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The Bengal Fan: the petroleum potential of the world's largest frontier province, offshore Bangladesh.

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Summary

The Bay of Bengal is one of the world's last remaining frontier provinces for petroleum exploration. Geological interpretation of new regional 2D seismic data over the Bay of Bengal, offshore Bangladesh offers new insights into the geological history, crustal architecture and petroleum potential of this frontier area. Basin reconstruction and source rock modelling shows the maturity of several source rock intervals for both oil and gas. Interpretation of seismic character allows for a stratigraphic architectural study of the shelf, slope and upper fan. All the elements of a working petroleum system are present and regional data is key to unlocking the full potential of this exciting area.

The Bengal Fan: the petroleum potential of the world's largest frontier province, offshore Bangladesh.

Introduction

The Bay of Bengal contains the world's largest deep-water fan and yet remains one of the largest frontier provinces for oil and gas exploration. Several wells and fields within the fan have proven both biogenic (e.g. Shwe Field; Shoup et al., 2017) and thermogenic (e.g. Sangu Field; Shahriar et al., 2020) gas-rich systems, yet within the last 20 years only 4 exploration wells have been drilled offshore Bangladesh, and no wells have yet been drilled in the deep water.

Assessment of the petroleum potential of the Bengal Fan, offshore Bangladesh has been undertaken using newly acquired regional 2D seismic data, in conjunction with gravity, magnetics and digitised historical well data. Revised regional basin modelling has provided confidence in the presence of active oil and gas producing source rocks at multiple levels. Mapping of the spatial and chronostratigraphic evolution of the fan in terms of architecture, geometry and depositional processes has provided regional insight into potential reservoir and seal systems.

Data Library

Over 12,000 km of 2D seismic, gravity and magnetics data were acquired offshore Bangladesh in 2023 and processed to PSDM in early 2024 (Figure 1). These long-offset high resolution data image the deep basement structures below the shelf, slope and mid-fan and have been processed through broadband Pre-stack Time and Depth migrated (PSTM/PSDM) workflows.

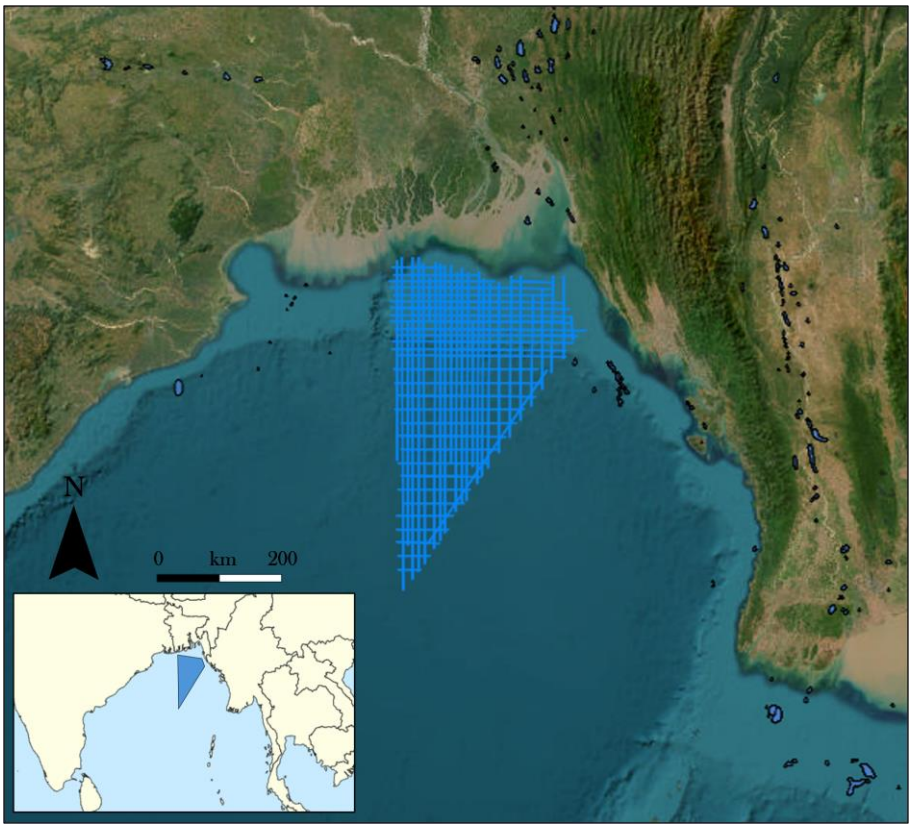

Figure 1 *Location map of the 2D seismic data acquired offshore Bangladesh as discussed in this study.*

Early Basin Evolution

The Bay of Bengal was formed in the Early Cretaceous with sea-floor spreading likely initiating between 120-130 Ma when the Indian plate separated from Antarctica (e.g. Gopala Rao et al., 1997). India drifted northwards and collided with Asia in the Palaeocene, however the "hard" continent-continent collision didn't commence until the Early Miocene. This event initiated the main Himalayan orogeny and the onset of the Bengal Fan deposition (Alam et al., 2003; Bastia et al., 2010; Curray, 2014). Previous seismic and gravity studies have questioned the nature of the crust under the Bay of Bengal. Some interpretations have considered the whole of the basin to be oceanic crust (e.g. Talawani et al., 2016), whilst others have hypothesised an area north of the present-day shelf break to be highly intruded thinned continental crust (e.g. Sibuet et al, 2016).

Imaging of the deep basement structures has provided insight into the early evolution of the basin. Depth migration of the data show a broadly flat lying basement with a northward tilt, and a distinct, potentially volcanic feature running parallel to the present-day shelf break. To the north of this feature there are indications of pre- and syn-rift grabens (Figure 2). The deep Cretaceous to Palaeocene early basin fill onlap the pre-existing basement structures to the north and east, indicating a sediment input source from the East Indian margin, likely through large underwater feeder systems observed to the west of the 85° E Ridge (Ismaiel et al., 2019).

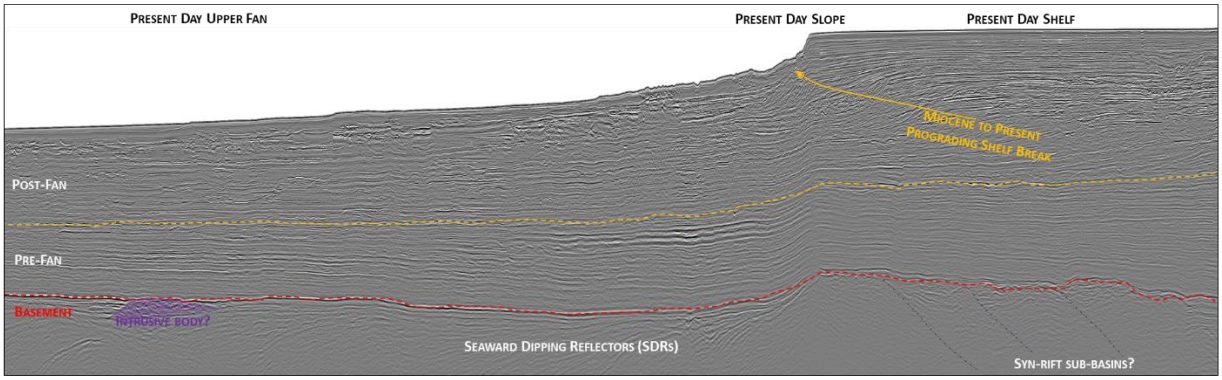

Figure 2 *2D Pre-stack time migrated (PSTM) seismic dip line through the shelf, slope and upper fan offshore Bangladesh.*

All the elements of a working petroleum system

Several source rock intervals have been proven within the basin; Upper Cretaceous (Turonian) source rocks in the east India margin, Eocene-Oligocene oil prone units producing offshore Myanmar, an early Miocene unit proven offshore Bangladesh and a biogenic Pliocene system (e.g. Shoup et al., 2017, Shahriar et al., 2020, Yanqun et al., 2017). Basin modelling using PSDM data shows that all these source rocks are currently within the oil and gas producing window within the area of interest (AOI). Due to the massive sediment influx rates, there is enormous potential for future discoveries of biogenic gas accumulations within the Pliocene and Late Miocene intervals. Direct Hydrocarbon Indicators (DHIs) and shallow gas events are very common within the data, particularly on the shelf, proving a highly active petroleum system.

Analogues from equivalent depositional settings have shown deep water sand systems to travel many hundreds of kilometres from the source. Within the Bengal Fan, coarse grained material has been recorded 2800-Km from the present day Bangladesh shoreline (Curray et al., 2003). Although the present-day feeder system for the Bengal Fan lies to the west of the AOI, migrating depositional centres are clearly imaged throughout the geological history of the fan, allowing for a more complete

model of the depositional system to be defined. A chronostratigraphic spatial model has been developed to describe the changing architecture of the fan system within the AOI. Identifiable sequence stratigraphic and downslope evolving systems have been identified, providing greater confidence in the likely occurrence of reservoir prone systems, stratigraphic trap geometries and seal development.

Conclusions

Geological interpretation of the newly acquired seismic and gravity/magnetics data, alongside historical well and seismic data from Bangladesh and adjacent systems in East India and Myanmar, has established a regional geological model for the basin and sedimentological evolution of the Bay of Bengal. All the crucial elements of a working petroleum system are present, with several source rock intervals, a well understood burial history and huge potential for good quality giant reservoir systems. Structural traps exist within the eastern margin and high-resolution seismic data allows for mapping of stratigraphic traps and reservoir systems.

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