[EA]Combination Traps in Jasmine and Ban Yen Fields, Gulf of Thailand: Identification, Recognition and Development Strategy*

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Abstract

The Jasmine and Ban Yen fields are located in the northern tip of the Pattani Basin in the Gulf of Thailand. The producing reservoirs in the fields are Middle to Upper Miocene post-rift fluvial channel-fill sands and Lower to Middle Miocene syn-rift lacustrine fan delta sandstones. The present-day structure of the fields is an *en echelon* fault zone that is a result of right-lateral shear movement. The depth structure map at the top of one of the main reservoir is presented in Figure 1.

There are more than 175 individual oil accumulation segments in the Jasmine and Ban Yen fields. In terms of hydrocarbon traps category, most of these segments are pure structural traps, where the geological structure alone forms the trap geometry and is responsible for the oil accumulation. However, in some segments, the observed oil accumulation requires a combination trap to work. The trap geometry is a result of the geological structure and the reservoir sandstone distribution. Most of the early exploration and development wells were optimized based on geological structure. Seismic attributes were utilized to ensure reservoir presence and quality, but within the structural trap. The presence of combination traps was initially identified through integrated evaluation of the well logs, formation pore-pressures, hydrocarbon and water production history as well as seismic data in the later stages of field development.

In the post-rift fluvial reservoir interval of the Jasmine and Ban Yen fields, it is well known that typical hydrocarbon columns are small, this being the result of one or more of the following factors: (1) limited vertical relief of the structural trap, (2) the vertical or lateral sealing capacity, or (3) the limited volume of hydrocarbon that migrated into the trap. However, pressure-derived fluid contact and/or production data in some segments suggest an oil column beyond the structural closure or spill point. Integration with seismic attribute analysis revealed the working combination trap responsible for oil accumulations beyond structural closure.

Trap Types

Figure 2 demonstrates a working combination trap in the Ban Yen field. The identified structural closures in Figure 2A suggests that larger potential traps are in the northern and southern blocks. However, the seismic attribute map indicates that the reservoir sands are present in the middle block and downdip, away from the two larger structural traps. Post-drill integrated evaluation revealed that the oil accumulation extends beyond the structural spill points suggesting that the working trap is a combination of fault, depth structure and sand geometry. The Well-1 drilled in the northern block confirms the lack of reservoir sand at Y26 level.

Relative to the structural trap element in the same block, there are at least four forms of combination traps observed in the fields. Figure 3 provides simplified illustration of these forms. All structural traps in the fields involve a crestal principal trapping fault. The four combination trap types are distinguished based on their relation to the principal trapping fault in the block. (1) Same trapping fault, same crest, within structural closure/above spill point (Figure 3A). (2) Same trapping fault, same crest – with Oil-Water Contact (OWC) beyond the structural spill point (Figure 3B). (3) Same trapping fault, but location of reservoir is offset from the structural crest (Figure 3C). (4) No trapping fault, with reservoir offset from the crest of the structure (Figure 3D).

Combination Trap Type 1 bears a condition that the non-reservoir (no shade) rock acts as a competent lateral seal. This condition also applies for all other types where the oil-water contacts are beyond the structural closures. If the non-reservoir rock does not act as a competent lateral seal, the working trap should be considered as the structural trap and the extent of oil accumulation should be limited by the structural spill point.

While type 2 is essentially similar in form with type 1, but the hydrocarbon accumulation extends beyond the structural spill point. These two types will be definitely explored and probably developed together with the structural trap plays in the block as they share similar a crest that is optimum for both exploration and development wells. If the trap type has been identified during pre-drill evaluation, it is better to take into account the range of possible oil-water contacts that can be above or below the corresponding structural spill point. The type 2 form may require additional down dip appraisal well in order to assess the resources.

Combination Trap Type 3 is challenging and requires additional effort to identify, assess and explore. This is because structurally optimized exploration or development wells will likely miss this trap. In some cases, this type of trap is unintentionally discovered while drilling non-crestal but fault-optimized development wells. Seismic attributes must be used during the identification process. The reservoir sand geometry has to be inferred from the seismic or seismic inversion data where available. In some cases, there is not enough isolation or shale thickness over and under to image the reservoir and well data becomes an important part of the evaluation.

Combination Trap Type 4 is more challenging to identify. The reservoir is not present in the crestal part of the structure where most of the wells are located. A channel sand might be present down-dip away from the fault(s) with a geometry that forms a hydrocarbon trap and hence not penetrated by any well.

Conclusions

Integrated evaluation of combination traps has led to a revision of the development strategy, as well as further appraisal of potential hydrocarbon accumulations. Three dimensional geological modeling and reservoir simulation were performed to better optimize the hydrocarbon development. In a structural trap with stacked reservoirs, it is geometrically straight forward to combine multiple reservoirs in a deviated development well. Additional effort is required to optimize the development of hydrocarbons that are not purely structurally trapped. Dedicated development wells are sometimes the only (or preferred) option. Downdip, off-structure exploration/appraisal wells were drilled to unlock the potential from the combination traps. Additional reserves from these combination traps will help to extend the life of the field.

Selected References

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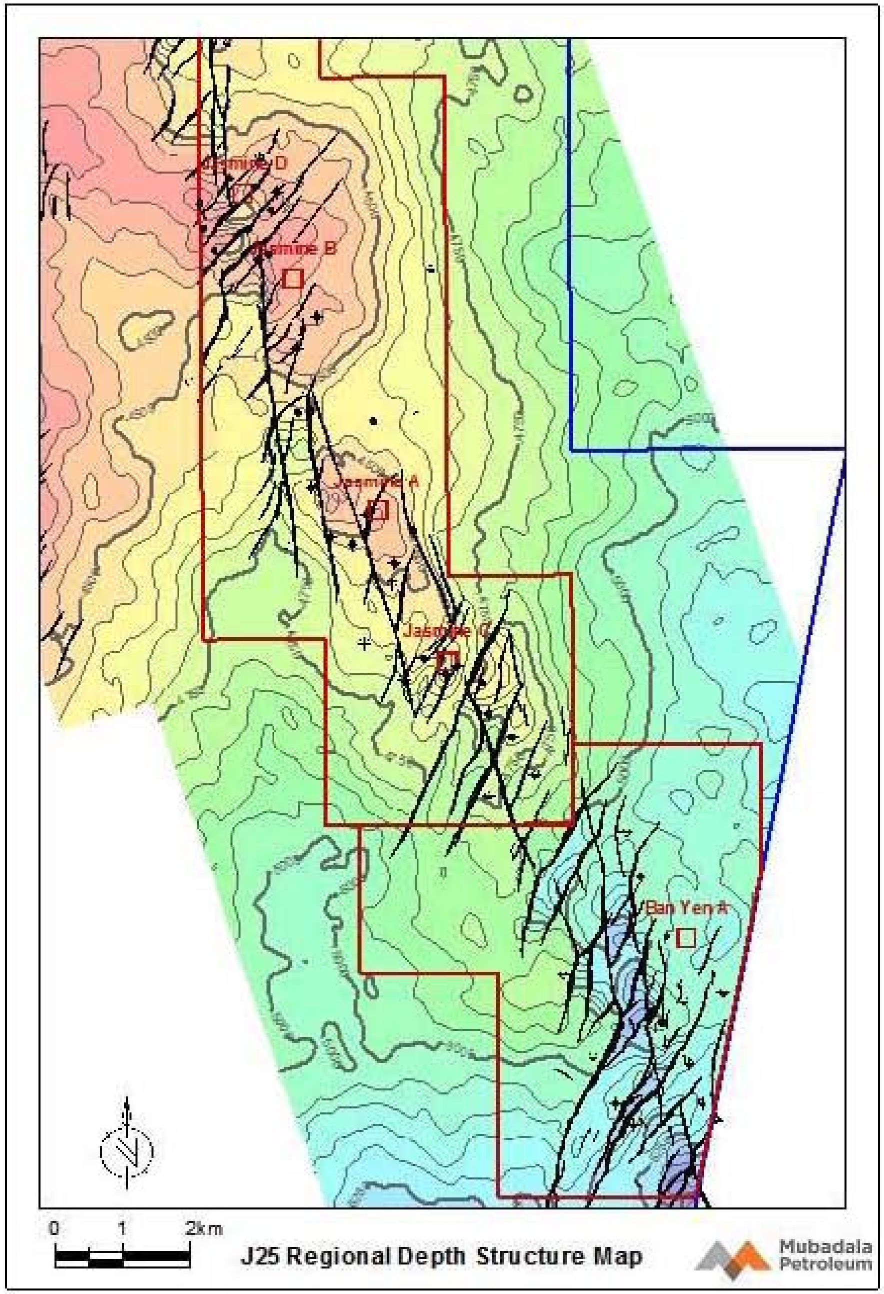

Figure 1. Depth structure map at Top of one main reservoir in the Jasmine and Ban Yen fields. Most of the hydrocarbon accumulations are trapped within the structural closures formed by the structure in each fault block and reservoir.

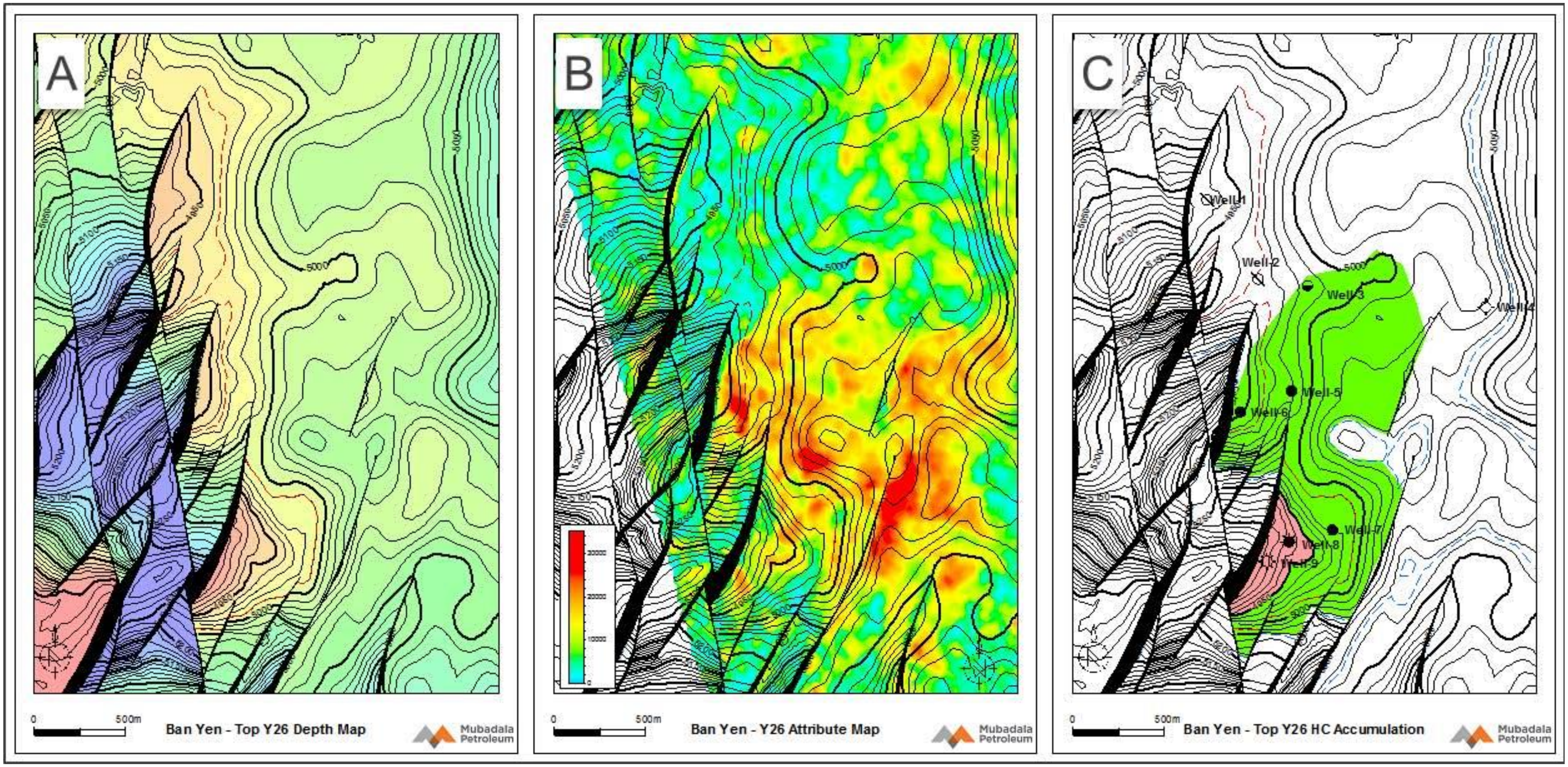

Figure 2. (A) Depth structure map of Top Y26 Marker with identified structural closures. (B) Seismic attribute (RMS Amplitude) map at the corresponding horizon. Note that the larger part of the structural closure in the north has no interpreted reservoir sands. (C) Hydrocarbon accumulation map in the same reservoir. Note that the oil accumulation extends beyond the structural spill point.

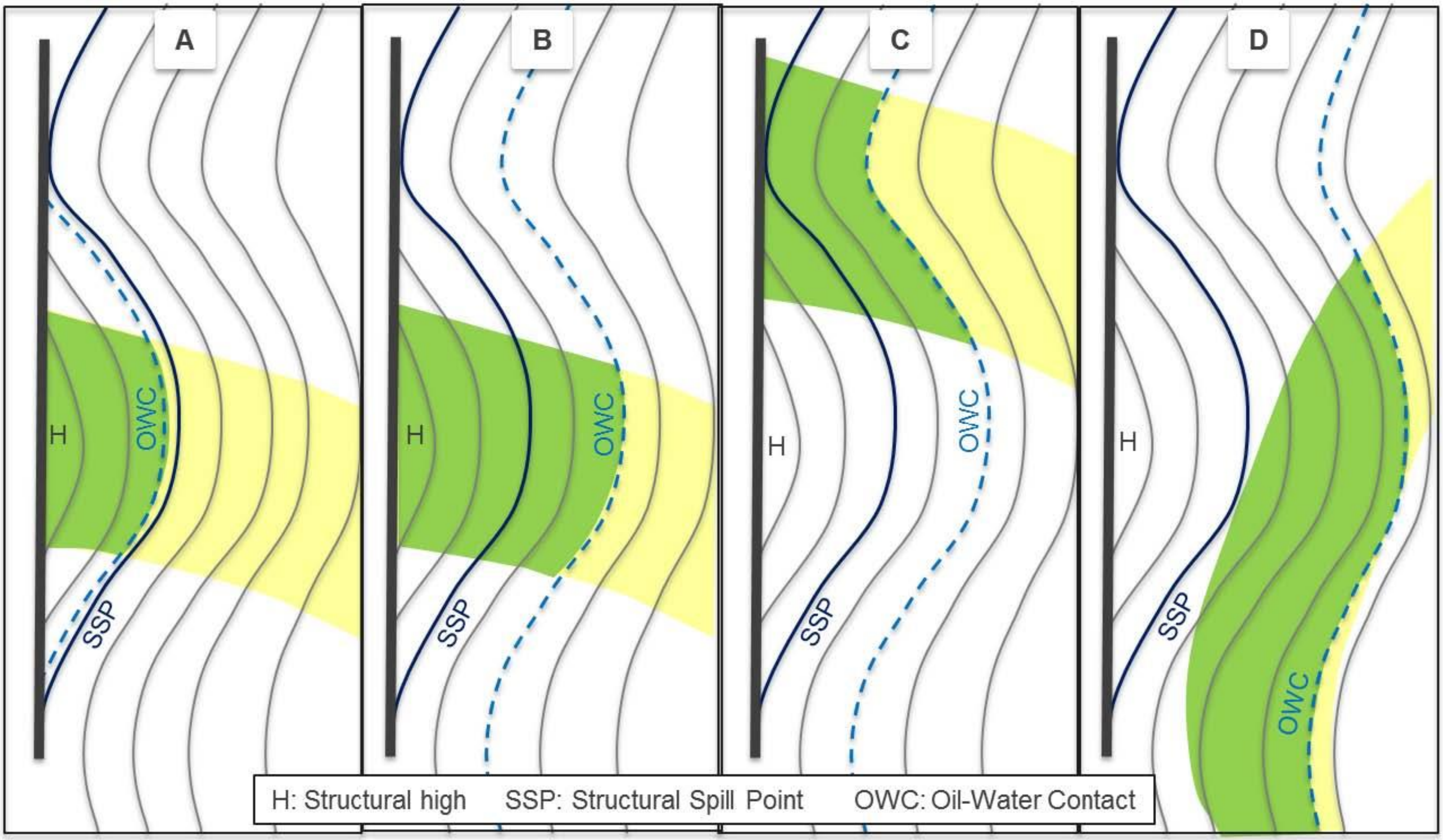

Figure 3. Four combination trap forms relative to the structure and sand fairway. Green and yellow colors indicate sand presence; green has trapped hydrocarbons, yellow is not oil-charged.