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Laboratory experiment on dynamic failure and degradation of sealing capacity of critically stressed cap rock due to gas infiltration

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We examined deformation and failure processes of critically stressed rock due to gas infiltration by laboratory experiment. A triaxial compression apparatus with flow pipes to pass fluids to a specimen was used. Kimachi sandstone was selected for a rock sample. Procedures of the experiment were as follows. Firstly, deviatoric stress condition which was very close to critically stressed condition was applied to a water saturated rock specimen. Then, the upstream edge, i.e. the bottom of the specimen was connected to a gas accumulator filled with air whose pressure exceeded the capillary displacement pressure. Both axial and circumferential strains and air pressure were monitored. Experimental results showed that the axial strain (positive for contraction) was increased, while both circumferential and volumetric strains were decreased, and air pressure was decreased monotonically. The results implied that dynamic failure and permeability increase of rock due to air infiltration occurred. The following processes were thought to occur during the experiment. At the bottom margin of the specimen where air was infiltrated, a sudden increase in equivalent pore pressure caused by high air pressure resulted in a sudden drop of effective stress, and local shear failure and air migration along the fault occurred. Although volume of air increased, decrease of air pressure was quite low due to its high compressibility, and as a result, failure condition was kept in the specimen where air was infiltrated. In the specimen, the region in which shear failure and air migration occurred extended upward from bottom to top gradually. The deformation and failure mechanism of critically stressed rock which we examined is important to evaluate sealing capacity of cap rock, because recent researches have argued that many sedimentary basins are under critically stressed condition. It is suggested that an understanding of in situ stress condition and consideration of the possible dynamic failure of cap rock are important to evaluate sealing capacity of cap rock.