers.

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