Characterization of facies and fracture patterns within chalk deposits: Example from the Mungo Field, UK Central North Sea

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Summary

The Mungo Field is located east of the UK Central Graben in offshore blocks 22/20A and 23/16A and is the largest field within the Eastern Trough Area Project (ETAP). Situated roughly 230 km east of Aberdeen, Scotland in 88 m of water depth, the Mungo Field has been on continuous production since 1998. Structurally, the field it is a pierced, four-way dip closure against a salt diapir (Figure 1). Reservoir intervals are located within steeply-dipping Late Palaeocene sandstones and Early Palaeocene-Late Cretaceous chalk on the flanks of the diapir. The sandstones (Forties Member, Lista Formation and Maureen Formation) comprise the primary reservoir while the underlying chalk (Ekofisk, Tor and Hod formations), in contrast, has seen little direct development except pilot production in selected wells in the western portion of the field.

A chalk appraisal well drilled in 1998 delivered 4 mbd. Unfortunately, this rate was considered disappointing when compared to primary reservoir performance within the Palaeocene reservoir. Subsequent Palaeocene wells, however, have provided valuable new chalk data. Notably, many similarities in the facies were found in this chalk data that compared favorably to the nearby chalk-producing Machar Field in ETAP. Fracture presence, and therefore chalk deliverability, still remained a key risk however to future chalk appraisal. In 2015, an acid stimulation of an existing well (A19) delivered gross liquid rates of 12 mbd (6000 mbd oil) within the chalk reservoir (Doghmi et al., 2016). The sustained production confirmed the presence of a natural fracture system and the potential of the chalk reservoir as an economically deliverable reservoir. Given the recent success, chalk potential for future drilling and development has been assessed via detailed structural and sedimentological studies to better understand the spatial distribution of fracture systems and reservoir facies.

Background

Within the Mungo Field, oil production began in July 1998 via three pre-drilled wells tied back to a normally unattended installation (NUI). The Palaeocene sandstones have been produced extensively over the past 20 years under combined water and gas injection. The underlying chalk reservoir, though largely undeveloped, has provided optimism for potential development going forward given the recent success of acid simulation on well A19 (Doghmi et al., 2016). As such, the chalk succession within the Mungo Field now represents an exciting opportunity to assess its potential as a relatively cheap to access secondary reservoir development at the center of a mature hub.

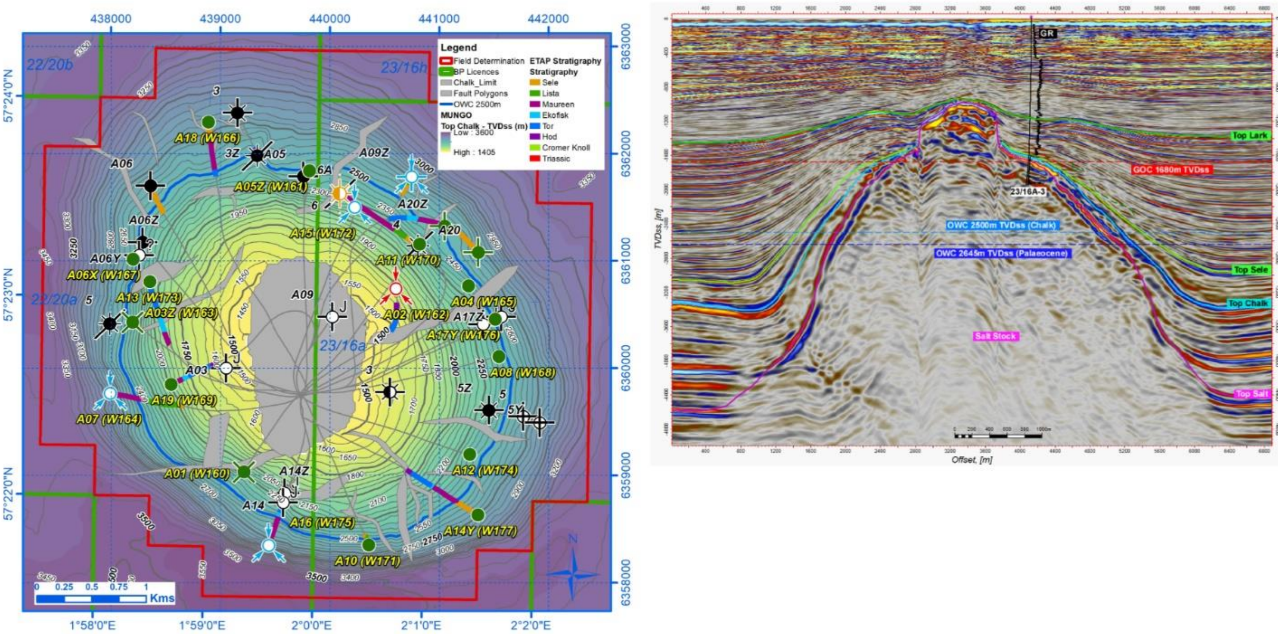

Figure 1: Mungo structure map (Top Sele Formation) and associated E-W seismic section showing the salt diapir and associated steeply dipping beds of the Palaeocene (Top Sele) and chalk reservoirs (Top Chalk).

Results

The chalk reservoir can be subdivided by well-logs and biostratigraphy into stratigraphic layers known as the Upper and Lower Ekofisk Formation, Upper and Lower Tor Formation, and Hod Formation. The chalks themselves were deposited as an accumulation of algal skeletons called coccospheres (10 to 30 µm in size), with small amounts of planktonic and benthonic foraminifera, and pelagic clays. The Mungo chalk reservoir can be subdivided into four primary facies associations (pelagic chalk, argillaceous pelagic chalk, reworked chalk and injected sands). Of the four, the reworked chalk represents the best reservoir quality. Porosities within these reworked chalks can range up to 32% and permeabilities of up to 5mD have also been observed. Perhaps most importantly, depositional mapping across the field suggests that the reworked facies most commonly occur within the Upper Tor and were influenced by the syn-sedimentary evolution of a salt wall. The growing salt wall therefore likely provided the topography from which remobilization was triggered

To better understand the spatial distribution of fracture systems within the chalk, seismic work was conducted. From this, it is observed that mass transport deposits (MTDs) are present, whereby up-dip extensional, mid-slope perched deposits, and lower (base of slope) compressional deposits occur around the salt stock (Figure 2). The mapped radial faults may represent the lateral boundary between MTDs or may have been the trigger for sediment movement. Concentric faults are developed within the MTDs and, depending on their structural position on the slope, can be extensional or compressional structures. There is clearly a protracted history of deformation, from early, unlithified chalk remobilization to later movement of consolidated sediments via MTDs as the growing salt structure steepened the slopes, and final stabilization of the MTDs through burial. Subsequent growth of the diapir is interpreted to have resulted in the development of further radial fault structures. Open fracture orientations in the subsurface are interpreted to be dominantly radial based on the observed fractures from image logs and the existing geomechanical model, whereby the *in situ* stress orientation is largely controlled by position on the diapir, with the maximum stress orientated perpendicular to the salt boundary.

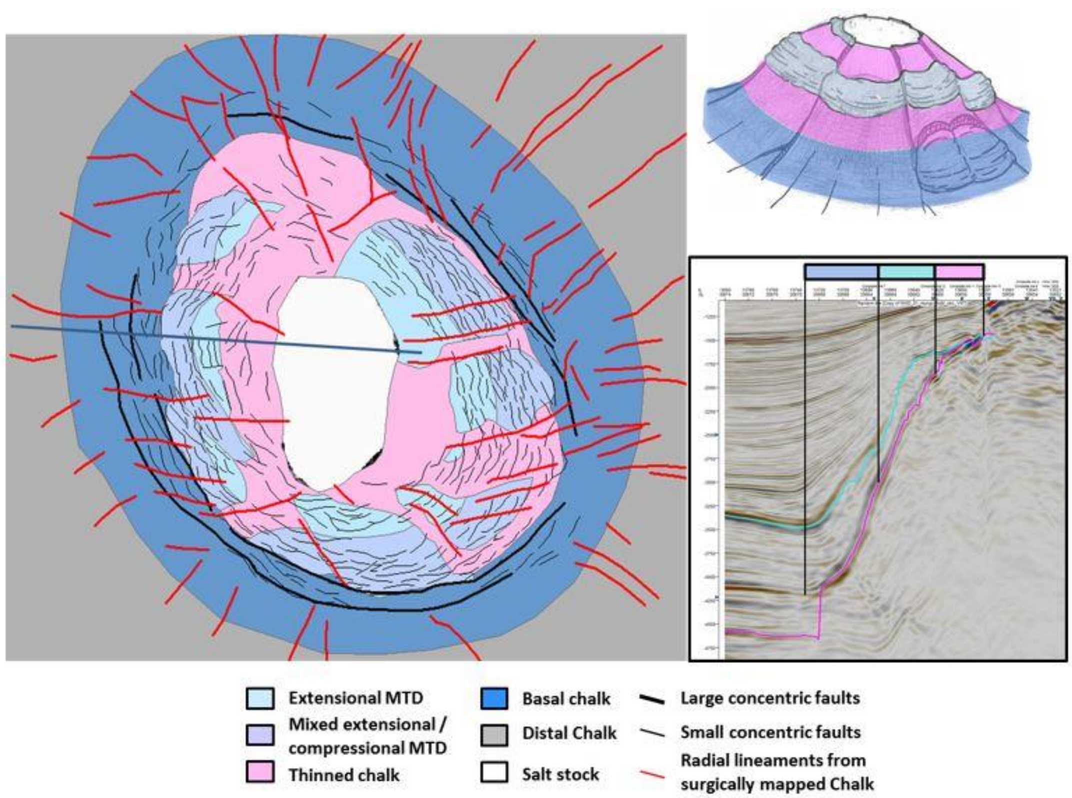

Figure 2: Major structural elements present within the Mungo chalk.

Conclusions

Recent oil production within the chalk suggests the presence of a natural fracture system and therefore the potential of the chalk reservoir as an economically deliverable reservoir. As a result, recent core work and seismic mapping have been conducted to better understand the spatial distribution of the chalk facies and fracture system across the Mungo Field.

Further progression to drilling will now require new data to be obtained from the Machar Field during blowdown to reduce uncertainty in critical gas saturation and relative permeability. Understanding these parameters, coupled with improved seismic imaging of the reservoir, will help determine the economic viability of a Mungo chalk development well in the coming years.

Acknowledgements

Many thanks to BP Exploration North Sea and JV Partner Zennor Petroleum for allowing us to discuss the contents presented in this abstract. Additionally, past and present members of the Central North Sea (CNS) team in the Aberdeen office are graciously recognized for all of their help over the years in understanding the technical challenges associated with chalk reservoirs.

Reference

Doghmi, A., Davies, A.Y. & Rylance, R. 2016. Unlocking tight chalk potential in mature North Sea oilfield through effective acid fracturing. SPE Hydraulic Fracturing Technology Conference, The Woodlands, Texas, SPE-179141-MW, 22p.