Monitoring microseismic activity by multi-well downhole sensors during a Massive Hydraulic Injection in Yufutsu Oil/Gas Reservoir

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Hydraulic fracturing stimulation is successfully applied to revive production of aging conventional hydrocarbon reservoirs or as a technique to bring production at economical rate from low permeability, tight formation reservoirs. Monitoring of the microseismic activity induced by the fluid injection during well stimulation is a valuable method to optimize well production and the field development.

In Japan, the Yufutsu gas/oil field in Hokkaido is a naturally fractured crystalline basement reservoir, characterized by a low permeability. Although there is no clear correlation between gas production and well positions, successful fracture characterization at the wellbore determined that high production of gas occurs only when boreholes intersect well-developed networks of high permeability natural fractures (so called Mega fractures). Multi-disciplinary studies have also indicated that induced shear fracturing could be the favorable mechanism to create a permeable network of such mega fractures.

To understand the reservoir behavior and to improve the reservoir modeling JAPEX conducted a series of hydraulic fracturing tests by injecting brine without proppant in order to stimulate shearing of rocks along pre-existing fractures. During the hydraulic stimulation and the intervening shut in periods, the seismic signals were recorded and monitored for microseismic activity.

In May 2005 a large-scale hydraulic fracturing experiment took place in the Yufutsu Gas Field. A total of 5600 cubic meters of fluid were injected during four main stages of pumping at a vertical depth interval that ranges from 4007 m to 4143 m. Fluid injection was monitored using four multicomponent seismic sensors two deployed on tubing in the treatment well and two deployed on wireline in existing monitor wells in the field. More than 2500 microseismic events were identified during pumping, of which approximately 450 gave identifiable compressional and/or shear arrivals in all three wells, enabling event location using picked transit times.

The velocity model used for the event location was based on VSP data acquired in the monitor wells and gave good agreement between the picked and modeled transit times. Processing results of the large scale HFM experiment including the event location based on the improved velocity model, as well as event rates and relative magnitudes correlated with the pumping schedule, are discussed.