Application of Hydrogeological Investigation to Determine Groundwater Modeling Approach in Taiwan Mountainous Region

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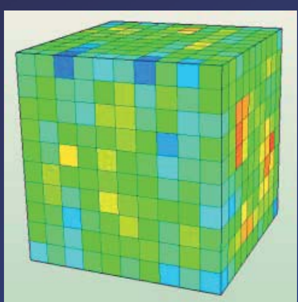
  - Y. T. Lin, C. C. Huang and S. Y. Wang
  - Give founds for support

Outline

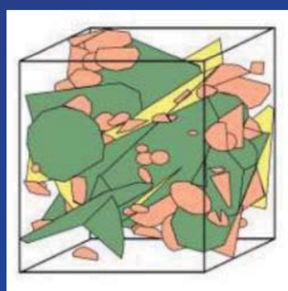
Introduction(1/2)

- Investigating a subsurface system of mountainous regions requires appropriate models (e.g. equivalent porous media, dual porosity, and discrete fracture network) of predicting groundwater flow and transport.



EPM

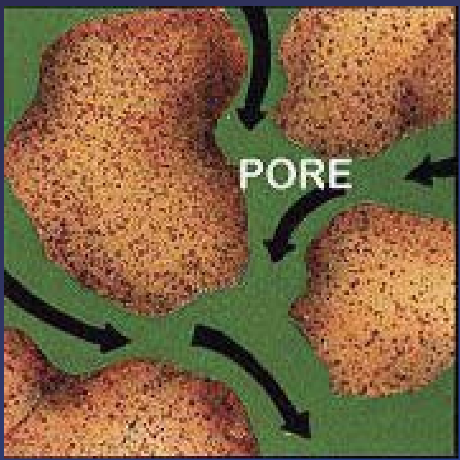
DPM

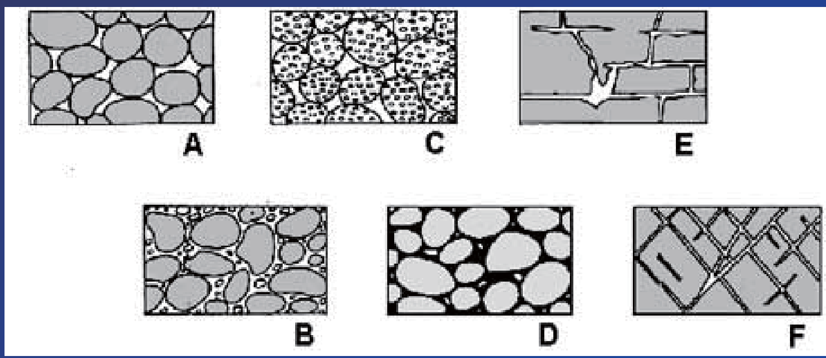


DFN

Introduction(2/2)

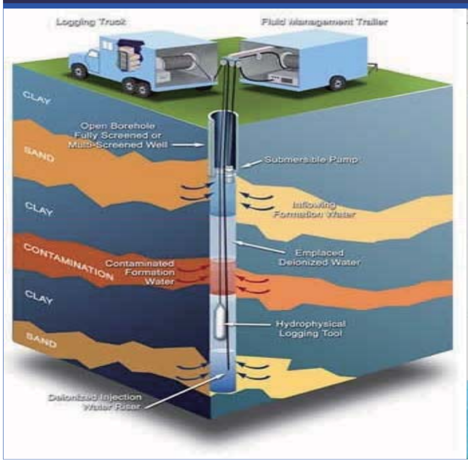
- The physical properties of geologic materials of the subsurface system which control the storativity and ability of fluids to move through them must be considered.

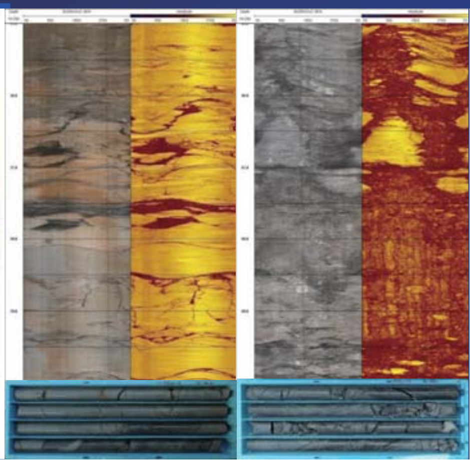




Study Objective

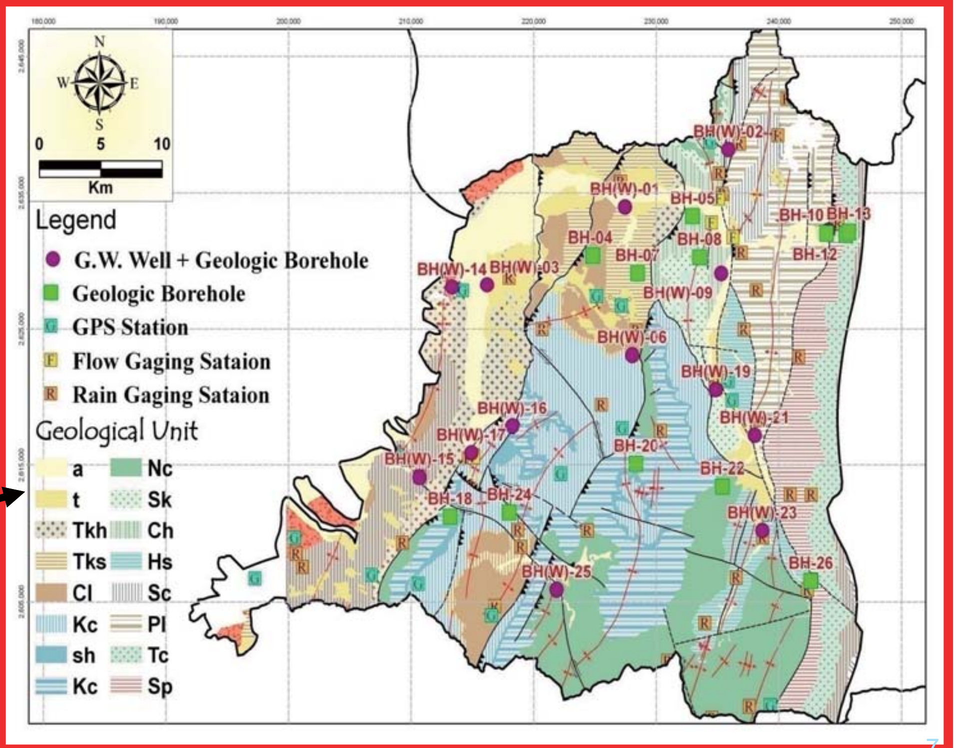
- By means of various hydrogeological tests at both field and laboratory scale, we determine applicable models for every corresponding subsurface system at the basins of Mid-Jhuoshuei River and Beigang River in Taiwan Mountainous Region.





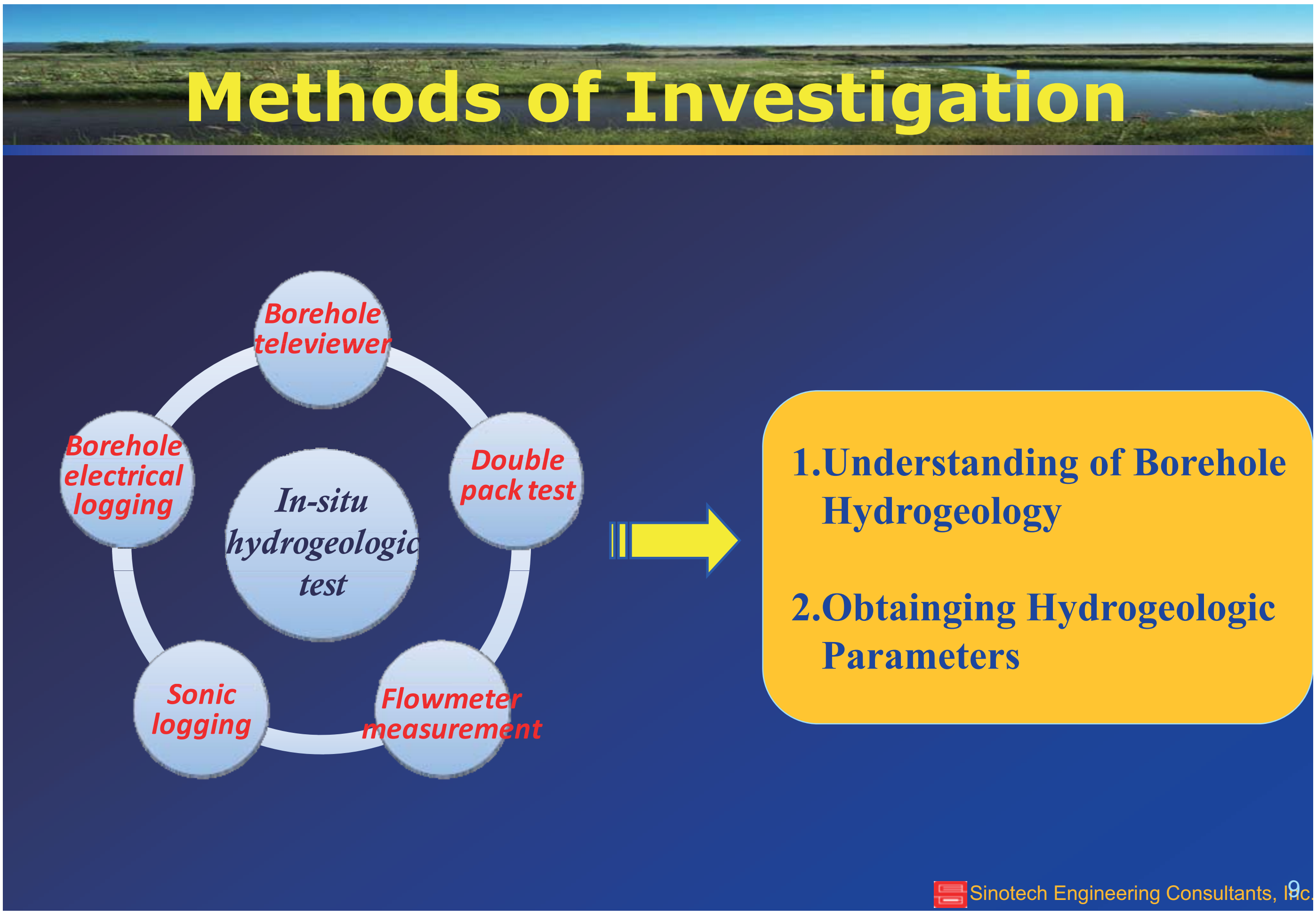
Study Area Description

- 1530 square kilometers
- All major classes of rocks-sedimentary and metamorphic
- 23 Geo-Units
- 30 faults
- 13 folds



Regional Hydrogeological Drilling

Stratigraphy	Geologic Age	Area (ha)	Percent (%)	Site
Colluvium	Pleistocene	7613	5.1	1
Toukoshan Formation Houyenshan Member (Tkh)	Holocene	6827	4.6	2
Toukoshan Formation Hsiangshan Member (Tks)	Holocene	11899	8.0	3
Cholan Formation (Cl)	Pliocene-Pleistocene	7475	5.0	1
Kueichulin Formation Tawo Sandstone Member (Kct)	Miocene-Pliocene	17409	11.6	4
Kueichulin Formation Kuantaoshan Sandstone Member(Kck)	Miocene-Pliocene	14567	9.7	2
Nanchuang Formation(Nc)	Miocene	20211	13.5	2
Shenkeng Sandstone(Sk)	Miocene	3457	2.3	2
Changhukeng Shale(Ch)	Miocene	3073	2.1	2
Hoshe Formation(Hs)	Miocene	5524	3.7	1
Shuichangliu Formation(Sc)	Oligocene	2999	2.0	1
Paileng Formation(Pl)	Eocene-Oligocene	11072	7.4	2
Tachien Shale(Tc)	Eocene	6841	4.6	1
Shihpachunghsi Formation(Sp)	Eocene	8008	5.4	2


Methods of Investigation
Borehole televiewer
Double pack test
Flowmeter measurement
Sonic logging
Borehole electrical logging
In-situ hydrogeologic test
1.Understanding of Borehole Hydrogeology
2.Obtainging Hydrogeologic Parameters
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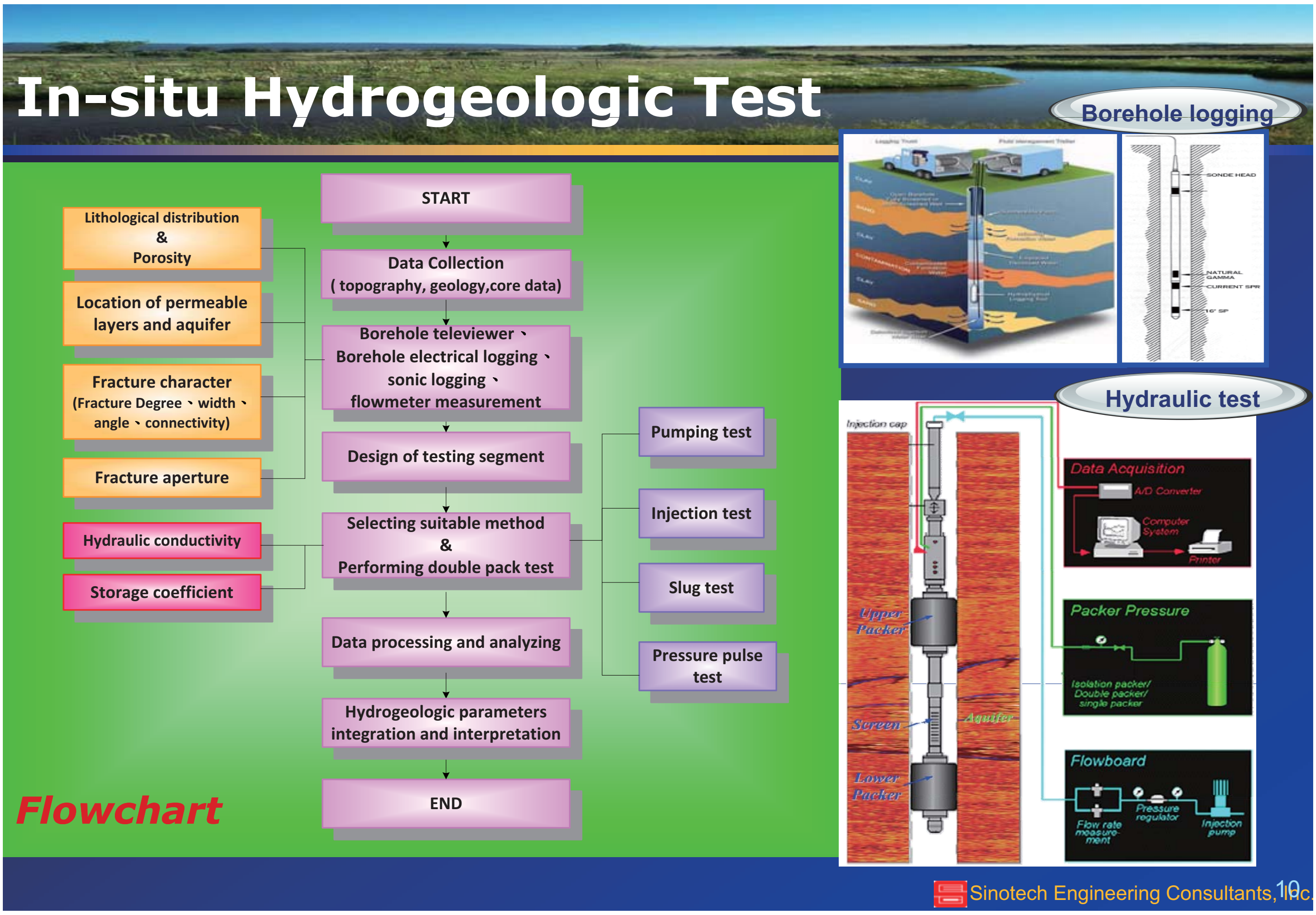
In-situ Hydrogeologic Test
Lithological distribution & Porosity
Location of permeable layers and aquifer
Fracture character (Fracture Degree、width、angle、connectivity)
Fracture aperture
Hydraulic conductivity
Storage coefficient
START
Data Collection (topography, geology,core data)
Borehole televiewer、Borehole electrical logging、sonic logging、flowmeter measurement
Design of testing segment
Selecting suitable method & Performing double pack test
Data processing and analyzing
Hydrogeologic parameters integration and interpretation
END
Pumping test
Injection test
Slug test
Pressure pulse test
Flowchart
Borehole logging
Hydraulic test
Injection cap
Upper Packer
Screen
Aquifer
Lower Packer
Data Acquisition
A/D Converter
Computer System
Printer
Packer Pressure
Isolation packer/ Double packer/ single packer
Flowboard
Flow rate measurement
Pressure regulator
Injection pump
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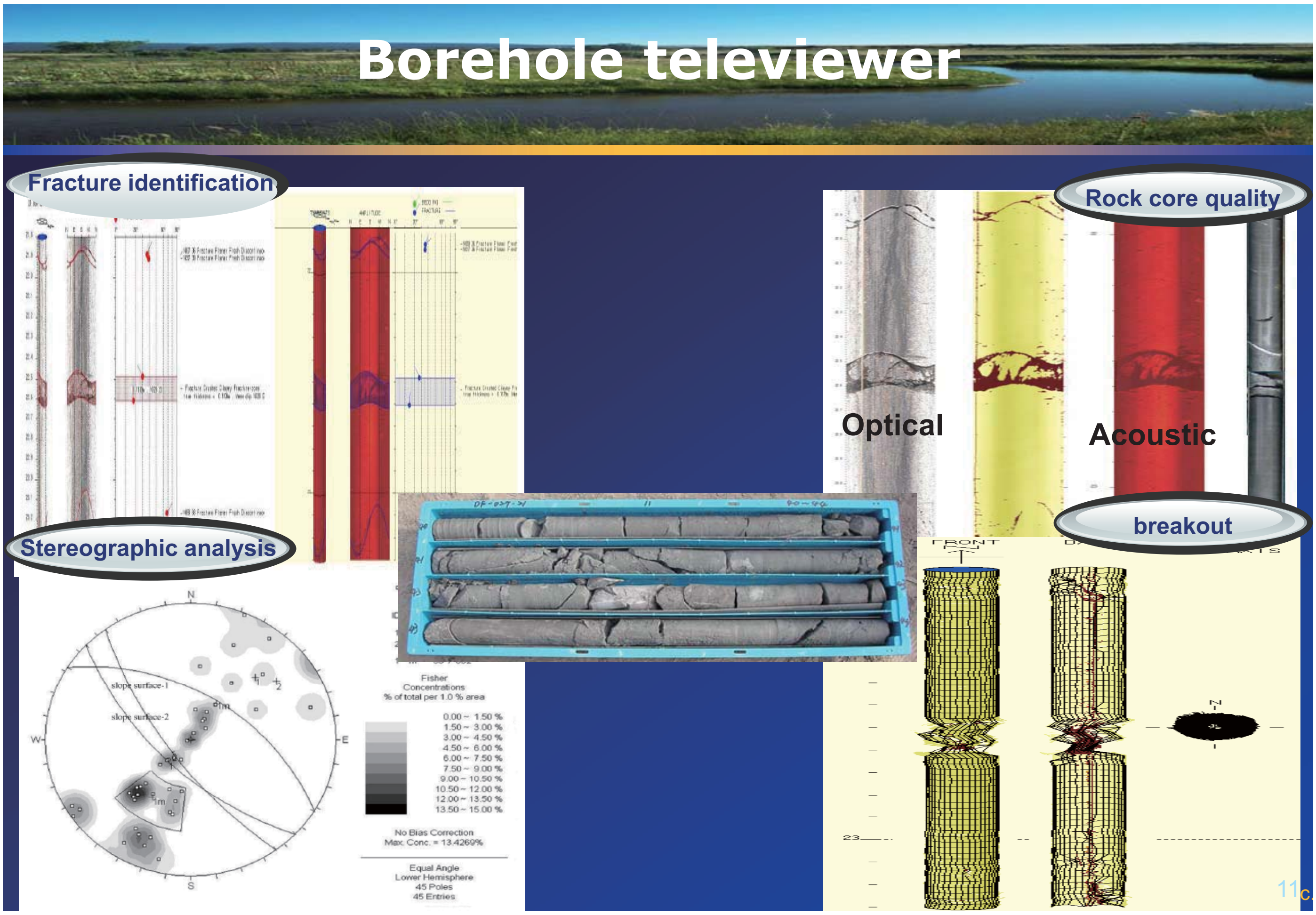
Borehole televiewer
Fracture identification
Stereographic analysis
Rock core quality
Optical
Acoustic
breakout
Fisher
Concentrations
% of total per 1.0 % area
No Bias Correction
Equal Angle
Lower Hemisphere
45 Poles
45 Entries
slope surface-1
slope surface-2
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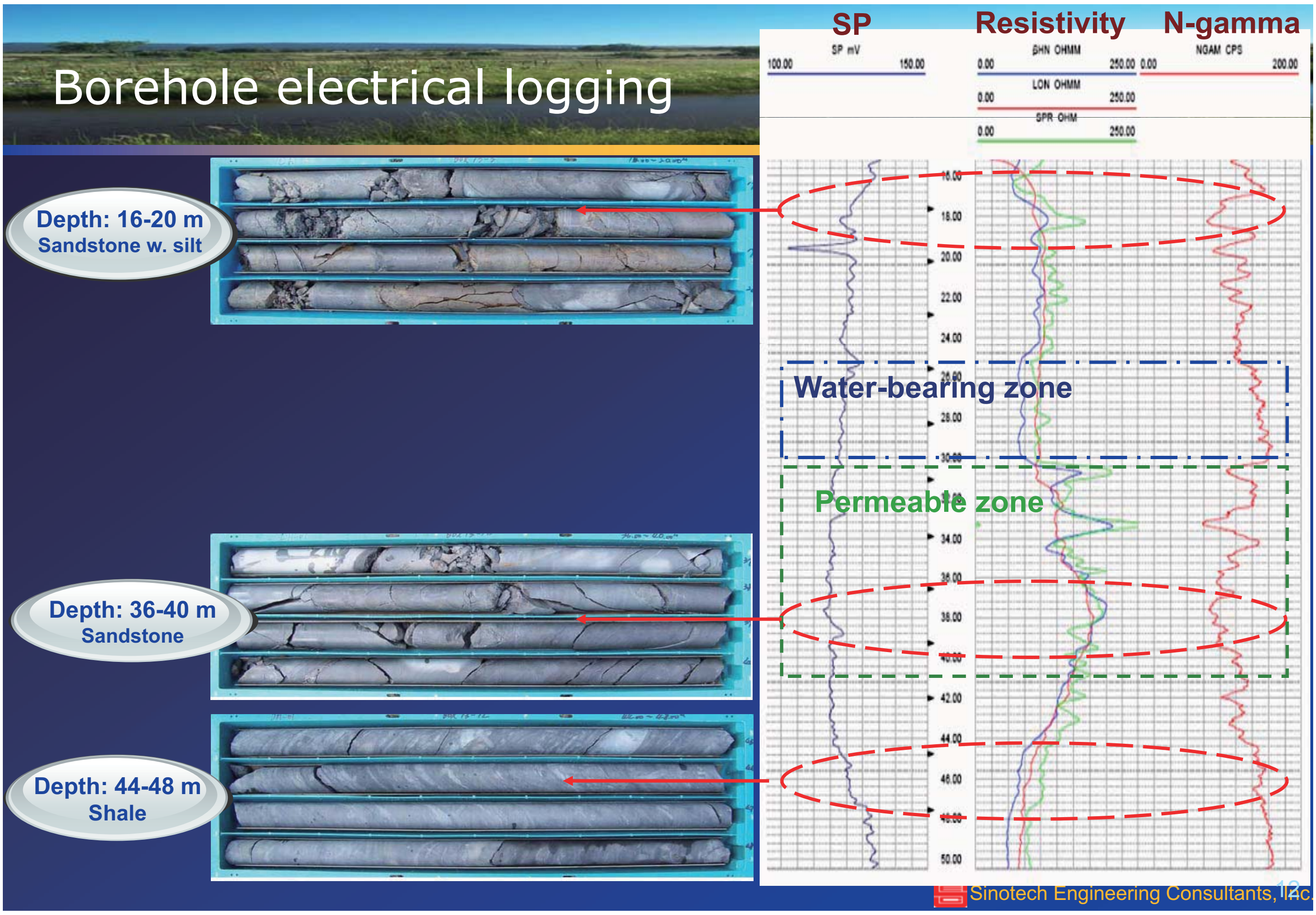
Borehole electrical logging
SP
Resistivity
N-gamma
Depth: 16-20 m
Sandstone w. silt
Depth: 36-40 m
Sandstone
Depth: 44-48 m
Shale
Water-bearing zone
Permeable zone
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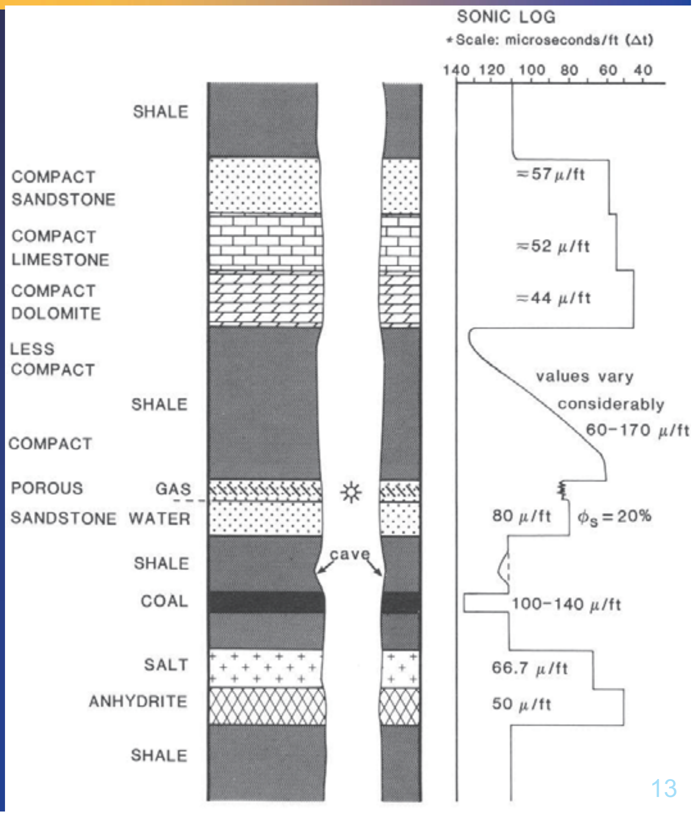
Sonic logging

- Sonic logging shows a formation's interval transit time.
- It is a measure of a formation's capacity to transmit sound waves.
- Geologically, this capacity varies with lithology and rock textures, notably porosity.

Note: stratum porosity can be obtained from empirical formula

$$\phi_{sonic} = \left(\frac{\Delta t_{\log} - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}}\right) \times 1/C_p$$

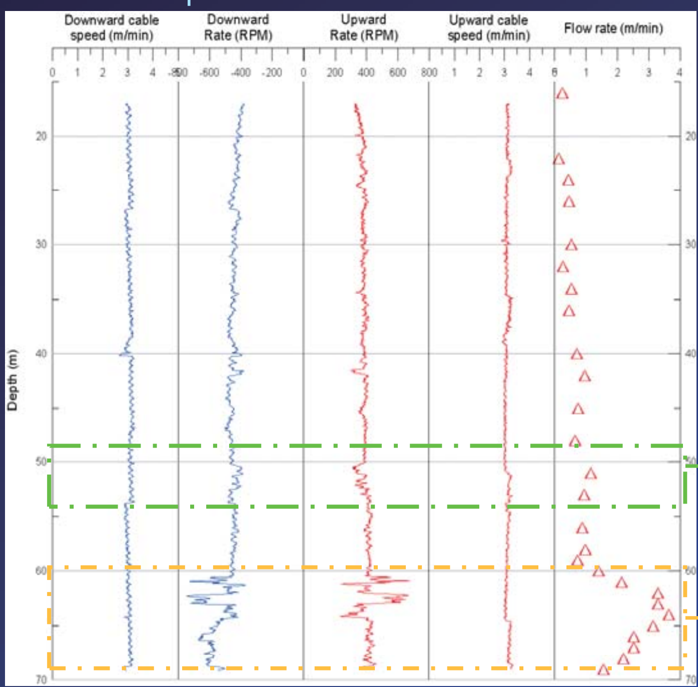
$$C_p = \frac{\Delta t_{sh} \times C}{100}$$

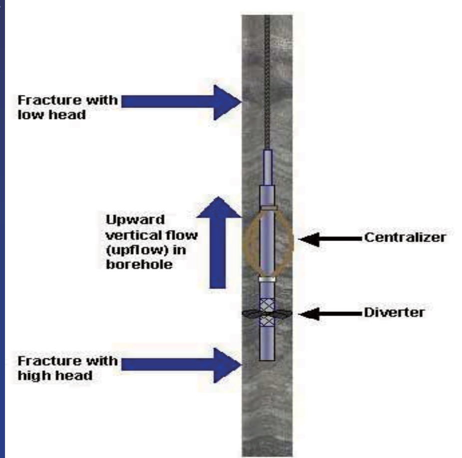


Flowmeter measurement

Impeller Flowmeter

Heat-Pulse Flowmeter



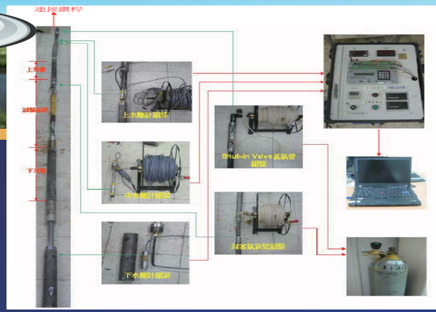


Permeable zone

- Permeable zone with high connectivity fractures
- Water-receiving zone

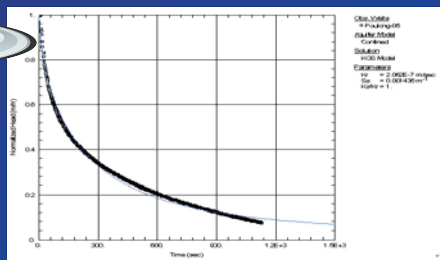
Double packer test

Packer System

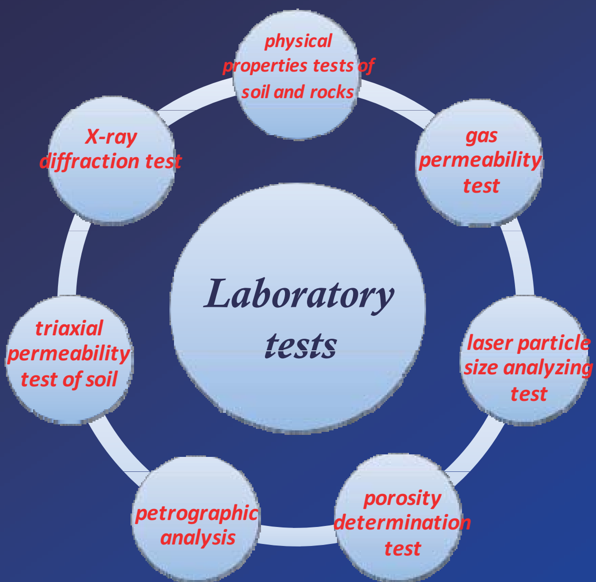


Real-time monitoring

Data analysis



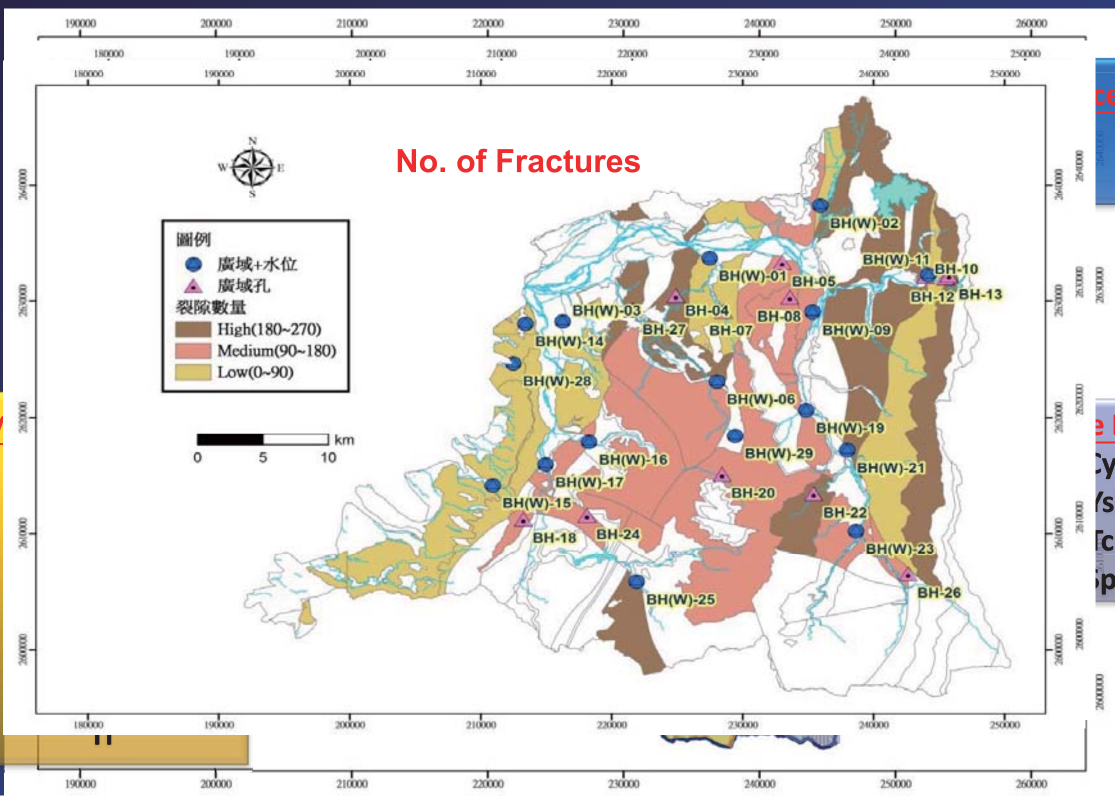
Laboratory tests



Laboratory tests

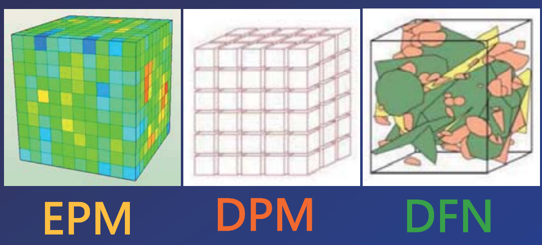
Test Categories	Purposes
Physical Properties Test of Soil and Rock	Grain size distribution; Specific gravity; Unit weight
Tri-axial Permeability Test	Permeability (Soil)
Gas Permeability Test	Permeability (Rock)
Mercury and Helium Porosimeter Test	Porosity
Laser Particle Size Analyzing Test	Particle size distribution for unconsolidated rocks
Petrographic Analysis (Thin Section Analysis)	Petrographic description, including grain size, sorting, porostiy, mineral abundances, etc.
X-ray Diffraction Test	Semi-quantitative determination of sample mineralogy

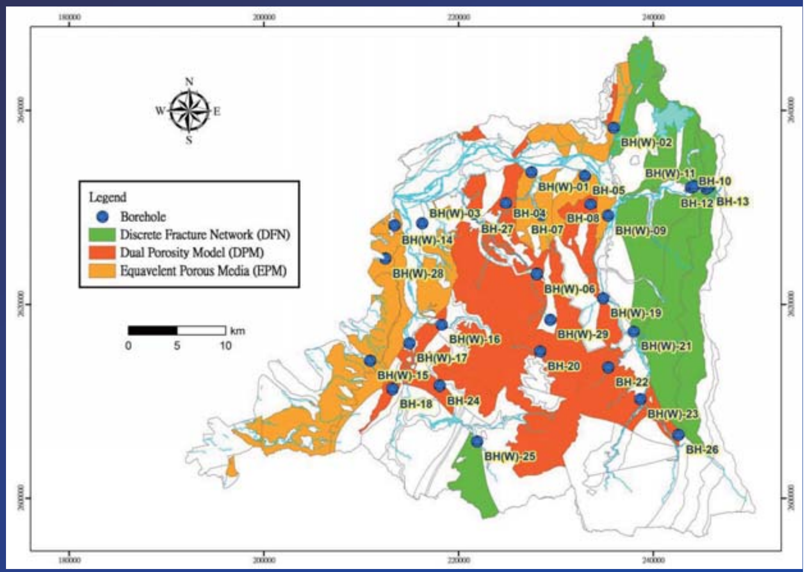
Spatial Distribution of Hydrogeologic properties



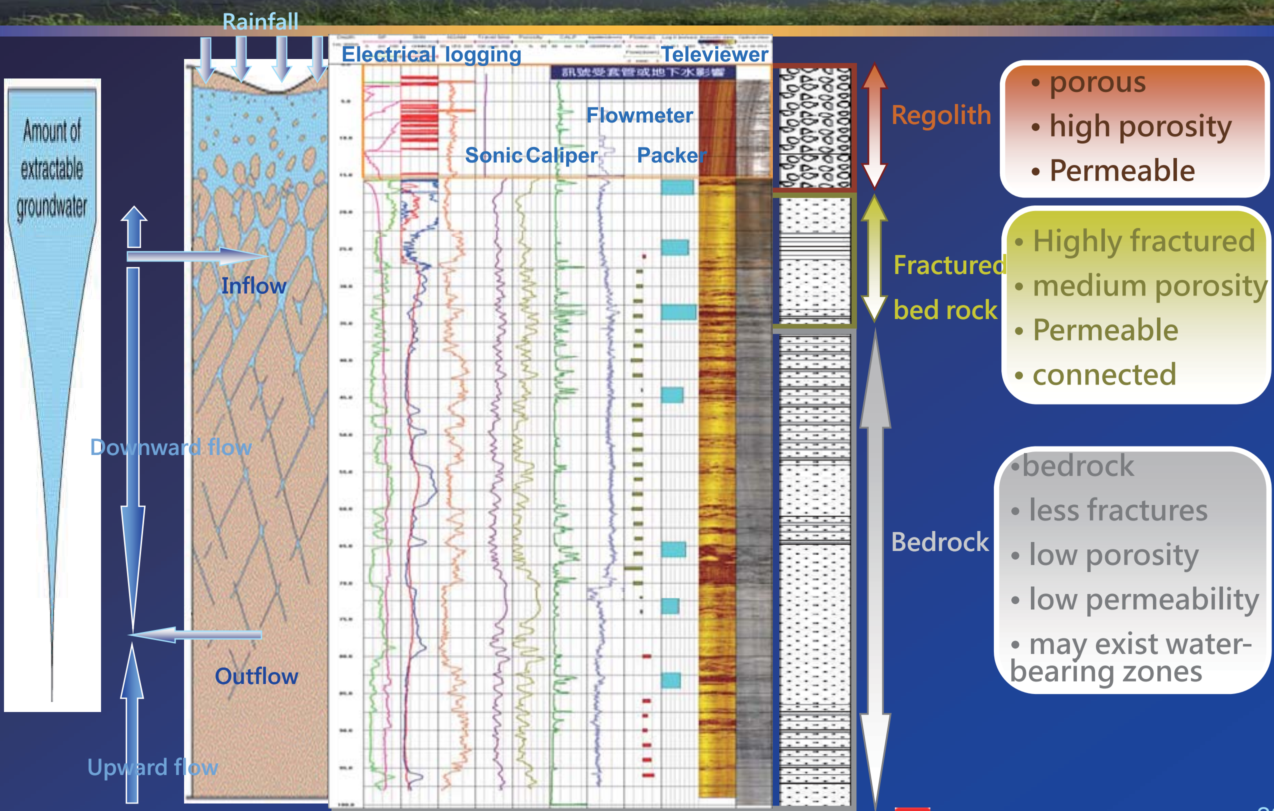
Determination of Groundwater Conceptual Model

- Criteria
  - Lithology
  - Permeability
  - Porosity
  - No. of fractures
- Model types
  - Discrete Fracture Network (DFN)
  - Dual Porosity Model (DPM)
  - Equivalent Porous Media (EPM)



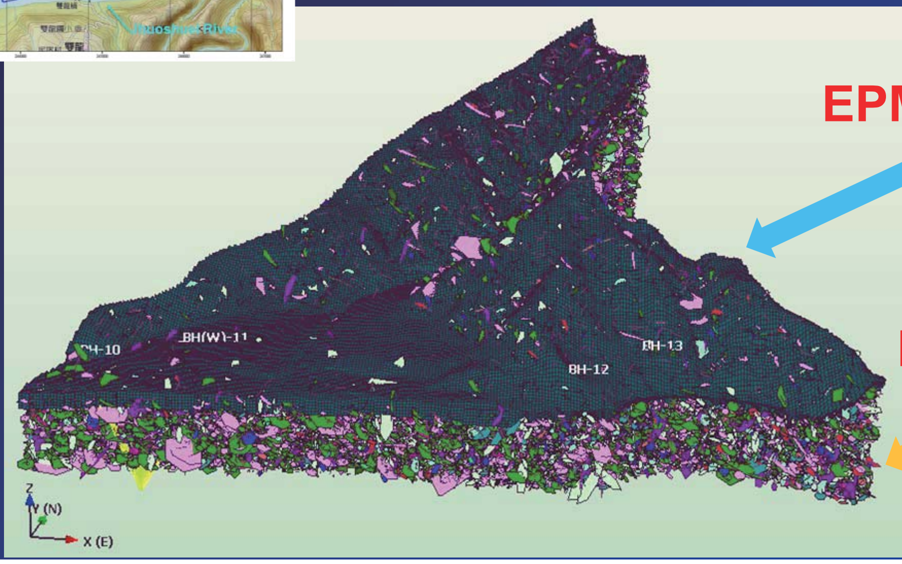


Hybrid EPM/DFN Model (1/2)



Hybrid EPM/DFN Model (2/2)

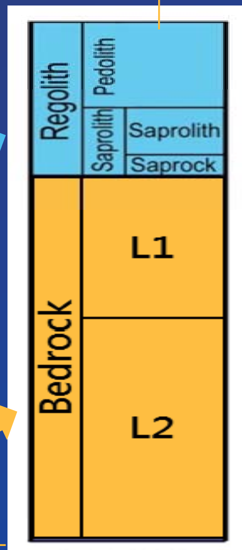
Study Area (Dili Village)



EPM

DFN

Thickness: 50 m



Conclusions

➢Hydraulic conductivity, storativity, and porosity on different geological formations have been revealed. The aforementioned results regarding the hydrogeological properties can be utilized to classify the study area into three types of groundwater conceptual models or hybrid model.

➢The map also presents spatially different flow characteristics leading to the further study of groundwater availability.

➢Based on a large scale, this work gives an advantage in selecting an appropriate model for modeling groundwater problems.

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