Revealing the CO2 source in Tangguh Jurassic Giant Gas Field Complex and How We Improve CO2 Prediction

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The Tangguh Gas Field complex is the biggest giant gas accumulation in eastern Indonesia with a total of more than 20 tcf of GIIP. This gas accumulation is distributed between Vorwata, Wiriagar Deep, Roabiba, Ofaweri, and Ubadari Fields, is sourced by F-D/E type Jurassic source rocks and contains 8-15% impurities of CO2. Initial understanding of CO2 source in the Jurassic is that it is due to carbonate mineral thermal decomposition of the seal at the fields and this is supported by the evidence of Carbon 13 Isotope CO2 values in the range 15 – 0‰.

The updated 3D basin model calibrated to more than 50 wells indicates however, that the Late Jurassic seal has not experienced standard thermal stress of more than 200℃ at field locations. This situation might not allow any carbonate mineral to be decomposed and generate CO2.

New data was acquired recently where the gas samples at Ubadari and Roabiba fields were analysed for Helium Isotopes. This analysis has revealed a new fact that the CO2 source in Tangguh is more complex than initially modelled. It appears that at least 60% of the CO2 is magmatic in origin, with the remainder being carbonate-derived and some trace amount from organic matter. This mixing is revealed by the plot of CO2/3He vs d13C CO2. The magmatic-sourced CO2 here is being 'hidden' as it does not clearly show up in the 3He/4He (R/Ra) ratio which is commonly used to interpret a magmatic or mantle origin of a fluid. The mixing with hydrocarbon gases which have typically low 3He/4He ratio dilutes the magmatic 3He/4He signature.

This evidence clearly changes the understanding of CO2 distribution. In Tangguh, CO2 has been recognized as one of the gas signatures in the reservoir compartmentalisation study, because it was interpreted as single sourced and positively correlates with gas migration. However, the CO2 distribution in Tangguh might not positively correspond to the migration or plumbing system in the basin as the CO2 is sourced from multiple origins.

Having multiple CO2 origins will make the prediction of CO2 distribution more complex and the integration of charge access model and structural model is very critical. The magmatism-sourced CO2 is very likely to correspond to the presence of deep-seated faults, whilst on the other hand, the carbonate-sourced CO2 likely formed downdip at the kitchen and migrated along with its hydrocarbon.

Keywords: Tangguh, Jurassic, Gas Field, Basin Model, CO2, Geochemistry, Noble Gas Isotope, Helium Isotope, Reservoir Compartmentalisation