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Pore Pressure Modelling in Data Limited Areas - A Case Study from a Deepwater Block, Offshore Rakhine Basin, Myanmar

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Summary

In frontier basins such as the deepwater blocks offshore Myanmar, determining the subsurface pore pressures is inherently challenging. Typically, offset well data is rare or irrelevant and the primary dataset is limited to seismic interval velocities with some form of interpretation of the geological depositional system. As a result, making any assessment of the pore pressure is problematic. One of the keys methods to unlock the potential of the deepwater blocks and to ensure successful exploration in the future is to adopt different approaches and include as much geological understanding as possible into the study to ensure consistency. The approach described here involves utilizing multiple techniques and data types to help model the pore pressures in the deepwater. Data include the use of seismic amplitudes, seismic interval velocities and 2D basin modelling. Using the integrated approach to model the pore pressures ensures consistency between the multiple disciplines and allows quantifying the uncertainties adequately.

Introduction

The Ganges-Brahmaputra Delta is one of the largest submarine deltaic fan systems in the world, with an aerial extent covering approximately 170,000 km^2 and where Tertiary sediments are up to several kmôs thick (Racey and Ridd, 2015). To date, much of the exploration has been focused in the north and east edges of the Basin where significant gas discoveries have been made (Thalim, Shwe, Shwe Yee Htung). Since the Myanmar 2013 bid round, interest in the basin has also focused on the deepwater exploration blocks of the central part of the basin.

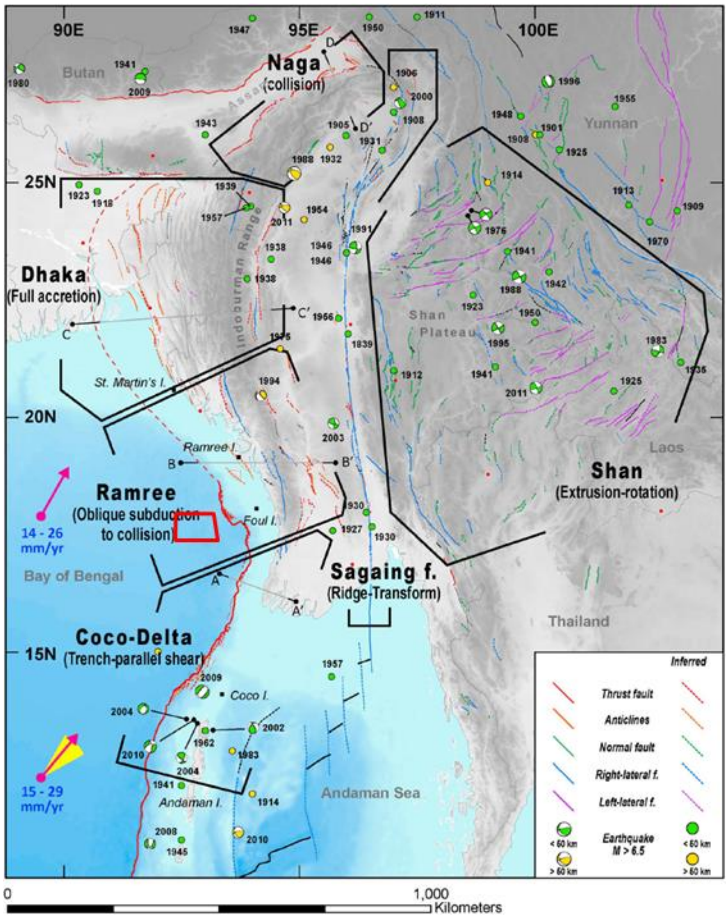

__Figure 1__ Location map showing the Rakhine Region and associated tectonic components (modified after Wang et al. 2014). Red box indicates the AD-3 Block, offshore Rakhine Basin, Myanmar.

In terms of historical overpressure occurrences there are known problems on the shelf of the offshore Rakhine Basin which, on first pass, appear to be difficult to resolve. There are several instances where wells have been abandoned early due to a shallow top of overpressure whereas others were abandoned due to much deeper overpressure or appear normally pressured. The strong variability in overpressure appears to present a significant drilling hazard. However, the eastern shelf of the Rakhine basin has been tectonised and uplifted due to the proximity to the Indo-Burma ranges (Rangin et al., 2013) and the value of the wells drilled there for calibration of the deepwater pressure model is questionable.

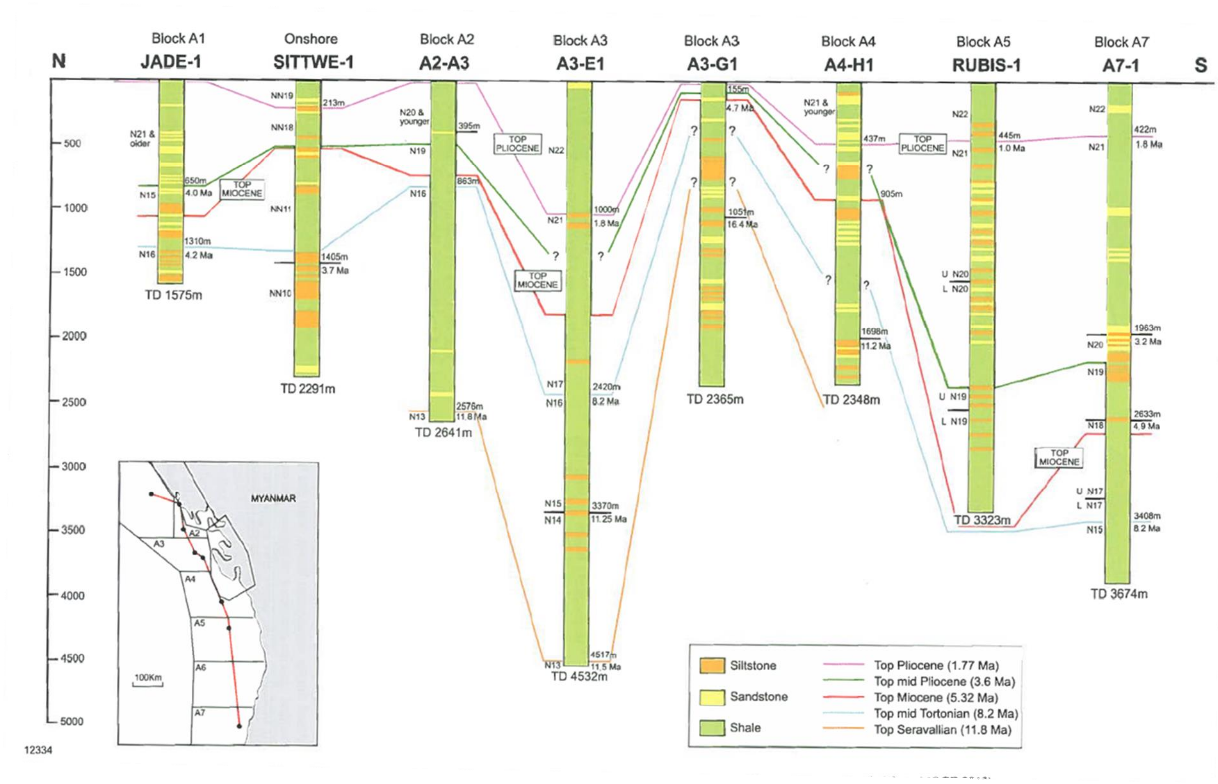

***Figure 2** Well correlation from north to south along the coastal belt of the Rakhine Basin, showing the stratigraphy, thickness and dominate lithology (after Racey and Ridd, 2015). Jade-1 was abandoned due to a shallow gas kick. SITTWE-1 there was no available well information on the drilling status of this well. A2-A3 was abandoned due to the presence of a shallow top of overpressure (approximately 688 m). A3-E1 had no indication of any overpressure and hence interpreted as normally pressured. A3-G1 was interpreted to have overpressure between 457-1570 m. A4-H1 was interpreted to have a top of overpressure approximately at 1981 m. RUBIS-1 was abandoned due to significant overpressure. A7-1 had overpressure interpreted between 2179-2636 m.*

Pressure Modelling in Frontier Basins

In frontier basins such as the deepwater blocks offshore Myanmar, determining the subsurface pore pressures is inherently challenging. Typically, offset well data is rare or irrelevant and the primary dataset is limited to seismic interval velocities with some form of interpretation of the geological depositional system. As a result, making any assessment of the pore pressure is problematic. One of the keys methods to unlock the potential of the deepwater blocks and to ensure successful exploration in the future is to adopt different approaches and include as much geological understanding as possible into the study to ensure consistency (Kim et al., 2011).

One approach, as described here, is to apply best practise pore pressure prediction methods extrapolated from the known areas on the shelf to the frontier deepwater domain providing the geology is similar. The types of questions that are raised initially that can help constrain the uncertainty in a geologically-derived pressure model are:

1. What pressure information can we gather from the existing offset wells?

2. What are the lithologyôs present? - Can the lithologyôs at the offset well locations be correlated with reflectivity and extrapolated to the deepwater location based on known relationships in the shallow water.

3. Integrating reservoir facies ï Experience in deepwater fans globally suggest two characteristics those that often connect to onshore, e.g. Agbada Formation Niger Delta, Wilcox Formation Gulf of Mexico, or those that are isolated sands with high pore pressure, e.g. Lange Formation, Mid Norway, Akata Formation Niger Delta.

4. Integrating temperature and/or age related diagenetic effects - At elevated temperatures an inter-play between diagenesis and temperature can occur such that secondary overpressure generating processes can occur (e.g. Gulf of Mexico, Mahakam Delta) adding additional overpressure into the system not related to burial.

5. Interpreting pore pressure profiles in deepwater shales ï What do we know about existing deepwater plays (e.g. Voring Basin, Nise Formations Mid Norway, Niger Delta, Nile Delta, Mahakam Delta, Indus Basin) or paleo-deep water fans (e.g. Jeanne dôArc and Scotian Shelf)?

6. Apply simple loading models - Deepwater sediments typically have pressure profiles parallel to the overburden. The depth at which these profiles start is controlled by rate of sedimentation shale lithofacies. Therefore, it is sensible to establish approximate chrono-stratigraphic markers from our seismic and then produce theoretical models for shale pressure based on sedimentation rates.

The geologically-sensible pressure model constructed must explain the current overpressure occurrences, taking into account the local geology and analogous areas (structure, stresses, temperature, basin history, sedimentation rates, and depositional architecture). Using the geopressure model we can then sense check seismic velocity based interpretations together with basin modeling performed in the uncalibrated area.

Case Study: Offshore Rakhine Basin, Myanmar

Located in water depths in excess of 2 km, the AD-3 block presents 5 to 7 km of late Miocene to Pleistocene sediments from the Bengal Fan depositional system. 10,000 km2 of high quality 3D seismic have been acquired in 2015 over the entire block, providing enough geological understanding to identify drillable prospects. Using the high quality seismic data in conjunction with the limited offset well data and available public information helped build a geologically-sensible model for the deepwater play. The approach taken included:

Phase 1: A state of the art review of the pressure regime of the Rakhine Shelf was undertaken on a series of offset wells in order to characterize the mechanisms driving the overpressure build up and derive a conceptual model of overpressure occurrences. As most of those well locations are affected by the stress and strain history linked to the uplift of the Indo-Burma Ranges, the Shelf pressure model itself cannot be directly implemented to the deepwater part of the basin, however some parameters proved to be useful for calibration.

Phase 2: An integrated approach, combining static 3D seismic inversion of velocities and 2D dynamic fluid flow simulations, was defined and implemented over the AD-3 block. A calibration phase was first performed on an existing field in order to determine qualitatively and quantitatively the parameters controlling the temperature, pressure, hydrocarbon charge and entrapment. The models were subsequently extrapolated to the AD-3 block, supported by a regional basement study and by mapping of the surface heat flow. Calibrated Gardner transforms were used to establish the relation between velocity and density and ensure a consistent and constant link between the two methods.

Phase 3: The uncertainties around the pore pressure models were captured by low, base and high-case scenarios. Additionally, a comparison between the profiles derived from 2D basin modelling and location-based seismic predictions was undertaken to ensure consistency of the different methods and optimise the well design. The 2D basin model proved instrumental to test the sensibility of the forecasts, notably for the magnitude of the high-case pore pressure by testing the impact of tight Miocene shales. The ramping of hard overpressures was also better constrained by the basin model where predictions based on interval seismic velocities alone would fail due to presence of shallow gas and/or silty lithologies.

Conclusions

Building pore pressure models in frontiers areas rely heavily on the use of analogue models and seismic datasets. The approach described here involves utilizing multiple techniques and data types to help model the pore pressures in the deepwater. Data include the use of seismic amplitudes, seismic interval velocities and 2D basin modelling. Using the integrated approach to model the pore pressures ensures consistency between the multiple disciplines and allows quantifying the uncertainties adequately.

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