Short communication

Late Syn-Rift Turbidite Systems in the North Sumatra Basin

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The North Sumatra Basin (NSB, Figure 1) in Indonesia is one of the most prolific petroleum provinces in SE Asia. It has been affected by rifting, transtensional and transpressional shear, and compression from the Paleogene to present day. This complex tectonic history has created numerous opportunities for petroleum exploration, including an inverted deepwater turbidite play (Figures 2 and 3) that has been relatively under-explored to date.

During the late syn-rift stage of basin evolution (Late Oligocene-Early Miocene), N-S to NE-SW oriented half-grabens in the central and northern part of the NSB (Figure 3) were subjected to rapid flooding, as a result of the complimentary effects of tectonic subsidence and a rise in eustatic sea level. Water depths reached several hundred meters (bathyal paleobathymetries), and slope and basin-floor turbidite systems of the Bampo Formation (Figure 2) filled the newly-created accommodation space. Time-equivalent basement highs are characterized by unconformities or condensed, shallow marine deposits.

Intra-formational, deep marine Bampo shales act as competent seals for individual turbidite sands (Figure 2). The shale-prone stratigraphy of the stratigraphically younger Baong Formation acts as a regional seal, across which overpressures tend to increase with depth (Figure 2).

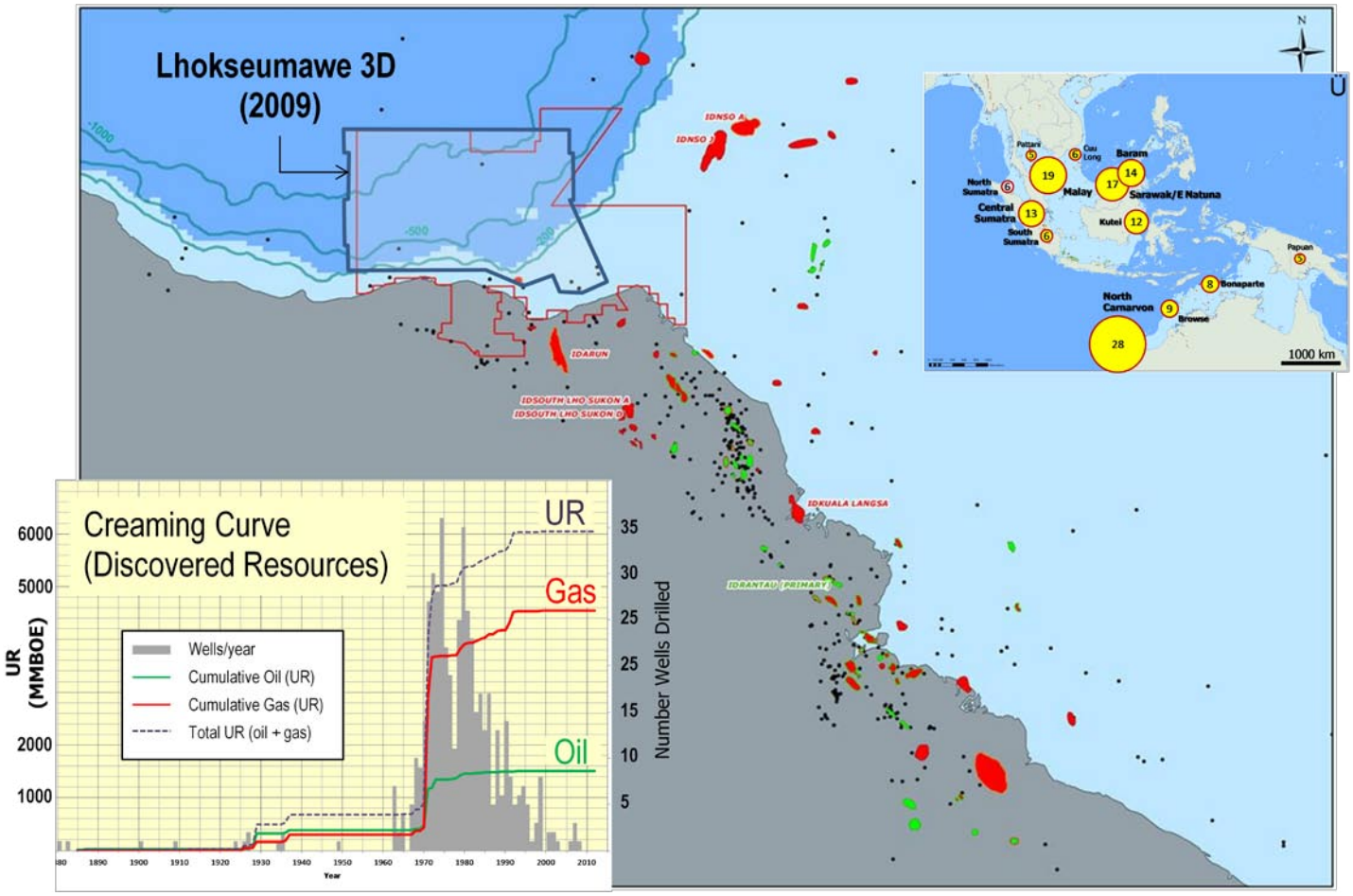


Figure 1. *Location map of study area (red box) in southern part of North Sumatra Basin relative to historical well database and existing oil (green) and gas (red) discoveries. Despite significant success in the onshore and on the shelf, fewer than 40 wells have been drilled in water depths greater than 100 m. Inset, upper right shows ultimate recoverable reserves (URR) for the 13 largest basins in SE Asia. Bubble size is scaled to UR. More than 6 billion barrels of oil equivalent have been discovered in the NSB. Inset, lower left, shows the creaming curve for the NSB. Note that exploration activity has been negligible in the past decade.*

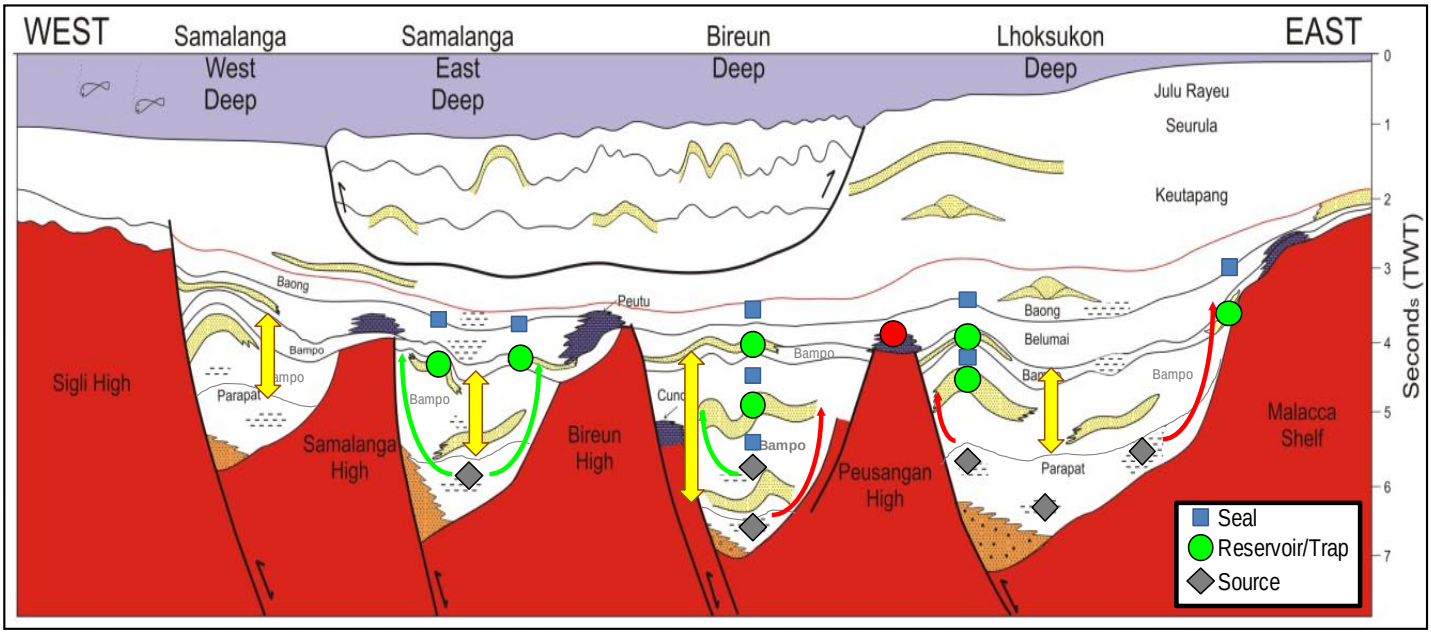


Figure 2. *Stratigraphy and petroleum system elements of the North Sumatra Basin. Late syn-rift (Bampo) turbidites, highlighted by yellow arrows, are the subject of this paper.*

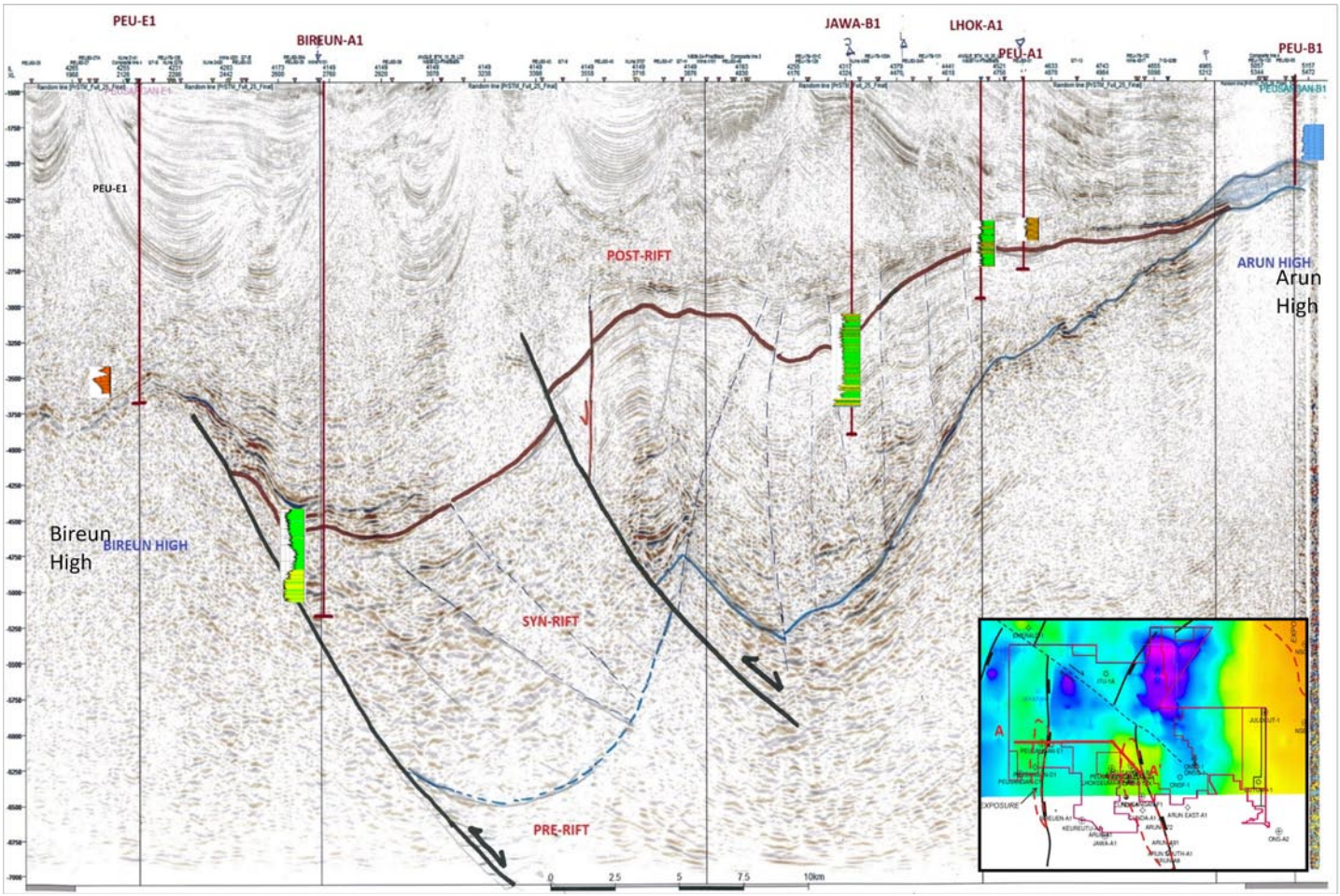


Figure 3. *Seismic section illustrating inverted syn-rift structure in the study area. Reservoir presence is demonstrated in regional wells. All wells have encountered hydrocarbon shows, although none is optimally placed to test the inverted syn-rift play.*

During the late Miocene to Quaternary, dextral transpression on NW-SE oriented faults and N-S oriented compression formed a series of inverted structures, with potential hydrocarbon traps in 4-way dip-closures at Parapat and Bampo levels (Figure 3). These traps have not been tested in the Indonesian portion of the NSB, but contain hydrocarbons in the Mergui Basin, the northern equivalent of the NSB, offshore Thailand.

Bampo marine shales are the most probable source rocks (Figure 2). The Bampo source rock has been typed to the gas-condensate at the super-giant Arun gas-condensate field.

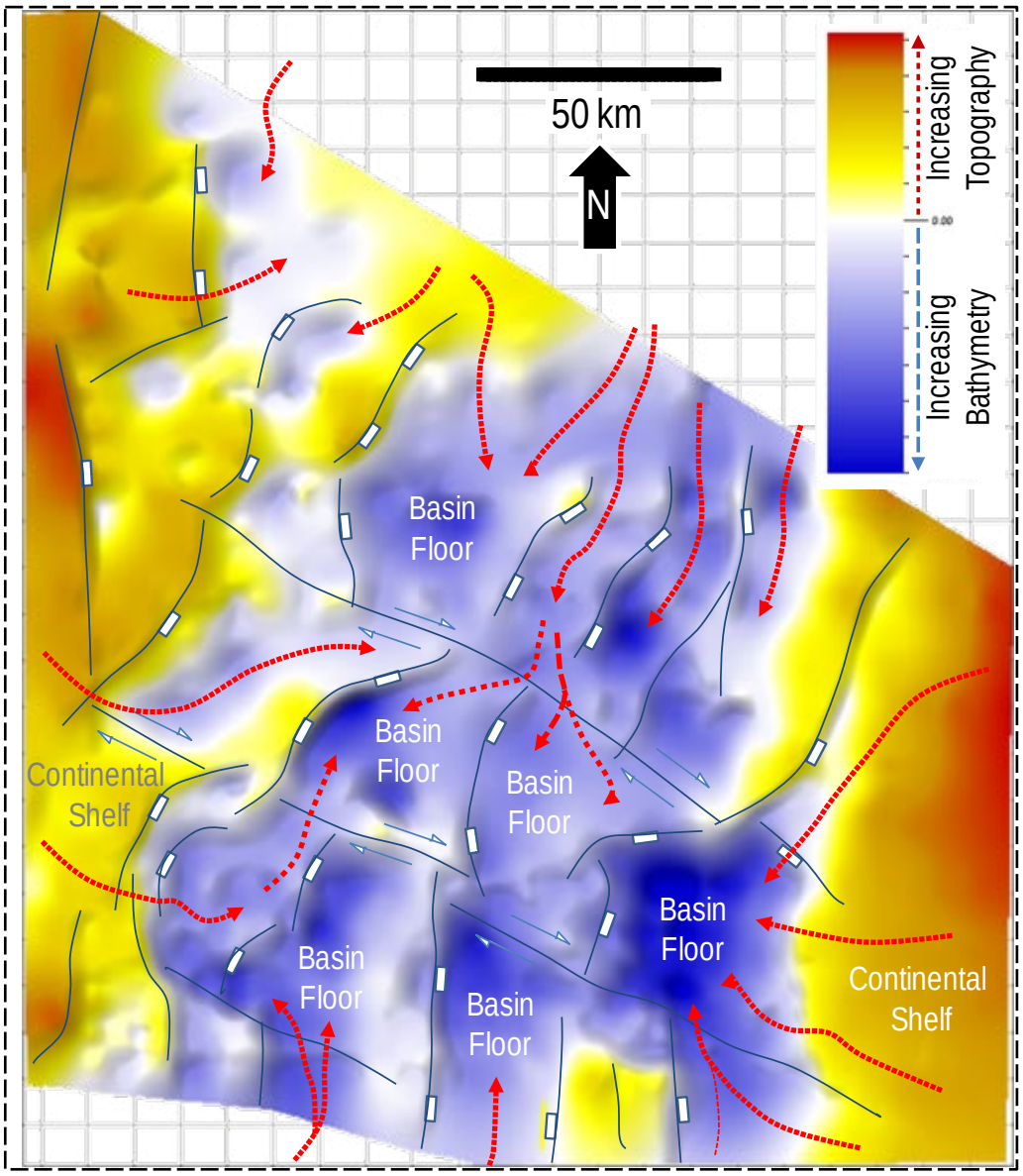


Figure 4. *Simplified map of late syn-rift architecture, offshore North Sumatra Basin. Map is a smoothed grid of interpreted top basement based on 2D and 3D seismic, and is corrected to reflect paleobathymetries inferred from well results (well locations not shown). Red arrows indicate possible deepwater sediment dispersal fairways. Subsequent tectonic inversion of these sand-prone fairways creates an under-explored play concept in the basin.*

It is a very lean source rock, with typical TOC values less than 1%, but has a demonstrated capacity to charge multi-TCF gas fields across the NSB, so must be considered to be an ultra-prolific - if not particularly spectacular - source rock. Older, syn-rift lacustrine shales, which could be liquid-prone, may also act as potential source rocks (Figure 2). Their presence across the basin is much more speculative, though, and they have not been definitively typed to any hydrocarbon accumulations. Migration is postulated to occur from deep grabens, which thermal models show to be in oil to post-mature temperature windows, up carrier beds and faults into closures.

This wildcat inversion play has not been explored previously in the NSB because it only occurs in the offshore part of the basin, where good-quality 3D seismic data, only recently acquired, are necessary to adequately characterize prospects. The play has high volumetric potential, and most aspects of the petroleum system have been proven previously. The play concept is also relatively under-explored elsewhere in southeast Asia, and opens possibilities in other basins in the region (Figure 4).