Comparative study on borehole images of BIPS and FVCS

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Outline of the presentation

Purpose of our study:

To examine the applicability of FVCS in the fracture analysis in borehole.

FVCS : Forward Vision Camera System

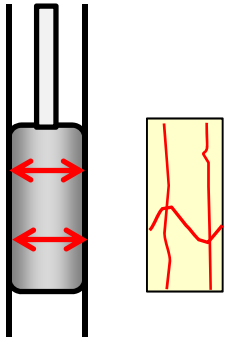
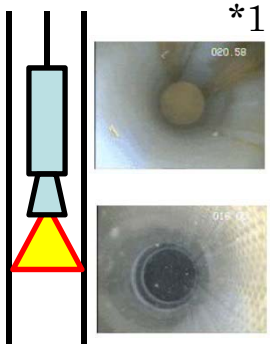
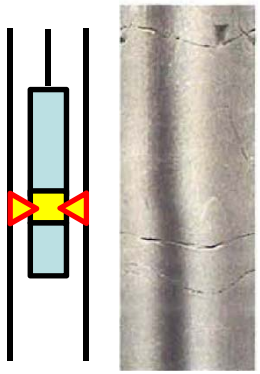
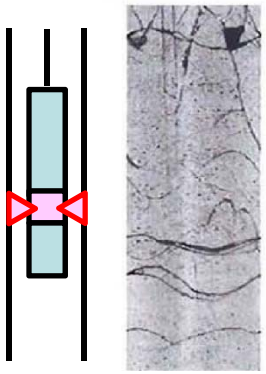
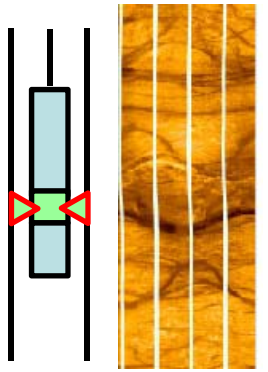
Contents of the study:

1) Measurement of test pieces with simple fracture using two method ; FVCS and BIPS.

BIPS : Borehole Image Processing System

2) Examination of the applicability of FVCS with comparing images with BIPS.

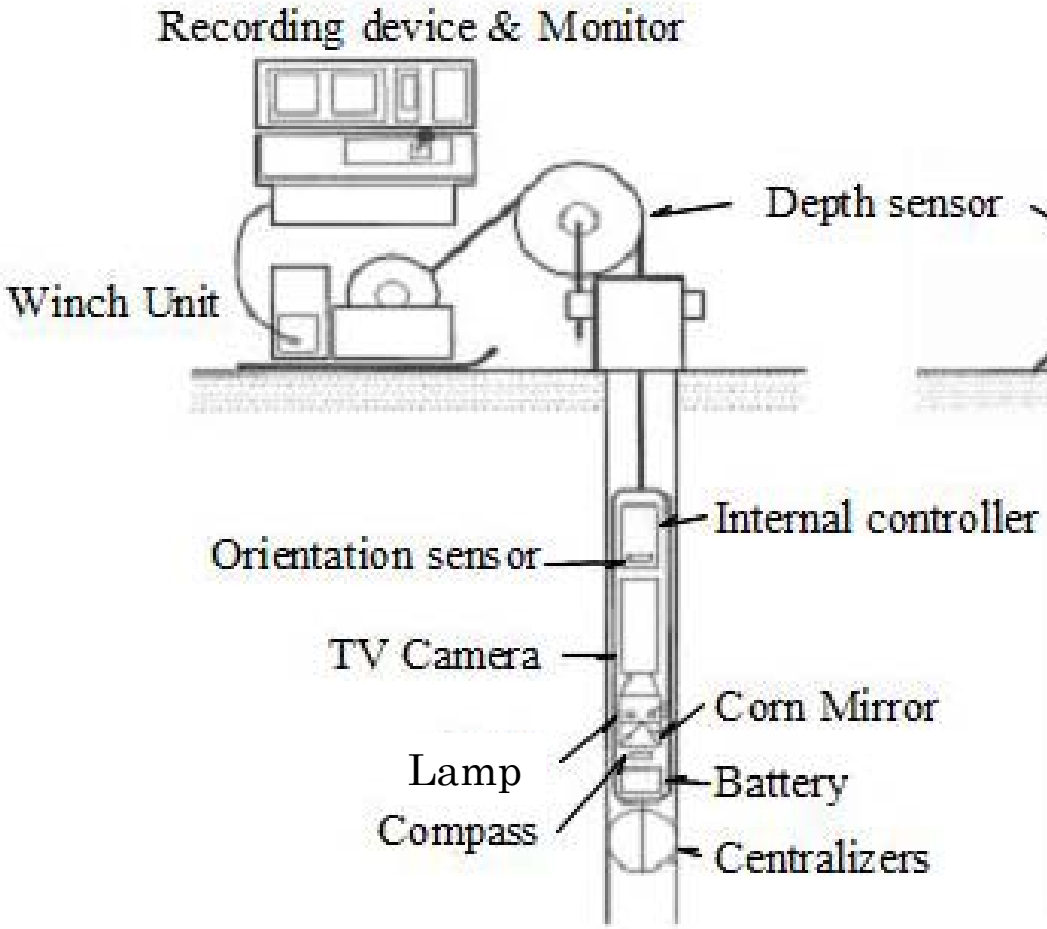
*Introduction.....*Tools for borehole imaging

No	1	2	3	4	5
Typical System	**Impression Packer**	**FVCS** Forward Vision Camera System	**BIPS(ODS)** Borehole Image Processing System	**BIPS(USS)** Borehole Image Processing System	**FMI or FMS** Fullbore Formation Micro-Imager
Measuring mechanism	Fracture tracing by rubber and inflation packer.	Optical downhole view.	Imaging by horizontal optical view.	Imaging by ultrasonic beam reflection.	Imaging by electric resistivity.
Sketch of equipment and data		*1 	*1 	*1 	*2 
Process and cost	**Simple Low**	**Simple Low**	**Complex Expensive**	**Complex Expensive**	**Complex Expensive**
Application Field	**Hydro-fracturing**	**Well inspection Civil/Energy**	**Frac. analysis Civil/Energy**	**Frac. analysis Civil/Energy**	**Frac. analysis Civil/Energy**

*1:http://www.esa.gr.jp/ *2:https://staff.aist.go.jp

Equipment of BIPS(ODS) and FVCS

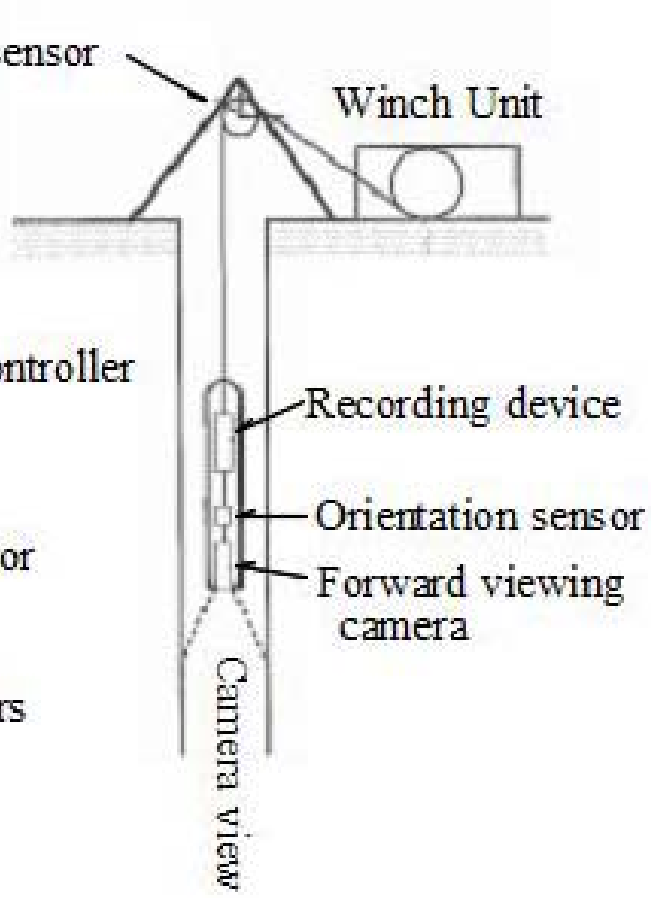
BIPS(ODS)



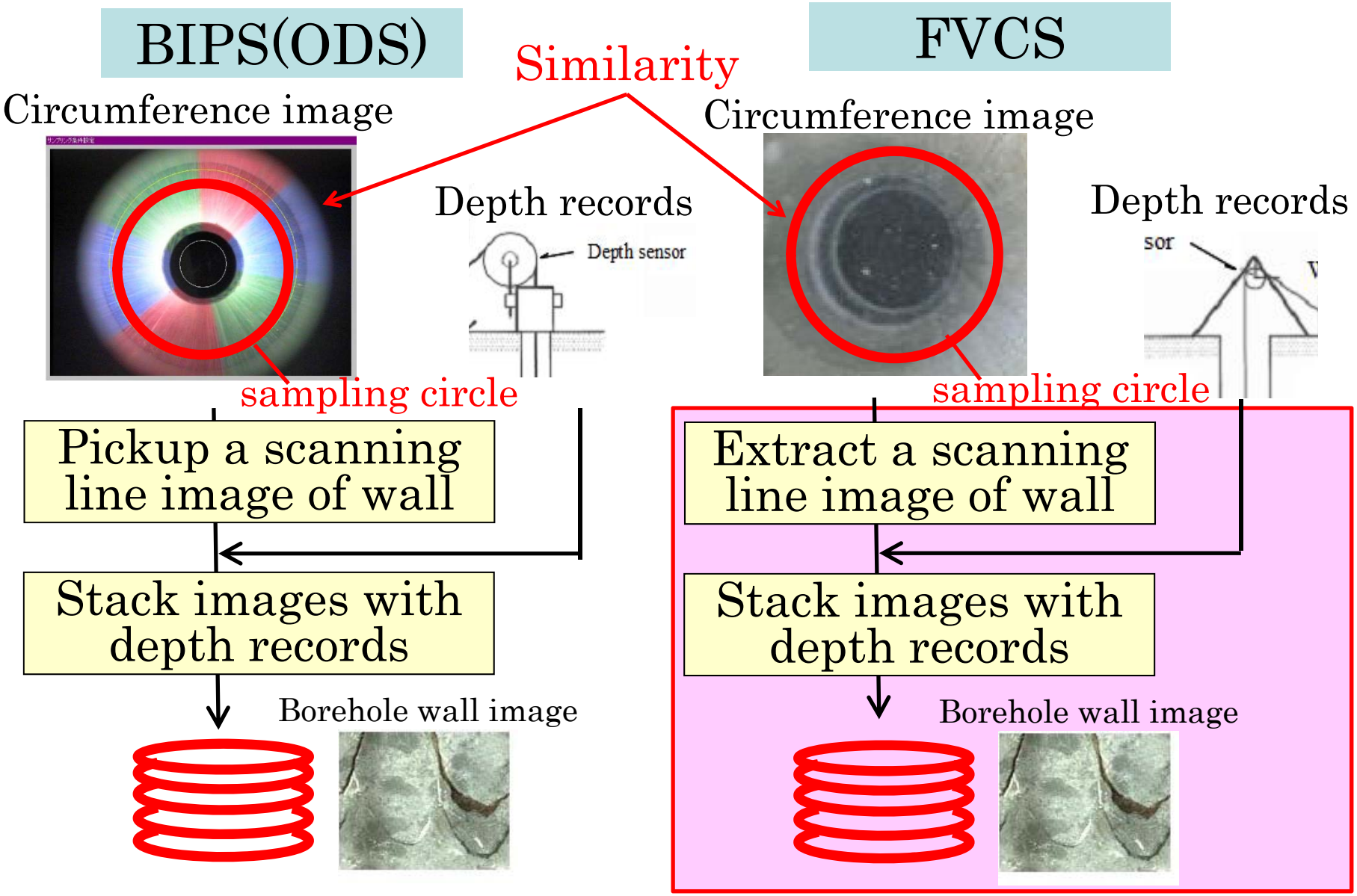
FVCS

Simple

Relatively low cost

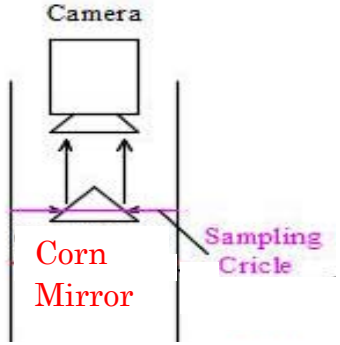


Outline of imaging process



Specification of measuring system

BIPS (ODS)

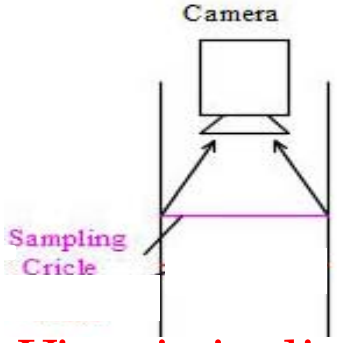


View is in right angle to the wall

Table 2.1 Hardware specifications of BIPS

Device	Parameter	Specifications
Controller	Input	AC 100V
	Output	NTSC, RCA Terminal (video/audio), USB (2.0)
Probe	Operation temp	0 - 40°C without condensation
	Water-proof depth	500 m
	Borehole diameter	φ56 - 200 mm
	Size	φ50 L= 1,030 mm
	Borehole water	None or clear water
	Resolution	0.25 mm (vertical, least), 360/720 pixels (horizontal)
	Direction sensor	Flux gate sensor, Mechanical compass
	Image color	Full color
Winch/Cable	Cable	5 cores of Kevlar fibers, φ5.5mm
	Active length	300 m
Pulley	Depth measurement	0.25 mm / pixel, equipped with mechanical counter

FVCS

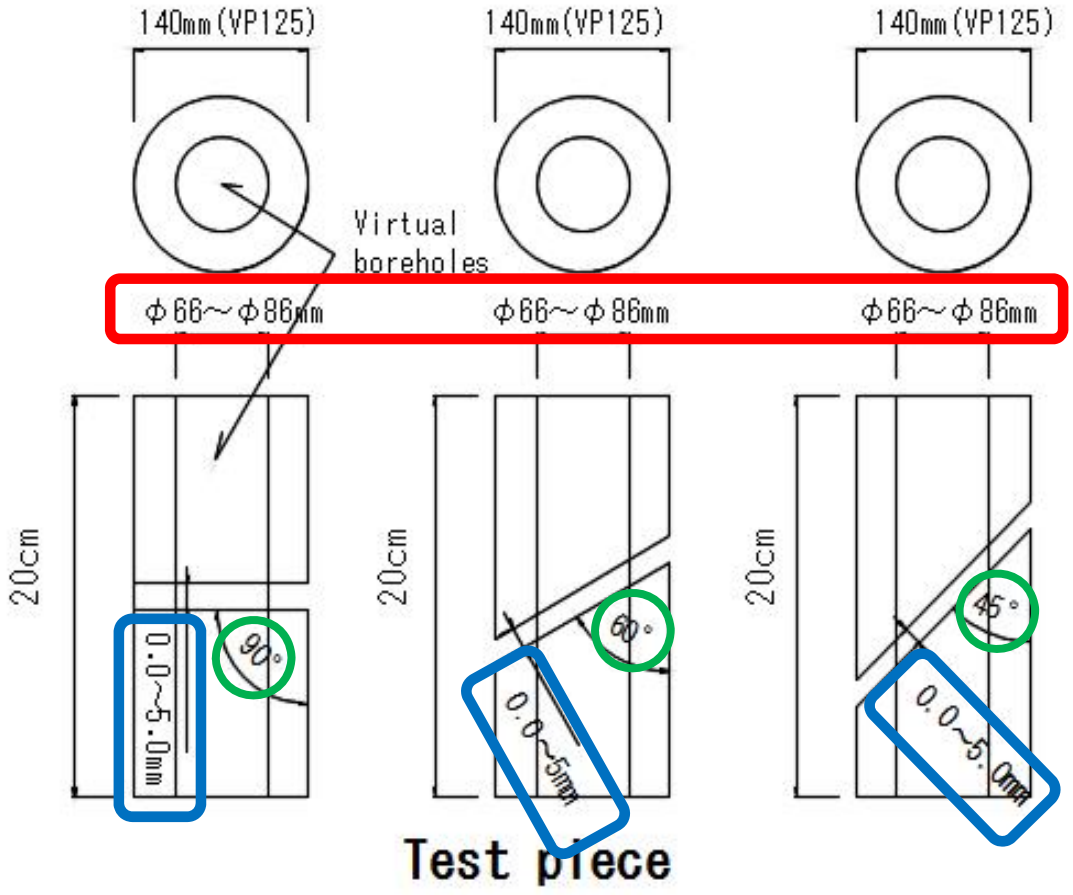


View is inclined to the wall

Table 2.2 Hardware specifications of FVCS (Smart camera)

Device	Parameter	Specifications
Controller	Operation temp	5 - 35°C without condensation
	Input	AC 100 V
	Output	RCA terminal (video)
	Data record	VTR
Camera/Cable	Operation temp	5 - 35°C without condensation
	Applied borehole diameter	φ40 - 150 mm
	Size	φ38 mm, L=275 mm
	Lighting	LED
	Borehole water	None or clear water
	Active length	200 m
	Resolution	250 k pixels
Pulley	Depth measurement	1 mm

Test pieces used in the measurement



The measurement were performed with changing the borehole diameter , the dip angle of a fracture, the width of a fracture and the camera position.

Photographs of measuring operation

Monitor and depth sensor

Test piece and measuring

Test cases and results of FVCS(in a part)

Fracture Condition / Camera Position			The same center positions		The different center position	
Diameter (mm)	Dip angle (degree)	Width (mm)	direction	width	direction	width
66	0	0.2	–	–	–	–
		1.0	○	△	×	×
		2.0	○	△	×	×
		5.0	○	△	×	×
	30	0.2	–	–	–	–
		1.0	○	△	×	×
		2.0	○	△	×	×
		5.0	○	△	×	×
	45	0.2	–	–	–	–
		1.0	○	△	×	×
		2.0	○	△	×	×
		5.0	○	△	×	×

○ measured correctly

× measured but incorect

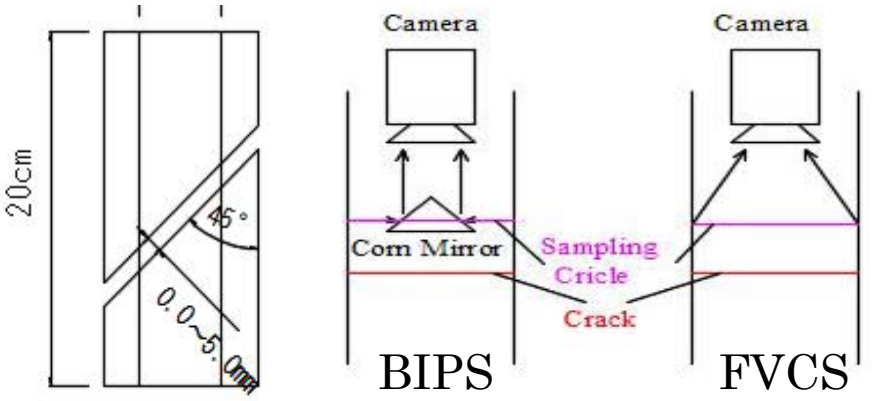
△ measured but low accuracy

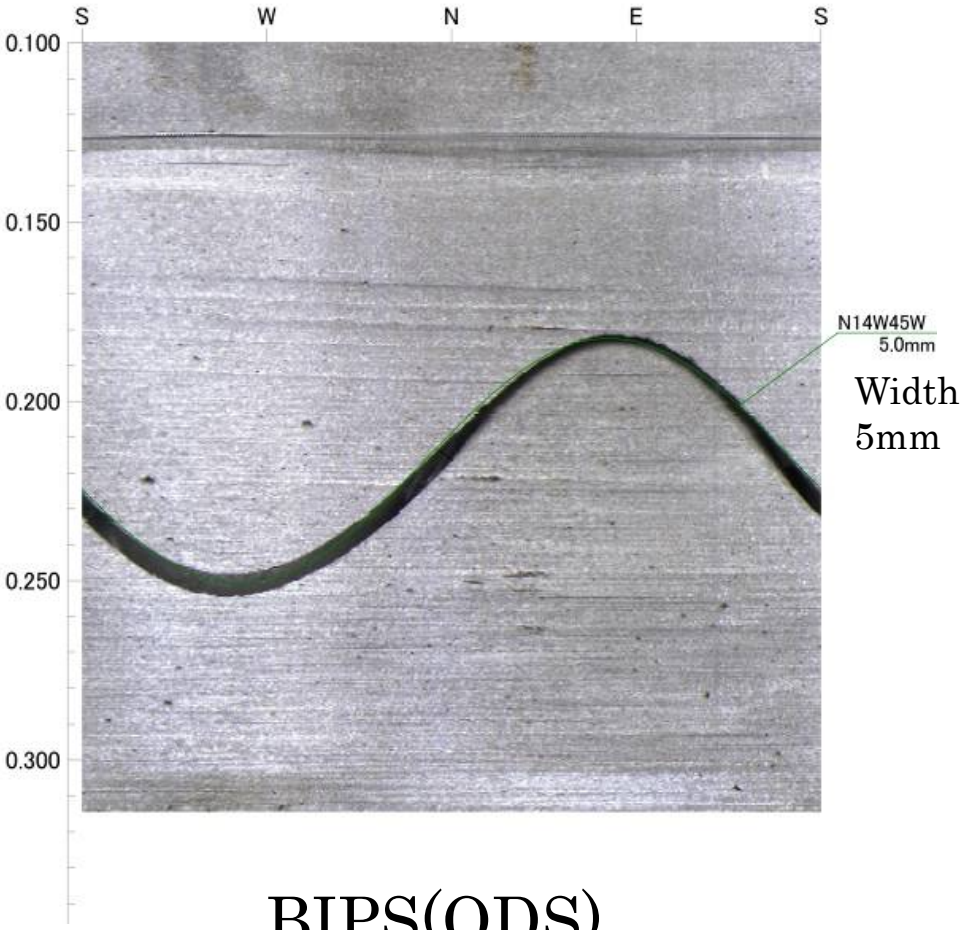
– not detected

Result of imaging

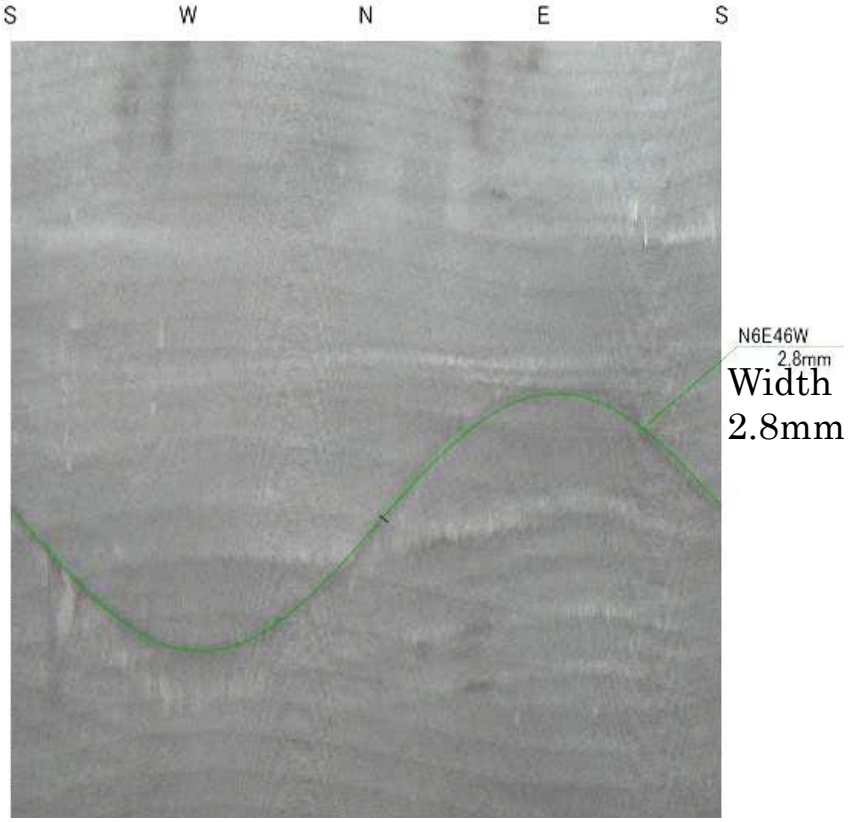
Fracture : 45 degree dipping
(width=5mm)

Camera position : center





BIPS(ODS)

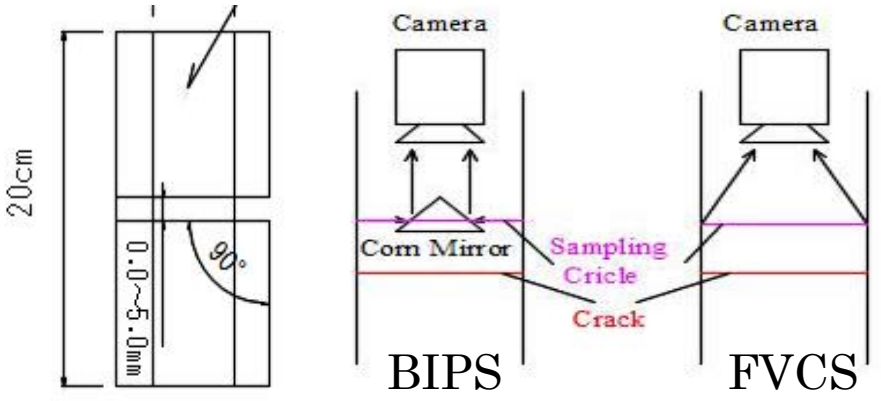


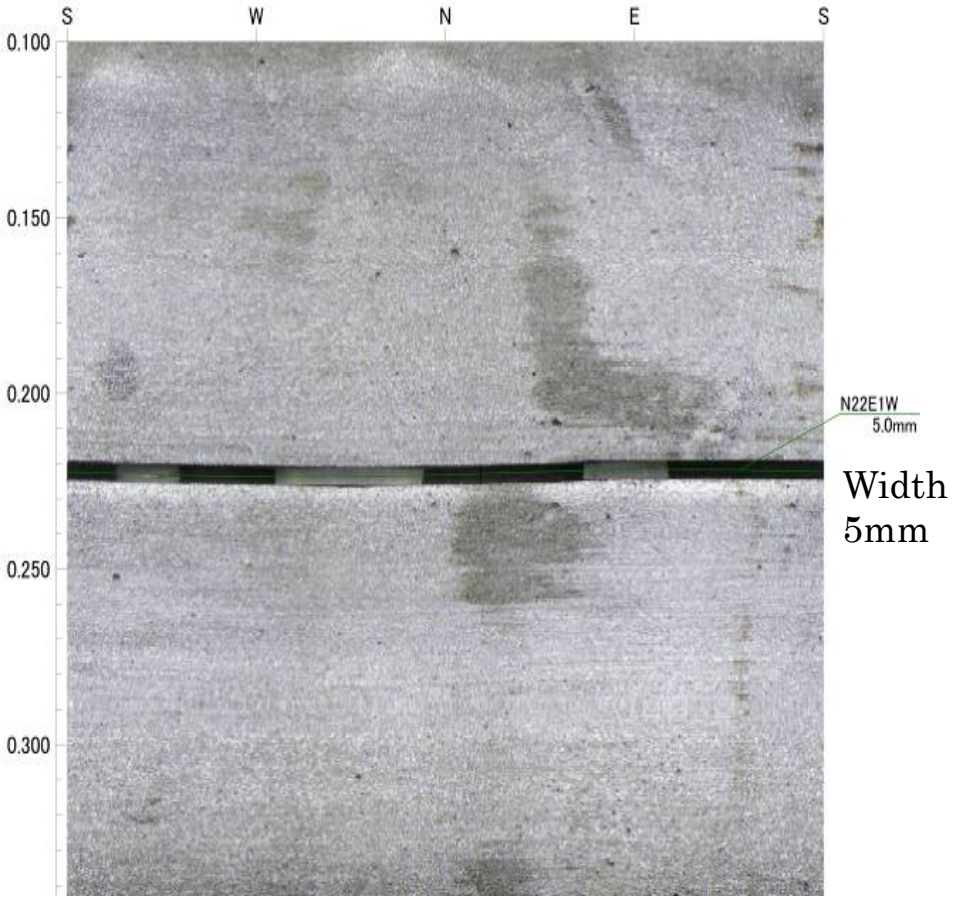
FVCS

Result of imaging

Fracture : horizontal
(width=5mm)

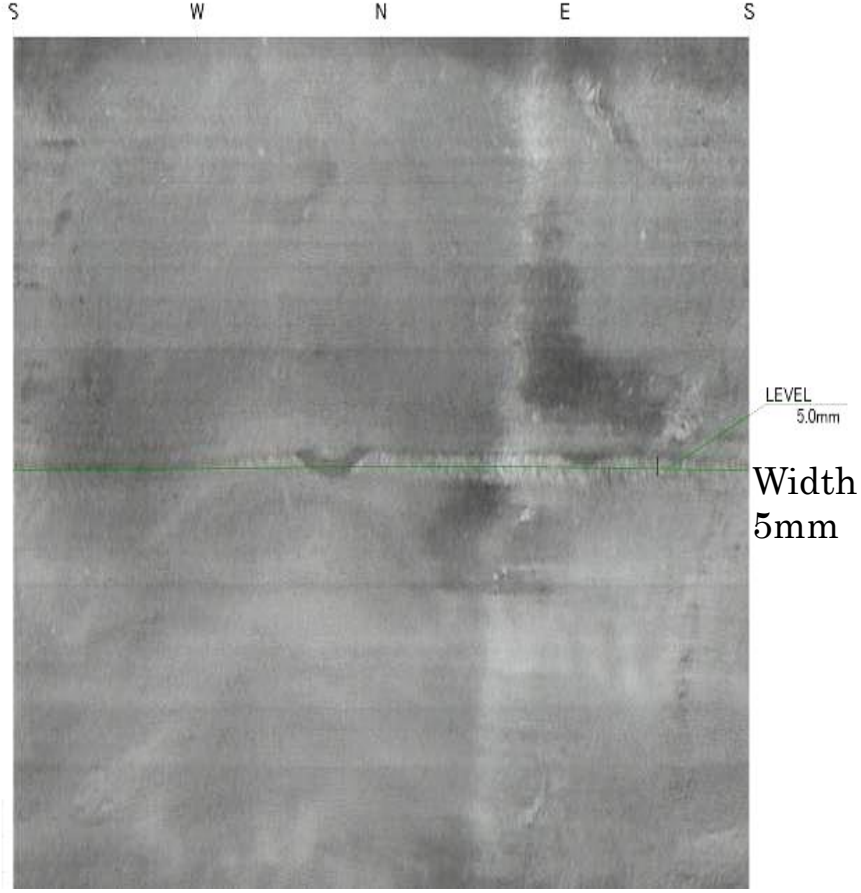
Camera position : center





Width
5mm

BIPS(ODS)



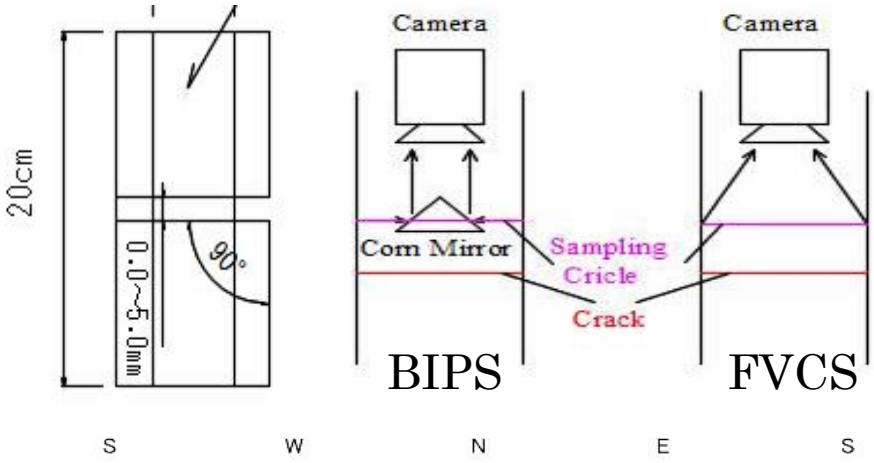
Width
5mm

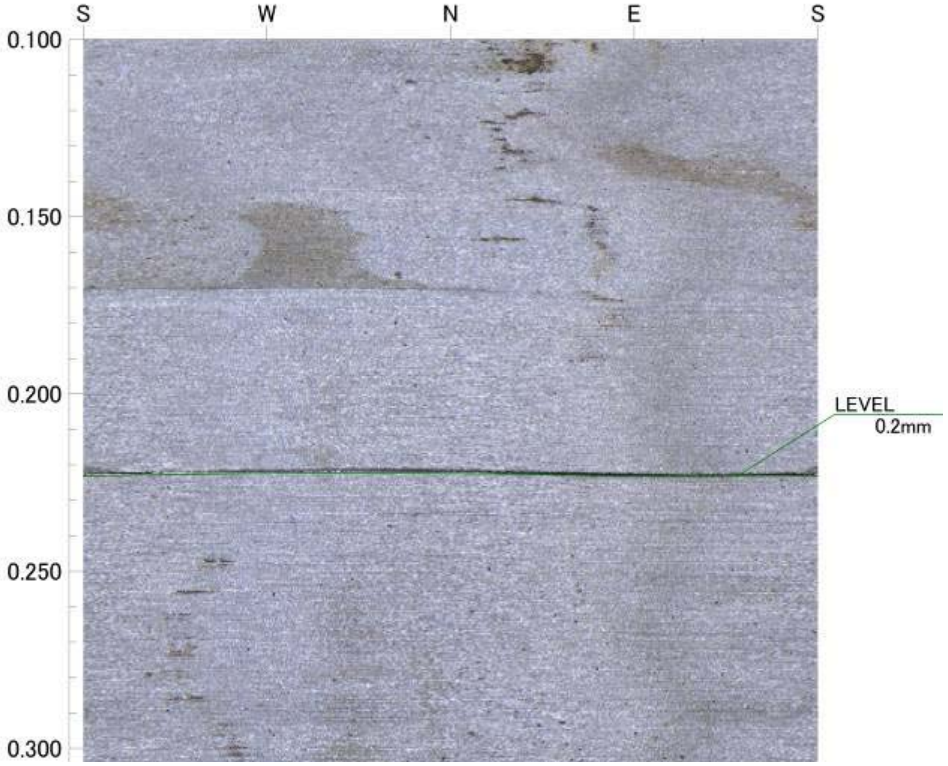
FVCS

Result of imaging

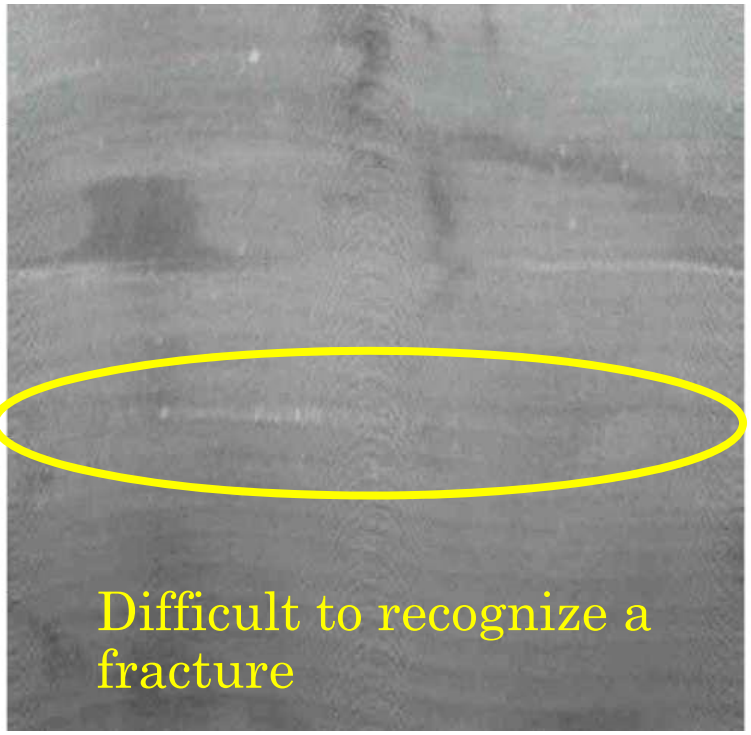
Fracture : horizontal
(width=0.2mm)

Camera position : center



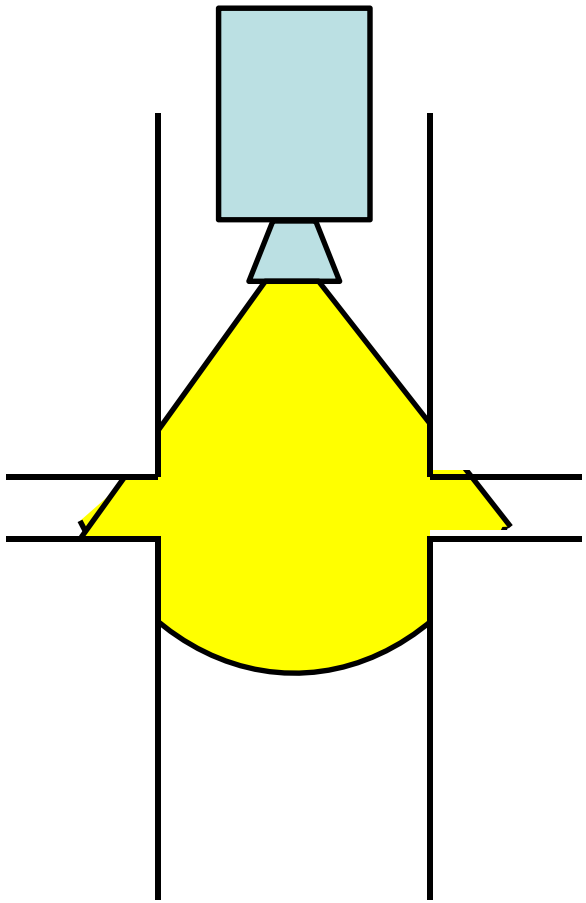


BIPS(ODS)



FVCS

Detection capability of fracture edges in FVCS



The camera axis of FVCS is inclined toward the wall.

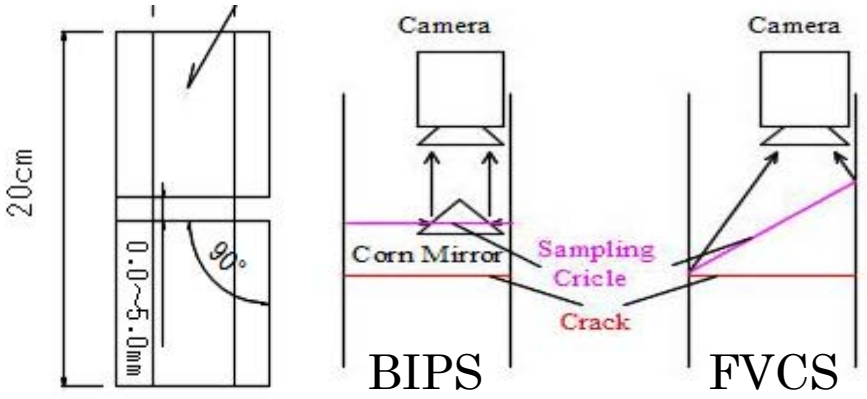
The borehole wall view and the fracture plane view are put in the image in the same way.

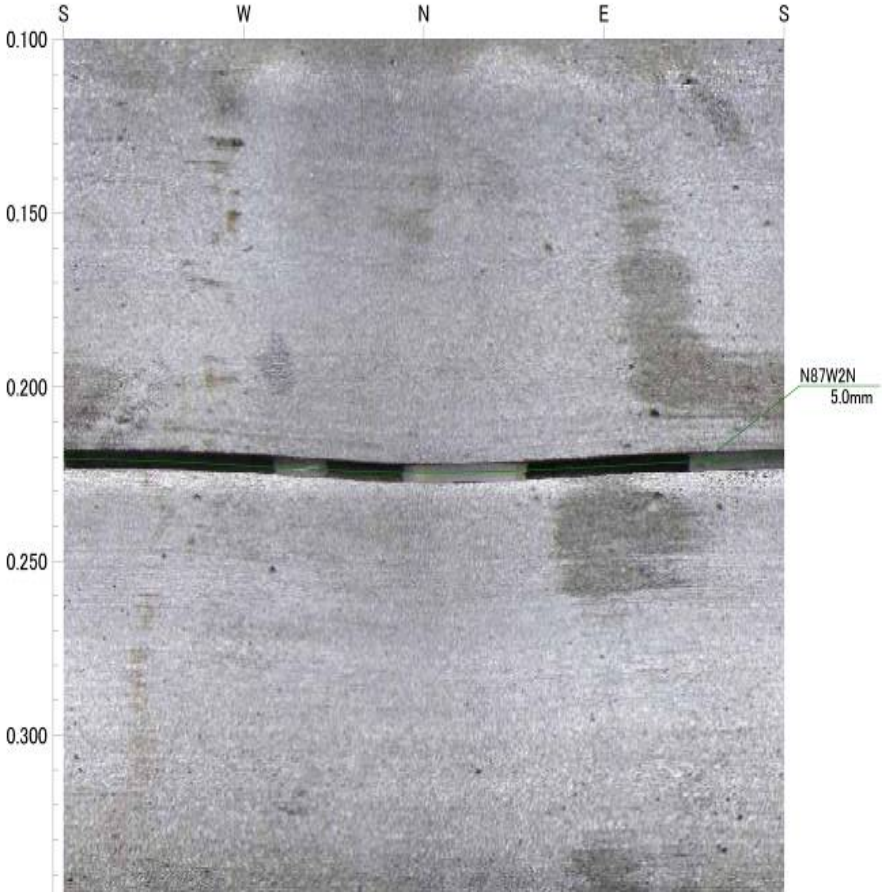
Detection capability of fracture edges is lower than BIPS which viewing axis is in right angle to the wall.

Result of imaging

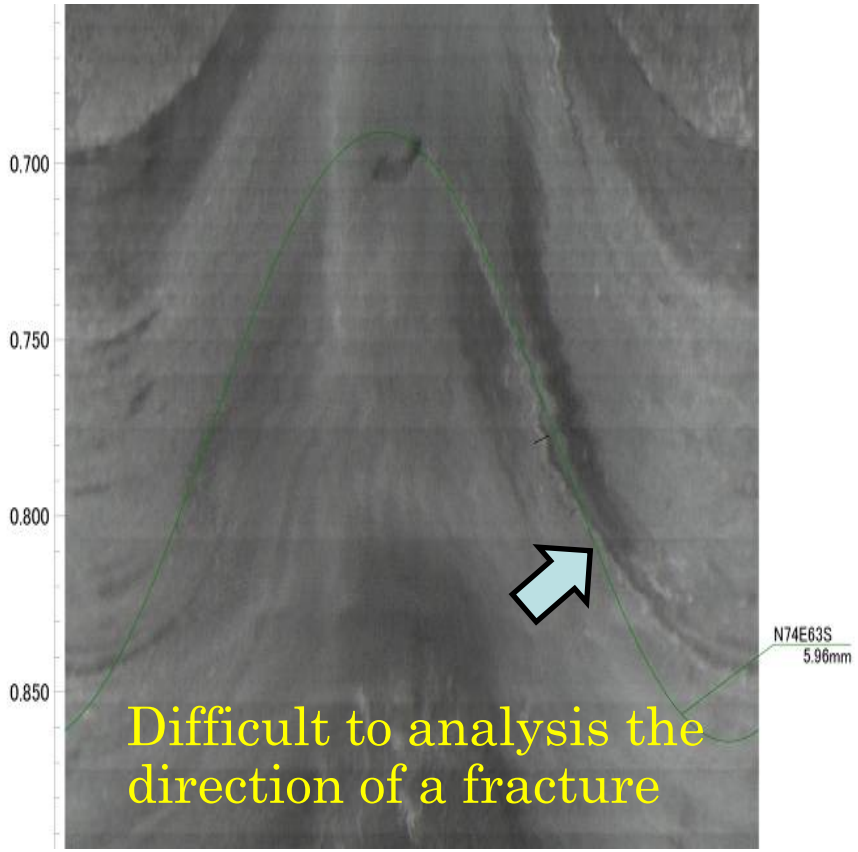
Fracture : horizontal
(width=5mm)

Camera position : not center



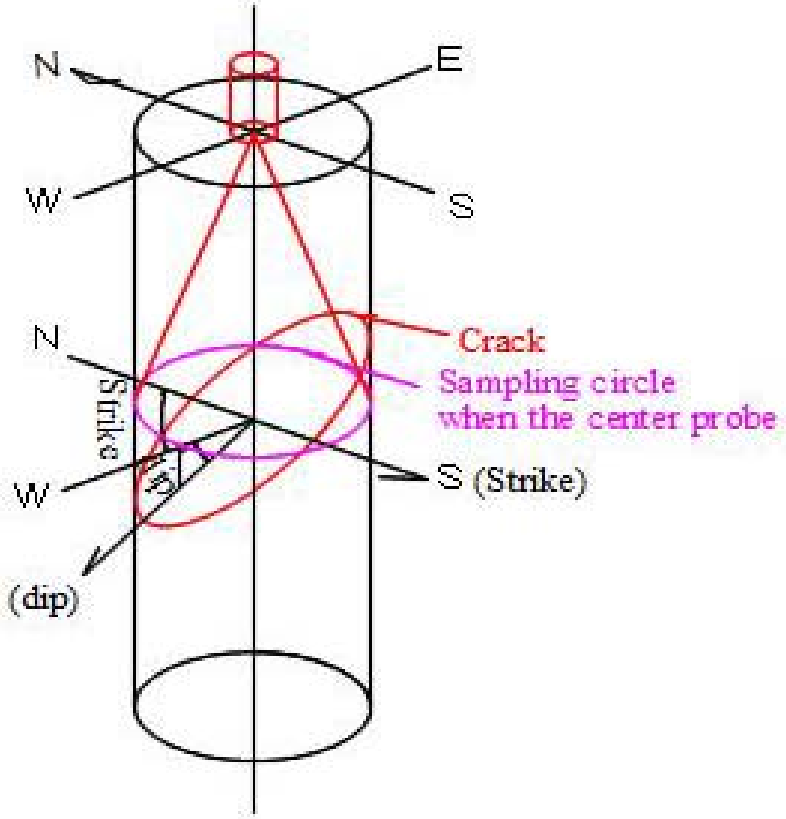


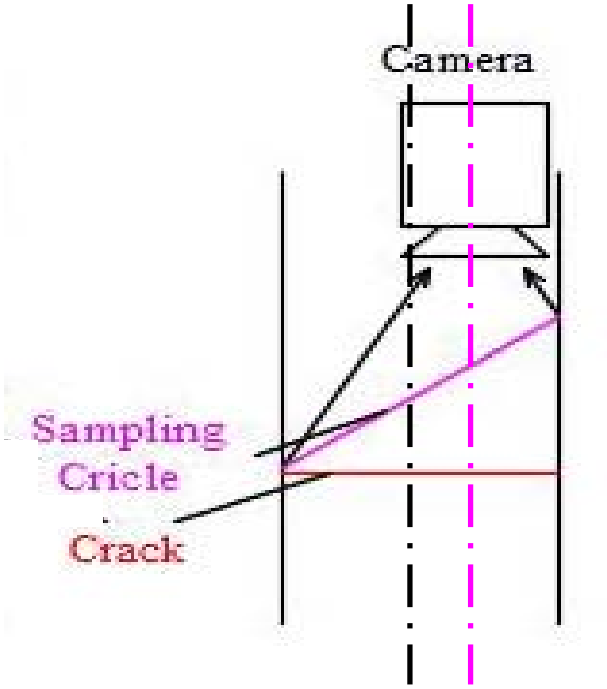
BIPS(ODS)



FVCS

Camera position and the accuracy of direction analysis in FVCS





Assumption of image processing;

Sampling circle is in a horizontal plane

Positioning gap between camera and borehole causes the degradiation of accuracy.

Summary of the study

1)Borehole wall image for the fracture analysis is obtained from FVCS image.

2)Below technical problems become clear about FVCS .

a)Accuracy decrease from the inclined view axis.

b)Accuracy decrease from the camera position.

3)As future plans for above problems

a) Improvement of the view axis using a fish-eye lens

b)Installing positioning equipment to keep the camera position.

Our study is performed as the ESA activity.

For more information, please visit our exhibition booth in the 3rd floor.

Thank you
For listening.