Stress measurements by the Baby Borehole Hydro-fracturing method, BABHY, in the vicinity of the Atotsugawa fault

Takatoshi Ito[1]; Kentaro Omura[2]; Harumi Kato[3]; Hiroshi Tanaka[4]; Kotaro Sekine[5]

[1] Inst. Fluid Sci., Tohoku Univ.; [2] NIED; [3] Geotechnos Co.,LTD, Geoscience Consulting Division; [4] Akema Boring; [5] Inst. Fluid. Sci., Tohoku Univ

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The principle of hydraulic fracturing is suited for stress measurements at relatively deep depths. However, in the current procedure and equipment for the in-situ tests of hydraulic fracturing, there are several problems to put the principle into practice. The most serious one is associated with hydraulic compliance of testing equipment [see Ito et al., Int. J. Rock Mech. Min Sci., 1999, Proc. US Rock Mech. Symp., 2005]. For the effective measurement of the reopening pressure as one of observed data, it is necessary to use the testing equipment with sufficiently small compliance. If not, there is no way to estimate the maximum stress in a plane perpendicular to a borehole, i.e. the maximum horizontal stress assuming a vertical borehole, from the reopening pressure. This limitation makes it difficult to apply the hydraulic fracturing for the measurement of the maximum stress, because the compliance of conventional equipments is generally so large. Taking account of this situation, in this work we have proposed a new concept which allows us to do the in-situ tests of hydraulic fracturing for stress measurement at depths more than 1 km. The system consists of two components which are (a) the compact drilling tool with a built-in downhole motor and (b) the packer tool with a built-in pump. Each of them is lowered inside drill string on wireline. The compact drilling tool is used to drill an additional hole with about 50 mm in diameter and 2 - 3 m in length at the bottom of an original borehole, and the hydraulic fracturing is carried out in the drilled hole by using the small packer tool. The additionally-drilled hole and the original borehole are referred to the baby hole and the mother hole respectively. For the verification of this concept, we have carried out the field test at the Kamioka mine which is located in the vicinity of the Atotsugawa fault. The test location was at the depth of about 500 m. The mother hole was drilled in PQ size, i.e. 123 mm in diameter, and the baby hole with 47 mm in diameter and 1 m in length was drilled at the bottom of the mother hole with the depth of 31.8 m. The straddle packer system with the pressurized interval of about 400 mm was set in the baby hole and hydraulic fracturing was carried out. As a result, we succeeded to have a pair of longitudinal fractures, and the reopening pressure and the shut-in pressures were observed at 15 MPa and 19 MPa respectively. From those values, the maximum and minimum horizontal stresses are estimated as 27 MPa and 19 MPa respectively. The induced fracture orientation showed that the azimuth of the maximum horizontal stress is at N23degW. The estimated azimuth was found to be almost perpendicular to the strike of the Atotsugawa fault. Note that the compliance in concern of the hydrofracturing system used for the present tests was 1.3 mL/MPa.

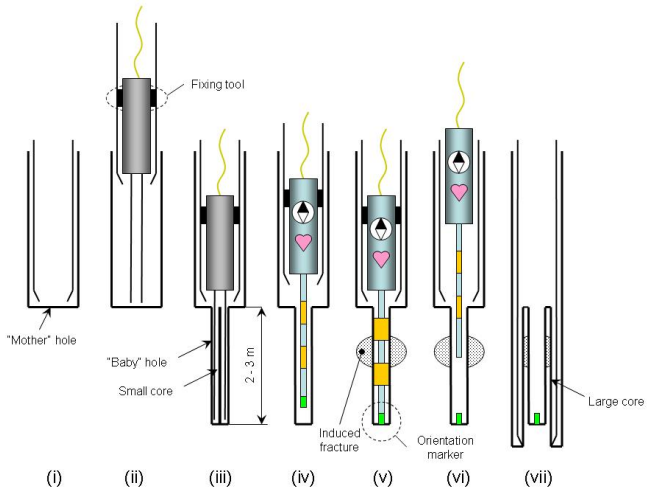

図1　BABHYの実施要領