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New Plays and Concepts to transform Ravva into a Giant Field

Abstract

Ravva field has produced 286 MMBBL oil & 352 BCF gas till date, from Middle Miocene (MM) and Late Miocene (LM) sandstone reservoirs of shoreface origin, trapped within listric growth fault blocks. Significant upside potential exists in new plays in deeper stratigraphic intervals eg. Early Miocene (EM) and Cretaceous section below docollement. While EM petroleum system is proven in Ravva, the Cretaceous synrift play is emerging in this region. Enhanced 3D seismic (PSDM processed in 2016) has helped in better imaging of deeper stratigraphy with enhanced fault definition and helped to identify several new plays & concepts. The newly identified plays can be sub-divided into two broad categories: **a. Cretaceous Plays below Decollement (KT):** This includes Lower Cretaceous synrift play similar to adjacent synrift Deen Dayal (GSPC/ONGC) field and Upper Cretaceous stratigraphic fan play. These two Cretaceous plays can add a significant resource based on preliminary estimation. **b. Tertiary Plays:** Several new plays are identified within Tertiary sequence. They are: 1) Stratigraphic Pliocene channel sands 2) Oligo-Miocene rotational fault traps 3) Strati-structural play in Oligo-Miocene sequence supported by AVO 4) Strati-structural traps formed by pressure seal in Early Miocene sequence. The Tertiary plays can add a significant resource to the block.

Introduction

The Ravva field is located within Godavari sub-basin, northern part of the Krishna-Godavari (KG) basin, in the East Coast of India (Figure: 1). It is a shallow offshore block with water depth ranging from 5m to 80m. Total block area is ~331 sq. km. of which 21 sq.km. is onshore where processing facility is established. Vedanta (Cairn Oil & Gas) is the operator and ONGC, Videocon, Ravva Oil are the JV partners. Field produces Oil & Gas from Late Miocene & Middle Miocene sandstone reservoirs of deltaic origin. Structurally it is predominantly growth fault setup over KT aged decollement originated during Miocene-Oligocene time due to gravity collapse as an effect of Himalayan orogeny. Entire Miocene-Oligocene sequence is heavily faulted through curvilinear listric faults. The field was discovered in 1983 by well Ravva-1 and development drilling occurred during 1996-98. First 3D seismic was acquired during 1991. Due to shallow water depth subsequently 3D ocean bottom cable (OBC) data was acquired in 2000-01.

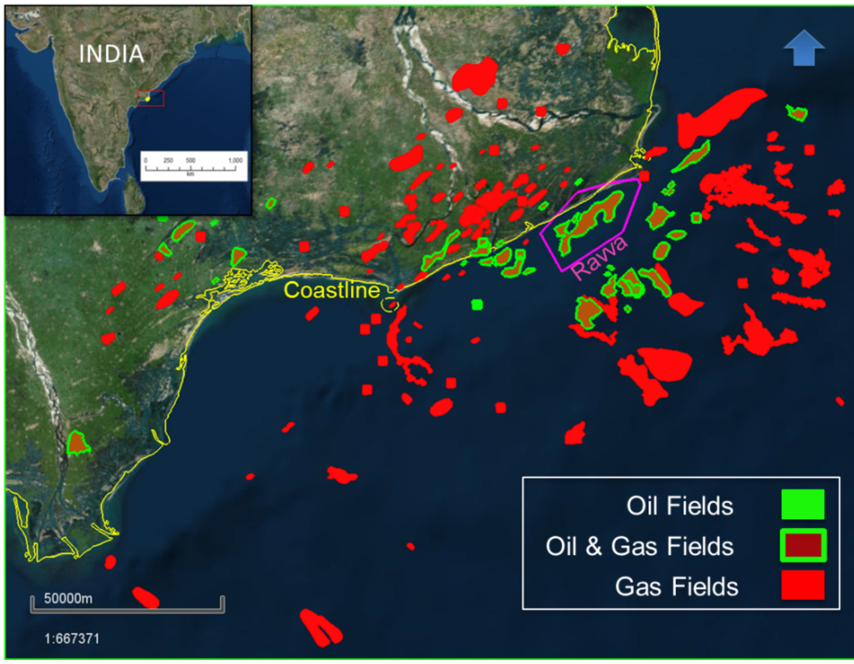

Figure 1: Location of Ravva block within Krishna Godavari (KG) basin along with adjacent fields.

Overall the field is subdivided is several fault blocks. Field produces gas (RH gas pool) from Upper Late Miocene (ULM) sequence and produces oil & gas from (RA/D & RE/F/B) Lower Late Miocene (LLM) and Middle Miocene (MM) sequence. There are several discoveries in Early Miocene (EM) sequence but no commercial production.

Regional Setting and Stratigraphy

Ravva is located in Godavari delta, northern part of KG basin which is predominantly rift basin with thick Tertiary cover (>4km) deposited as deltaic to deep shelfal deposit in passive margin setup. Tertiary sequence is mostly growth sequence of Miocene to Oligocene age formed due to gravity collapse over KT aged glide plane termed as Decollement. Tertiary sequence overlies Late Jurassic-Early Cretaceous rift sequence showing NE-SW trending horsts and grabens structures due to India-Antarctica separation. This younger NE-SW trending rift overprints the earlier NW-SE trending failed rift of Permo-Triassic age, equivalent to Gondwana rift.

Presently thick Tertiary deltaic sequence is the main exploration focus for the block though there are numerous potential hydrocarbon entrapment identified within Cretaceous sequence below Decollement (Figure: 2). Tertiary sedimentation has been primarily influenced by eustatic sea-level fluctuations along with up-liftment and erosion of hinterland caused by Deccan hotspot, Himalayan collision and local gravity collapse tectonism. Relative sea-level rise and fall through time has continually shifted the depositional environment from shore-face to shelf to slope setting in the block area. Two major sequence boundaries show significant erosions. These are in the Lower Late Miocene (making LLM sequence boundary) and Early Pliocene (marking Base Pliocene Unconformity, BPU) levels and were followed by rapid sea-level rises depositing thick marine shale sequence.

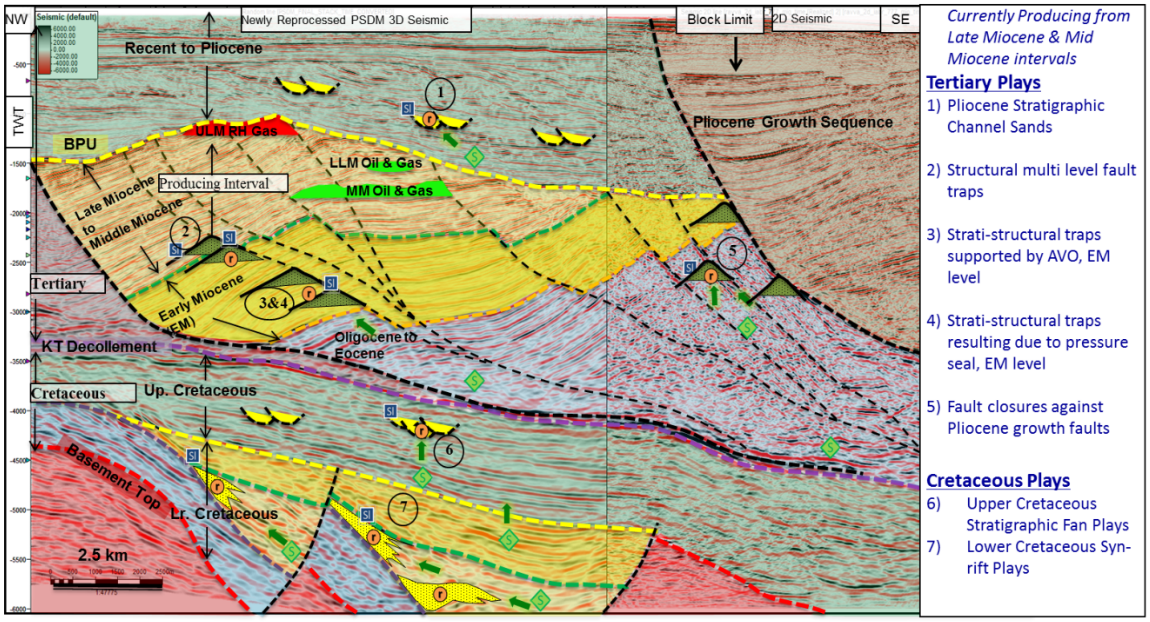

Figure 2: Subsurface seismo-geological cross section showing potential plays along with producing intervals

Over the Archean basement, the oldest sedimentary sequence starts as rift fill sequence of Late Jurassic - Early Cretaceous age. Based on latest PSDM processed 3D seismic data, numerous rift grabens are seen within the block premises. Upper Cretaceous sequence is post-rift sequence and deposited in passive margin setup. Top of the Cretaceous sequence (KT boundary) is marked as regional detachment surface where all the younger listric growth faults glide over.

Above the detachment surface Palaeocene and Eocene sequence are inferred to be present based on seismic but there is no well penetration within block area. Vadaparu shale of Paleocene age is considered as regional source rock. Overlying this is the Late Oligocene sequence of predominantly shale and thin sands. Conformably overlying Early Miocene sequence is dominantly shale sequence with several thin sandstone and limestone units present. Top EM is local unconformity surface, separating Early Miocene and Middle Miocene sequence.

Middle Miocene sequence can be subdivided in two parts, the sub-M20, and the M20-M30 & above. The sub-M20 unit is dominantly shale with thin sand inter-beds. Whereas the M20-30 sequence is dominantly sandstone interval and main hydrocarbon producing interval. This interval is substantially thick and thickness is more than 100m at places. Variation in thickness in this interval is partially due to depositional and partially due to erosion at top, marked as Lower Late Miocene (LLM) unconformity.

Overlying this is thick deep water shale sequence with occasional channel sands of Lower Late Miocene age. This sequence passes into the Upper Late Miocene alternating sand and shale sequence. Top part of the Late Miocene and few places Middle Miocene sequence is cut by major erosional unconformity, termed as Base Pliocene Unconformity (BPU). The interval above the unconformity surface consists of predominantly shales of deep marine setup with some isolated incised channel fills.

New Plays

With respect to complete stratigraphy, production of Ravva is limited to Late Miocene and Middle Miocene sequence. Thus the major part of the stratigraphy remains unexplored (Figure: 2).
The newly identified plays can be sub-divided in two broad categories:

a. **Tertiary Plays:**

Several new plays are identified within Tertiary sequence

1) Stratigraphic channel sands within younger Pliocene sequence: Pliocene channel sands pinching out against continental slope muds, up-dip is to be targeted for this play. Drilled wells have proved the presence of sands in these channels. Hydrocarbon discovery in this play in one of the drilled wells proves the presence of an active petroleum system in Ravva (Figure: 3).

2) Oligo-Miocene Structural Fault traps: Numerous three way dip and fault closures are identified within Miocene and Oligocene intervals. Targeting vertically stacked multiple closures at crestal position through deviated well drilling parallel to fault is key to the success for this play (Figure: 4). Significant HC potential lies within this play.

3) Seismic anomaly based (AVO anomaly) Strati-structural play in Miocene and Oligocene level: Several leads and prospects are identified based on seismic AVO (amplitude variation with offset) anomaly (Figure: 5a). Using latest technology, thin fault likely hood (TFL) 3D volume is generated using seismic data. This TFL volume helps to identify minor faults which enable us to define the traps for some of these leads.

4) Strati-structural traps due to pressure seal, Early Miocene level. 3D pore pressure volume is generated from 3D seismic velocity for whole Ravva block. The pore pressure volume is calibrated to the drilled wells. At deeper part of Early Miocene sequence a pressure reversal is observed forming a possible pressure seal trap. The high pressure interval may act as top seal and hydrocarbon can get accumulated in low pressure zone just below it (Figure: 6).

The Tertiary plays can add a significant resource to the block.

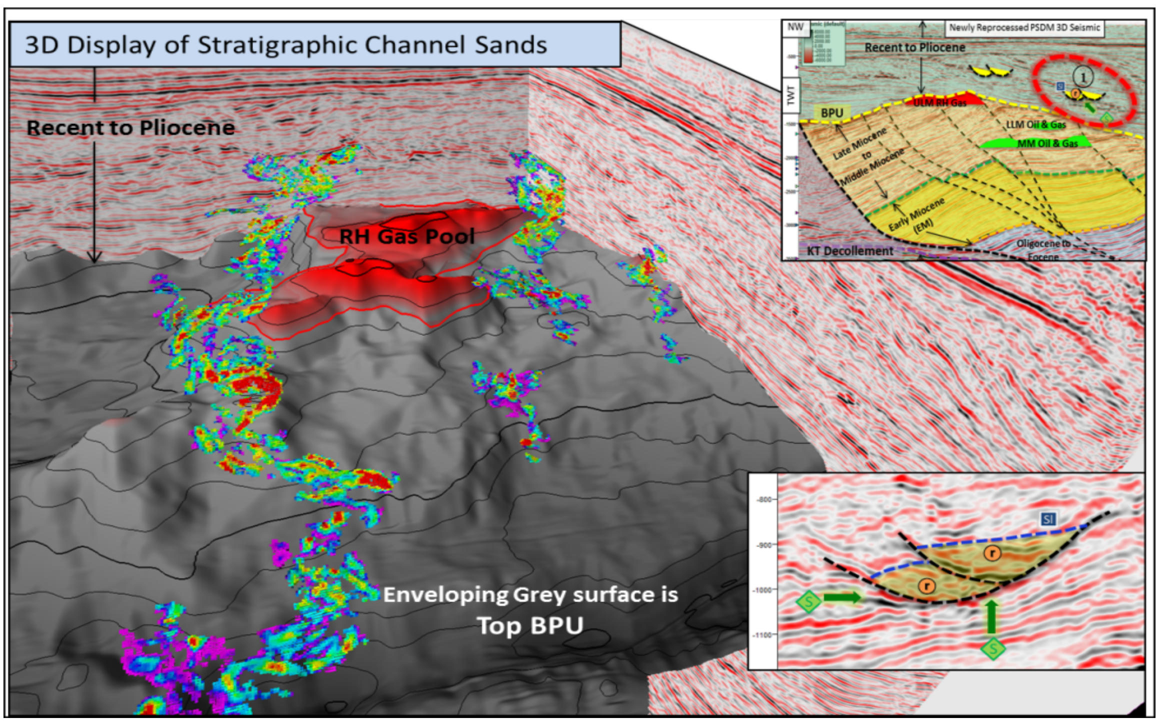

Figure 3: 3D display of stratigraphic channel sands within Pleistocene-Pliocene sequence.

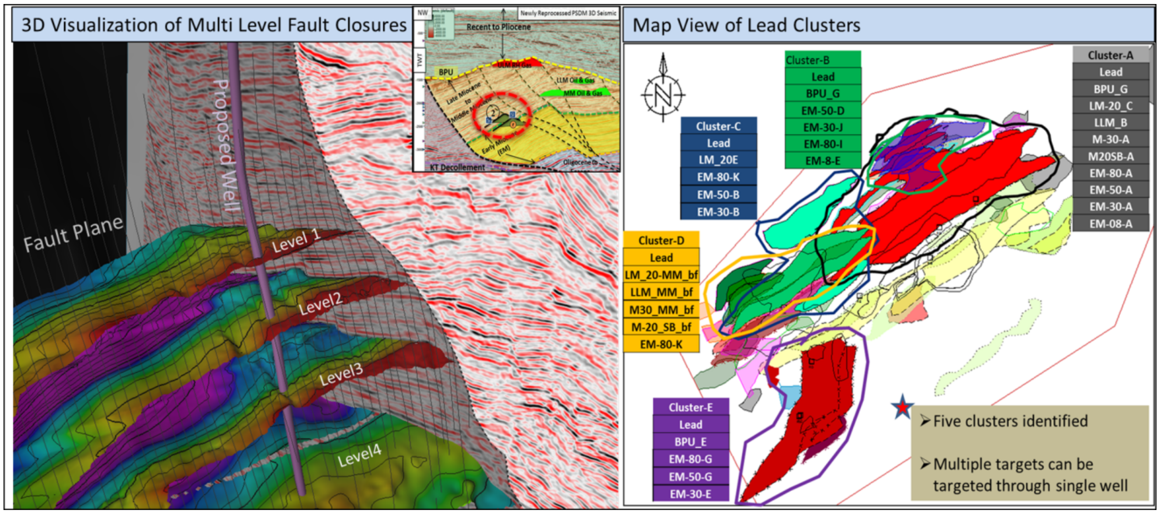

Figure 4: 3D visualization of multilevel fault closures and map view of different clusters

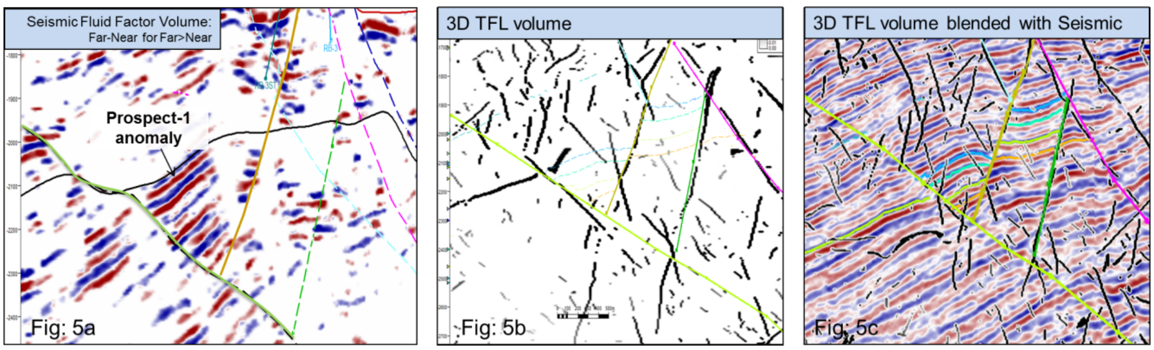

Figure 5: Prospect identified based on seismic AVO anomaly. TFL volume blended with seismic

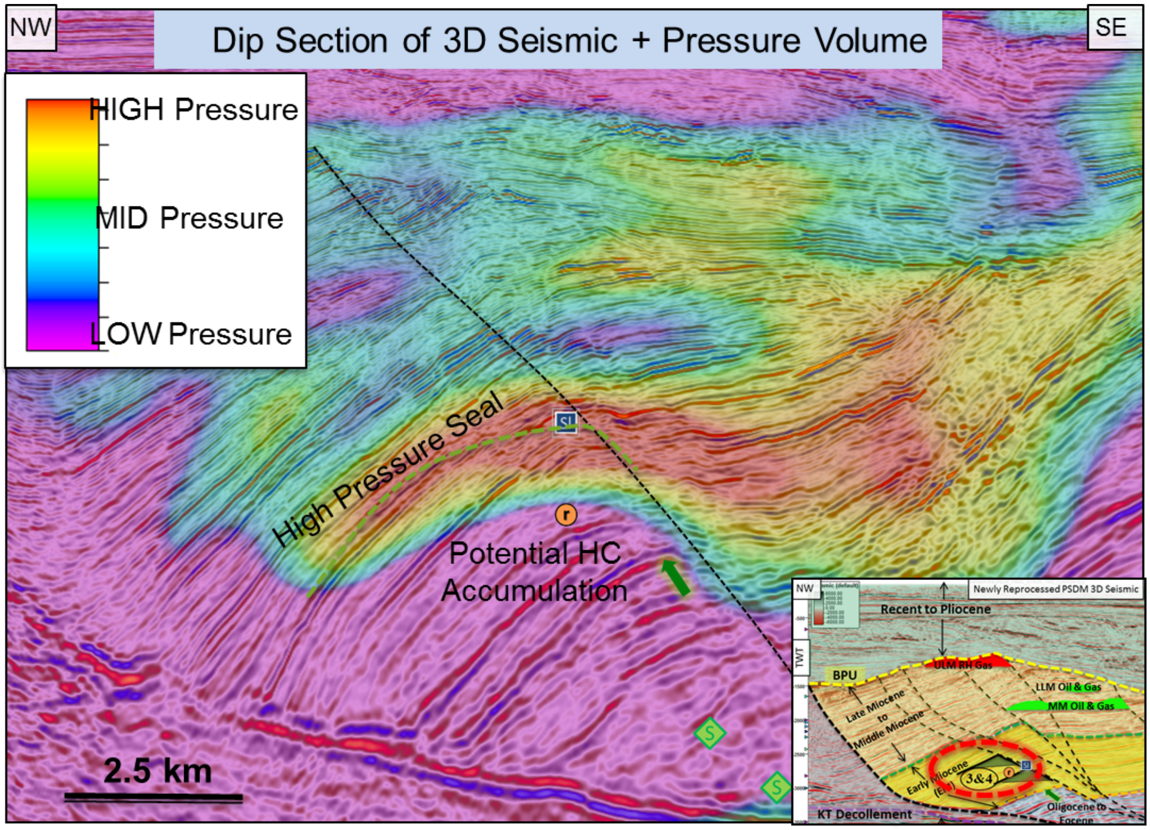

Figure 6: Trap defined by pressure seal

b. Cretaceous Plays below Decollement (KT):

This includes predominantly two types of plays. Upper Cretaceous Stratigraphic Fan play and Lower Cretaceous Rift play.

Upper Cretaceous Slope Channel/Fan Play: Seismic attribute map show presence of slope channel/ slope fan system within Upper Cretaceous section. Updip pitchout closure against shale interval need to be targeted (Figure: 7). Reservoir presence is key risk for this play.

Lower Cretaceous Synrift Play: Seismic image quality, especially deeper section below Decollement has significantly improved in the latest 2016 re-processed Pre-stacked-depth-migrated (PSDM) data. Two rift grabens are visible within block area and these rift grabens are in trend within existing discoveries, Deen-Dayal gas discovery by GSPC, D6-MA oil/gas discovery by RIL. Within the rift sequence both structural (footwall fault closures) and strati-structural (updip pinch out closure) traps are identified (Figure: 7). Reservoir quality is key risk identified for this play.

The Cretaceous new plays can add a significant resource based on preliminary estimation.

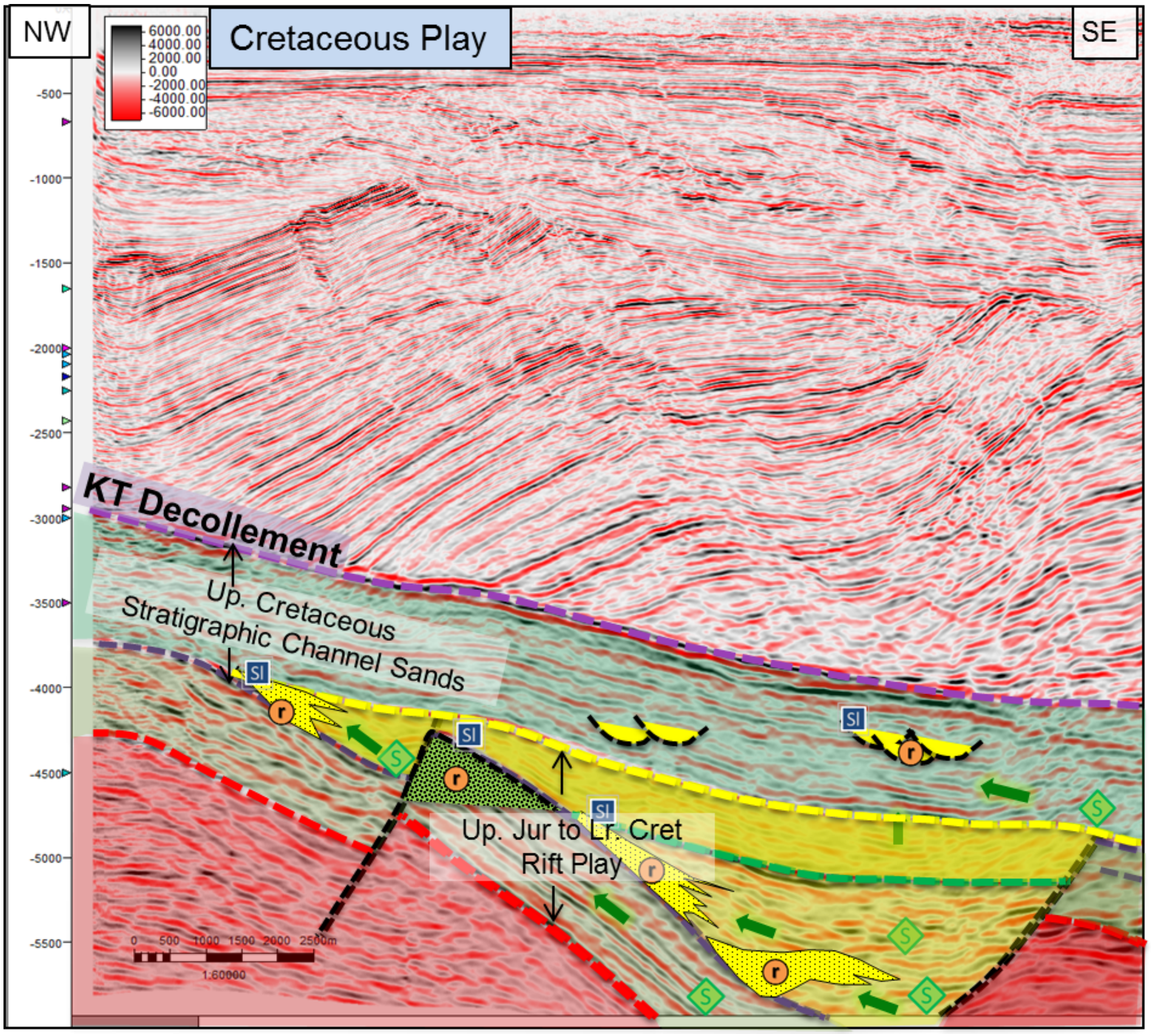

Figure 7: Upper Cretaceous slope channel/fan play and Lower Cretaceous rift play

Conclusions

The exploration portfolio in Ravva including the identified prospects, leads and concepts constitute a significant resource potential. The forward plan is to mature these leads and concepts identified within new plays to prospects through detailed seismic interpretation and integrated petroleum system study.

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