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CO2 and sour gas recycling model in carbonate gas condensate reservoir: Dynamic storage, upstream pollution reduction and enhancement of hydrocarbon recovery

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Two biggest challenges in the third millennium are global warming (Stern report, 2006) and the depletion of oil and gas reserves. The problem of global warming requires effective storage of already emitted carbon dioxide gas (CO2) together with a decrease in the emissions of CO2 and other greenhouse gases. Considering M. Hubbert's curve of oil production data distribution with time, the highest oil production peak in the world is most likely to occur in the first half of this century. After production peak is reached the trend will lead to hydrocarbon depletion of reservoirs, in spite the fact that about 60-70% of oil is left in place. In general reservoir oil recovery techniques displace crude oil and gas from the sediment pores in permeable directions towards producing wells and to the surface. But they extract in best cases more than 1/3 of the discovered oil reserves. However, it is known that the oil recovery efficiency is greatly increases by injecting miscible CO2 gas in order to displace hydrocarbons, which also simultaneously might be used for CO2 storage during production phases of Exploration and Production Cycle and also after complete depletion of the reservoir. Thus, mutually beneficial results can be achieved altogether in CO2 storage and additional oil and gas recovery efficiency. In both cases critical factors are the knowledge of the most appropriate storage reservoirs, their rock porosity and permeability distribution, and reservoir seal integrity.

For this purpose we propose one of the best candidates for the CO2 storage, using as an example one of the giant carbonate gas condensate and oil field in Kazakhstan. This field has strong seal, large capacity, good petrophysical parameters and already proven successful containment CO2 and sour gas in HPHT conditions. The field is a deep isolated Lower Permian and Carboniferous carbonate platform covering an area of about 30 km by 20 km. At its largest point the reservoir contains a gas column around 1450 m deep with a 200 m deep oil section below. The strong massive sealing consists of the Kungurian evaporites. The geological evolution of the reservoir was controlled by Pre-Caspian tectonics and the Hercynian compression. Field production began about 27 years ago maintaining a strategy in full replacement of gas voidage to maintain pressure of the reservoir above the dew point. Gas and oil were separated before being piped to further processing. This was partially due to the sour nature of the gas, with a H2S content of about 3.9-5.4% and CO2 content over 5%. Reservoir is now in a phase of liquid recovery.

In the field are used gas utilization methods such as flaring, gas refining and gas injection introduced about 7 years ago. Calculations show that injection of produced and additional gas (including CO2 and sour gases) is economically viable, ecologically safe and more suitable method because it increases gas and oil extraction. Gas injection monitoring using surface injection well head pressures and measured injected volumes demonstrates a highly effective gas injection process. Injection well head pressure response shows no increase, indicating absence of compartmentalization close to the near well bore gas injection region in reservoir. And injector pulse study shows interconnectivity across the injection region highlighting good quality reservoir across the potential CO2 injection zones from coal power plant. Preliminary CO2 storage potential was also estimated for this type of hydrocarbon reservoir together with other advantages.