MULTIPLE-SCENARIO MODELLING OF THE ASTOKH RESERVOIRS, PILTUN-ASTOKHSKOYE FIELD OFFSHORE SAKHALIN ISLAND, RUSSIA

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Summary: The Astokh Development is the first of several large offshore oil and gas accumulations to be placed on production within the offshore area of Sakhalin Island in Sea of Okhotsk, Russia. The field was discovered in 1985 and appraisal and development undertaken by Sakhalin Energy beginning in the 1990's. The field has been under oil production since 1999 with pressure support being provided by a peripheral water injection program begun in 2004. Despite this, the field is still considered to be in the early stages of development and production is expected to continue beyond 2020. A progradational complex of stacked Late Miocene shallow-marine shoreface systems deposited under deltaic and shelf conditions dominates the reservoirs at Astokh. The technical team has built a suite of detailed reservoir models, which cover a wide range of geologically valid, seismically constrained static models incorporating unique dataset of seasonal production and shut-in pressure measurements. This approach provides a series of connectivity model scenarios as the best input to dynamic simulation of a complex oil field as a guide to the next phase of infill producer and peripheral injector drilling is planned for 2009.

Thick floating sea ice during extreme winter weather conditions between December and May each year in the offshore Sakhalin areas prevent tanker access to the oil export buoy moored near the Molikpaq production facility. These conditions force a 6-month shut-in period for all production wells, although water injection continues year-round. This provides a unique opportunity to study long pressure build-ups in the producers together with investigation of interference effects by controlled variation in the rate of water injection during the shut-in. The result is that the subsurface teams can build an understanding of the reservoir connectivity between wells across the field and between layers and this insight is included in the modelling process.

The Astokh Subsurface Team has utilised the Shell Integrated Reservoir Modelling Process to guide the construction of multiple, seismically-constrained reservoir model scenarios within Petrel. The applied workflow initially entailed a "back-to-basics" revision of key well and seismic datasets. Subsequent seismic reprocessing and inversion, in conjunction with detailed rock physics modelling has enabled the use of inverted impedance data to guide the population of reservoir properties. Quantitative use of inversion products integrated with detailed well correlation has yielded significant insights into reservoir architecture and enabled the construction of multiple connectivity scenarios within complex reservoir intervals.

A review of the reservoir correlation through an iterative interpretation of sequence stratigraphic princi-

ples and performed by geological, geophysical and reservoir engineering staff provided a robust correlation consistent with seismic scale layering, production pressures, core and well logs at a seismic scale. At a sub-seismic level, the influence of various correlation possibilities on dynamic behaviour was tested by building different, but equally valid cases. Faults and other geological heterogeneities were considered as potential barriers, baffles or conduits to lateral fluid flow in the dynamic model.

Analysis of an acoustic impedance seismic volume combined with core and well log derived rock physics models allow the calculation of seismic-derived porosity. This was then used to guide to porosity distribution across the model with the aid of geostatistical techniques including output distribution curves of covariance as a further constraint. From a number of derived realisations, a preferred single case was selected through a process of comparison with geological understanding of porosity distribution and matching input porosity distribution curves. Porosity/permeability transforms derived from core data provided the extrapolation of permeability across the model and was input to saturation-height functions for the derivation of hydrocarbon saturation.

Multiple static model realisations were constructed for transfer to dynamic simulation including two Mid-Case scenarios reflecting different correlation possibilities, whilst High and Low cases were based on different structural architecture, time/depth uncertainty and using different property model geostatistics as constraints.

Conclusion: Complete integration and conditioning of geological and geophysical datasets has aided the construction of a suite of reservoir models, which match observed pressures and historical seasonal production information. The resulting models have enabled improved forecasting confidence, infill well placement and prediction of injected water behaviour.