

DEVELOPMENT OF BOREHOLE SCANNER
FOR UNDERGROUND GEOLOGICAL SURVEY

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ABSTRACT

The borehole scanner has been developed by the authors to obtain digital imagery of inner wall of a borehole for geological survey. As compared with the existing borehole TV camera system, the following significant advantages were obtained.

- 1) Continuous color image of inner wall of the whole borehole can be obtained in digital form, while the TV camera system produces only a partial image in analogue form.
- 2) The speed of data acquisition is very high of 36 m/hour, while TV system is only 2 m/hour.
- 3) Digital image analysis can be effectively applied to extract useful information on rock characteristics underdams, power plants etc..

INTRODUCTION

For the construction of facilities in/on rocks such as tunnels, dams and power plants, the advance geological evaluation is of major importance. Up to now the conventional methods for such an investigation of geology and fractures in rock have been to bore in through the surface and lower a TV camera to examine the borehole wall.

However, the type of borehole TV camera system exhibits the following disadvantages because the TV camera must be rotated approximately 40 degree for each shot at the same borehole level to obtain the full view of the wall.

- 1) Excessive observation time is required.
- 2) Each photograph taken by the TV system must be manually re-arranged into a mosaic.
- 3) The image quality is not uniform in a TV scene due to shading and illumination effects.

As a result, there has been a strong demand for the development of a new system that would improve observation speed with continuous image of a good quality.

BOREHOLE SCANNER

The borehole scanner is composed of the following units as shown in Fig. 1.

- 1) Scanner
- 2) Control Unit
- 3) Cable Unit

The scanner is composed of a light, a rotating mirror, an optro-electronic converter with R, G, B channels, a compass, a data transmitter and an amplifier, as shown in Fig. 2.

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

Fig. 3 shows the borehole scanner system on site.

PERFORMANCE OF BOREHOLE SCANNER

a. Observation speed

The borehole scanner achieves observation speed of 36 m/hour, 15 times faster than is possible with the conventional TV camera system.

b. Image quality

The borehole scanner provides substantially full scale and continuous video color images of the inner wall of a borehole for the angle of 360 degree in real time, which can be monitored on the ground. The image quality is uniform on an image because of a constant angle of illumination. Even under turbid water level, 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 the continuous scanned images of 360 degree view angle in a scrolling manner.

Table 1 shows the comparison of performance between the borehole scanner and the existing borehole TV camera.

Fig. 4 and Fig. 5 show the comparison of the two images taken by the borehole scanner and the TV camera respectively. Much better image can be obtained by the borehole scanner.

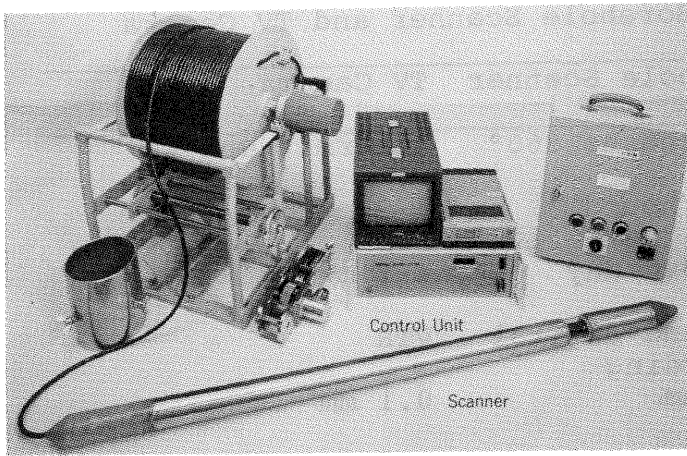


Fig. 1 Borehole Scanner System

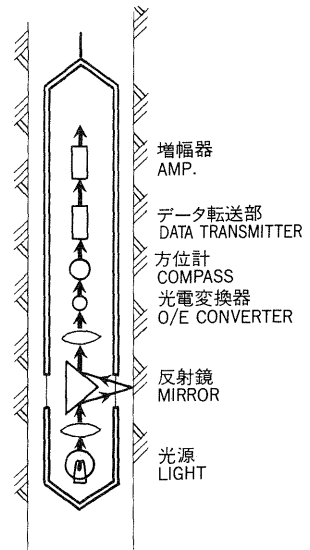


Fig. 2 Scanner

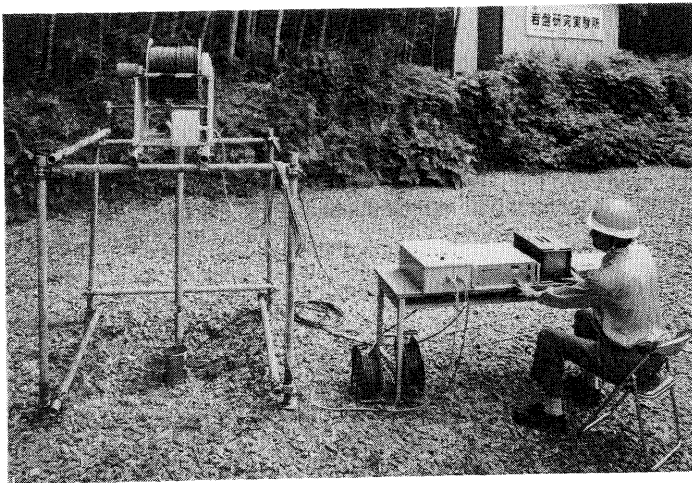


Fig. 3 Borehole Scanner on Site

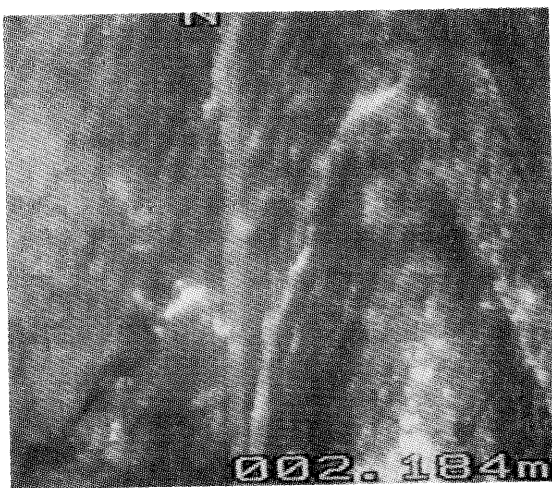


Fig. 4 Image of Borehole Scanner

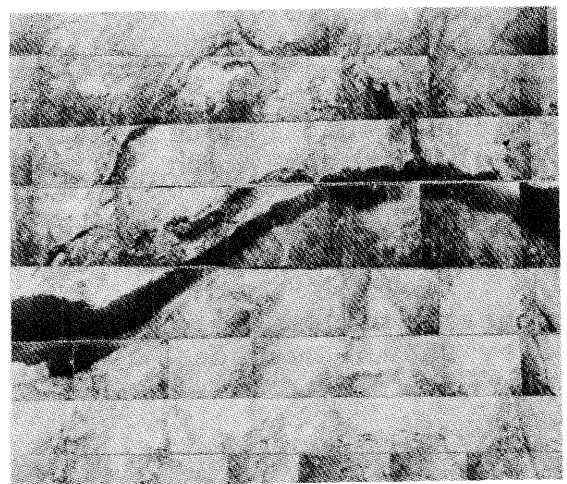


Fig. 5 Mosaic of Borehole TV Camera

Table 1 Comparison between Borehole Scanner and TV Camera

	Borehole Scanner	TV Camera
View angle	Continuous 360°	Intermittent 40°
Observatin speed	36 m/hour	1-2 m/hour
Analysis efficiëncy	10-50 m/day	1-2 m/day
Recording method	VTR and digital recording	VTR
Resolution	0.1 mm	0.1 mm
Max. observation depth	200 m	200 m
Borehole diameter	66-86 mm	66-86 mm

APPLICATIONS

The following applications have been carried out using the borehole scanner.

- a. Advance geological investigations for facilities in/on rocks such as dams, nuclear power plants, subsurface power plants, underground crude oil storage caverns and nuclear waste repositories.
- b. Maintenance and quality inspections for massive concrete structures such as dams etc..
- c. Grouting efficiency evaluations for dams.
- d. Evaluations for soil efficiency improvements in soil foundations.

Fig. 6 shows very big open cracks in black tone in the rock of chart.

Fig. 7 shows a layer of quatz in the rock of granite with a numer of cracks.

CONCLUSIONS

The underground remote sensing has been carried out with the borehole scanner which has been developed by the authors.

The borehole scanner has been producing outstanding images with high evaluation from the users.

Further development for a special image processing for geological survey should be made.

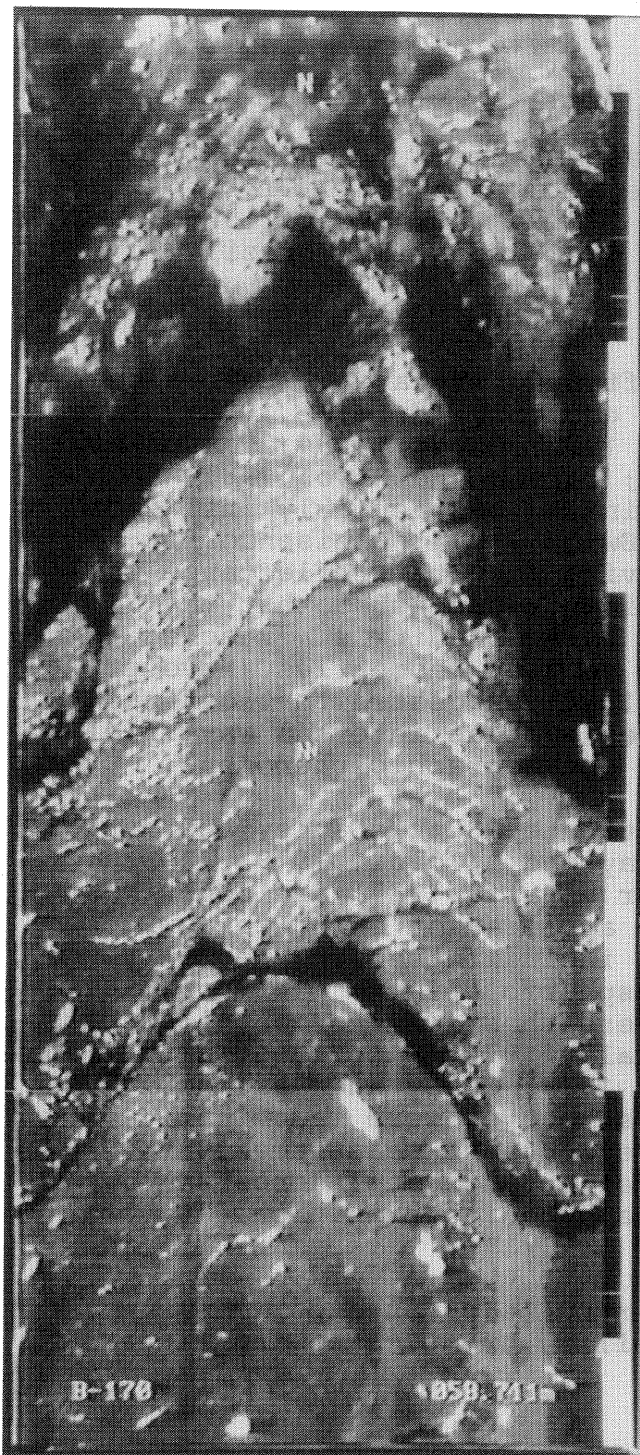


Fig. 6 Open Cracks in Chart

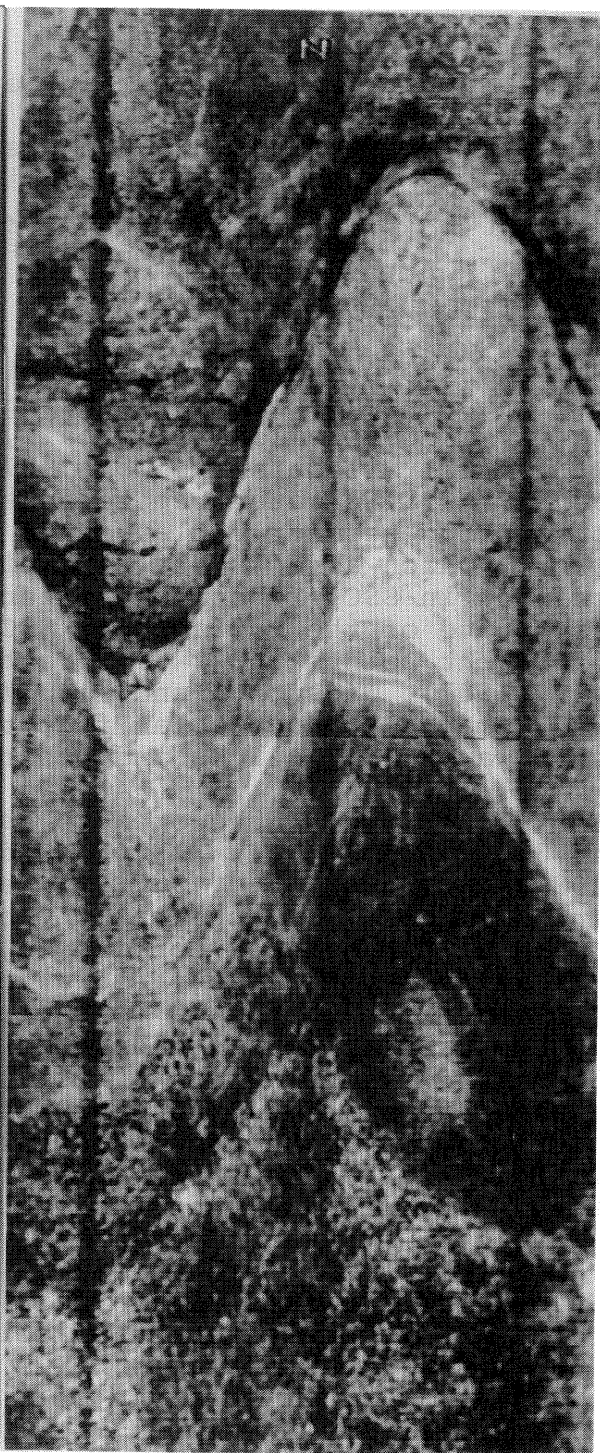


Fig. 7 A Layer of Quartz