PS Integrated Cores, Well Logs, MRI and NMR Data for Carbonate Pore Type Characterization: Case Study of the Cretaceous Mishrif Formation in Southeast Iraq*

Yang Li[1], Bo Liu[2], and Zaixing Jiang[1]

Search and Discovery Article #51534 (2018)**
Posted December 10, 2018

*Adapted from poster presentation given at AAPG 2018 AAPG Annual Convention and Exhibition, Salt Lake City, Utah, May 20-23, 2018
 DOI:10.1306/51534Li2018

[1]School of Energy Resources, China University of Geosciences (Beijing), Beijing, China (leeyounger@126.com)
[2]School of Earth and Space Sciences, Peking University, Beijing, China

Abstract

To characterize pore type distribution of carbonate rocks is a meaningful work for evaluation of reservoir quality and flow properties. The thin sections and core data with well logs provide ways to link both pore types and rock fabrics to petrophysical responses quantitatively. Take the Cretaceous Mishrif Formation as an example: six core wells from a prolific hydrocarbon reserve located in southeast Iraq have been used to classify carbonate pore types. The Mishrif carbonate rock includes interparticle pores with connected vugs, intraparticle pores with isolated vugs and moldic pores, and micropores. Fractures are rare among multi-scale recordings. Based on conventional well logs, micro-resistivity images, and NMR data, detailed characteristics are: (1) Interparticle pores and connected vugs that correspond to increasing acoustic transit time (AC) and produces positive separation between deep and medium electrical resistivity measurements. The pores develop in bioclastic limestone within biostrome and shoal facies after undergoing two major meteoric dissolution in the lower part of Mishrif intervals. The connected pore system displays aggregated dark color and scattered dark dots under grain-supported light backgrounds in borehole dynamic images. Connected and enlarged pores cause large transverse-relaxation-time (T_2) with right-towards unimodal peaks in NMR spectra. (2) Isolated vugs, intraparticle and biomouldic pores are common in packstone and wackstone in back-shoal and lagoon facies or in grainstones that experienced marine or early burial cementation. These pores contribute to reducing AC and produce moderate positive or weak negative separation between resistivity logs. Nodular grains with calcite cements display light patches in borehole images, along with spotty or separated dark images representing isolated or weak connected pores. This type of pore system causes dominant right peaks with left-hands sub-peaks in T_2 spectra. (3) Micropores originate from interparticle pores between micrites and remained space within calcite or dolomite crystals in lagoon and back-shoal facies, which makes AC shorter with lower rock density and weak resistivity differences. The micropore system shows low amplitude left-hands peaks with or without right-hands peaks in T_2 spectra. This study is basic work for spatially geophysical pore system characterization as well as rock-physics models for reservoir evaluation, and also has implication for geologic understanding of carbonate pore system.

Selected References

Choquette, P.W., and L.C. Pray, 1970, Geologic Nomenclature and Classification of Porosity in Sedimentary Carbonates: American Association of Petroleum Geologists Bulletin, v. 54, p. 207-250.

Dunham, R.J., 1962, Classification of Carbonate Rocks According to Depositional Textures, *in* W.E. Ham and R.J. Dunham (eds), Classification of Carbonate Rocks: A Symposium: American Association of Petroleum Geologists, Memoir 1, p. 108-121.

Flügel, E., 2010, Microfacies of Carbonate Rocks: Analysis, Interpretation and Application (Second Edition): Springer, ISBN 978-3-662-08726-8, 916 p.

Integrated cores, well logs, MRI and NMR data for carbonate pore type characterization: case study of the Cretaceous Mishrif Formation in southeast Iraq

Yang Li[1*], Bo Liu[2], Zaixing Jiang[1]

1. China University of Geosciences, Beijing, China; 2. Peking University, Beijing, China

***Email: leeyounger@cugb.edu.cn**

Introduction

There are prolific carbonate hydrocarbon reserves in the Middle East region, one of them located in southeast Iraq was selected for this study. As we know, the pore space is the important aspect for carbonate reservoir. The characterization of pore types and their distribution is an effective approach for reservoir evaluation and analysis of flow properties of carbonate rocks. Take the Cretaceous Mishrif Formation as an example, six core wells have been used to classify carbonate pore type. The integrated method is based on cores, petrophysical logs, micro-resistivity images and nuclearmagnetic resonance data, which reached investigation and genetic interpretation for carbonates.

Geological settings

The Mishrif carbonate rocks deposited in ramp settings, including the facies of shoal, biostrome, back-shoal, fore-shoal, lagoon based on thin section observations and poro-perm analysis. The diagenetic modifications comprised dissolution, cementation, rare dolomitization and weak fracturing effects. The association of sedimentary facies and diagenetic overprints made various lithofacies and pore types.

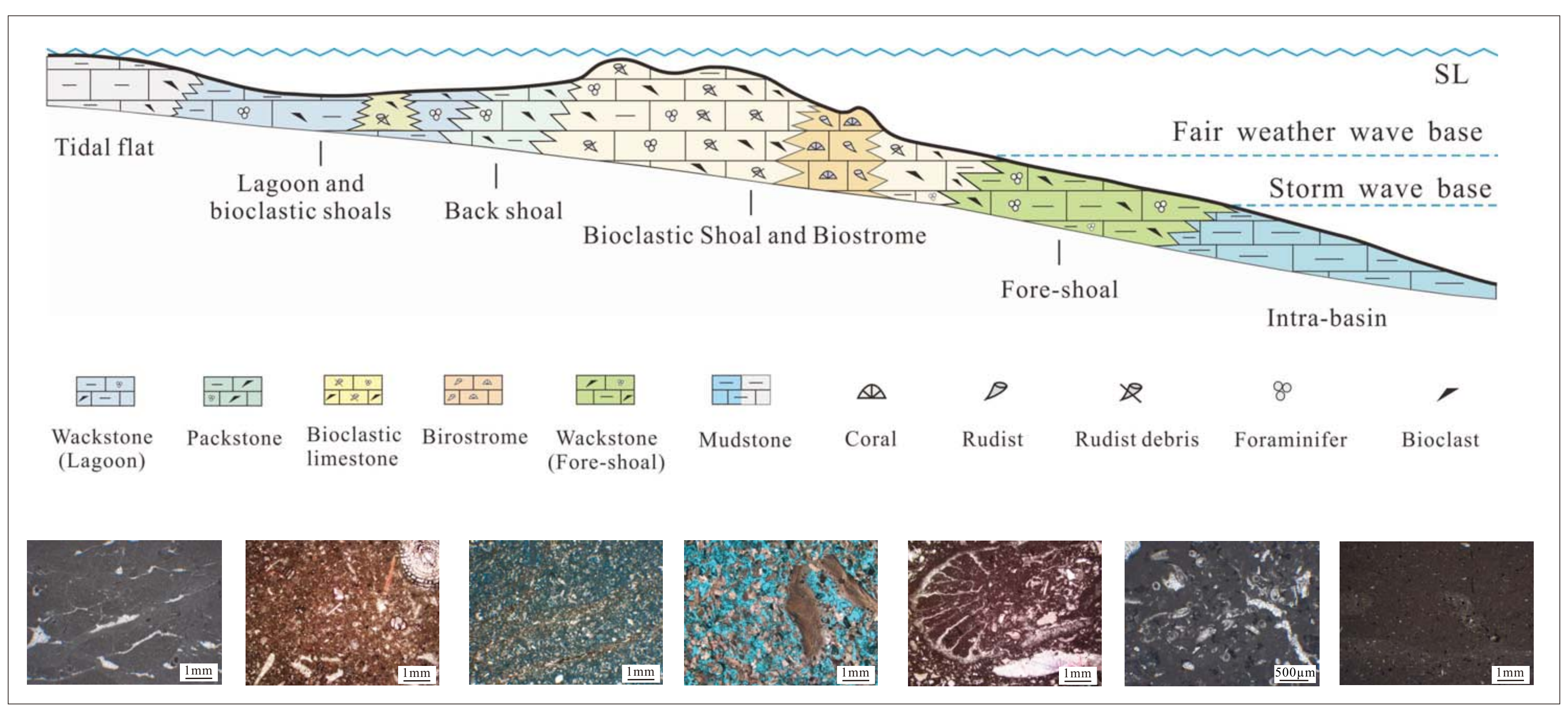


Fig.1 Sheme of petrological and sedimentary characters of the Mishrif rocks

Methods and Data

The integrated method realized multi-scale data, including thin sections, cores, poro-perms, petrophysical logs, such as gamma ray, density porosity, shallow/deep resistivities, and advanced techniques including micro-resistivity imaging (both static and dynamic images) and nuclear magnetic resonance (transverse-relaxation-time known as T2) data, which considered as effective ways describing rock fabrics and pore structures for hetergeneous carbonate rocks.

Results

The Mishrif carbonate rock mainly includes three pore systems,

- Pore type I: interparticle pores with connected vugs
- Pore Type II: intraparticle pores with vugs and moldic pores
- Pore Type III: micropores

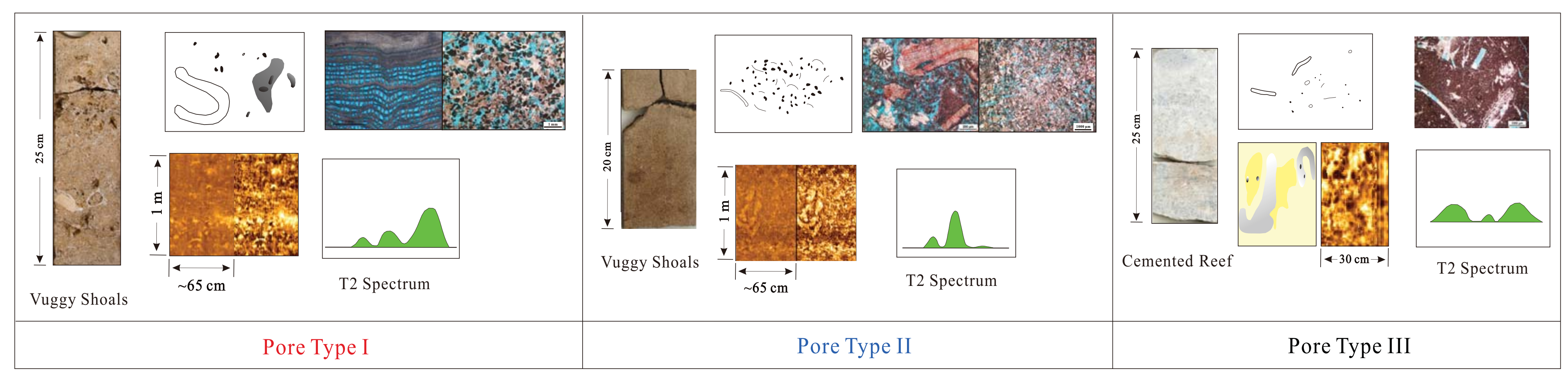
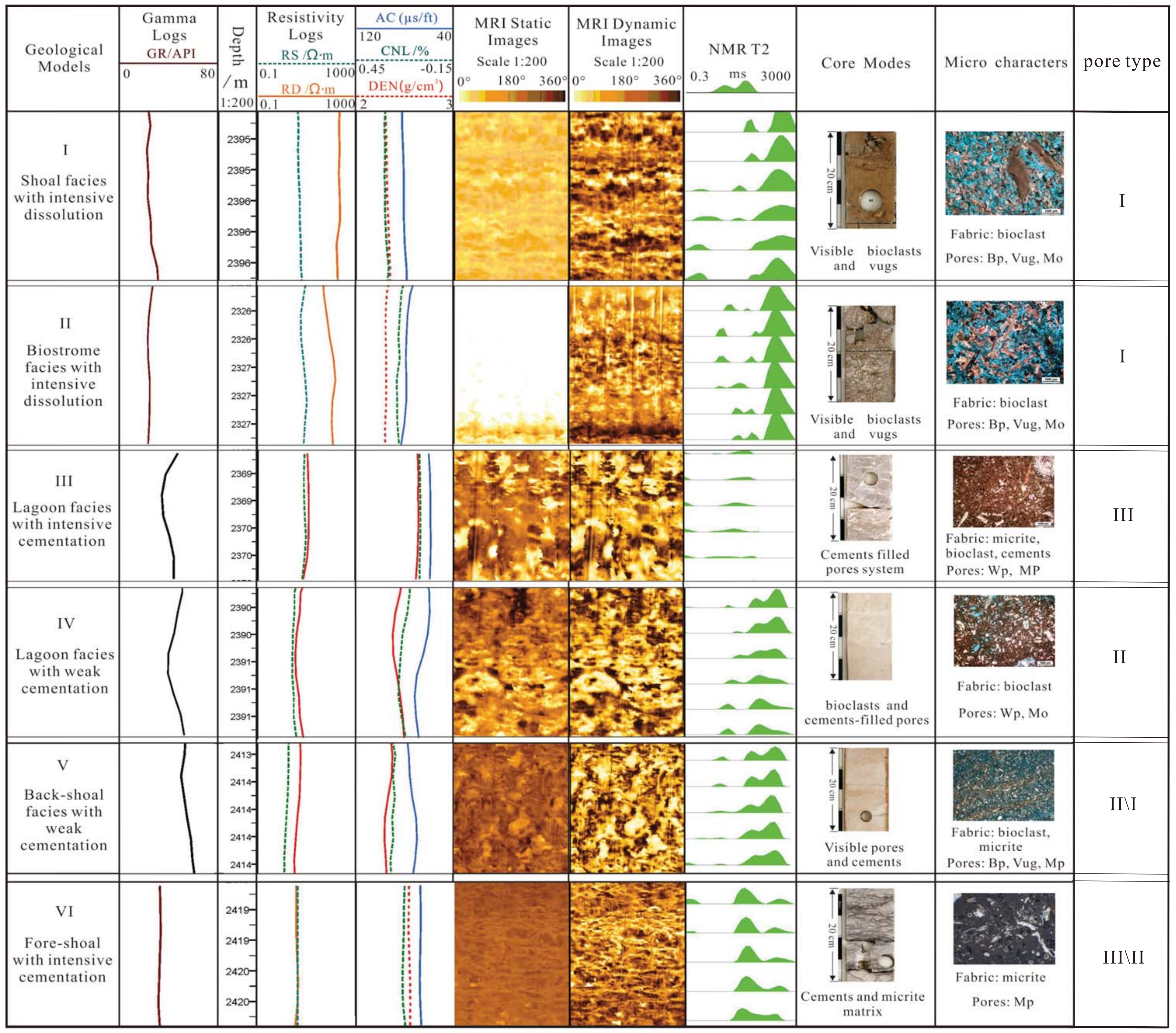


Fig.2 Pore types and petrophysical properties of the Mishrif carbonate rocks

- Pore type I: increasing acoustic transit time (AC) and positive separation between deep and medium electrical resistivities; displays aggregated dark colors and scattered dark dots under grain-induced lights in dynamic images; large transverse-relaxation-time (T_2) with right-towards peaks of high-amplitude.

- Pore type II: contribute the reducing of AC and positive or weak negative separation between resistivities; Nodular grains with calcite cements display light patches in borehole images, along with spotty dark images representing isolated or connected pores; dominant right peaks with left-handed sub-peaks in T_2 spectra.

- Pore type III: make AC shorter with lower density porosity and weak resistivity differences; shows low amplitude left-handed peaks with or without right-handed peaks in T_2 spectra.



Bp-interparticle pore Vug- vuggy pore Mo- moldic pore Wp- intraparticle pore Mp- micropore

Fig.3 The geological models and electrifacies modes

Discussions

- Pore type I developed in bioclastic shoals and biostrome, the massive thickness of deposits experienced major meteoric dissolution within the geological time forming Mishrif carbonates. The dissolved interparticle pores and vugs made excellent connnected pore networks with small proportion of calcite cements.

- Pore type II was commonly formed in packstone and wackestone in back-shoals and lagoon facies. The cementation likely happened in meteoric or burial phase, filling early interparticle pores and molds, or vugs. The intraparticle pore also appeared, making complex but intra-fabrics pore network.

- Pore type III was micropore which characterized by interparticle pores in micrites, as well as the remained space between calcite or minor dolomite crystals, forming in lagoon and back-shoal settings. or in grainstone suffered marine or early burial cementation.

Applications

- Based on pore types interpretation along with petrophysical logs, reservoir qualities were analyzed.
- Reservoir properties were examined considering geologica genesis, based on the integrated models.

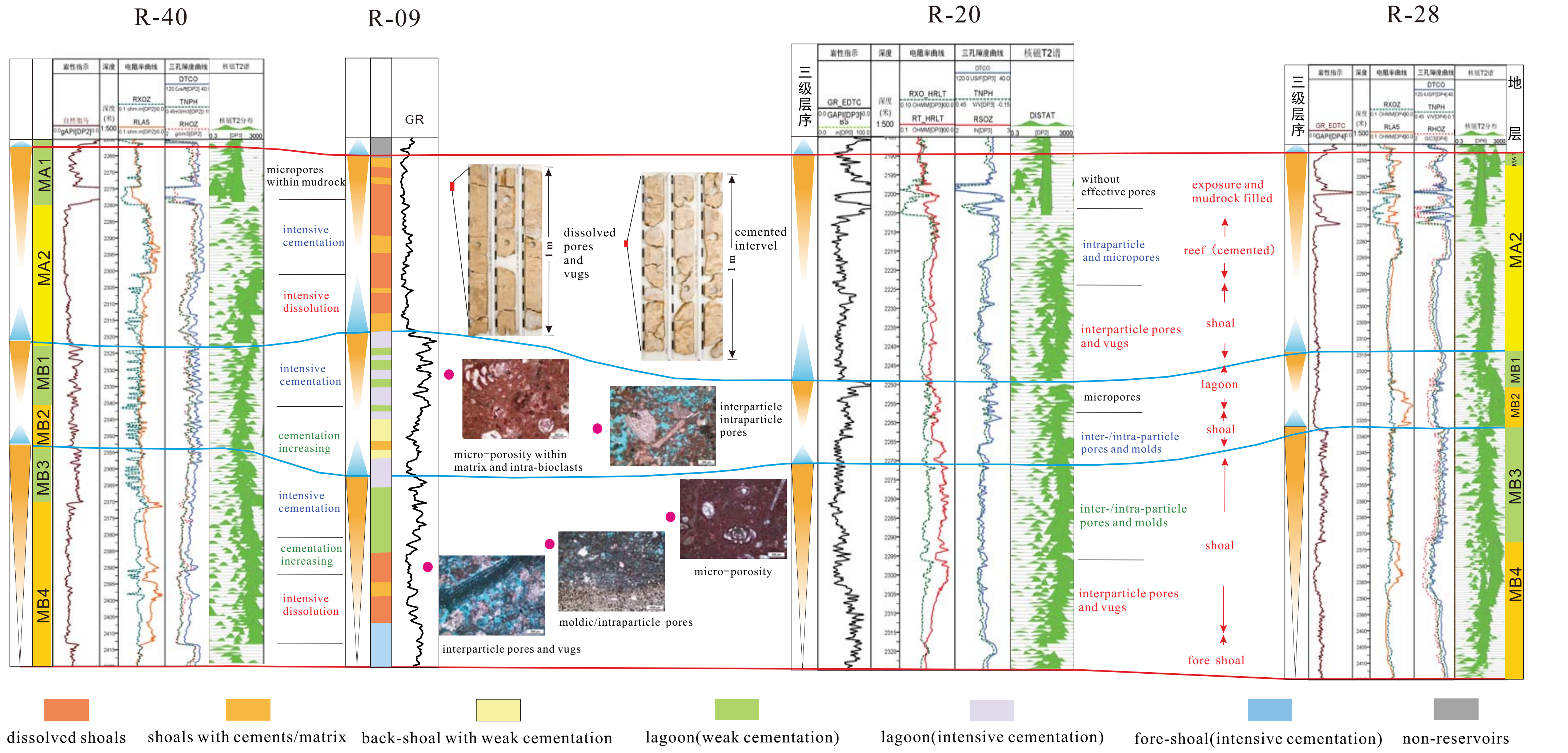


Fig.4 The interpretation of reservoir properties of the Mishrif carbonates

Conclusions

The Mishrif rocks formed in carbonate ramp settings, including the facies of bioclastic shoal, rudist biostrome, back-shoal, fore-shoal and lagoon with differential reservoirs.

Three dominant pore types were grouped, known as connected pores, isolated pores and micropores, which were the functions of both sedimentary settings and diagenetic modifications.

This study provided the basic work to describe pore distribution based on core and well logs, and also made sense of reservoir properties for carbonate rocks, which would be applied to conduct the study of reservoir characterization.

References

1. Flügel Erik. 2010. Microfacies of carbonate rocks: analysis, interpretation and application (Second Edition). Springer.
2. Choquette, P. W., and L. C. Pray. 1970. Geologic nomenclature and classification of porosity in sedimentary carbonates. AAPG Bulletin 54:207-250.
3. Dunham, R. J. Classification of carbonate rocks according to depositional textures. 1962. William E. Ham, Robert J. Dunham in Classification of carbonate rocks: a symposium. AAPG Memoir 1: 108-121.

Acknowledgements

The study is supported by National Natural Science Foundation of China (41672123), and China Major Project of Science and Technology (2017ZX05009-002).