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DEVELOPMENT OF BOREHOLE SCANNER SYSTEM FOR FRACTURE ANALYSIS

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ABSTRACT

A borehole scanner has been developed to obtain digital imagery of inner wall of a borehole for geological and geothermal survey. The conventional methods for such an investigation of geology and fracture in rock have been to drill a borehole and to lower a TV camera to examine the borewall. As compared with borehole TV camera system, the borehole scanner system has the following advantages:

1) Continuous color image of inner wall of the complete borehole can be obtained in digital form.
2) The maximun speed in the data adquisition is 72 m/hr.
3) Digital image analysis on VTR can be effectively carried out any time to obtain desired information on fractures and rock characteristics.

INTRODUCTION

For the construction of facilities in/on rocks such as tunnels and for the evaluation of fracture system in a borehole, an advanced geological evaluation is of major importance. Up to now, the conventional methods for such an investigation of geology and fracture in rocks have been to lower a TV camera to examine the borehole wall.

This conventional type of TV camera system exhibits some disadvantages because the TV camera must be rotated approximately 40 degrees for each shot at same borehole level to obtain a full view of the wall. Among the disadvantages, it can be mentioned the followings:

1) Excesive observation time is required.
2) Each photograph taken by the TV system should be manually rearranged into a mosaic as shown in Fig. 1.
3) The image quality is not uniform in a TV scene due to shading and illumination effects.

Fig. 1 Manually spliced developed photos taken with a conventional TV system (one chip photo: lxl.5cm)

As a result of the above, there has been a strong demand for the development of a new system that would improve not only the observation speed, but also the quality of a continuous image.

The borehole scanner presented here is composed of the following units as indicated in Fig. 2

1) Scanner
2) Cable Unit
3) Control Unit
4) TV monitor and VTR

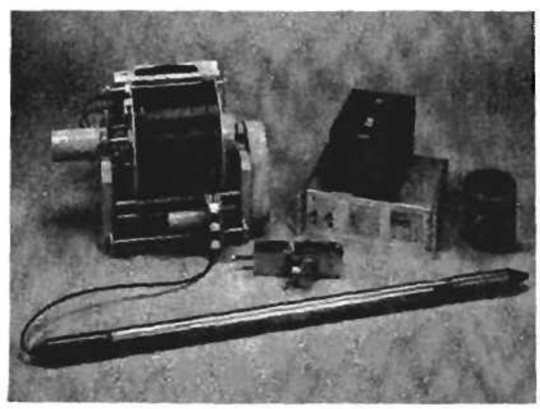

Fig. 2 General view of the Borehole Scanner equipment

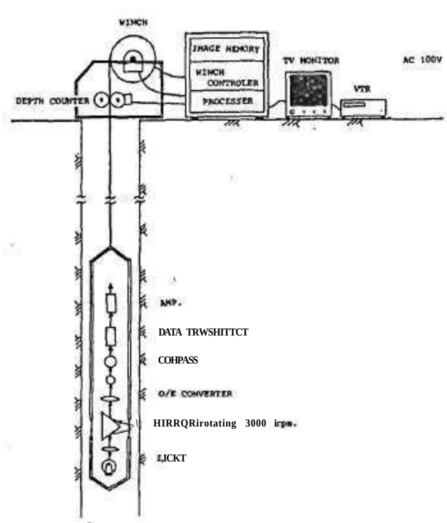

Fig. 3 Conceptual mechanism of the Borehole Scanner

The scanner is composed of a ligth, a rotating mirror, an opto-electronic converter with R, G, B channels, a magnetic compass, a data transmitter and an amplifier as shown in Fig. 3.

The scanner is carefully lowered into a borehole within a size from 66mm to 86mm in diameter. A mirror then rotates rapidly to collect the reflected light through an observation window of 360 degrees around the borehole wall. Data obtained by the scanner are transmitted to the surface control unit and recorded on a video tape or on a digital magnetic tape either for reproduction on a monitor system or for data processing.

Fig. 4 shows the borehole scanner system on site.

Fig. 4 Borehole Scanner system on site

PERFORMANCE OF BOREHOLE SCANNER

a) Observation speed
The borehole scanner has achieved an observation speed of 72m/hr, which is 30 times faster than that of a conventional TV camera system.

b) Image quality
The borehole scanner provides a substantially full scale and a continuous video color images of the inner borehole wall for an angle of 360 degree in real time, which can be monitored on the ground. The image quality is kept excellent due to the short distance between the rotating mirror and the inner wall. The resolution is 0.1 mm on the surface of the wall.

c) Recording method
VTR and digital recording are available. VTR recording system utilizes commercially available video tape which permits geological analysis or evaluation by geologists away from the site. The analysis efficiency can be improved with a continuous scanned images of 360 degree view angle in a scrolling manner.

Table 1 shows some of the specifications in the performance of the proposed borehole scanner.

Table 1. Specification of the borehole scanner

Borehole diameter	66-86mm0
Water proof pressure	1200 m
Cable length	200 m (can be extended up to 1200 m)
Ambient temperature	1 -60°C
Resolution	0.1mm
Method of recording	NTSC signal recording (video tape recorder) and digital signal recording
Velocity of probe	> 30 m/hr

FUTURE DEVELOPMENT

To overcome the temperature durability of the electronic circuit inside the probe by eliminating its mechanical part, a fixed prism of pyramidal shape has been designed to be located right above the light source. The ring shaped light is then reflected from the borewall and gathered and transmitted into an optical fiber. The received optical signals are thereafter recorded on the ground where the fracture pattern can be further analized. Numerical analysis can also be applied to the data in order to interpret the color variation of the rock. The designed system is expected to stand a temperature durability of 200 °C. to 2000mdepth.

As a result of the recorded fractured system, data such as upper depth and direction, lower depth and direction, strike and dip, width of fracture, width after correction of inclination, etc, can be summarized in a table. Frequency of fractures and distribution map of them can also be useful in the interpretation work.

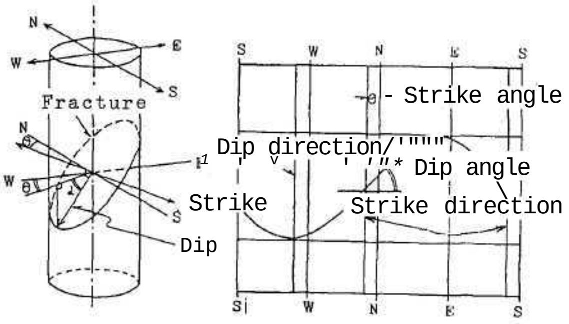

Fig. 5 Results obtained from the recorded fracture system

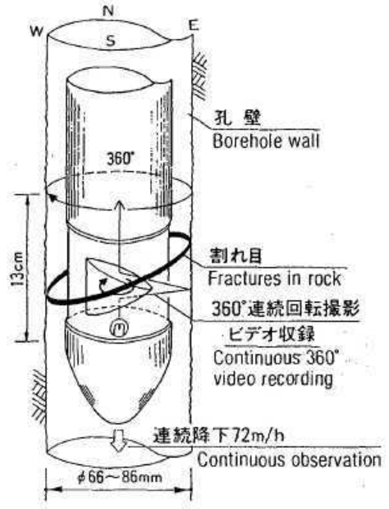

Fig. 6 Scanner unit indicating the mechanism for fractures detection in rock

Fig. 7 Recorded borehole image of slate

Fig. 8 Recorded borehole image of mud and tuff