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Interactive Comment

Interactive comment on "Klinkenberg effect for gas permeability and its comparison to water permeability for porous sedimentary rocks" *by* W. Tanikawa and T. Shimamoto

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In our tests, permeability is measured by steady state gas flow method, and upstream of pore pressure is kept from 0.2 to 1.2 MPa, and downstream of pore pressure is 0.1 MPa of atmospheric pressure. Therefore pore pressure has a variation within the sample during experiments, and selecting average pore pressure, (Pup+Pdown)/2, is suitable for the effective pressure calculation. However, average pore pressure is much smaller than confining pressure and downstream of pore pressure is atmospheric pressure, therefore effective pressure was assumed to be equivalent to confining pressure in all figures. If such small variations of effective pressure due to pore pressure changes can not be neglected for permeability, permeability becomes large with a decrease of effective pressure at same confining pressures. However our results for gas permeability showed inverse relationship. This result may support our assumption that small variation of effective pressure can be neglected, and confining pressure can be nearly equivalent to effective pressure. We focused on the Klinkenberg effect for the reason of the gap between gas and water permeability, and we did not discuss any other possible mechanism for the significant reduction due to the change from gas to water. However in section 6.3, we indicated possible mechanisms for water permeability dependence on pore pressure. This surface adhesion of water may reduce the permeability. We do not know in detail whether wetting enhances the mechanical collapse deformation, though it is generally true that rocks become weaker in wet condition than in dry condition. However we still can not explain why plastic deformations at 30 MPa had occurred at wet condition instead of dry gas flow condition because IVA418 had already pre-consolidated up to 160MPa at first effective pressure cycle. Therefore we do not have confidence in the effect of mechanical effects, though we still feel it is necessary to consider other possible mechanisms for the gap. In section 6.3, we tried to explain our experimental results of the water permeability dependence on the differential pore pressure. Generally, water flows as a Newtonian flow that adhesive power from the pore walls does not acts on water. General Darcy's law, that permeability does not depend on the pore pressure, is based on Newtonian flow and the equation (7) for Newtonian flow is described as, Q=$\pi\Delta$pR^4/(8Lμ). However when pore spaces are small, fluid might flows as Buckingham fluid that fluid starts to move at above a certain differential pore fluid pressure, because of the adhesion of pore walls resists water flow. Therefore permeability becomes small. As the referee mentioned, it might be better to increase sentence to explain for equation (7) more kindly.

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