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DEVELOPMENT OF TECHNIQUES TO CREATE AND ESTIMATE MULTIFRACTURES AT AKINOMIYA SITE. JAPAN

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ABSTRACT

CRIEPI has proposed some new techniques to create and estimate man-made fractures in the hot dry rock since 1986. A hydraulic fracturing operation with Casing Reamer Sand Plug (CRSP) method was performed at Akinomiya site in Japan in a well at depth of about 400m in 1987.

The distribution of Acoustic Emission(AE) indicated the growth of a set fracture sloping downward toward N45°W at about 45°NW inclination. Three(3) fractures (1 or 2mm in width) on the inside wall of the well could be observed by using a Borehole Television Scanner (BTVS) system. The strike and the inclination of these fractures were consistent with the distribution of AE.

These results gave suggestions that CRIEPI's techniques may be proper to make a multi fracture system at different depth in a well and would be necessary for the geothermal energy extraction system.

INTRODUCTION

CRIEPI has been promoting research on the following technical developments for the hot dry rock geothermal energy extracion system :

1. Creation of man-made multi fracture system at different depth in a well
2. Observation and evaluation of the newly hydraulic fractured plane in the bed rock

Hydraulic fracturing operations with open-hole packers were performed at Fenten-Hill. However the operations were often failed because the packers made some troubles or were damaged in the deep hole influenced by high temperature and high pressure (Franke et.al, 1984).

CRIEPI has been developed a new hydraulic fracturing method (named " Casing Reamer Sand Plug (CRSP) method ") without using open-hole packers (Kaieda et.al, 1988) and a new Borehole Television Scanner (BTVS) system to observe the inside wall of the well (Miyakawa et.al,1987) and applied these new techniques at Akinomiya site and successed to make several fractures in a well.

AKINOMIYA SITE

The Akinomiya area is situated in the south of Akita pretecture, Japan (Fig. l). The thick formation of Neogene volcanic rocks commonly called "Green Tuff" is widely distributed in the area.

The Akinomiya site exposes the Miocene Yakunaigawa Formation and the Miocene Torakeyama Formation, the former consisting largely of lapilli tuff and the latter consisting of acidic volcanic rocks (Fig. 2). These formations uncomformably overlies the Cretaceous granitic rocks (Fig. 3). The Takamatsudake pyroclastic rocks of Quaternary age deposited in the valley along the Yakunaigawa river (Takenohashi et.al ,1982).

A fracturing well was bored 400m through lapilli tuff. The rock temperature showed about 60 °C at the bottom of the well. Some micro cracks or pyrite veins were recognized by BTVS system. These planes trend northwest and dip southwest (Fg. 4).

Fig.l The location map of the Akinomiya site.

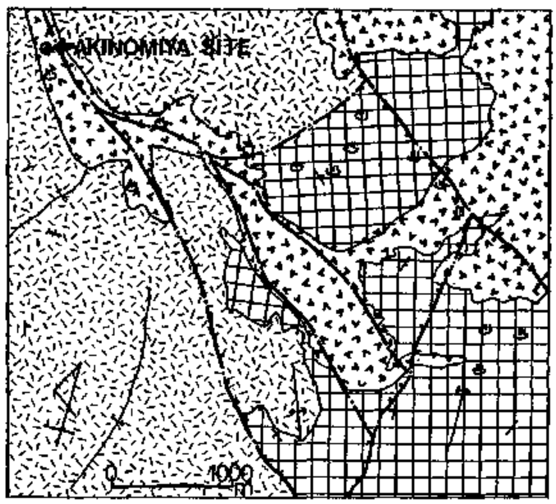
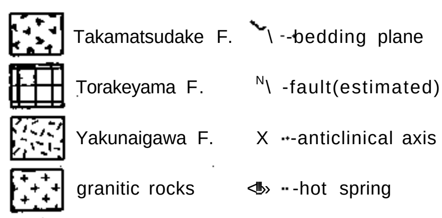


Fig.2 The geological map of the Akinomiya area simplified from Takanohashi et.al,1982.

Legend of fig.2 and fig.3



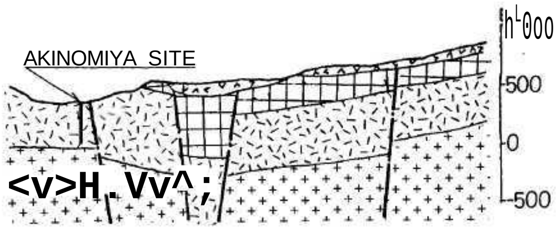


Fig.3 The schematic geolgical section of the Akinomiya area.

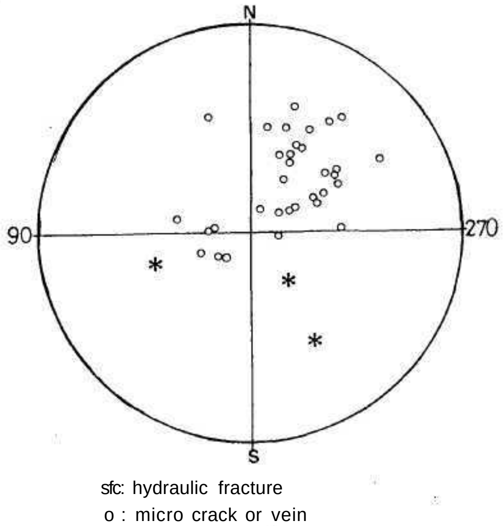


Fig.4 The directions of fractures, cracks and veins observed by the BTVS system are projected or the lower hem. of the Wulff net.

CASING REAMER SAND PLUG METHOD

The hydraulic fracturing operation was performed according to the following methods (Fig. 5).

1. The well completed with the casing pipe except the bottom part.
2. Hydraulic fracturing was conducted by full-hole pressurizing at the uncased bottom part.
3. Sand plug was emplaced below the next fracturing part to prevent the injected water leakage into the pre-created fractures.
4. Fracturing part was made by using the casing reamer which cut the casing pipe set in the well.
5. Hydraulic fracturing was conducted again by full-hole pressurizing at the casing cut zone.
6. By repeating the above methods, multi fracture system can be created at different depth in a well.

BOREHOLE TELEVISION SCANNER

The borehole television system has been developed by some research institutes and applied to various geological explorations. CRIEPI developed a new system (named " Borehole Televison Scanner (BTVS) system") in 1985 which had heat resistance during 1.5 hours at 100°C and the computerized image processing system.

During the operation of the BTVS system the television camera is pulled down and rotated into the borehole without stops. Because the lowering speed of the camera is synchronized with the speed of the rotation, the camera is scanning spirally the inside wall(Fig. 6). samples (the visual angle of one sample : 6°) obtained from the stepping scan transmit to the computer loading on the car. The computerized process images are projected one after the other on the monitor screen (Fig. 7). By these systems a operator can continuously observe the expanded image of the inside wall in the geothermal borehole.

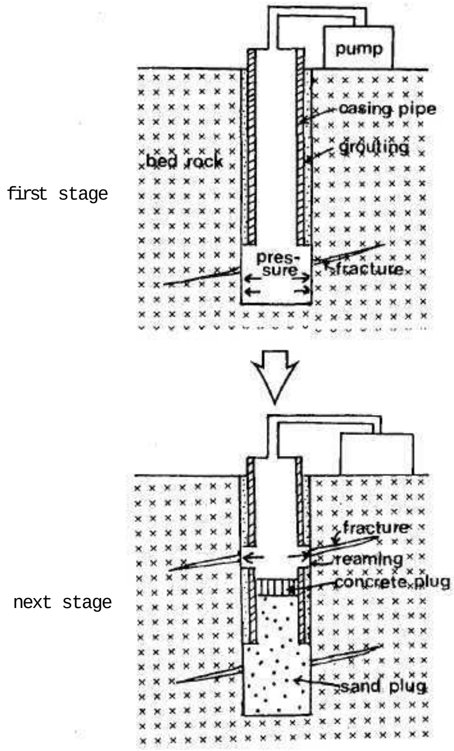


Fig.5 The conception of the CRSP method.

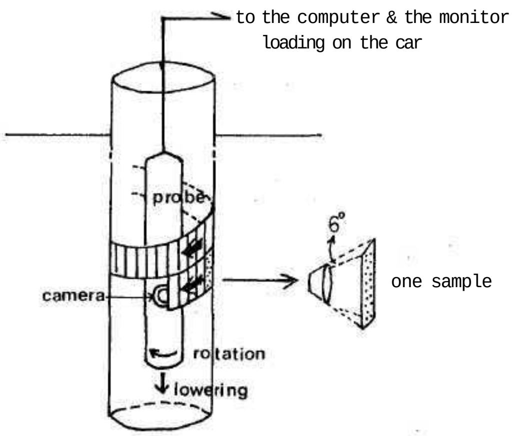


Fig.6 The camera is scanning spirally the inside wall of the well.

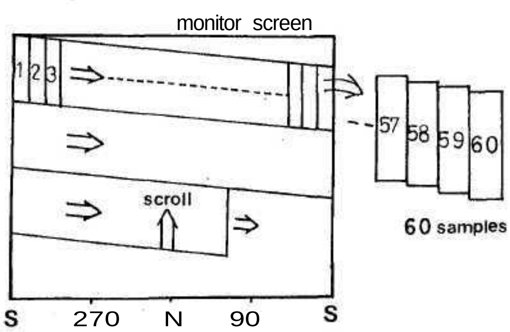


Fig.7 The images processed by the computer are projected on the monitor screen.

FRACTURING OPERATION

The casing pipes (inner diameter : 78,1mm, outer diameter : 89.1mm) were set in the well down to a depth of 390m. The first hydraulic fracturing operation was performed by full-holl pressurizing.
By the CRSP method, the casing pipe set was cut from a depth of 371.5m to 373.5m (2m interval). The second hydraulic operation was performed again by full-hole pressurizing. Total 81m^3 of water was injected with flowrate up to 2851/min and the well head pressure

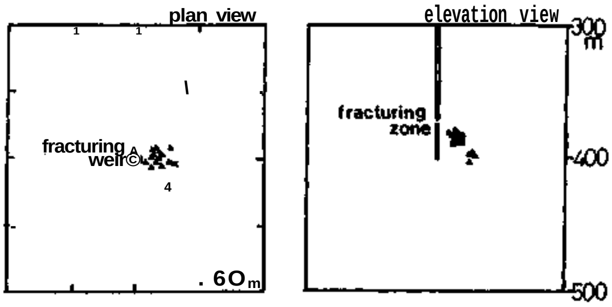


Fig.8 The distribution of AE.

reached a maximum of 190 kgf/cm^a.
The distribution of 14 AE detected at the second operation indicated the growth of a set fracture sloping downward toward N45° W at about 45° NW inclination (Fig. 8).
Three (3) fractures (1 or 2mm in width) on the inside wall of the open-hole section were observed by using the BTVS system. The strikes and inclinations of these fractures were respectively N45°E/30°NW, N20°W /50°NE and N60°2/60°NW (Fig. 4). The directions of 2 fractures which strike north-east and dip north-west were consistent with the distribution of AE.

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