



HOKKAIDO UNIVERSITY

Title	Variation in Permeability of Rocks due to Transient Disturbances in Axial Stress or Pore Pressure [an abstract of dissertation and a summary of dissertation review]
Author(s)	Boeut, Sophea
Degree Grantor	北海道大学
Degree Name	博士(工学)
Dissertation Number	甲第14004号
Issue Date	2020-03-25
Doc URL	https://hdl.handle.net/2115/77979
Rights(URL)	https://creativecommons.org/licenses/by/4.0/
Type	doctoral thesis
File Information	Sphea_Boeut_abstract.pdf, 論文内容の要旨



学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称 博士（工学） 氏名 Sophea Boeut

学 位 論 文 題 名

Variation in Permeability of Rocks due to Transient Disturbances in Axial Stress or Pore Pressure
(軸応力や間隙水圧の過渡的な擾乱による岩石の浸透率変化)

Large earthquakes can lead to persistent variations in the groundwater level in the near-field resulting in the persistent variations in the permeability of the rock mass due to permanent change in the strain through fault movement. These persistent variations in the groundwater levels may occur in the intermediate and even in the far-fields which cannot be explained by variation in permeability associated with the change in strain caused by fault movement because the change in strain is transient in the intermediate- and far-fields. The persistent increase in the permeability of rock mass caused by transient stress disturbances by earthquakes, if it exists, could explain not only the variation in groundwater level but also increase in petroleum production due to artificial vibrations, induction of small earthquakes by seismic waves, etc. in intermediate- and far-fields. However, it has not been verified whether the transient stress disturbances induce a persistent increase or decrease in the rock permeability.

To clarify the effects of transient stress disturbances on rock permeability, three rock types, wacke fine-grained Kushiro Cretaceous sandstone, volcanic Shikotsu welded tuff and hard crystalline Inada granite were considered for the experiments in this study. The permeability values of intact and triaxially fractured Kushiro Cretaceous sandstone and Shikotsu welded tuff were measured before and after transient axial stress or pore pressure disturbances. Kushiro Cretaceous sandstone was tested under a constant pore pressure of 1 MPa, confining pressures of 3-15 MPa, and the transient disturbance amplitudes of 0-11 MPa and 0-0.8 MPa in axial stress and pore pressure, respectively. Shikotsu welded tuff was tested under the constant pore pressures of 0.1 or 0.5 MPa, a confining pressure of 10 MPa and the transient disturbance amplitudes were 0-8 MPa and 0-0.8 MPa in axial stress and pore pressure, respectively. The permeability of triaxially fractured Inada granite was measured under multiple transient disturbances in axial stress with the disturbance amplitudes between 0 and 8 MPa under a pore pressure of 1 MPa and confining pressure of 5 MPa.

According to the experimental results, the stress disturbances showed either decreasing or increasing effects on the permeability depending on the rock type and experimental conditions. The permeability of the Kushiro Cretaceous sandstone decreased at zero stress disturbances. For the intact rocks, the permeability was kept almost constant with the disturbance amplitude. For the fractured rocks, the reductions became larger as the disturbance amplitudes increased. Regarding the pore pressure disturbances, the reductions in the permeability of the intact rocks decreased as the pore pressure disturbances increased, whereas the reductions increased as the disturbance amplitudes increased for the fractured rocks.

For the Shikotsu welded tuff, virtually the same results were obtained for both the axial stress and

pore pressure disturbances. There were negligible effects of stress disturbances on the intact rocks. The permeability of the fractured rocks decreased at zero stress disturbances, and the reductions in permeability decreased as the disturbance amplitudes increased, and a permeability increase was even observed in some cases.

The permeability of fractured Inada granite decreased with time in the tests. However, the permeability increased with each series of axial stress disturbances for amplitudes of 3 MPa or larger. The degree of increase in permeability increased with the axial stress disturbance amplitudes. The permeability decreased with time and recovered to its value before the disturbances. The time of recovery was longer for larger axial stress disturbance amplitudes.

When focusing on the fractured rocks rather than the intact rocks, which would be more important in field applications, the argillaceous Kushiro Cretaceous sandstone mainly exhibited decreasing effects mainly due to the closure of the rupture planes and the clogging of flow pathways by fine particles. In contrast, the glassy Shikotsu welded tuff and the crystalline Inada granite mainly exhibited increase in permeability. The effects were mainly due to the expansion of the apertures, the enhancement of new microcracks and the removal of the fines from the flow pathways.

Variations in permeability due to transient stress disturbances have already been employed in seismic enhanced oil recovery (EOR) technique expecting an increase in permeability due to the movement of entrapped fluid in the reservoir. The increase in permeability could be employed to enhance natural gas recovery, to reroute underground water flow for various purposes, to prevent large earthquakes by inducing many small earthquakes, etc. in the future.