Subcritical Crack Growth in Rock

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1. Introduction

Subcritical crack growth in rock has been studied by using Double Torsion (DT) method under different environmental conditions. Using isotropic rock, environmental dependence of subcritical crack growth was investigated quantitatively. In the study using anisotropic rock, effects of environment and rock fabric, especially pre-existing microcracks on subcritical crack growth were investigated.

Fig. 3 Kumamoto andesite. (4.5×6.1mm)

2. Subcritical crack growth in isotropic rock

Subcritical crack growth in isotropic rock is described. Rock studied was Kumamoto andesite (see Fig. 3). Relations between the crack velocity and the stress intensity factor obtained by DT tests are shown in Fig. 4. In this figure, open symbols and solid symbols indicate the results obtained under the conditions of low water vapor pressure and high water vapor pressure, respectively. From Fig. 4, it is recognized that the reproducibility of the experimental result was high under the same environmental condition. It is shown that the crack velocity became higher when the water vapor pressure was higher.

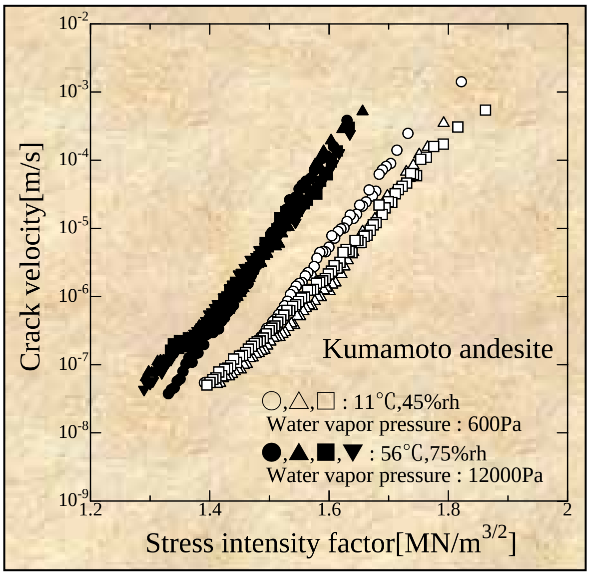

Fig. 4 Results of DT tests for Kumamoto andesite.

Publications

Y. Nara, Y. Imai and K. Kaneko, Dependence of subcritical crack growth on rock fabric and environment, Shigen-to-Sozai, **120**, pp.431-439, 2004 (in Japanese with English abstract).

Y. Obara, H. S. Jeong, T. Matsuyama, Y. Nara and K. Kaneko, Stress corrosion index of Kumamoto andesite, Shigen-to-Sozai, **121**, pp.84-89, 2005 (in Japanese with English abstract).

Y. Nara and K. Kaneko, Study of subcritical crack growth in andesite using the Double Torsion test, Int. J. Rock Mech. Min. Sci., **42**, pp.521-530, 2005.

3. Subcritical crack growth in anisotropic rock

Subcritical crack growth in anisotropic rock is described. Especially, effects of the pre-existing microcracks and water vapor were investigated. Oshima granite, Westerly granite, and Inada granite were used as rock samples. In Fig. 5, photomicrographs of these granites are shown.

(a) (b) (c)

Fig. 5 Photomicrographs of granite. (4.5×6.1mm)
(a) : Oshima granite, (b) : Westerly granite, (c) : Inada granite

In general, granite possesses the orthorhombic elasticity due to the preferred orientation of microcracks. In this study, principal axes of granite were defined as axis-1, -2, and -3 in order of P-wave velocity. The planes normal to these axes were defined as plane-1, -2, and-3, respectively. Hence, there are the most microcracks parallel to plane-3. Taking into account the propagation direction and the opening direction of the crack in DT specimen, 6 kinds of specimens were prepared (see Fig. 6).

In Fig. 7, Results obtained for Oshima granite under the same environmental condition are shown. Anisotropy of the crack velocity was shown. The crack growth behavior depended on the crack opening direction. When the crack propagated parallel to plane-3, the crack velocity was the highest.

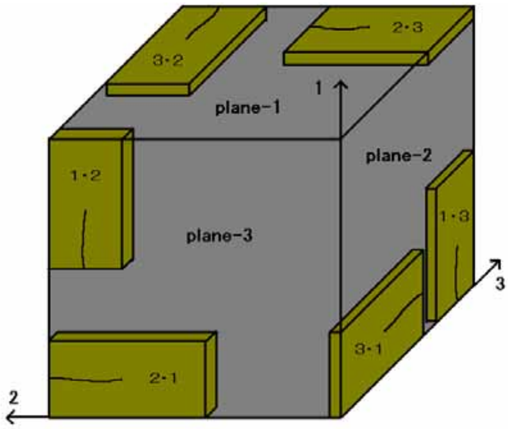

Fig. 6 Specimen preparation for granite.

In Fig. 8, results obtained for Oshima granite under different temperatures and humidities are shown. In this figure, open and solid symbols indicate results under low and high water vapor pressures, respectively. As shown in andesite (see Fig. 4), the crack velocity became higher when the water vapor pressure was higher.

Preparing polished thin sections from DT specimens and observing the crack paths by using Electron Probe Micro Analyzer (EPMA), the relation between the crack growth behavior and the geometry of the crack path was clarified. In Fig. 9, an image obtained by EPMA is shown. From the fractal analysis, it was shown that the activation energy for subcritical crack growth was larger when the geometry of the crack path was more complicated.

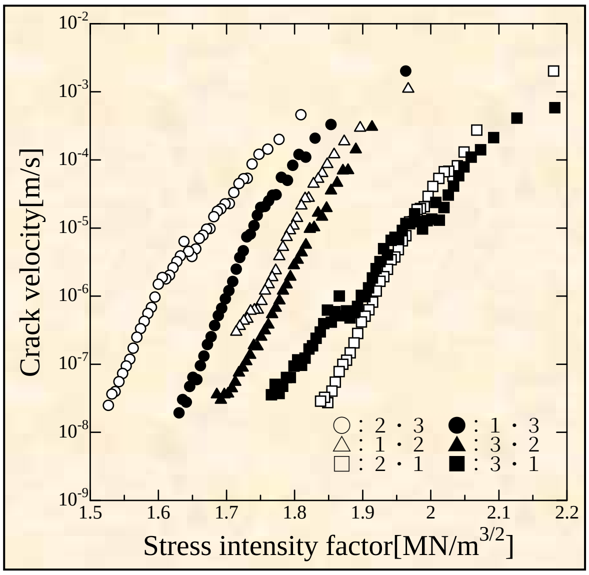

Fig. 7 Anisotropy of subcritical crack growth in Oshima granite.

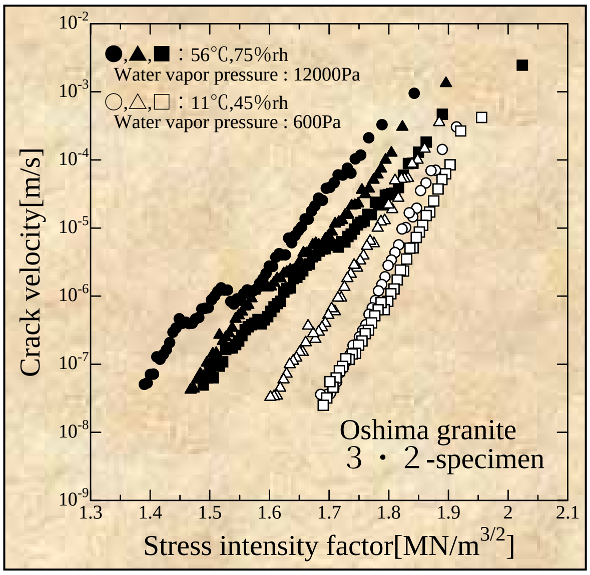

Fig. 8 Environmental dependence of subcritical crack growth in Oshima granite.

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Y. Nara and K. Kaneko, Evaluation of the elastic constants of granite, Shigen-to-Sozai, **119**, pp.396-402, 2003 (in Japanese with English abstract).

Y. Nara, Y. Ohno, Y. Imai, and K. Kaneko, Anisotropy and grain-size dependency of crack growth due to stress corrosion in granite, Shigen-to-Sozai, **120**, pp.25-31, 2004.

Y. Nara, Y. Imai and K. Kaneko, Dependence of subcritical crack growth on rock fabric and environment, Shigen-to-Sozai, **120**, pp.431-439, 2004 (in Japanese with English abstract).

Y. Nara and K. Kaneko, Subcritical crack growth in anisotropic rock, Int. J. Rock Mech. Min. Sci., **43**, pp.437-453, 2006.

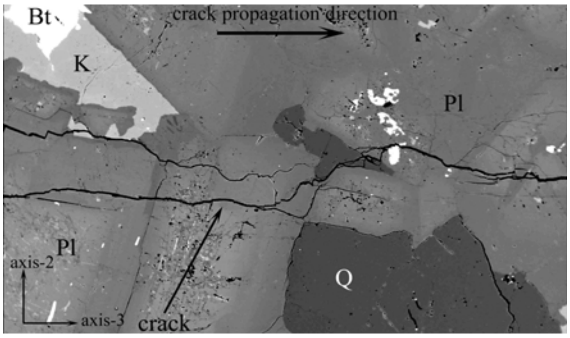

Fig. 9 Image of the crack path obtained by EPMA. (0.9×1.5mm)

Y. Nara, K. Koike, T. Yoneda and K. Kaneko, Relation between subcritical crack growth behavior and crack paths in granite, Int. J. Rock Mech. Min. Sci., 2006 (in press).