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Tracing fluids migration in Bohai Bay Basin (Eastern China) using noble gas isotopes

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Noble gases are featured by the distinct elemental and isotopic compositions in different reservoirs and have provided robust evidences for tracing the origins and transportations of various fluids in the subsurface system [1]. Here, we present original noble gas and main gas abundance and isotopic compositions in natural gas from Bohai Bay Basin (Eastern China), a tectonically active region, to quantificationally access the migration of the fluids therein.

The helium concentrations are positively correlated with the $^{3}He/^{4}He$ isotopic ratios (0.36-2.63 Ra), suggesting an important contribution from the mantle. Ne isotopes indicate an obvious mixing trend between the air and the mantle endmembers. The above noble gas geochemical signatures and the existence of abiogenic CO_2 gas reservoirs are consistent with the mantle uplift, crust thinning, intense magmatic and volcanic activity and other tectonic activization phenomena in eastern China that occurred since the Jurassic [2].

The $^{40}Ar/^{36}Ar$ ratios are highly related to the water cut of the sampled oil field, suggesting that the enhanced oil recovery (EOR) procedures in part of the research area have modified the pristine noble gas features. The noble gas data unaffected by EOR can be explained by an oil-modified groundwater-exsolution model which predicts the involvement of oil, gas and groundwater quantity in the system. Besides, there is a positive correlation between $CO_2/^{3}He$ ratios and ^{20}Ne concentrations, which could be caused by the CO_2 dissolution into groundwater in large quantities during the gas-water equilibrium process, further supporting the fractionation model. Noble gases provide a tool to reveal the interaction mechanisms of fluids from different sources in the hydrocarbon system.

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