Geophysical characterisation of the Elk reservoir, Gulf Province, Papua New Guinea

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The Elk reservoir is an approximately 200 km^2 carbonate reservoir situated in the Gulf Province of Papua New Guinea. The reservoir was discovered in 2006 when the Elk-1 exploration well flowed gas while drilling a structural high identified by the 2D Elk Seismic Survey acquired in 2005.

Due to the paucity of well data in the Elk reservoir and the requirement for resource estimates very early in the appraisal process, generation of estimates was based on a static 3D reservoir model guided by geophysical and geological data not commonly used in reservoir characterisation.

The rock type and degree of weathering on the surface greatly attenuates the sonic velocity and recoverable frequency in seismic data recorded in this area. The refraction velocity model put forward here identifies the near surface seismic velocity trends, improves surface static corrections, and identifies shallow refractors to assist with a robust depth conversion and fault modelling in a non-reflective overburden. The model employs up-hole time and first break picks to identify LVL velocities and depths and identify velocity boundaries between rock types, structure and/or burial character.

In addition to the already mentioned problems, the presence of a non-reflective overburden made it difficult to delineate major faults and fracture zones. Potential field data collected from ground stations were used to help constrain the results derived from refraction studies on the Elk Prospect and to assist in fault mapping. Best-fit modeled profiles of the gravity and magnetic observations were analysed for the presence of faults and/or fault zones, major fractures, lithological boundaries, and any perceived indications of variations in subsurface geology. 2D forward modelling was applied to some sections where possible. The gravity and magnetic data were also gridded to map anomalous trends and surface locations of the interpreted features.

The lack of reflective sequences in the overburden complicates well and seismic correlation. To address this further, a series of Walkaway Vertical Seismic Profiles (WVSPs) were acquired simultaneously with the surface seismic 2D data. These data allowed a low fold 3D cube from both compressional and shear data to be generated around the Elk-2 well. These cubes intersect the 2D surface seismic improving well and seismic correlation. Two Zero-Offset VSPs were also acquired to provide corridor stacks and further data for additional surface seismic processing such as Q attenuation.

The WVSP data allows some quantification of seismic anisotropy, and this provides important parameters to correctly image, depth convert, and to understand rock properties in and above the reservoir. To compare the anisotropy measurements derived from the WVSP data, independent log analysis was performed in the overburden where polar anisotropy was observed. Finally, to confirm the log and WVSP data anisotropy results the stacking velocity data and well data were compared. All these datasets demonstrate an unusual form of seismic anisotropy where one of the Thomsen parameters, delta, is a negative. This implies that the shale overburden behaves as undeformed clays, as measured in laboratory conditions, rather than as a highly deformed shale expected from geological mapping. How this anisotropy varies around the field (from well data) reveals properties of the overburden as well as for velocity modelling required for accurate depth conversion.

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