Investigation of Present-Day Stress States at KURT Site

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1. Introduction

In situ stress states of bedrock are a fundamental parameter, needed to analyze a wide range of potential geomechanical problems, including reservoir characterization, faulting and earthquake mechanism, and geotechnical problems such as underground excavation [1].

The states of stress (orientations and magnitudes) can be estimated through various stress indicators obtained from various sources, such as hydraulic fracturing test, borehole observations, rock core data, and earthquake focal mechanism solutions [2, 3].

In this study, we investigated in situ stress states in KURT site, using hydraulic fracturing tests and borehole wall failure observations.

2. Tested boreholes

To investigate the stress conditions at KURT site, we conducted hydraulic fracturing (HF) tests and borehole image logging, using three wells located in that site (Fig. 1).

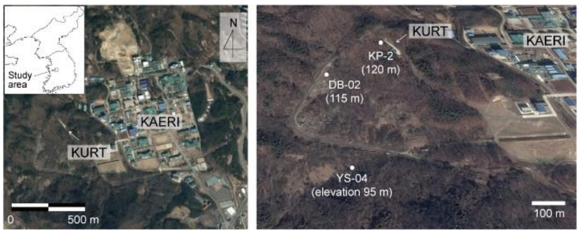

Fig. 1. Locations of boreholes tested in this study. Altitudes of individual boreholes KP-2, YS-4, DB-2 are 120, 95, 115 m, respectively.

A series of HF stress measurements were carried out in two boreholes of KP-2 and YS-4. Based on results from HF tests, we determined stress states in shallow depths. The borehole DB-2, a 1 km deep test hole, was image-logged using an acoustic televiewer (BHTV) to identify fractures and faults crossing the borehole, and also probable borehole stress indicators such as breakouts. The stress indicators allowed us to understand stress states in deep depths in the study site.

3. In situ stress estimation

3.1 Stress orientations

Based on the image logs and rock core analysis, we identified several intact rock intervals in the boreholes that were suitable for hydraulic fracturing stress measurements. A total of six depths in KP-2 and six depths in YS-4 (117.5, 160.5, 234, 315, 328, 343.5 m) were tested where the intervals are devoid of pre-existing natural fractures. After the tests, we used impression packers to identify the orientations of HF induced fractures, which were used to determine stress orientations.

Borehole ultrasonic image logs show borehole breakouts (BO) and drilling induced tensile fractures (DITF) along the whole logged section to ~ 738 m in DB-2. The observed BO and DITF, although scattered in their azimuth somewhat (within ±13°), generally indicating a maximum horizontal principal stress (S_{Hmax}) direction of E-W.

All stress indicators, derived from boreholes, consistently argue the S_{Hmax} direction of E-W compression. The determined average orientation of S_{Hmax} at KURT site is N98±13°E (Fig. 2) [4].

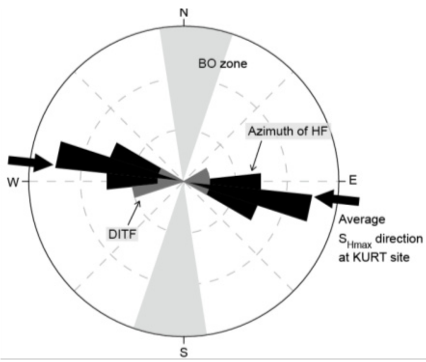

Fig. 2. Result of S_{Hmax} orientation determinations merging stress indicators, taken from [4].

3.2 Magnitudes of stress

The magnitudes of the minimum horizontal principal stress (S_{hmin}) were determined using the pressure-time curves recorded during HF tests and those of S_{Hmax} using the relationship between logged borehole wall failure and rock strength. The vertical stress (S_v), calculated from overburden weight of rocks, was either the minimum or the intermediate principal stress depending on depths (Fig. 3) [4].

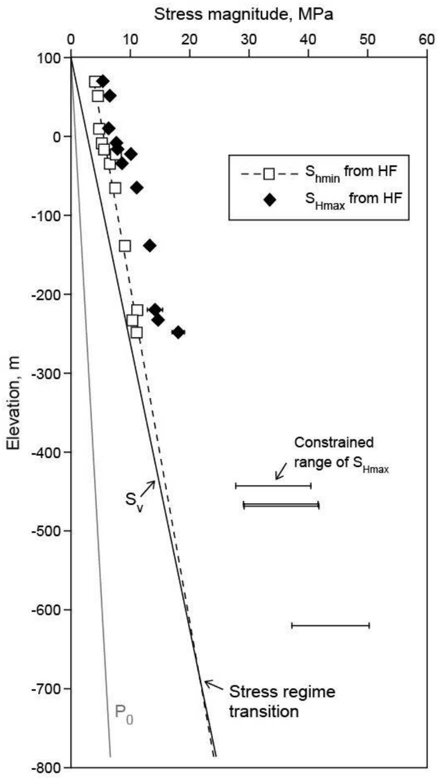

Fig. 3. Investigated in situ stress state profile as a function of elevation, taken from [4].

Results of our stress estimations indicate that stress regime in KURT site is in favor of thrust faulting ($S_v < S_{hmin} < S_{Hmax}$). Another noticeable aspect of the stress condition at this site is that S_v is intermediate between two horizontal stresses ~700 m below. It signifies a transition from near surface thrust faulting regime to one favoring strike-slip ($S_{hmin} < S_v < S_{Hmax}$). These results are in agreement with the regional scale crustal stress pattern in Korean Peninsula reported from the previous studies [5].

4. Conclusions

In this paper, we investigated in situ stress conditions at KURT research site, using the results of hydraulic fracturing and borehole observations.

The estimated stress regime in study site is in favor of thrust faulting (<700 m) or strike-slip faulting, which agrees with earthquake focal mechanisms in Korea and previous stress results.

We expect that our stress estimation results can be provided as an initial parameter for various studies to exploit the study site, such as construction of underground facility in the future.

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