Fiber-optic sensing for CO_2-induced strain detection

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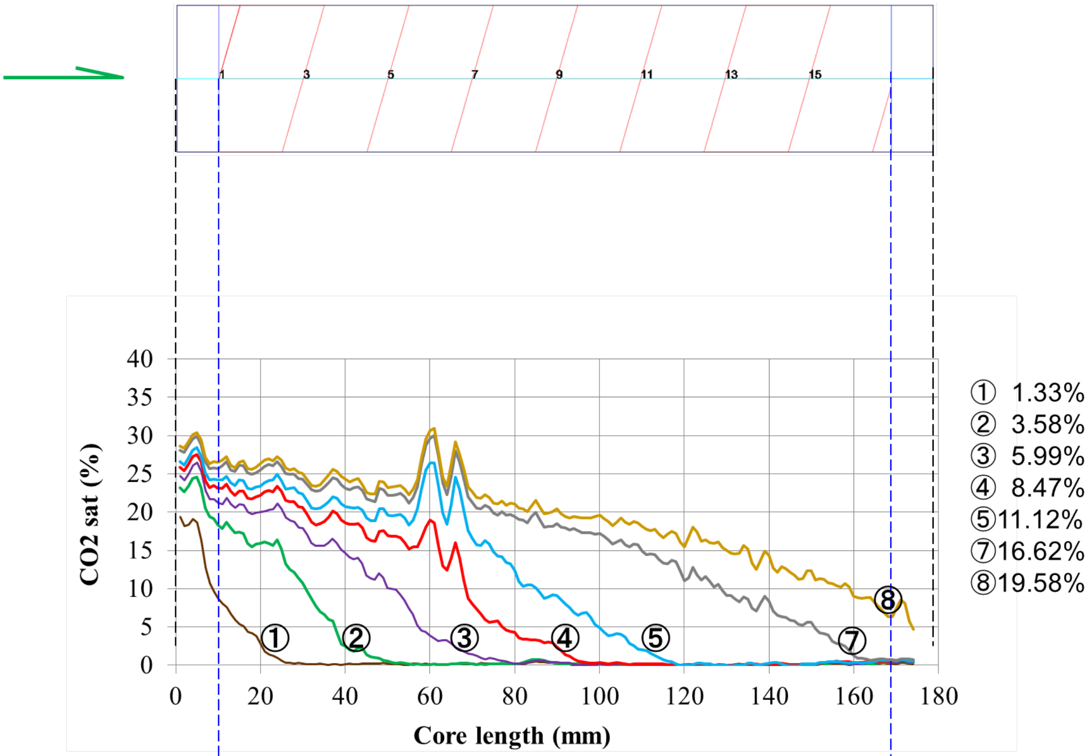
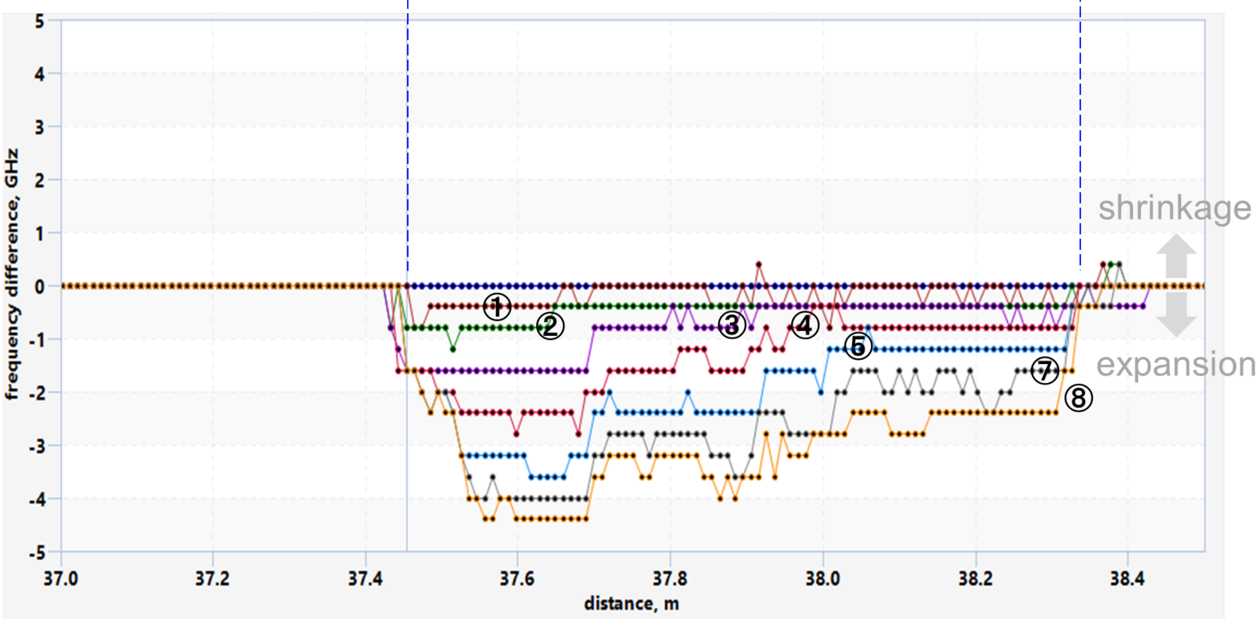
For CO_2-induced strain detection, we carried out a laboratory experiment of CO_2 flooding in a core scale sandstone. Single optical fiber was used as distributed fiber optic sensors in this study. X-ray CT imaging was used to measure the CO_2 saturation. We compared the CO_2 transfer by X-ray CT imaging and the response of the optical fiber. Sarukawa sandstone (diameter: 34.83mm, length: 179.50mm) was used in this study. It has a relatively homogeneous structure and has irregularly shaped grains and voids. Microbubble filter (diameter: 34.33mm, length: 5.02mm) was located in between distributor and core specimen in the upstream side. Porosity of the specimen determined by X-ray CT imaging is 23.38%. The permeability is about 7.3 mDarcy. The experiment was conducted under the pressure and temperature conditions that simulate underground environments; pore pressure: 10MPa, temperature: 40 degrees Celsius. The confining pressure selected in this study was 12MPa. The specimen was first saturated with KI aqueous solution (11.5 wt%). The permeability was confirmed using the KI aqueous solution. The upstream pump was prepared at 10.5 MPa for differential pressure of 0.5MPa. Optical fiber measurement and X-ray CT imaging were performed in all experimental steps. Breakthrough occurred after about 0.2PV (pore volume) CO_2 injection. It took about 8 minutes in this study. The CO_2 saturation obtained by the X-ray CT was about 19.58%. When comparing the front of CO_2 saturation and the front of optical fiber frequency difference, they showed good agreement. This suggests that the frequency information of optical fiber can play a role as a sensor representing the behavior of CO_2 in rock.

Keywords: Fiber-optic sensing, X-ray CT imaging, CO2-induced strain, CO2 saturation



X-ray CT imaging result (CO_2 saturation)



Fiber-optic sensing result (CO_2-induced strain)