Reservoir Quality Development in the Oligocene of the Topkhana-1 Well, Block 39, Kurdistan, Iraq*

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Abstract

The Topkhana-1 exploration well was drilled by Talisman (Block K39) B.V. in the Kurdistan Region of northern Iraq. The well identified and drill stem tested a significant gas/gas condensate resource in the Oligocene Kirkuk Group. This Group is regionally composed of back-reef and reef limestone, dominated by forams and red algae with abundant skeletal fragments. Outcrops of the Kirkuk Group in the nearby mountains reveal tight limestone intervals alternating with porous, partially to completely dolomitized intervals, suggesting a heterogeneous distribution of reservoir quality within the Group. Topkhana-1 was cored to better understand the distribution of reservoir rock in the subsurface. This paper presents the description of that core and additional studies in an effort to predict the distribution of the best reservoir rock.

Core Description

A core was cut over an 11 m interval (2280-2291 m MD) in Topkhana-1 and approximately 10.5 m of material was recovered from the Kirkuk Group in what we believe to be the transition between the Baba and Bajawan formations based on the biostratigraphic analyses. Within the core, there is a limited suite of primary depositional facies, but they do represent the primary facies with the best potential to be reservoir rock. Nearly the entire core can be classified as bioturbated, skeletal packstones dominated by large benthic foraminifera. There are no preserved sedimentary structures and very rare discrete trace fossils. As a result, the interpretation of the environment of deposition (EOD) is largely based on the relative abundance of the different biota, the degree of abrasion of the different allochems, and relative proportion of carbonate mud. From these criteria, three different EOD's are described: an inner ramp facies, an upper medial ramp facies, and a mid-medial ramp facies.

The core captured a limestone to dolomite transition which allowed us to study the paragenesis of the formation. Petrographic analyses of cross-cutting relationships provide a preliminary paragenesis as follows: After initial deposition of the sediment, some neomorphism and recrystallization occurred such that early marine cements are unrecognizable if they were present. Common in situ breakage of foraminifera tests suggests that there may have been some early mechanical compaction. An early stage of anhydrite was deposited as nodules. Following this, there is a phase of cementation where many allochems are coated with a rim of coarse prismatic, non-ferroan calcite crystals with euhedral terminations. Dolomitization seems to follow this phase of cementation and in parts of the reservoir, bioclasts are also dissolved. Minor fracturing occurs after dolomitization and dissolution, but does not seem to be extensive. Finally, a last phase of cementation occurs with late anhydrite and calcite filling some of the molds.

Reservoir Quality

Reservoir quality is highly dependent on dolomitization of the original rock. Limestone intervals are considered non reservoir with very low porosity and permeability. The zones of best reservoir rock occur where there is intense dolomitization followed by a dissolution event. In order to come up with a predictive model of where the dolomitized zones would occur, it is critical to understand the nature of the dolomitizing fluids and the timing of the event(s). Additionally, to refine our understanding of the "best" reservoir, a full paragenetic history, including understanding where dissolution would occur, could prove to be quite useful for future well locations.

Regionally, reflux dolomitization is the proposed mechanism for dolomitizing the Kirkuk Group sediments and is likely the mechanism at Topkhana. But, the timing of reflux dolomitization is unclear. It is possible that dolomitization occurs frequently at the end of each of the Oligocene Kirkuk cycles. If so, then the variation in dolomitization may be quite heterogeneous with frequent intervals of intense dolomitization grading into partially dolomitized zones and finally into limestone. Additionally, the lagoon to sabkha zone where dolomitizing fluids are created by evaporation should lie updip adjacent to the deposited sediment. However, anhydrite sediments, representative of the evaporative zone, are not found extensively in this time interval in outcrop or drilled in adjacent wells. However, with the active tectonics, it is possible that much of the anhydrite facies has been eroded away. Another possible time for dolomitization is during the Miocene Fars time. Here we find thick deposits of anhydrite which could represent the source of dolomitizing fluids. If dolomite formed during the Miocene, then one could expect less heterogeneity in the dolomite intervals than the previous model. Instead, there could be one "sweet spot" of intense dolomitization.

Isotope Investigation

To determine the nature of dolomitizing fluids, strontium, oxygen, and carbon isotopes of bulk rock have been used successfully to build an understanding of the diagenesis of carbonate rocks. The oxygen isotopes can constrain the type of fluid (seawater, meteoric water) and temperature (low or high) and the carbon isotopes help in correlations between wells and sometimes provides insight on the source of carbon (methane, seawater, soil CO_2). Strontium isotopes can generally constrain the timing of diagenesis and sometimes provide insight into the source of the fluid (basinal, seawater). The $^{87}Sr/^{86}Sr$ isotope curve for the Oligocene to Miocene shows a significant variation in values (Figure 1). If we measure the $^{87}Sr/^{86}Sr$ isotopic composition of dolomite, we may be able to determine whether the dolomite was formed during the Oligocene (Kirkuk time) or Miocene (Fars time). A series of samples ranging from pure dolomite to pure limestone have been sent for oxygen, carbon, and strontium isotopic analyses. Additionally, a more in-depth paragenesis is also being worked with further petrographic inspection under cathodoluminescent and UV light. Results of the isotopic analyses and paragenesis study will be discussed at the core workshop.

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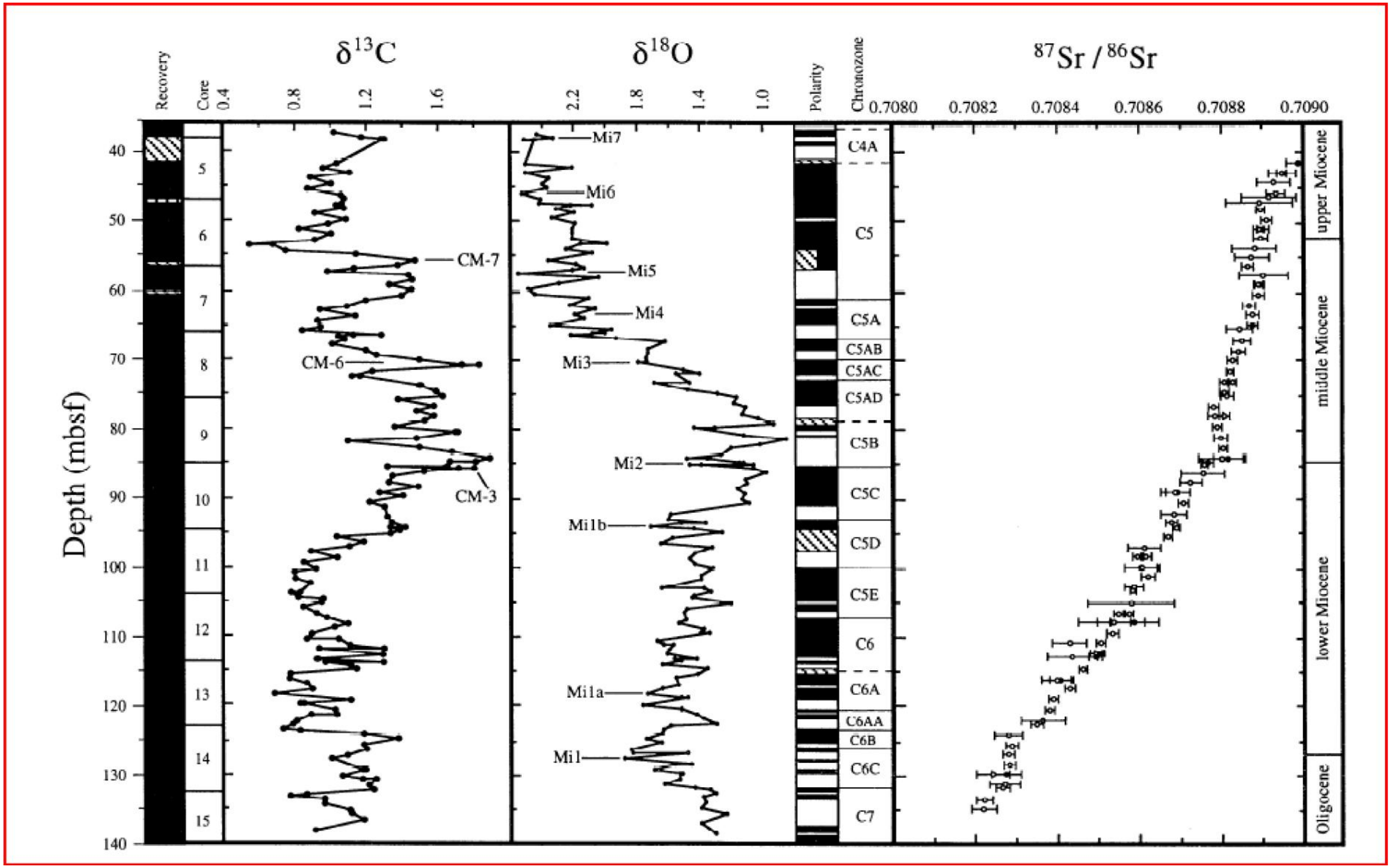

Figure 1. $^{87}Sr/^{86}Sr$, Oxygen and Carbon isotopes vs depth (age) from Oslick et al, 1994. The variation in $^{87}Sr/^{86}Sr$ isotopic composition is different enough between Miocene and Oligocene time to be able to postulate timing of dolomitization.