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The rock physical approach to the complex CO_2 flow in the beded Tako sandstone

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In this study, we try to elucidate the effect of thin low-porosity layer in porous Tako sandstone on CO_2 flow by experimental and theoretical studies. Tako sandstone is early Miocene marine sandstone, mainly composed of quartz and plagioclase. This rock is characterized by the well-developed and low porosity foliations are mainly composed hematite. We have measured two channels of P-wave velocities (Vp) on the foliation channel (LPZ) and high porosity zone (HPZ) by using 1MHz P-wave transducers during CO_2 injection stage (drainage) and water re-injection stage (imbibition). In drainage, both of channels show large velocity reduction over 0.2 km/s ($>$10 %). In imbibition, they indicate different Vp-change with injecting water. The Vp of HPZ starts the Vp-recovery from 50ml injection and almost recovers at 120ml.On the other hands, LPZ starts Vp recovery from 100ml water injection and do not finish at 250ml. These results suggest that the HPZ has large CO_2 mobility and the LPZ has different CO_2 flow pattern between drainage and imbibition. Next, we try to 2D core-scale flow simulation by TOUGH-2 to check and discuss about CO_2 behavior in Tako sandstone. This simulation is based on 2-D porosity distribution map of core and uses relative permeability for parameters. The result of our simulation indicates that the foliation (LPZ) has large trapping potential of CO_2. The HPZ, which is directly beneath of foliation zone (DBFZ), has large CO_2 saturation in early stage of drainage. We confirm that CO_2 have large mobility and vigorous vertical flow in HPZ. After reaching upper foliation, CO_2 flows laterally along foliation and raise saturation of whole HPZ. In imbibition, CO_2 saturation of HPZ decreases rapidly to assign residual CO_2 saturation over 40ml water injection. However, DBFZ keep high CO_2 saturation after 100ml water injection. On the other hands, CO_2 saturation of LPZ is smaller than HPZ in drainage stage, but they show large saturation value over 20ml water injection. These results suggest that the foliation of Tako sandstone behaves as a barrier of CO_2 flow. It is implied that the thin low-porosity layer may be a barrier of CO_2 flow in porous saline aquifer.

Keywords: P wave velocity, foliation, CO_2 flow pattern, porosity distribution, CO_2saturation, TOUGH-2