South Viking Graben, Norway – Play potential of deep Upper Jurassic mass transport complex (MTC) revealed by multi-azimuth and ocean bottom node seismic data

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ABSTRACT

The Viking Graben is an asymmetric Jurassic rift basin with an eastern flank consisting of multiple basin-ward stepping structural terraces that enter a number of graben sub-basins. Conventional legacy seismic data show presence of clusters of Upper Jurassic wedges close to the fault scarps separating individual terraces. Wells penetrating the faulted terrace edges and clastic wedges found heterogenous Upper Jurassic reservoirs with noncommercial accumulations. Because of great burial depths the basinal Upper Jurassic in the graben centers is poorly imaged with conventional seismic data and although the Viking Graben is a mature petroliferous basin, the deeply buried Jurassic section can be considered underexplored. However, a recent well in the Vana Sub-basin reported gas and condensates in thin Upper Jurassic turbidites at depths > 4800 m (well 25/7-11S).

INTRODUCTION

Multi-azimuth (MAZ) multisensor towed streamer seismic data and ocean bottom node (OBN) data provide significantly improved imaging of basin margin flanks and associated structure and sedimentary facies even at large depths. The data image local lateral successions of fault scarp graben edges, terrace floor gravity deposits, terrace incisions and basin floor fans extending out on the graben center at current burial depths greater than 4000 m.

RESULTS

The presence of toe thrusts suggests that clastic wedges are slumps which were dislodged from the faulted terrace edge and emplaced instantaneously. Excess rock masses in the compressional toe zone of the slumps are compensated by formation of accommodation space in the depletion zone closer to the fault scarp. Later erosion of the fault scarps that expose reservoir quality sediment sections remobilizes sand that is trapped in the slump depletion zone, on top of the toe thrust, and as debris flows and turbidites on the distal basin floor. The formation of ponded sand on and in the back of toe thrust is shown in OBN data over an oil discovery (Hanz, well 25/10-8). Porosity cubes derived from MAZ seismic data inversion, and multi attribute rotation of pre-stack attributes show high porosities in elongated ponded sand accumulations in depletion zone of the slumps (Figure 1 bottom section). Ponded sand presence is indicated by subtle differential compaction features in the slump depletion zone. While the basin floor sand thickness is expected to be below seismic resolution, it is possible to use seismic morphology to map slumps and terrace incisions to pinpoint the location of base of slope fans that form basin floor lobes (Figure 1, top map). The lobes can merge to form laterally extensive sand bodies. Slumps constitute positive morphological features on the sea floor for some time past emplacement and sediment transport into the basin will accordingly be diverted. The location of gullies is evident on horizon slice and Upper Jurassic layer post stack attributes.

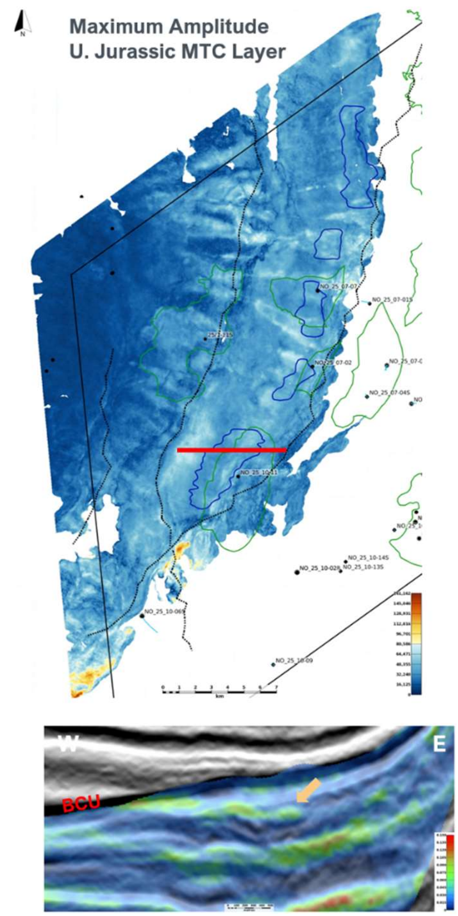

Figure 1: Top map shows the maximum amplitude in a layer top to base of Upper Jurassic MTC. Blue ploygons outline slumps , green plygons are fields and discoveries. MAZ East-West section at the bottom shows details of a slump with toe thrust and ponded sands (arrow), inversion porosity overlay indicates elevated porosities of 10-15% (green-red): Section depth 4-4.5 km below sebed, location shown as red line on top map.

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