Introduction

After several major gas discoveries made offshore Tanzania and northern Mozambique, the entire East Africa margin has been assumed to be a gas province. Well successes and satellite seeps have proven the presence of more than one working petroleum system in the wider Mozambique Channel area. Studies on potential source rocks and variations in geothermal gradient of the region indicate a favourable setting not just for gas as established in the Rovuma Basin in northern Mozambique, but also for oil in the Angoche Basin further south. From the Rovuma basin discoveries such as Coral and Mamba, we know that the reservoirs are heavily influenced by the interplay of turbidite flows and ocean currents, meaning coarser versus finer material can be mapped within a mixed depositional system as proxies for reservoir and seal. Understanding the provenance of the sediment influx is an important parameter to determine the reservoir quality of mapped fairways, but understanding the depositional architecture and setting is paramount. Recent advances in understanding sandy mixed systems from academic and industry research (reference drifters?) give a good assessment of grain size distribution and a guide to predict where the sands in the system would likely be deposited. For this interpretation, it is crucial to understand the palaeo-current systems and, therefore, the palaeo-geographic reconstruction stages of the area of interest. This study will showcase the interpretation methodology for mixed contourite-turbidite systems and demonstrate examples of these mixed systems and mapped sandy fairways in the Rovuma and Angoche Basins offshore Mozambique in greater context.

Method and Examples

The offshore Angoche Basin developed as a result of the break-up of the Africa-Antarctic Corridor between the West-Gondwana (Africa and South America) and East-Gondwana (Antarctica, India, Madagascar and Australia) super-continents in the Middle Jurassic period (Mueller and Jokat, 2019). Magnetic anomalies indicate oceanic crust formed in the Angoche Basin at 164 Ma (late Callovian) (Mueller and Jokat, 2017). The continental break-up also resulted in the fragmentation of the Gondwana super-continent leaving remnants such as the Beira High, where pre-rift sediments are observed (Figure 1, inset map). Plate tectonics controlled the gate ways for water masses and at times caused a new ocean connection to open and another to close, changing how the water masses mixed. Processes like these, shape the depositional patterns in deep-marine sediments, across continental slopes and basin floors. Which, in turn, controls the basin-scale architecture of deepwater depositional systems and key components of morphology and stratigraphy (Hernandez-Molina et al., 2022). Regional seismic 2D data and proprietary 3D across the Mozambique Channel area have allowed us to identify basin floor fans and channel onlaps in the Angoche Basin, basin floor fan onlaps towards the uplifted shelf, sheeted sands within contourite waves, turbidite channels, sheeted sands and basin floor fans within mixed turbidite and contourite systems in both the Angoche and Rovuma Basins. Based on our observations, potential plays associated with mixed turbidite and contourite systems are mostly present within the upper post-rift section, after the Turonian Unconformity (Intawong et al., 2019). In the context of the existing water masses and gate ways during the time of deposition, we can assess internal depositional architecture in greater detail: Reservoir quality clastics delivered by turbiditic flows down-dip interact with ocean bottom currents flowing parallel to the slope. This interaction may well be responsible for winnowing the finer grains away as seen in mounds in the Angoche Basin and asymmetric levee build up in the Rovuma Basin. This process often results in increased reservoir quality in the channels and fans of the mixed system, such as the Lower Eocene targets at Coral (Palermo et al., 2014). With the currently understood reservoir provenance providing sandstones of the Upper Cretaceous Lower Grudja Formation, as tested in Pande, Buzi, Tamane and Inhassoro fields, and other drainage of Mesoproterozoic material between the Rovuma and Zambezi deltas, these mixed systems yield great opportunity for mapping reservoir quality fairways.

Conclusions

In frontier basins such as the Angoche offshore Mozambique do often provide structural understanding based on regional 2D data sets, which can provide a reasonable understanding of the thermal and burial history of the basin, allowing the assessment of source maturity and hydrocarbons in the basin, as long

as proof of source rock presence exists, such as the samples from ODP wells 692B and 693 which targeted locations that sat in the wider Mozambique Channel during the Late Jurassic-Early Cretaceous era (Eagles & König, 2008). The detailed mapping of fairways, moreover a robust mapping of reservoir quality sands within large offshore systems across a long time-span and varying sediment influx routes is, however, quite challenging without additional or wide coverage of 3D seismic data. A much better understanding of mixed turbidite-contourite systems and their overall typical diagnostics can improve reservoir presence and trapping significantly if applied in the context of reservoir provenance and existing discoveries such as from the nearby Rovuma Basin, as this study will show.

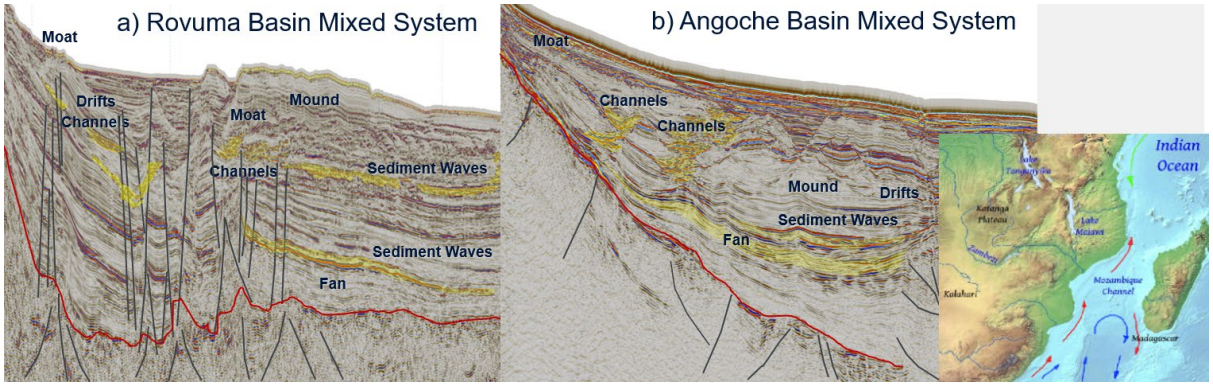

Figure 1 *. Mixed systems in the Rovuma (a) and Angoche (b) Basins. The inset map shows present day water masses in the Mozambique Channel, representative since 66Ma (Hernandez-Molina et al., 2022).*

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