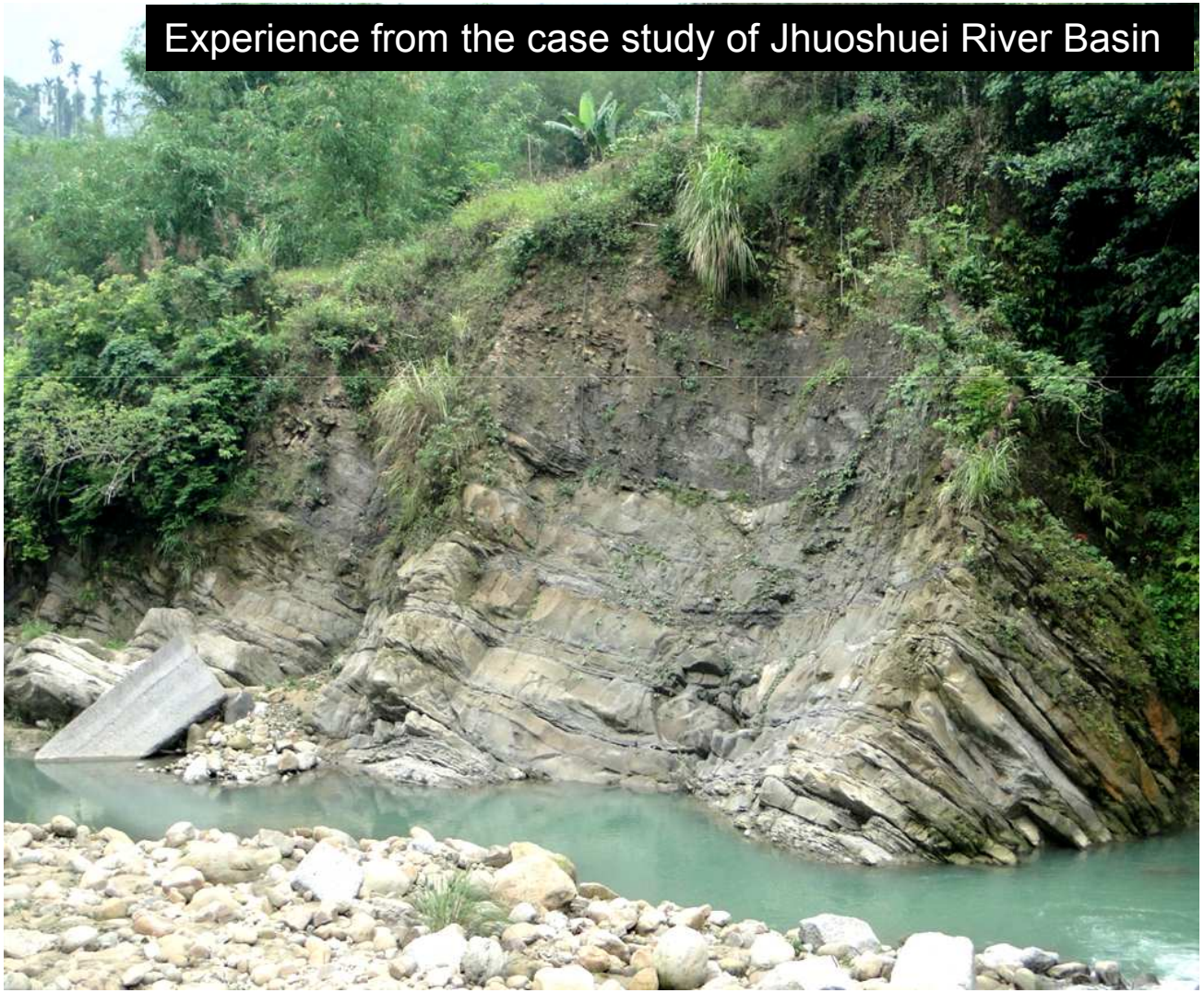
大地工程研究中心
GERC RESEARCH CENTER

AOGS
8 August to 12 August, 2011
Taipei International Convention Center, Taipei

Characterisation of Fracture Permeability in mid-Taiwan Mountainous Region:



by

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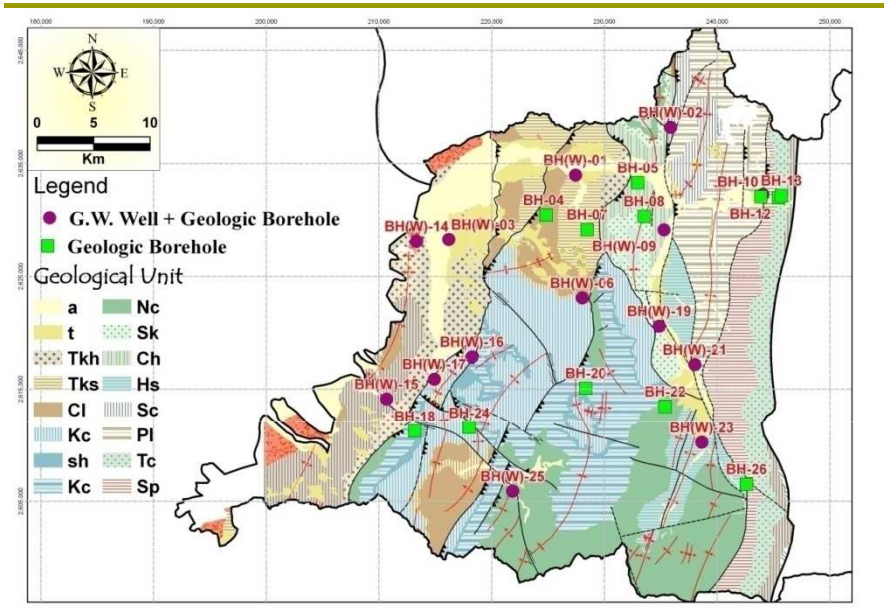
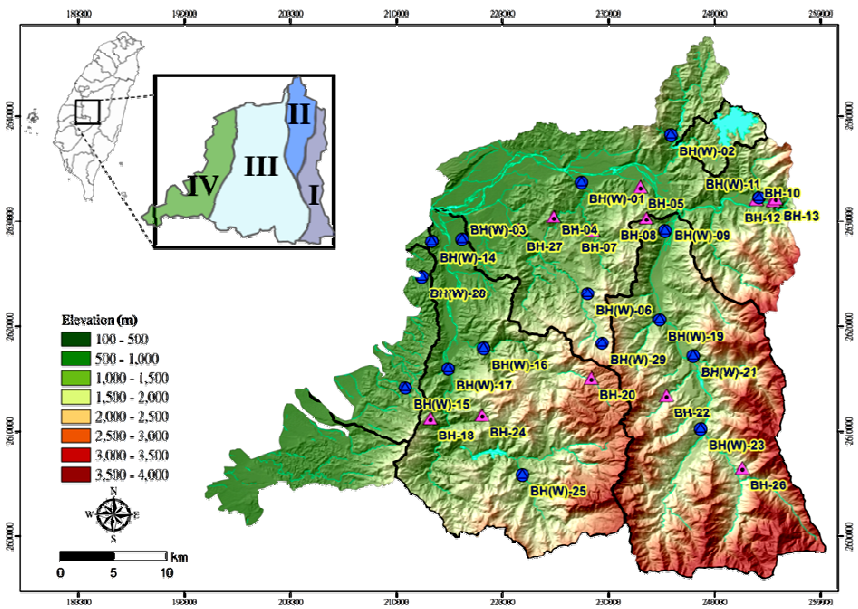
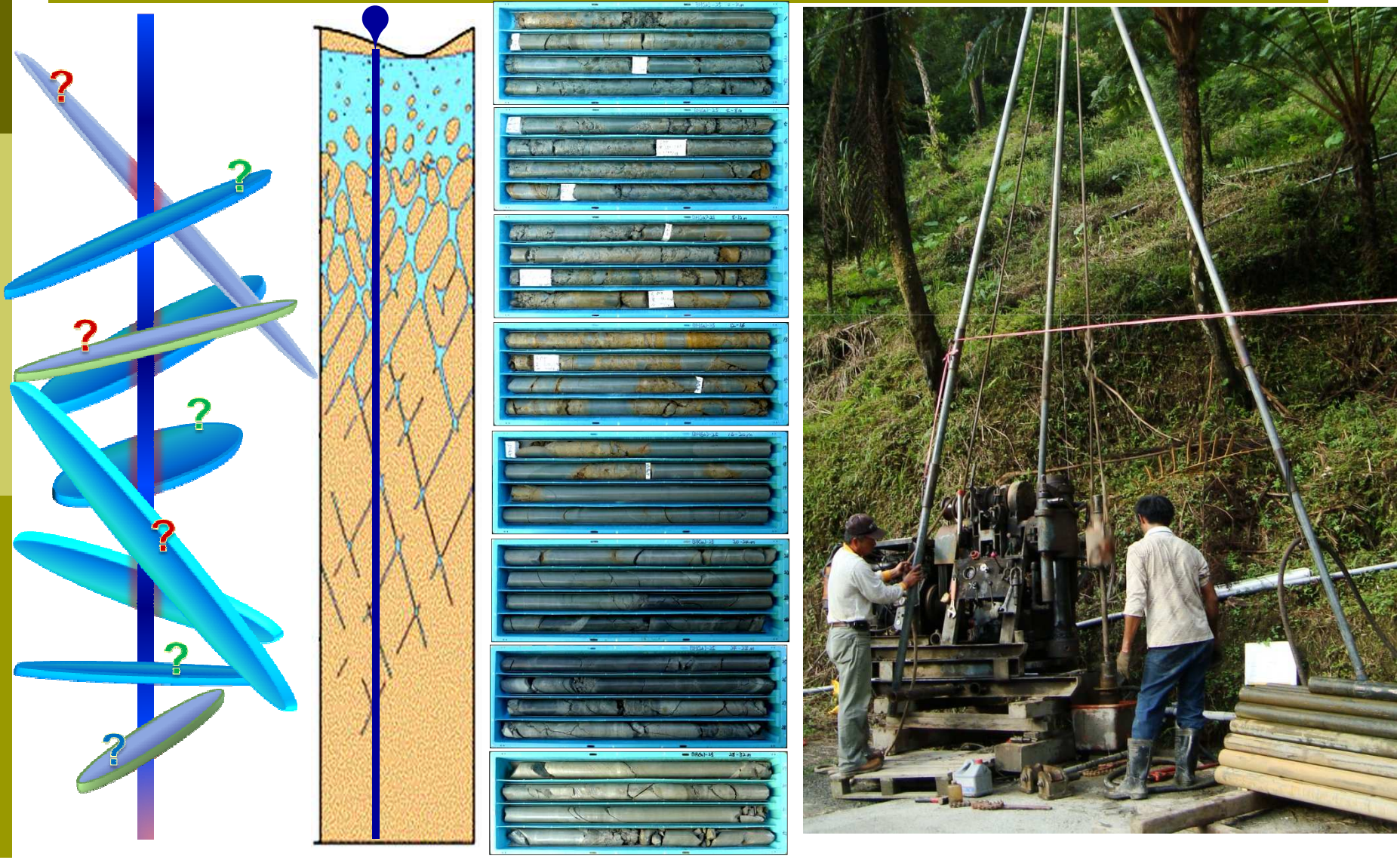
Project outline and specific research focus



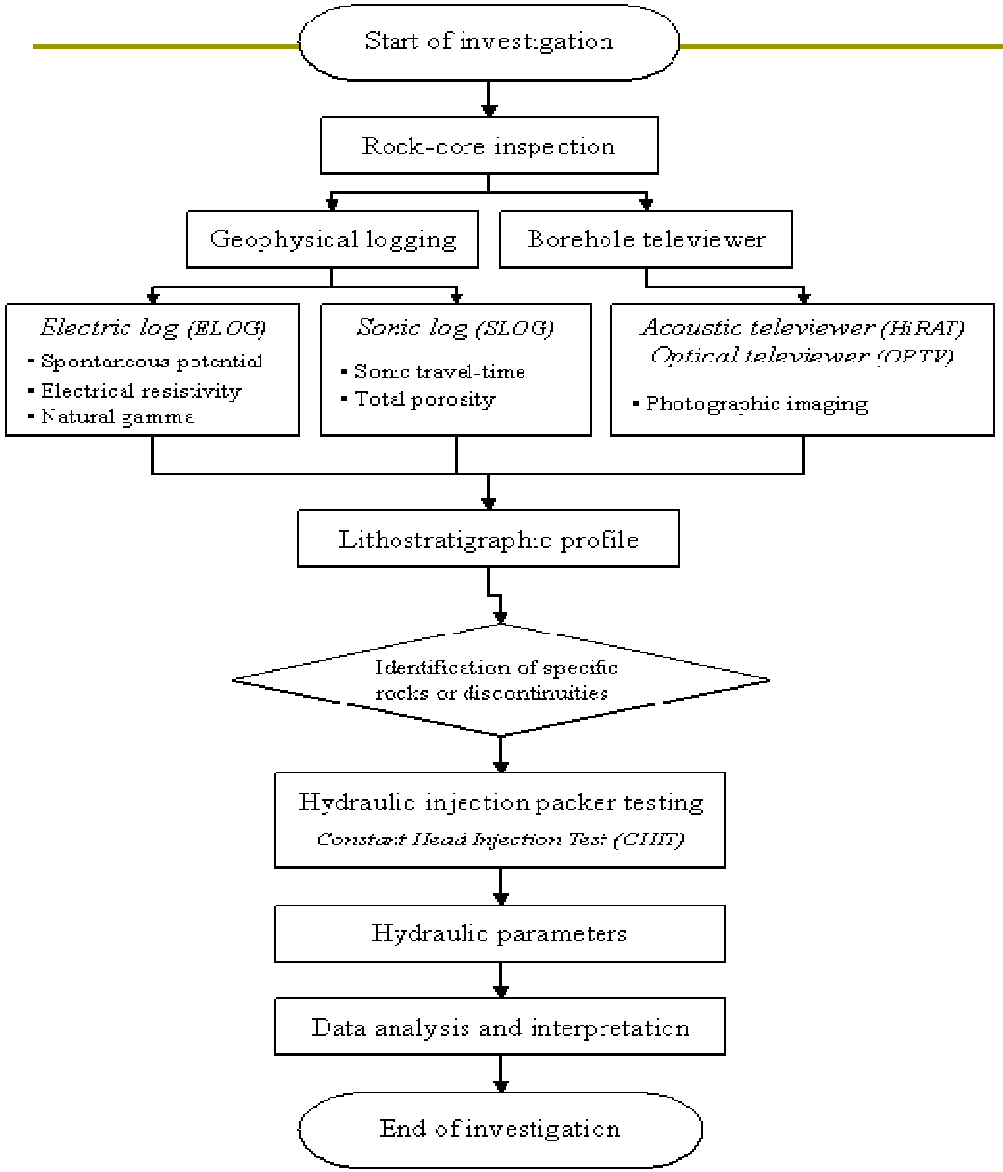


- How to identify fractures that are **significant hydraulic conductors** ?
- What **factors** govern flow and transport in such fractured system ?
- **How can changes in this fractured system be quantified** ?

Where is the probable conductive pathway of ground-water ?



Procedure of in-situ downhole investigation



Checklist for quick identification of conductive pathway

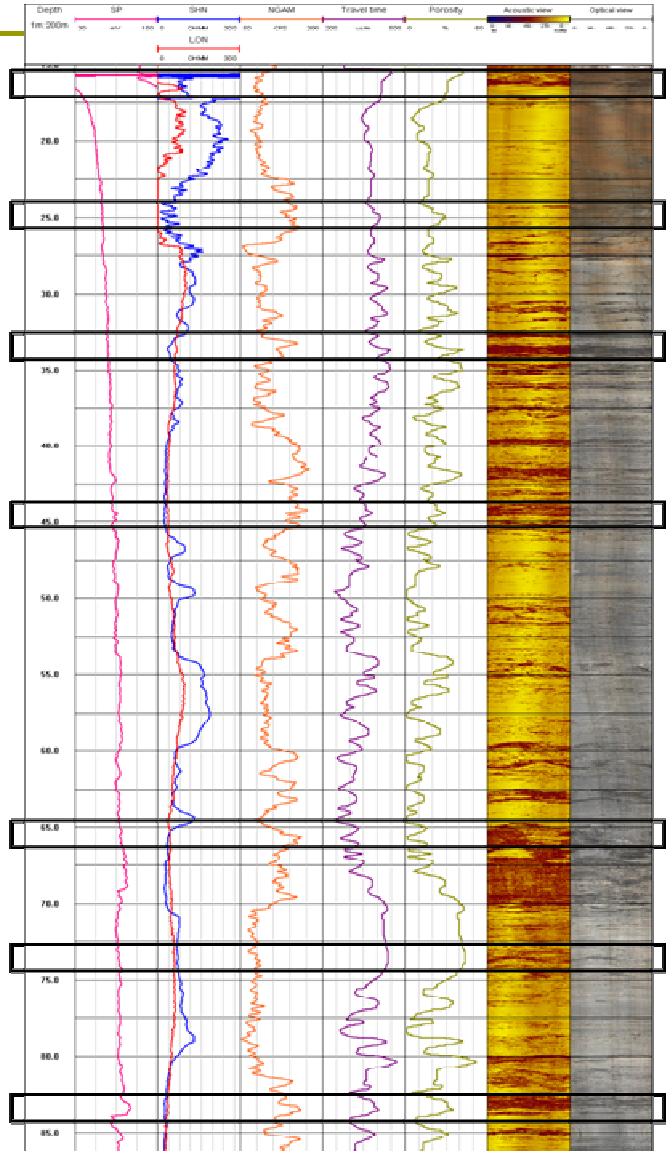
Target zone could be dominated by coarse-grained rock where is…

I. Low in gamma-ray response in contrast to the average

II. High in short normal-resistivity relatively to the long one

III. Longer sonic travel-time, and/or larger porosity (acoustic-velocity derived)

IV. Discernible openings - confirmed by televiewer imaging



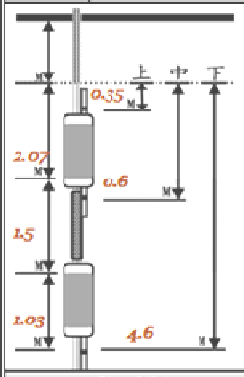
Checklist for identification of conductible segments in borehole

Depth of interval	Criterion I	II	III	IV	Predominate lithologic type
15.9m to 17.4m	○	○	○	○	regolith (saprock)
24.0m to 25.5m	×	○	○	○	shale
32.7m to 34.2m	×	○	○	○	sandstone/shale interbedding
43.9m to 45.4m	×	×	×	○	sandstone/shale interbedding
64.7m to 66.2m	○	○	×	○	sandstone
72.5m to 74.0m	○	×	○	×	sandstone (mud-filled)
82.5m to 84.0m	×	×	×	×	sandstone (mud-filled)

Determination of formation permeability by packer-test

GERC, Sinotech Engineering Consultant Inc. / In-situ Packer Test Record

Catchment	Shuishue i	Position	Taichung	GPS	22.3925, 268.6950
No.	03	People	Darvid Lee / Jack Huang	Project	TG11202
Station	C3f-01	Data/Time	2011 / 07 / 15 time 1200 to 1450		
GW. level	-6 M	Depth	100 M	Testing Segment	60 M ~ 61.5 M
Test manner	■ CHT □ PPT □ Slug			Packer	■ Double packer □ Single-packer



Numbers of drill collars :
3M : ____ / 2M ____
1M : ____ / ½M : ____
Above the surface : ____M
Panel: No.

Lithological classification

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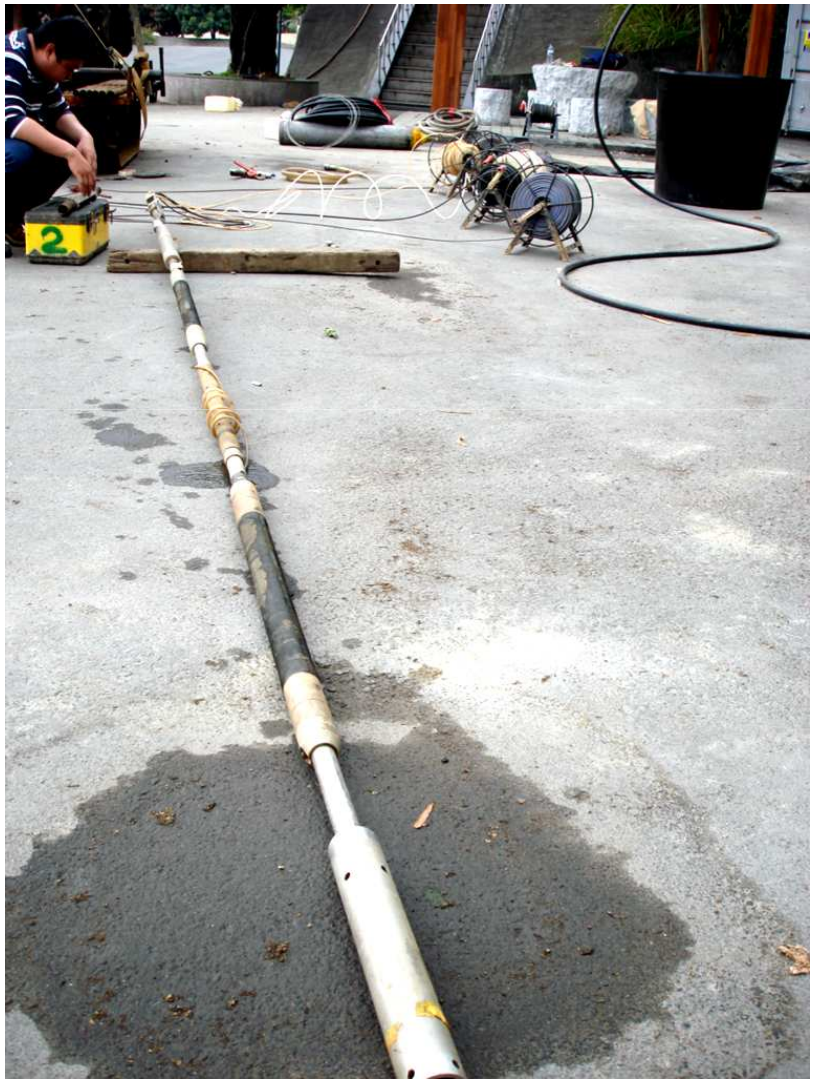
Checklist	Range
1. Gouging? Yes■ No□	-
2. Casing? Yes■ No□	-
3. Reaming? Yes■ No□	-
Others	
Inflation pressure 2 kg cm^{-2}	

4. Starting time :

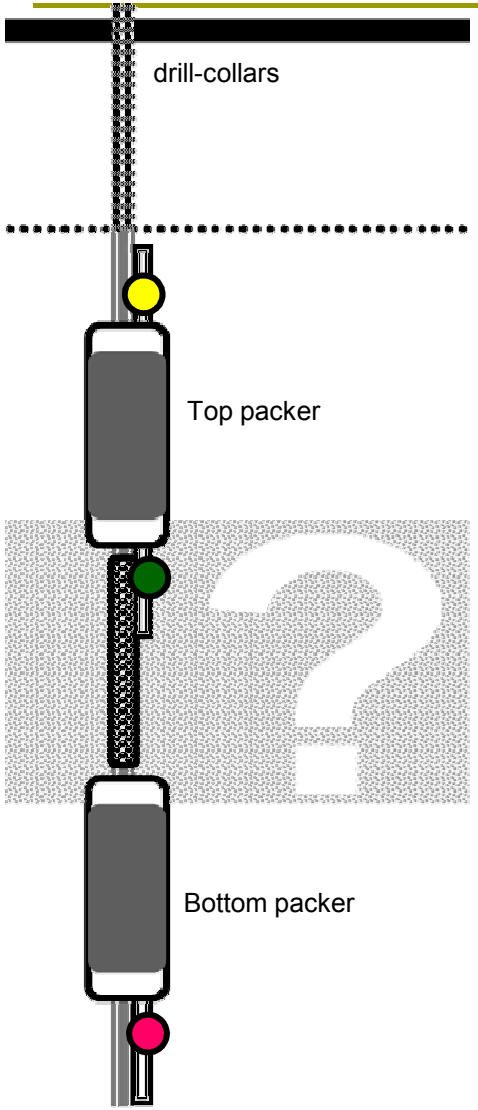
Pressure record	Surface	Up	Middle	Down

5. End of test :

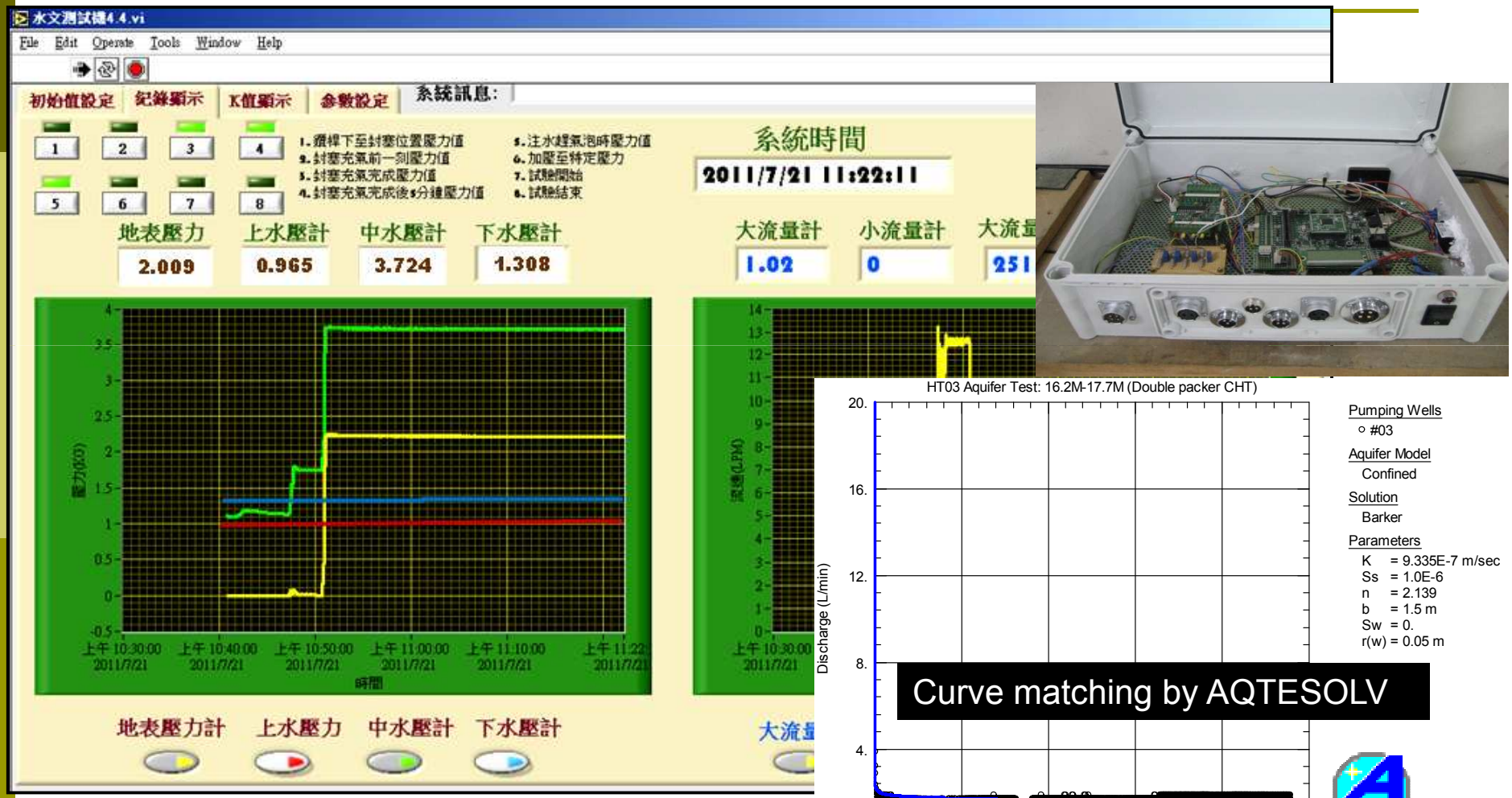
Estimation of hydraulic conductivity K = _____ (m sec^{-1})



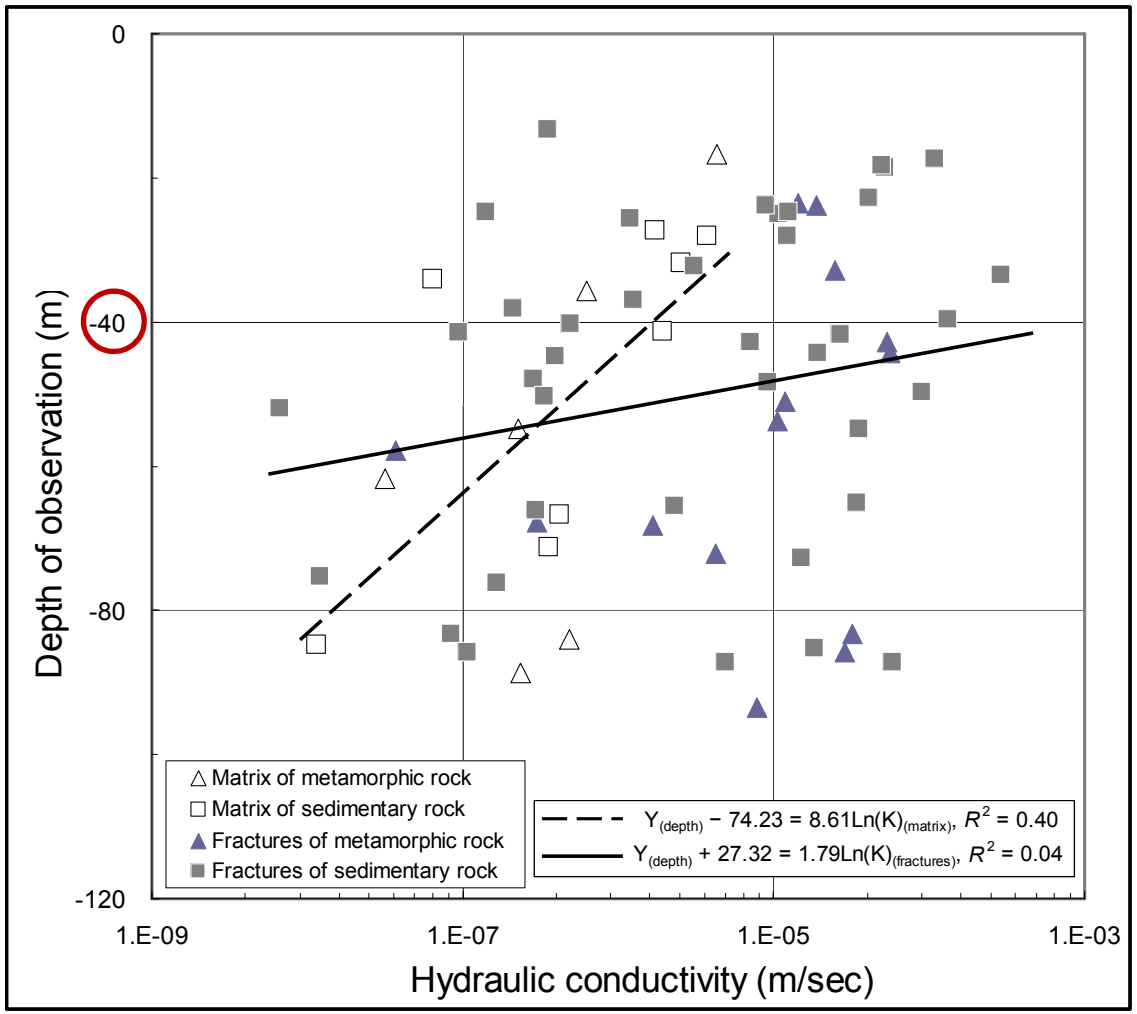
Determination of formation permeability by packer-test



Real-time monitoring system developed by Sinotech



Hydraulic conductivity (K) vs. Depth



Hydraulic conductivity (on a logarithmic scale) with respect to different types of rock against depth

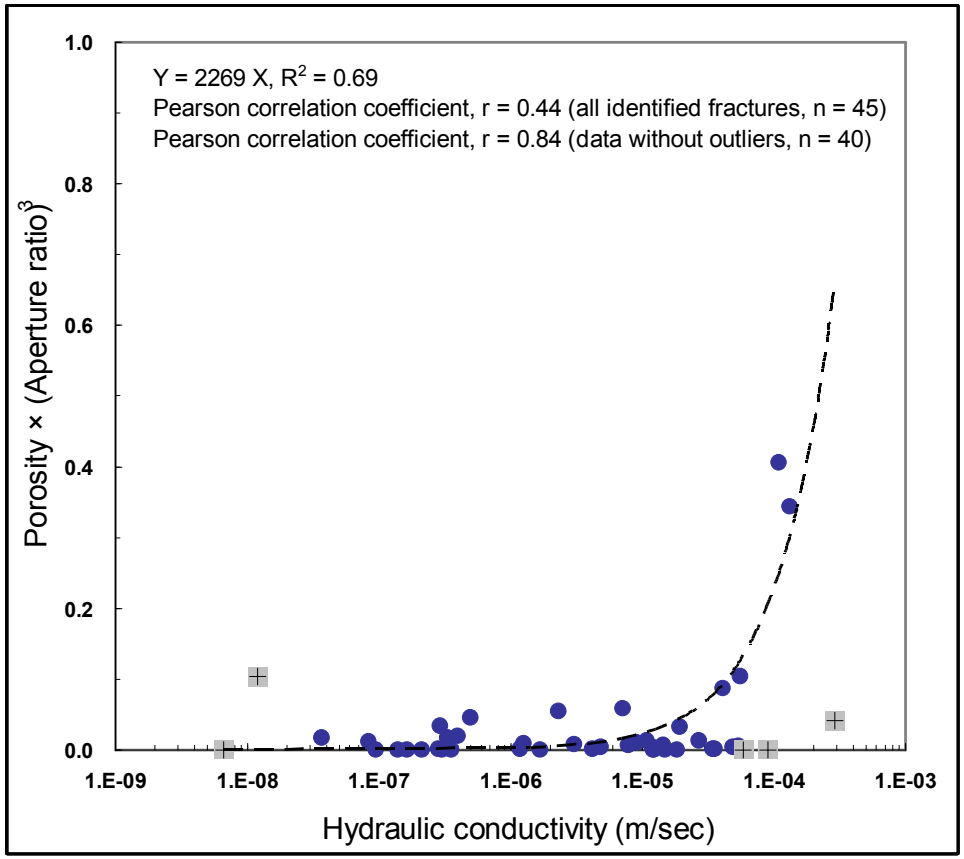
Hydraulic conductivity (K) vs. Porosity and Aperture

Hydraulic Conductivity v.s.

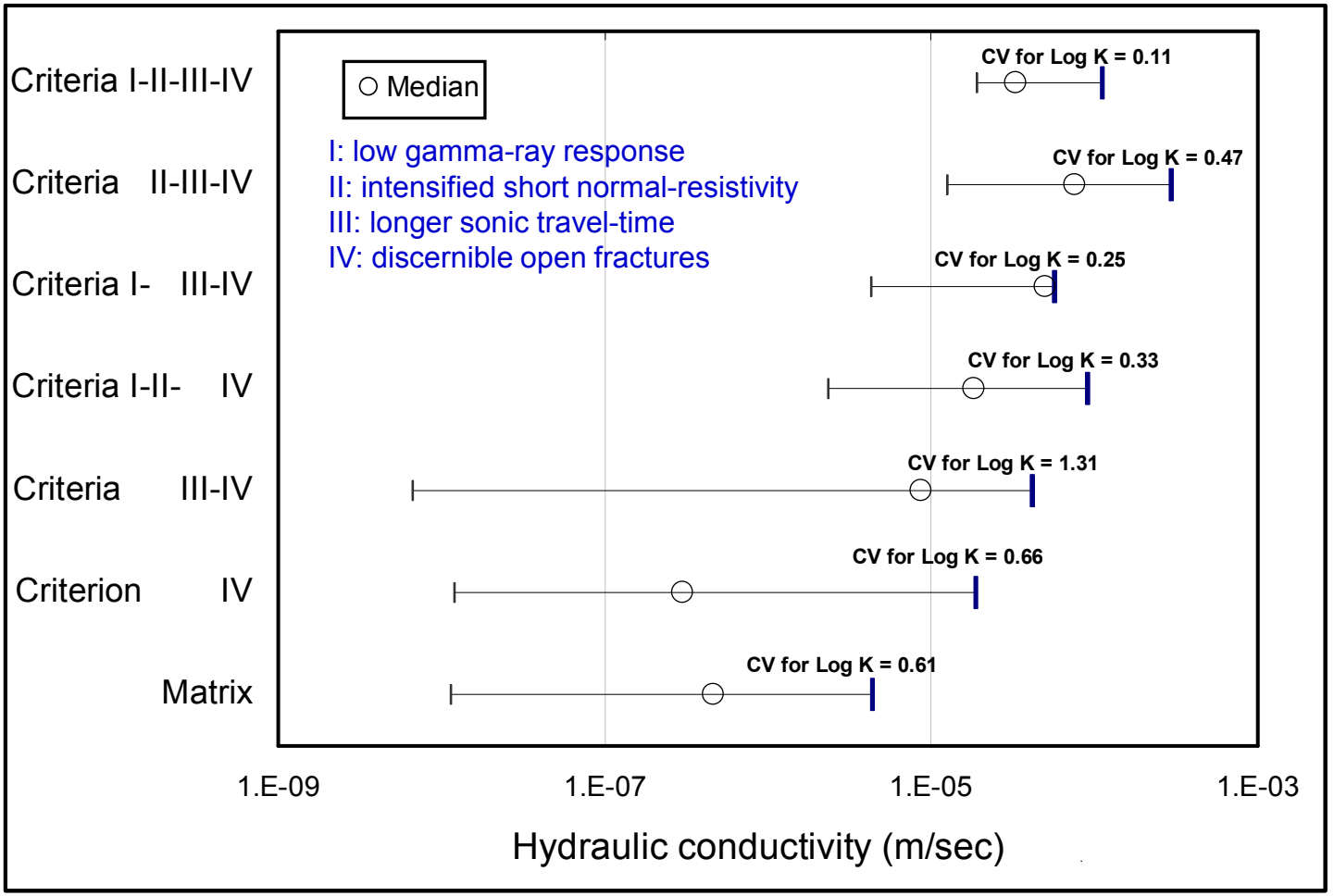
1. Porosity (intra-aggregate pores) obtained from sonic log

$$\Delta t = \frac{1}{VL} = \frac{\phi}{Vf} + \frac{1-\phi}{Vm}$$

2. Aperture ratio (inter-aggregate void) defined as fracture spacing / sealed-off interval between packers, 1.5 m)
3. Porosity x Aperture ratio
4. Porosity x (Aperture ratio)^3



Comparison of criteria for identifying conductive fracture



Comparison of the criteria for identifying hydraulic conductive fracture

Conclusions and outlooks

- How to identify fractures that are **significant hydraulic conductors** ?

➔ It is necessary, and sufficient, to jointly consider lithologic characteristics and fracture related properties.

- What **factors** govern flow and transport in such fractured systems ?

➔ The flow of groundwater in the mountain area is proportionally regulated by the intra-aggregate pores and the inter-aggregate voids (aperture).

- **How can changes in this fractured system be quantified** ?

➔ A simple linear relationship was obtained between K and Porosity x (Aperture ratio)3.

Thank you for your listening

Acknowledgment

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Geotechnical Testing Group 大地工程研究中心 GERC RESEARCH CENTER