# Strategy to Unlock Hydrocarbon from Middle MM Reservoir (Umm Gudair Field, West Kuwait)

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## Extended abstract

### Introduction

Middle Marrat (MM) formation in Umm Gudair (UG) field consist of three reservoirs (Fig. 01): Upper MM (F11/12/13), Middle MM (F14/15/F16), and Lower MM (F19-F27). Production of UG Marrat was mainly derived from the main reservoir - Upper MM since it contains the best reservoir properties. However, this reservoir is facing critical issue of depleted pressure. The Lower MM poses different challenges with tight rock & fluid contact uncertainty. Therefore, it is strategized to unlock the potential of the Middle MM reservoir that has decent properties as well as lower uncertainty of fluid contact to obtain extra production.

Middle MM is still under-developed due to facies heterogeneity and localized distribution. In the past, Middle MM was perforated in commingle with Upper MM. However, it was not conclusive about the productivity because of following reasons:

- In early stage of production, Upper MM has much better properties & pressure, which might dominate the flow and minimize the contribution from the Middle MM.
- Once Upper MM reservoir is depleted, cross-flow might occur since Middle MM reservoir has higher pressure than the depleted zone.

Due to above-mentioned reasons, a strategic plan was made to target only Middle MM reservoir while waiting for the deployment of water injection to re-pressurize Upper MM.

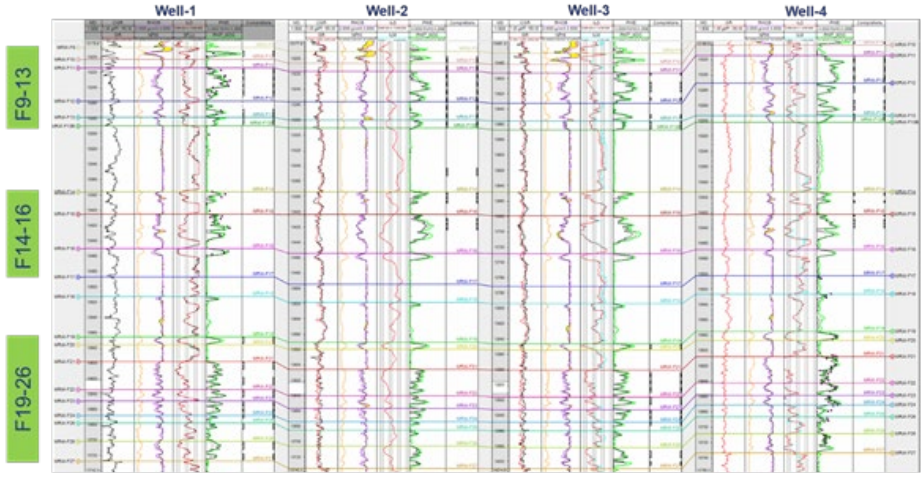

Fig. 01 Middle Marrat reservoir in Umm Gudair Field with focus on F14-16

**Methodology**

Intensive study was carried out to identify the high potential area for Middle MM resulting that good reservoir properties are developed in the East & South UG field. Reservoir thickness in F14/15/16 varies in the range of 20- 50 feet that is gradually thin towards the North of Umm Gudair with increased risk of high water saturation and reservoir quality deterioration (Fig. 02). The reservoir interval represents progradational parasequence, which is shallowing & coarsening upwards. Each parasequence consists of shale and argillaceous lime mudstones passing up through mudstones and wackestones to subtidal bioclastic packstones sharply overlain at the flooding surface by the shales at the base of the next parasequence. The packstones are commonly dolomitized and this has locally improved reservoir quality. However, even where dolomitized, reservoir quality is typically poor to medium with porosity less than 15 pu and permeability less than 1 md.

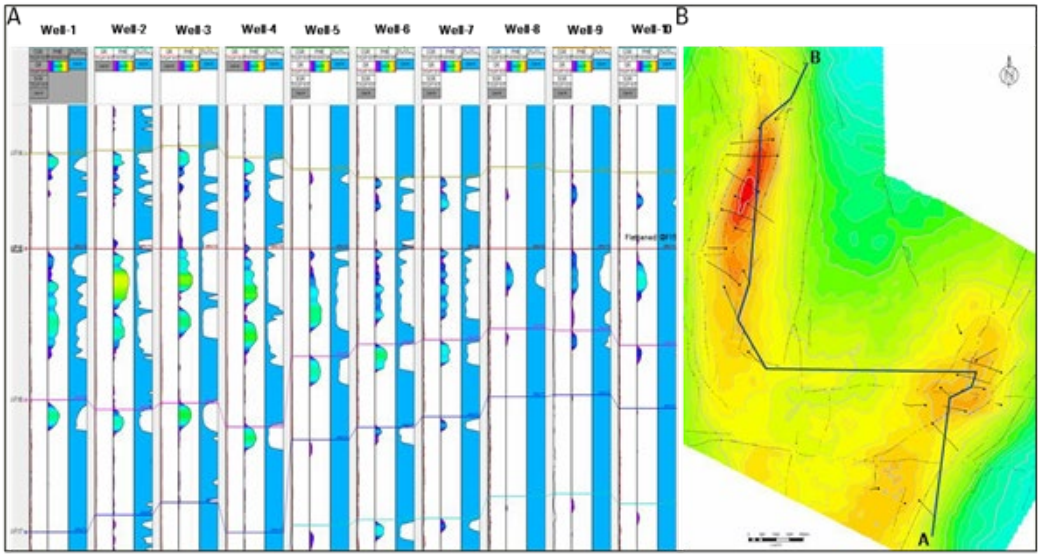


Fig. 02 Middle MM reservoir quality & thickness variation from South to North (Track-1: GR, Track-2: Porosity, Track-3: Water Saturation)

Consequently, one deviated well & two horizontal sidetracks were planned to drill in the East & South East of the field (Fig. 03). The objectives were to (1) confirm the feasibility to produce Middle MM reservoir, and (2) produce from the Upper MM if the first objective does not succeed. In order to mitigate the risk, a detailed program was delineated as following:

- Deploy Manage Pressure Drilling (MPD) system to overcome the differential pressure issue since Upper MM was significantly depleted.
- Conduct wiper trips more frequently in the reservoir section to ensure proposer hole cleaning. This is to avoid cuttings remained in the hole which could not be circulated to surface due to highly deviated well profile.
- Propose to sidetrack & drill Dharuma formation with only 10-11 ppg mud weight to avoid differential pressure.
- Maximize the data acquisition in Logging While Drilling (LWD) mode, especially to geo-steer the horizontal well.

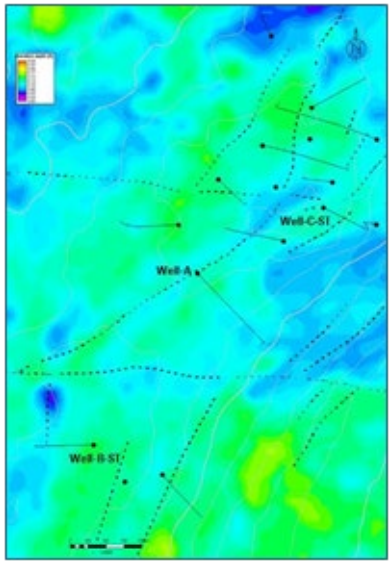


Fig. 03 One deviated (Well-A) & two sidetracks (Well-B-ST & Well-C-ST) targeted for Middle MM reservoir

Detail geomechanical study (Fig. 04) was conducted to ensure the feasibility of sidetracking from Dharuma formation. This formation was selected to open the drilling window to minimize operational efforts such as liner milling and also facilitate the high angle build in the Middle MM target. Dharuma was usually drilled with high mud weight (16-17 ppg emw) due to commingling with high pressure zones in Najmah & Sargelu. In order to drill all the way down to Middle MM from Dharuma kick-off point, applied mud weight should be reduced to 10-11 ppg since Marrat reservoirs were depleted.

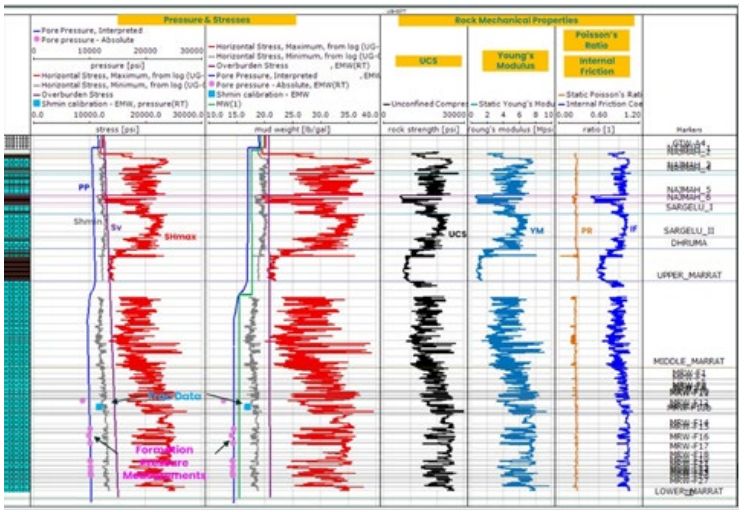

Fig. 04 1D MEM of Well-C

**Result**

The new well (Well-A) was drilled successfully & petrophysical interpretation confirmed good HC potential in both two reservoirs (Fig. 05): Upper MM & Middle MM. The first has decent porosity with average 12 pu, while the latter has higher porosity with average 16 pu. Due to the uncertainty of log quality in F14 interval, it was decided to perforate only F15 & F16. The test results showed stable oil flow with negligible water cut, and the well is currently producing with steady flow (Fig. 06).

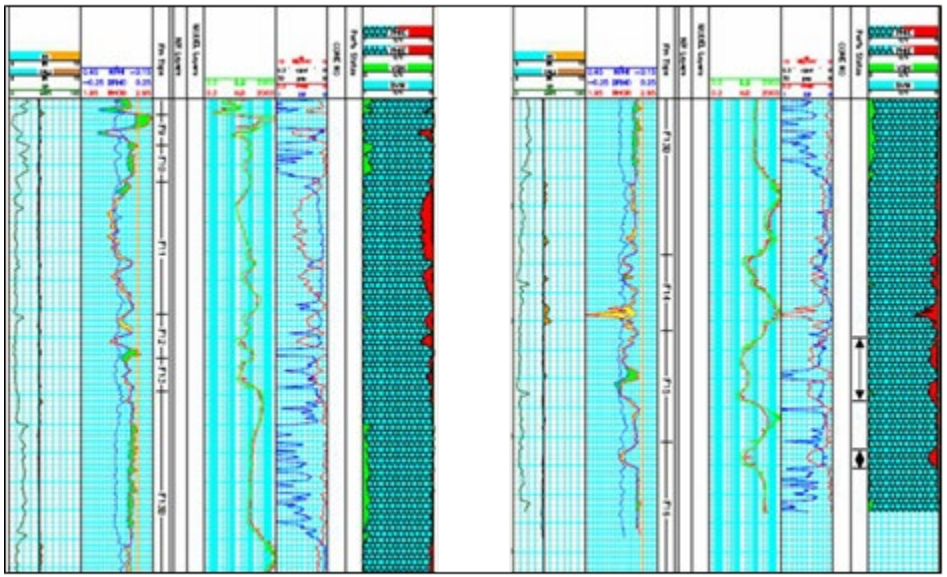

Fig. 05 Well-A Petrophysical Interpretation of Upper MM (left) and Middle MM (right)

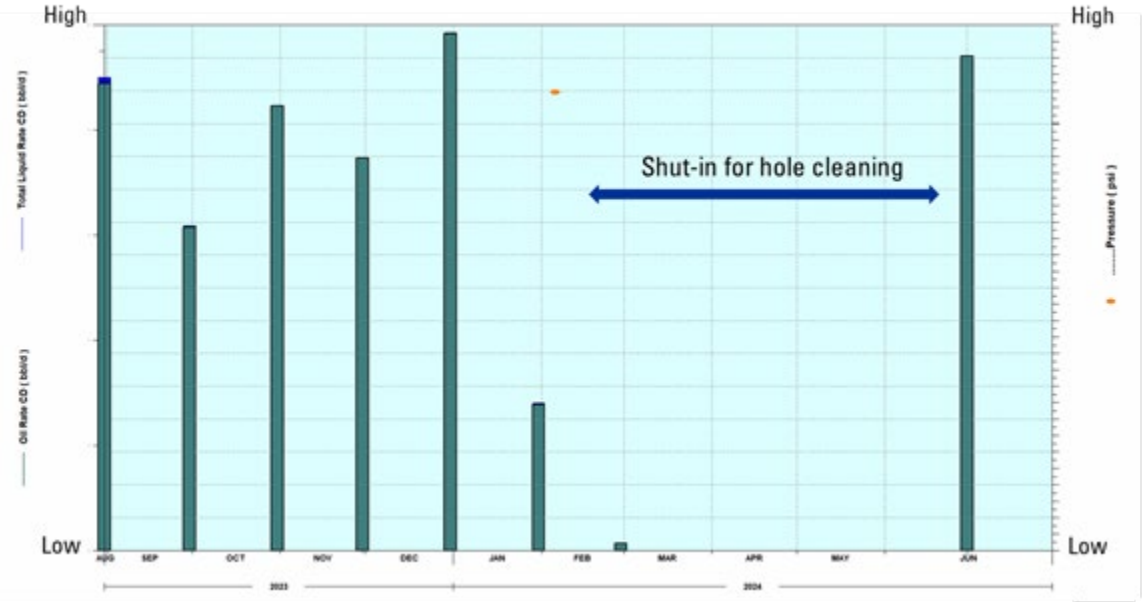


Fig. 06 Well-A Production Profile

Well-B-ST was aimed to appraise the Eastern side of Well-B original hole with expectation to penetrate higher structure & better reservoir quality. The well resulted great amount of oil and confirmed the HC potential in the South East of UG field (Fig. 07). Due to some concerns about water saturation in F16, the well was perforated in F14 & F15 only. Consequently, testing result show good oil flow without water cut.

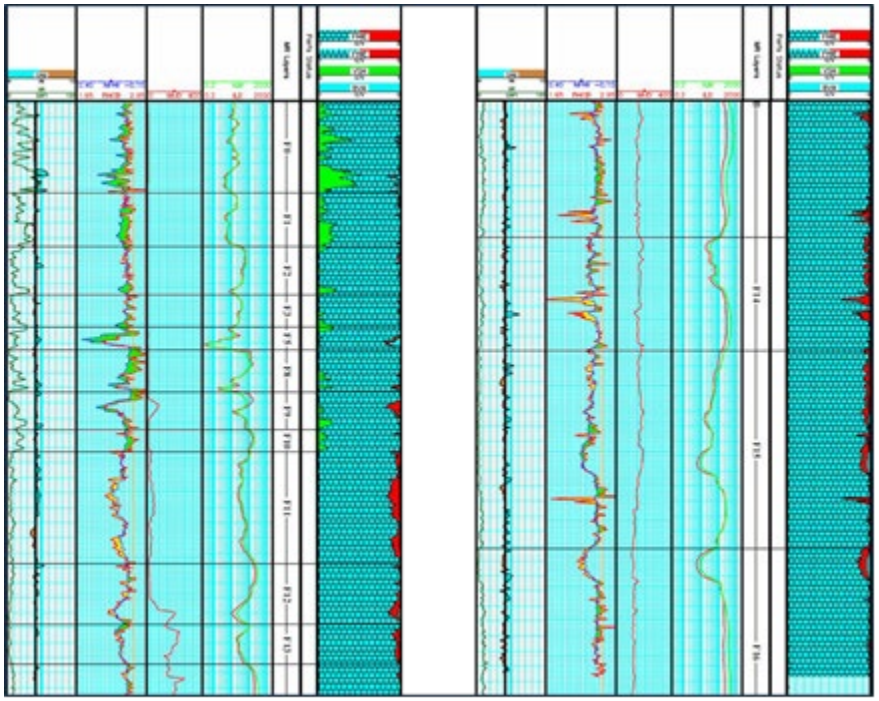

Fig. 07 Well-B-ST Petrophysical Interpretation of Upper MM (left) and Middle MM (right)

Following by the successes of the first two wells, a highly deviated sidetrack was proposed for Well-C to maximize reservoir exposure as well as reaching the defined sweet spot of Middle MM reservoir in the crestal structure of East UG field. The petrophysical interpretation indicated outstanding hydrocarbon potential with more than 300 feet of reservoir in Middle MM to perforate without any concern of water production (Fig. 08).

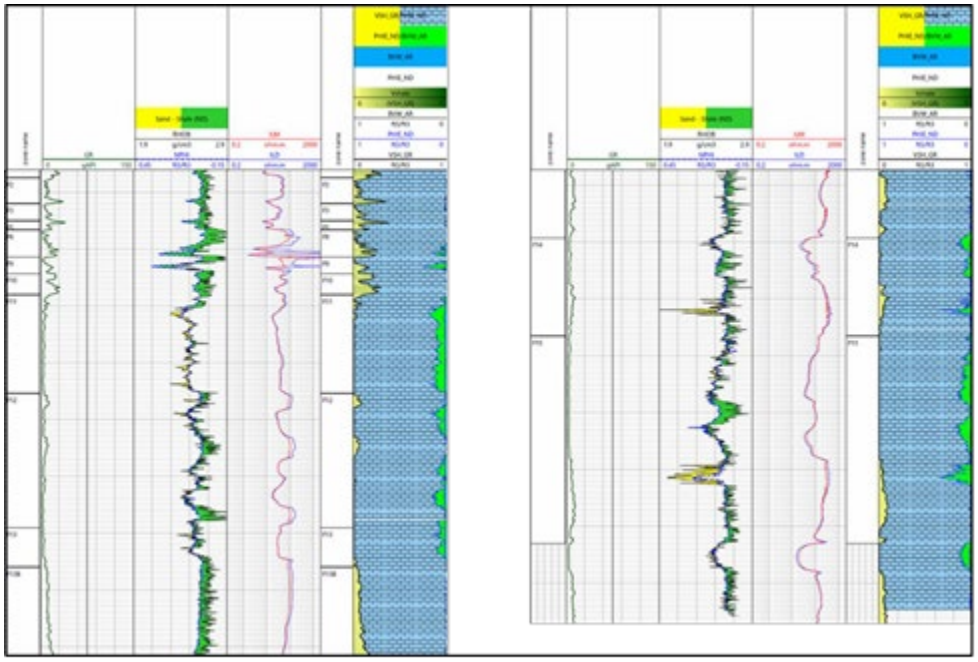

Fig. 08 Well-C-ST Petrophysical Interpretation of Upper MM (left) and Middle MM (right)

**Conclusion**

The successes of Well-A, Well-B-ST, & Well-C-ST have contributed significantly to production target as well as illuminating the strategy to develop extra oil reserve in Middle MM reservoir of UG field. Besides, it has helped to optimize the strategy for the upcoming producers while awaiting for water injection project in Upper MM depleted reservoir.

The results from these wells also confirmed the hydrocarbon potential in the main reservoir (Upper MM) since this object is currently preserved after depleting the current producing zones. The remarkable achievement from the campaign has proved that the challenging Jurassic reservoirs in West Kuwait could be developed with thorough analysis & appropriate strategy.

**References**

Nguyen, et al. 2024. Application of Gas While Drilling in Fluid Detection and Perforation Strategy in Jurassic Reservoirs. Presented at International Petroleum Technology Conference, February 2024. Dhahran, Saudi Arabia. https://doi.org/10.2523/IPTC-23517-EA

Nguyen, et al. 2022. Application of Logging While Drilling-Nuclear Magnetic Resonance in Reservoir Evaluation and Geosteering: A Case Study in Marrat Reservoir, Umm Roos Field, West Kuwait. SPE-211699-MS. Paper presented at the ADIPEC, Abu Dhabi, UAE, October 2022. https://doi.org/10.2118/211699-MS

S. Mohamed, et al. 2024. A Proactive Geosteering Approach Integrating Advanced LWD Nuclear Magnetic Resonance and Deep Azimuthal Resistivity Tools for Landing a Deep Jurassic Horizontal Well in the Best Carbonate Reservoir Facies. SPE-218692-MS. Paper presented at the SPE Conference at Oman Petroleum & Energy Show, Muscat, Oman, April 2024. https://doi.org/10.2118/218692-MS