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Effects of Geomechanical Mechanism on the Gas Production Behavior: A Simulation Study of Class-3 Type Four-Way-Closure Ridge Hydrate Deposit Offshore Southwestern Taiwan

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The future energy police of Taiwan will heavily rely on the clean energy, including renewable energy and low-carbon energy, to meet the target of mitigating CO_2 emission. In addition to developing the renewable energies like solar and wind resources, Taiwan will increase the natural gas consumption to obtain enough electrical power with low-carbon emission. The vast resources of gas hydrates recognized in southwestern offshore Taiwan makes a great opportunity for Taiwan to have own energy resources in the future. Therefore, Taiwan put significant efforts on the evaluation of gas hydrate reserves recently.

Production behavior of natural gas dissociated from gas hydrate deposits is an important issue to the hydrate reserves evaluation. The depressurization method is a useful engineering recovery method for gas production from a class-3 type hydrate deposit. The dissociation efficiency will be affected by the pressure drawdown disturbance. However, when the pore pressure of hydrate deposits is depressurized for gas production, the rock matrix will surfer more stresses and the formation deformation might be occurred.

The purpose of this study was to investigate the effects of geomechanical mechanism on the gas production from a class-3 hydrate deposit using depressurization method. The case of a class-3 type hydrate deposit of Four-Way-Closure Ridge was studied.

In this study a reservoir simulator, STARS, was used. STARS is a multiphase flow, heat transfer, geo-chemical and geo-mechanical mechanisms coupling simulator which is capable to simulate the dissociation/reformation of gas hydrate and the deformation of hydrate reservoirs and overburdens. The simulating ability of STARTS simulator was validated by duplicating the hydrate comparison projects of National Energy Technology Lab.

The study target, Four-Way-Closure (FWC) Ridge hydrate deposit, was discovered by the bottom simulating reflectors (BSRs). The geological parameters were collected from the geological and geophysical studies and the geo-mechanical data were analogized from Japan's hydrate production case. The first step for the geological modelling was to digitize the structure map of FWC Ridge and built a grid system for the reservoir. The formation parameters, such as formation thickness, porosity and permeability, the phase behavior parameters, rock-fluid parameters, initial conditions (including formation pressure, temperature and hydrate saturation), geo-mechanical parameters were assigned into each grid. In this case we used a horizontal well with specific operating conditions to produce water and dissociated gas from the reservoir.

The sensitivity analyses on geological and geo-mechanical parameters were conducted in this study. The case of different pressure drop showed that the recovery factor (RF) was 2.50%, 13.50% and 20.47% when the pressure drop of 60%, 70% and 75% from the initial reservoir pressure was used respectively. Based on the case of pressure drop of 75% (from the initial reservoir pressure), the RF was 35.13%, 25.9%, 20.47% and 16.65% when the initial hydrate saturation of 30%, 40%, 50% and 60% was assumed respectively. The greater formation permeability, the better gas recovery. The capillary pressure had a minor affection on the gas production in this case study. The best well location was at the upper layer because of the gravity effect.

For the effects of the geo-mechanics, we observed that the rock mechanisms had impacts on the final cumulative gas production. The larger the Young's Modulus and the smaller the Poisson's Ratio, the smaller the subsidence on the seabed. Our simulation results showed that the seabed subsidence in FWC Ridge was about 1 meter during the production period.