

# **Technical Innovation of Engineering Geology ----idea and practice**

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**Shaoxing University, China**

**September 24, 2019 Jeju Island**

**Background**

**The Idea and Promotion**

**The Practice in China**

# I. BACKGROUND

- **We don't worry about theory, our concern is technology!**

**We have well known on**

- **Soil and rock: properties and behavior;**
- **Interaction: geo-medium and human activities;**
- **Geo-hazards and geo-environment: mechanism and process,**
- **.....**

- **Technology is original and lagged far behind the demand of the industry!**

**The current state:**

- ◆ **Geological mapping with heavy labour**



**Field Investigation**



**Joint Measuring**



- ◆ **Prospecting and in-situ testing with equipments produced 30-40 years ago**



**Drilling and Sampling**



**Trench observation**



**Geophysical Prospection**



**Adit Cataloging**



**In-situ Testing**

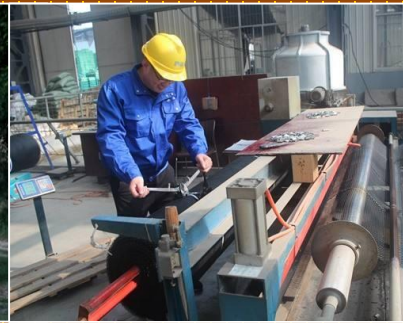
- ◆ Laboratory testing with long time, heavy equipments and complicated process



Sampling



Transportation



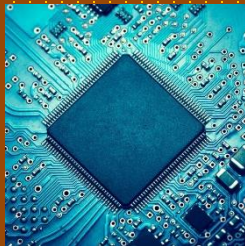
Specimen Making



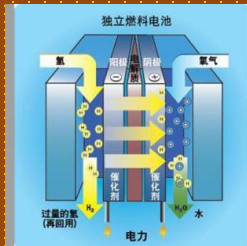
Lab Testing

**The current geo-engineering survey is a labour intensive, time consuming and expensive job!**

- The time has provided blowout-like high-Techs and Cool-Techs for our practical applications.



Integrated chip



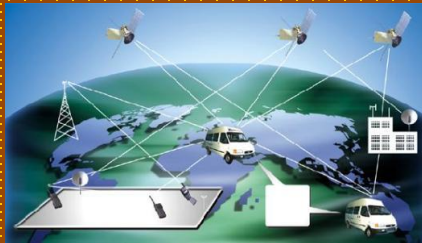
Fuel cell



AI tech



Big data



Satellite positioning



Drone



IoT tech



Optical fiber sensor



BIM tech



Intelligent Robot

- ◆ **We have had rich experiences and accumulations on new tech applications**
- Large number of semi-finished products from universities and institutes by students, but stopped at their graduation.
- Large number of fragmented applications of new techs in companies but not popularized in the industry.
- Most of new techs have not been popularized by writing into technical standards since they are not mature enough and productized.



- **It is the time for integrated innovation of geo-engineering technology.**
- **It is a historical mission of the industry, rather than any individual action!**

## **II. THE IDEA AND PROMOTION**

- **Idea: to initiate an action on technical innovation, or even revolution, in the industry, and worldwide!**
- **Aim: a more convenient and intelligent engineering geology.**

- **Frame of the action**

An overall re-organizing and raising of technology of the industry, through modern techs using and integrated innovation:

- Space-air-ground mapping;
- In-situ testing and data acquisition;
- Advanced prospecting and data collecting;
- High-performance computation and analyzing;
- IoT Monitoring;
- Modernized technical standards;
- Professional education and training, etc.

- **Promotion of the action**
- **Actions by Ministries of S&T, Education, Environment, etc, and NSFC**
- **Natural Resources Ministry launched a technical developing plan through 12 engineerings**

**Network for observation** of natural resources;

**Survey and monitoring** of natural resources;

**Intelligent management** of natural resources;

**Prospection and exploitation** of new resources;

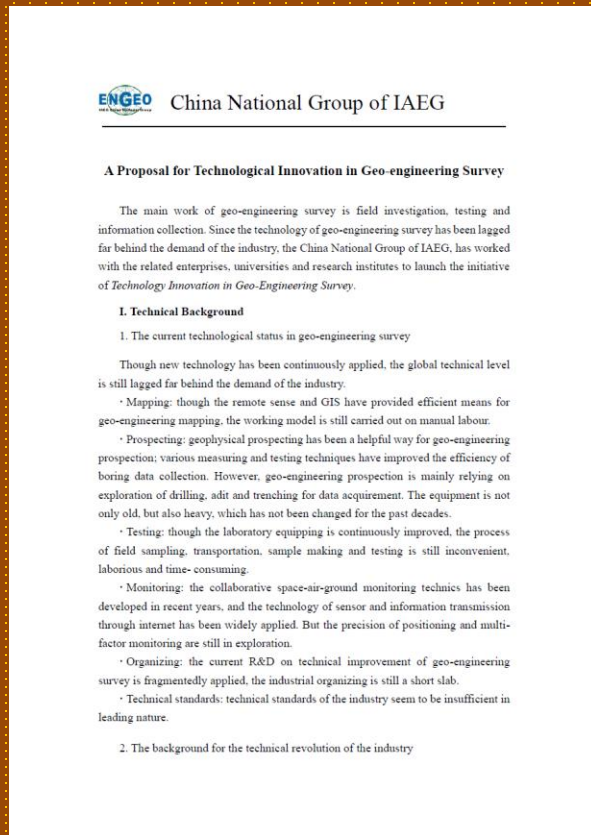
**Marine and geological hazards monitoring and warning;**

**New GIS technology** and applications;

.....

**Standard system** construction for natural resources.

# • Proposal by IAEG China National Group



China Commission of Engineering Geology, CGS  
China National Group of IAEG  
Geo-Survey Standardizing Commission, China Railway Society  
Shaoxing University  
China Railway Design Group Co., Ltd.  
China Railway 1<sup>st</sup> Survey and Design Institute Group Co., Ltd.  
CIGIS (China) Limited  
China Jikan Institute of Investigation and Design, Co., Ltd.  
China Ordnance Survey and Geotechnical Institute Co., Ltd.  
Power China Huadong Engineering Co., Ltd.  
Yangtze Academy of Sciences  
Yellow River Engineering Consulting Co., Ltd.  
Bei Fang Investigation, Design & Research Co., Ltd.  
China University of Geosciences  
Tongji University  
Chengdu University of Technology  
Chang'an University  
Zhejiang University  
Institute of Geology and Geophysics, CAS  
Institute of Rock and Soil Mechanics, CAS  
Huahui Design Group Co. Ltd.  
Zhejiang Rock Innovation Co., Ltd.  
RUHR IoT Technology Co. Ltd  
OST Slope Protection Co. Ltd

• More institutions applying to join the proposal!

- **The Proposal has been reported to IAEG**



**IAEG Executive Committee Meeting and Council Meeting**



**12<sup>th</sup> IAEG Asian Regional Conference**

# The proposal will be launched at 2<sup>nd</sup> Shaoxing Forum, and promote the IAEG IRP.

The 2<sup>nd</sup> Shaoxing International Forum  
on Rock Mechanics and Engineering Geology (SXFRG)

## New Technologies in Rock Mechanics and Engineering Geology



October 19–21, 2019  
Shaoxing, China

Hosted by



Sponsored by



Supported by



### Keynote Speakers



**Runqiu Huang** MEEP, China  
**Rafiq Azzam** RWTH, Germany  
**Xiating Feng** Northeastern University, China  
**Chungsik Yoo** Sungkyunkwan University, Korea  
**Jian Zhao** Monash University, Australia

### Agenda

Date	Time	Program
Oct. 18 (Friday)	18:00-20:00	Registration
	08:00-08:30	Opening
Oct. 19 (Saturday)	08:50-17:45	Technical Reports
	18:00-19:30	Welcome Dinner
	20:00-21:30	Enterprisers Forum
Oct. 20 (Sunday)	08:00-16:00	Technical Reports
	16:20-17:30	Proposal Announcement
	17:45-18:00	Closing
Oct. 21 (Monday)	09:00-12:00	Technical Excursion



- JTC2 Tech Standards: data standardization
- CSRME: group standard

## 中国岩石力学与工程学会

岩学字[2018]030号

### 关于申请编制“中国岩石力学与工程学会团体标准”的通知

各二级机构、地方学会、相关单位：

我会自2017年5月开展团体标准编制工作以来，得到各方的大力支持与积极参与，已有20份团体标准申请获批，并正在编制过程中。为进一步推动岩石力学与工程界及相关企事业单位的技术创新与管理进步，满足市场与学科发展需求，加快我国标准与国际标准对接，中国岩石力学与工程学会现启动“中国岩石力学与工程学会团体标准”（第二批）制定项目的征集工作，欢迎有计划编制团体标准的单位与个人踊跃申报。现将有关事项通知如下：

#### 一、立项原则

团体标准编制要适合经济社会发展需求原则；技术先进、经济合理原则；安全、环保与节能原则；适合贸易全球化需求原则；维护公共利益原则；协商一致原则；广泛参与、公开透明原则。

#### 二、立项要求

1. 团体标准应满足国家有关法律、法规要求，符合“中国岩石力学与工程学会团体标准编制管理办法”。
2. 申报单位应对标准制定的意义、国内外研究现状、标准主要



中国岩石力学与工程学会团体标准

(T/CSRME-XXX-XXX)

### 工程岩体参数计算与岩体质量分级技术规程

Technical Specification for Parameter Calculation and

Classification of Engineering Rock Mass

(征求意见稿)

2019-12-20 发布

2020-1-1 实施

中国岩石力学与工程学会发布



中国岩石力学与工程学会团体标准

### 《岩石隧道工程地质信息交换标准》

(T/CSRME-XXX-XXX)

编制大纲（讨论稿）

同济大学  
二〇一八年四月

- **IAEG will also start actions by supporting IRP and Awarding under the leadership of IAEG promotion committee.**
- **Available financial supports for the action**
  - ◆ **From the institutions of the proposers**
  - ◆ **By the projects from government:**

# III. THE PRACTICE IN CHINA

# 1. Geo-Data

## ◆ Geo-Cloud ----China Geological Survey

The screenshot displays the Geo-Cloud website interface. At the top, there is a header with the logo and navigation links for '中文版', 'Intranet version', 'Official mailbox', 'Register', and 'Log in'. Below the header is a main navigation bar with dropdown menus for 'Home page', 'Geological data', 'Geological products', 'Geological archives', 'Standards and specifications', 'Methods and equipment', 'Project Management', 'Intelligent geological survey', 'Cloud tools', and 'Feedback'. A red box highlights the 'Geological data', 'Geological products', 'Geological archives', and 'Standards and specifications' dropdown menus. Below this is another red box highlighting 'Methods and equipment', 'Project Management', 'Intelligent geological survey', and 'Cloud tools'. The main content area features a search bar with the placeholder text '请输入搜索关键字' and a 'search' button. To the right of the search bar, there is a text snippet: 'Braided channel in Kunlun Mountains from The Geology Museum of China'. Below the search bar, there are eight service categories, each with an icon and a brief description:

- Remote sensing data**: Provide original imaging data of Gaofen-1, Gaofen-2 and Resource-02C satellites
- Collections information**: Provide latest collections of material data and result materials
- Borehole data**: Online browsing Application of national important drilling data according to requirements Acquires relevant drilling holes data
- Geoscientific literatures**: Online browsing Various Geoscience related Literatures Information retrieval of partial, Acquire partial content of literature
- Sharing of large instrument**: Providing large-scale instruments and equipment sharing service with online booking and acquirement
- Geological cloud disk**: Provide online disk services for geological survey teams and technicians

# ◆ Cloud calculation

----Rock Innovation Co. Ltd & Shaoxing University

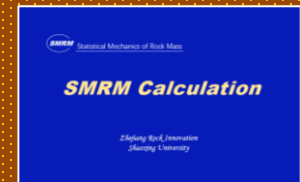
## SMRM Rock Mass Parameter Calculation Platform



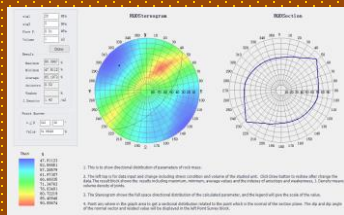
SMRM Calc V1.0



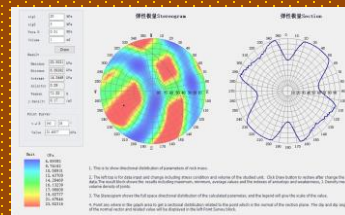
SMRM Parameter



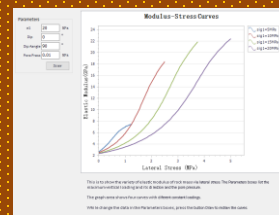
SMRM calc V1.1.net



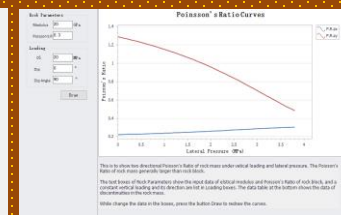
Directional RQD



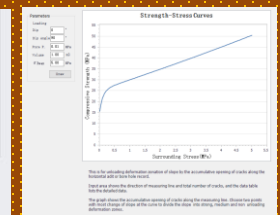
Full Directional Modulus



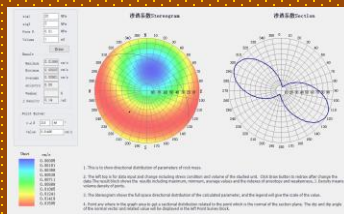
Modulus Curves



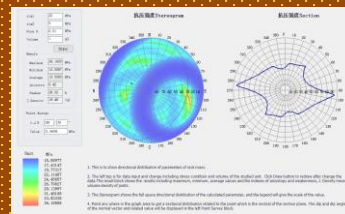
2 Direction Poisson's Ratio



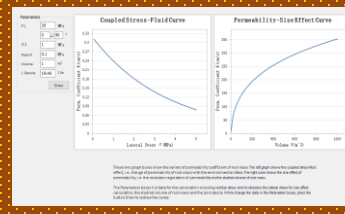
Compressive Strength



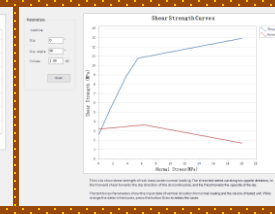
Full Directional Permeability



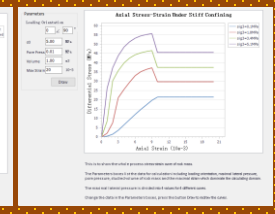
Full Directional Compressive Strength



Permeability Curves



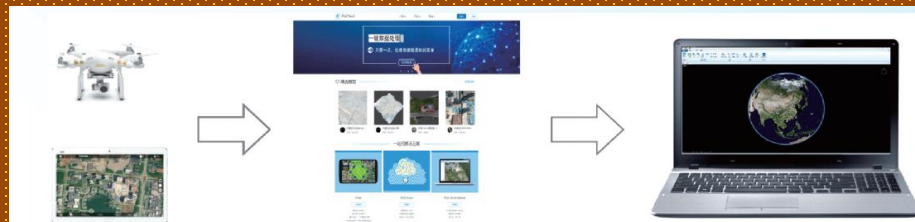
2 Direction Shear Strength



Deformation Curve

# 2. Convenient GeoEng-Survey

- ◆ Non-contact measuring & 3D modeling  
----China Institute of Geo-environment Monitoring



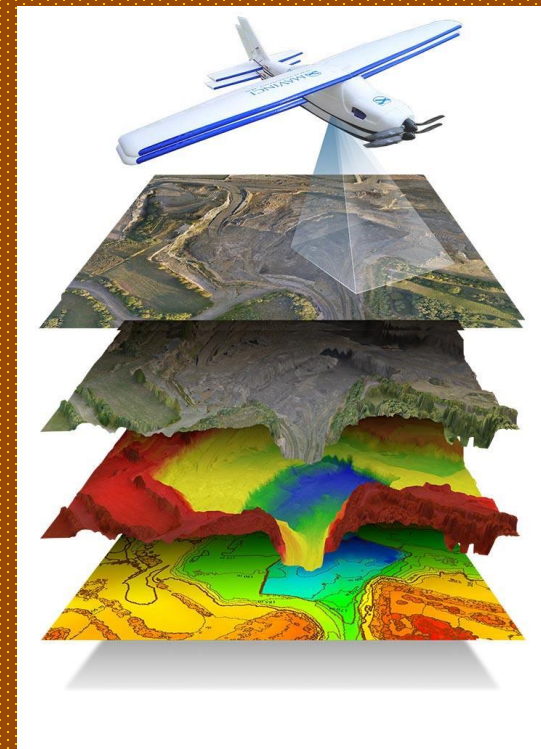
Drone control

Data process

Application platform



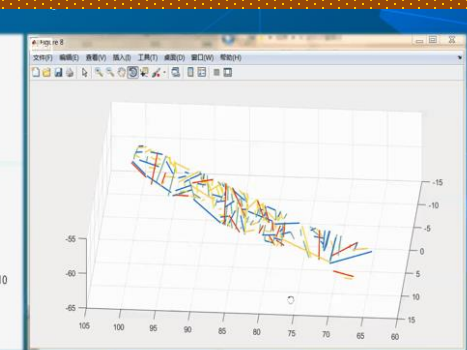
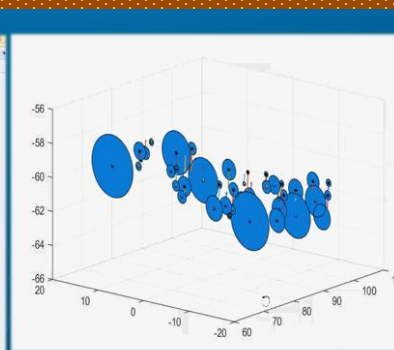
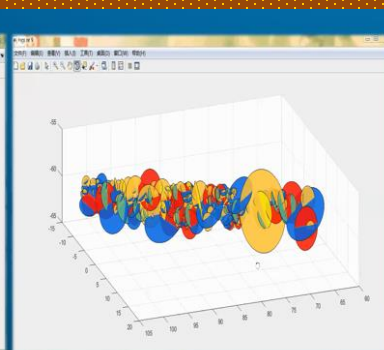
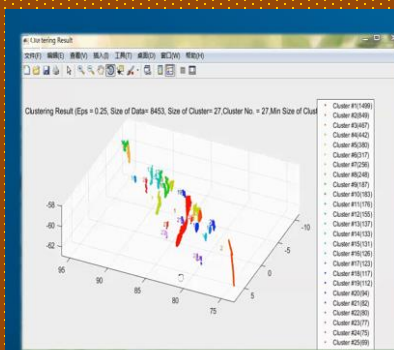
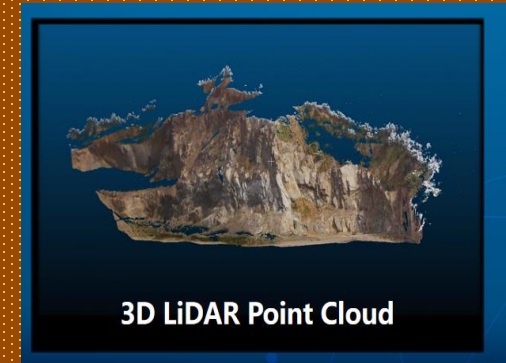
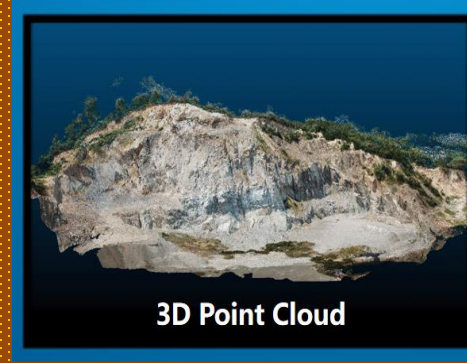
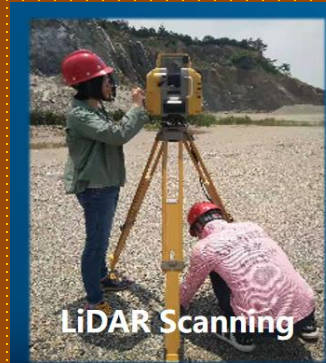
3D model of geo-relics, Hebei, China



Digital Orthophoto Mapping

# ◆ Rock mass structure identification

----Rock Innovation Co. Ltd &  
Shaoxing University



# ◆ Portable laboratory

----Rock Innovation Co. Ltd &  
Shaoxing University



Point Load, UCS and Frictional Angle



Triaxial Compressometer



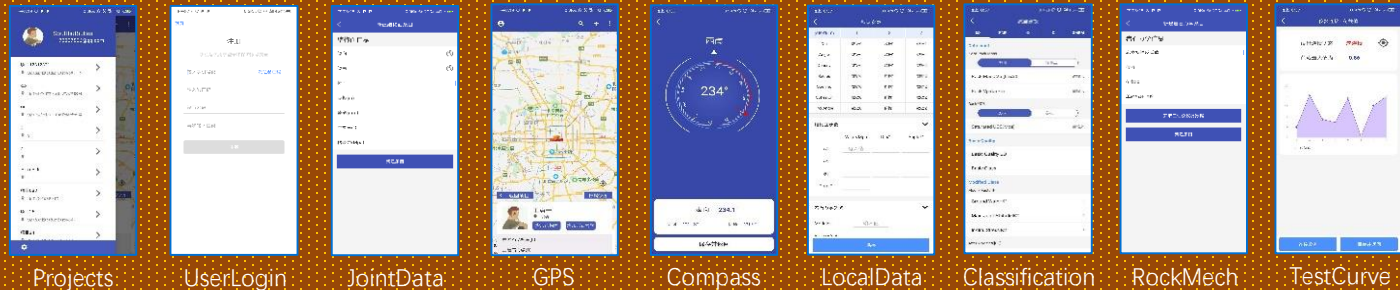
# ◆ Mobile noter and compass

----Rock Innovation Co. Ltd & Shaoxing University

V 1.0



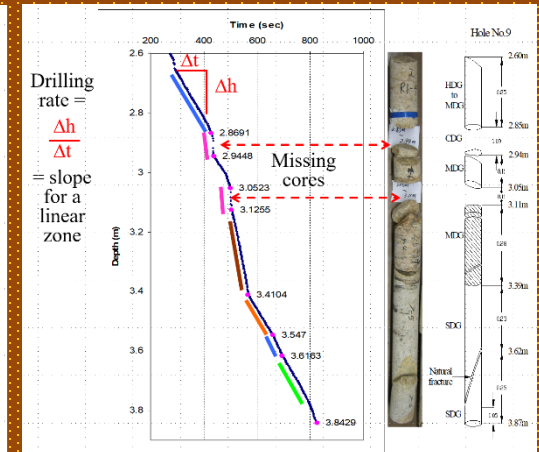
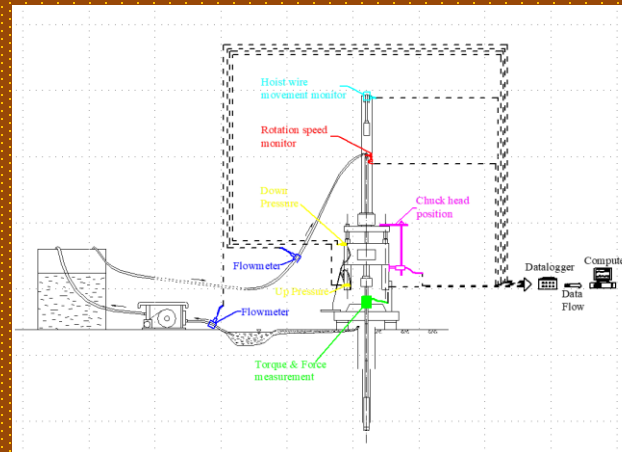
V 1.1



# 3. Borehole Testing & Data Collecting

## ◆ Borehole Data Collecting

----Hong Kong University



Divide the strata through drillability

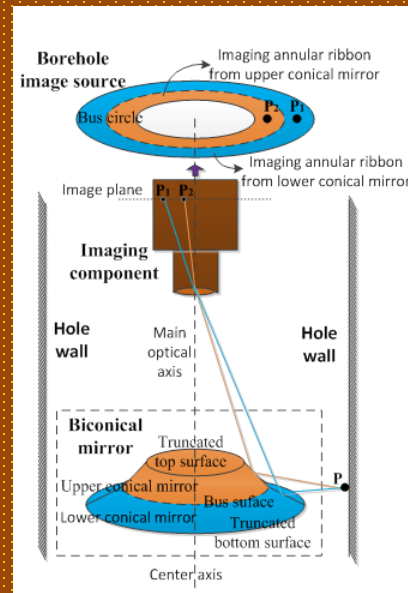
# ◆ Borehole Stereopair Imaging

----Institute of Soil and Rock Mechanics, CAS

Obtain 3D point cloud of borehole wall by two conical reflecting mirrors.



Equipment & Software



Principle

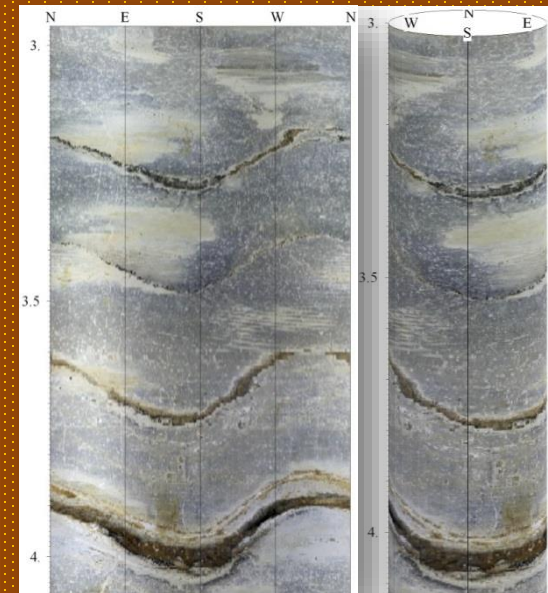
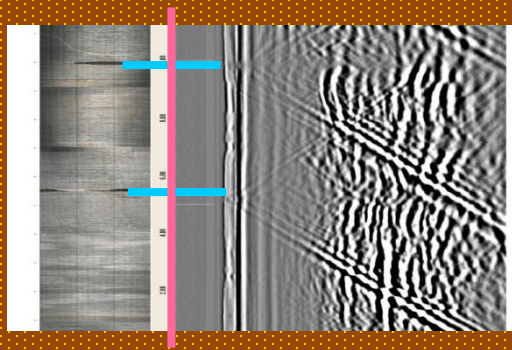
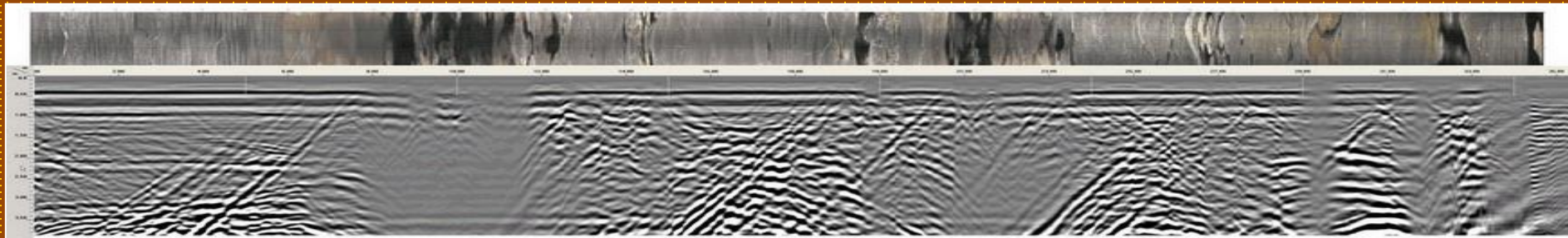


Image of 360° borehole wall

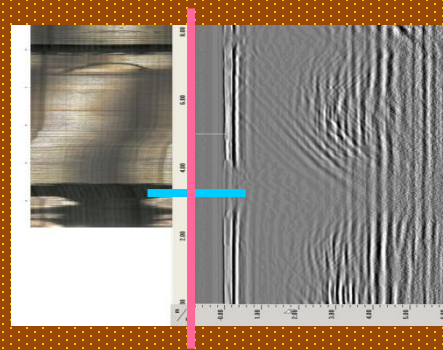
- **Borehole televiewer and GPR**

----Institute of Soil and Rock Mechanics, CAS

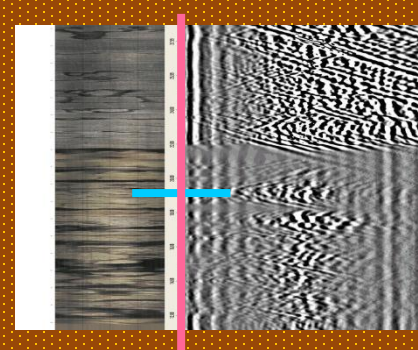
Recognize fractures, caves, corrosion and soil-rock interfaces



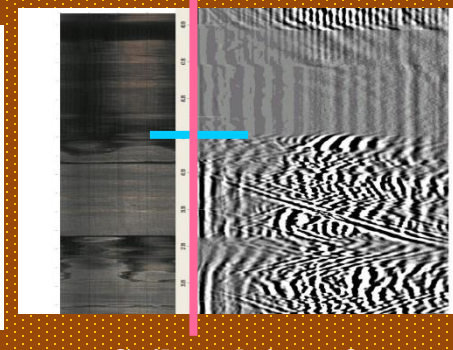
Fractures



Caves



Corrosion



Soil-rock interface

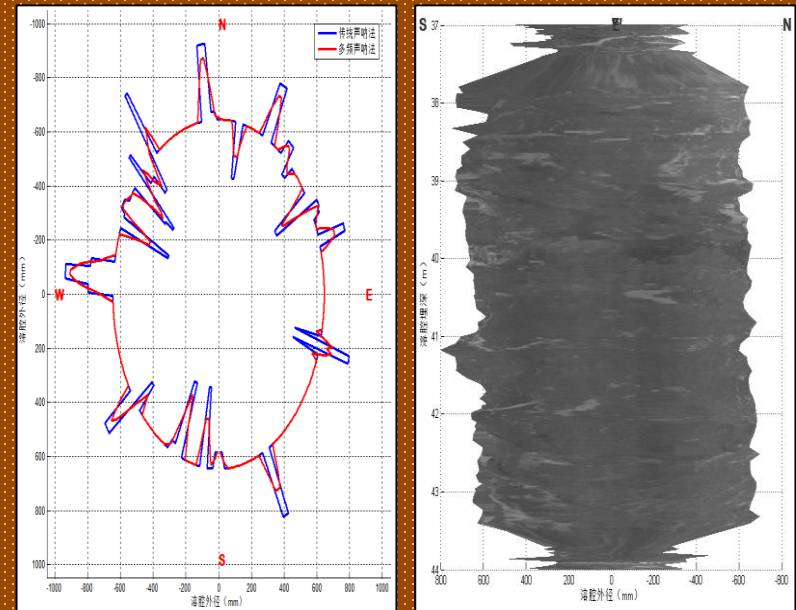
- **Borehole Ultrasonic Televiewer**

----Institute of Soil and Rock Mechanics, CAS

By borehole ultrasonic logging televiewer, we can build the 3D shape of caves through borehole.



Borehole Ultrasonic Logging Televiewer



The cave 3D borehole cross-sectional shape

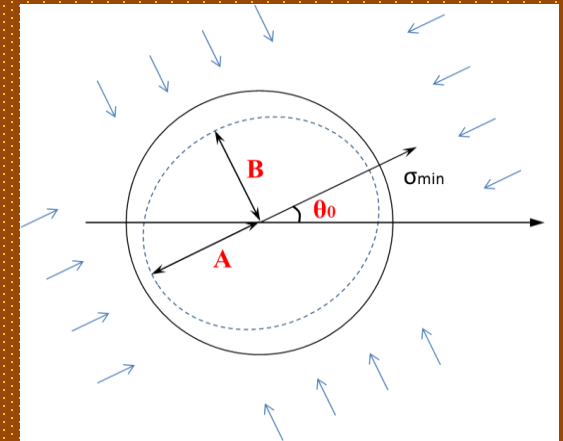
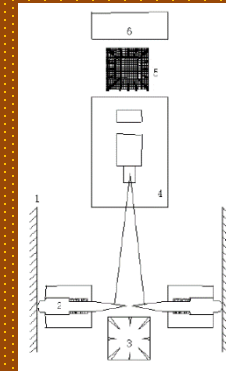
# • Borehole Geo-Stress Calculation

----Institute of Soil and Rock  
Mechanics, CAS

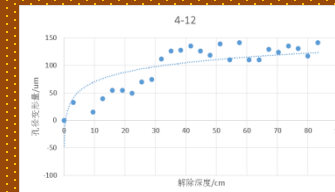
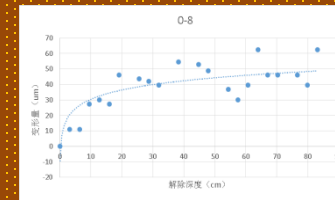
Obtain the 2D stress state  
by section scanning of  
borehole wall based on  
elasticity.



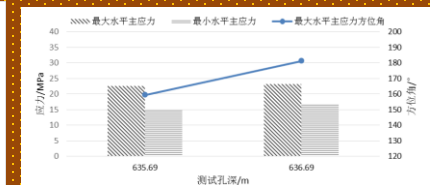
Stress relief test



Principle



$$\begin{cases} \sigma_1 = \frac{E}{1-\mu^2} \times \frac{3\Delta A + \Delta B}{8a} \\ \sigma_2 = \frac{E}{1-\mu^2} \times \frac{\Delta A + 3\Delta B}{8a} \end{cases}$$

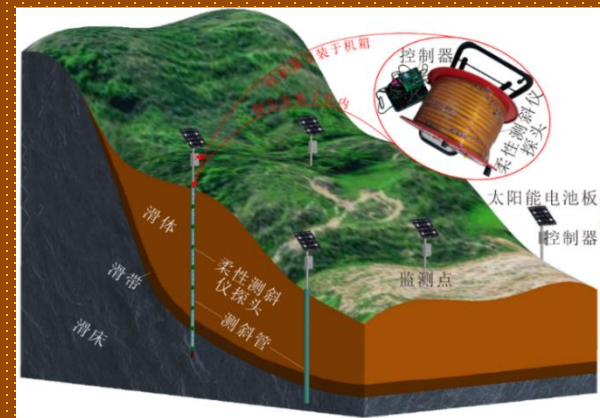
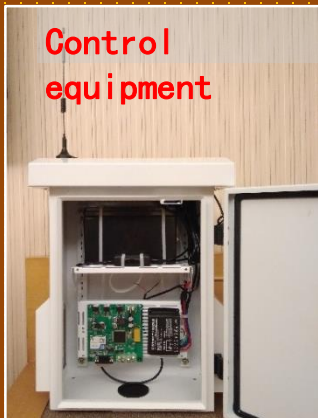
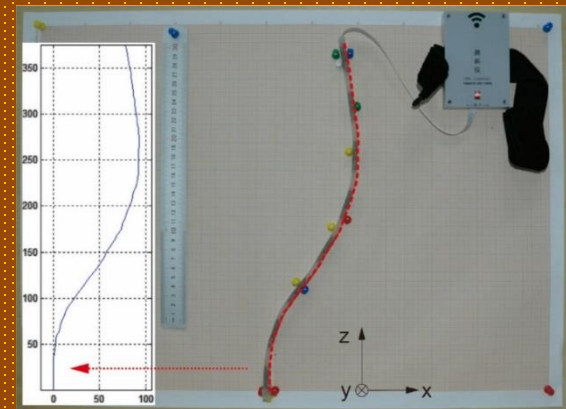
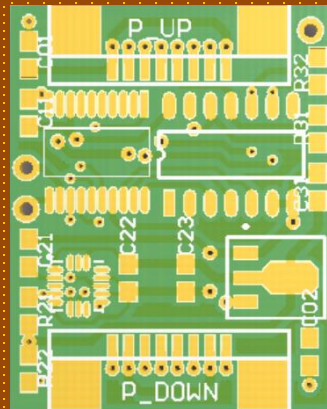
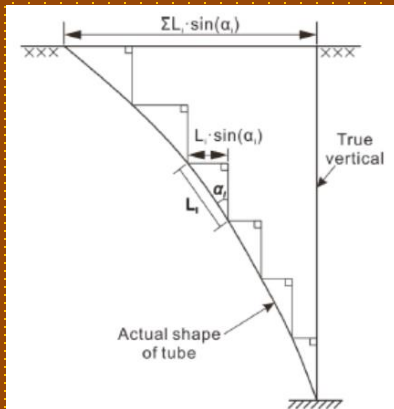


Geostress calculation

- **Borehole monitoring**

-----China University of Geosciences (Wuhan)

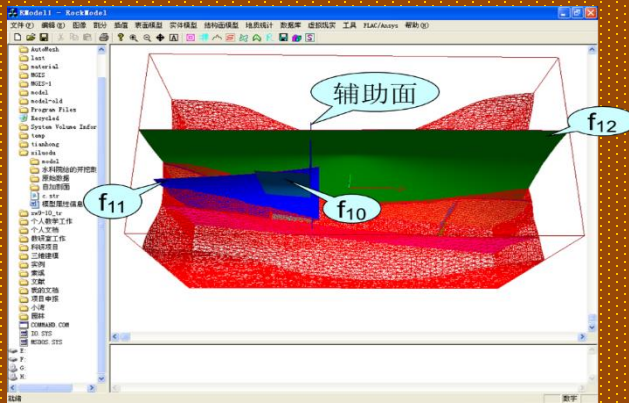
**Flexible high precision inclinometer for deep displacement  
Badong in-situ testing station**



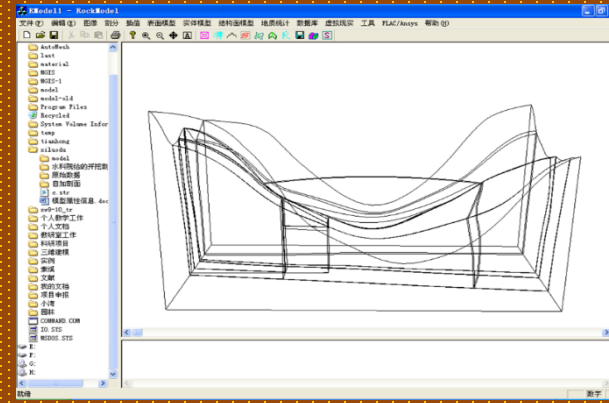
# 4. 3D Geo-modeling

-----China University of Geosciences (Beijing)

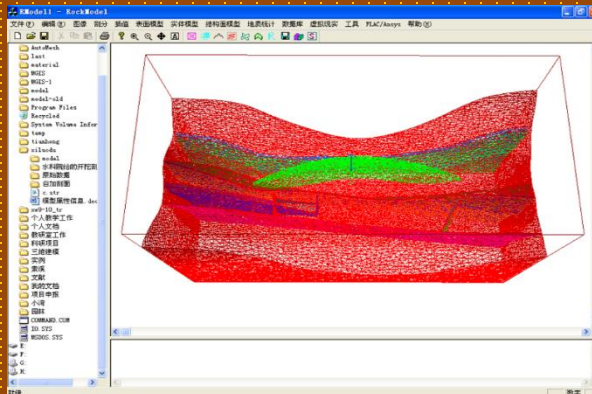
## ◆ ROCKModel and Numerical Simulation



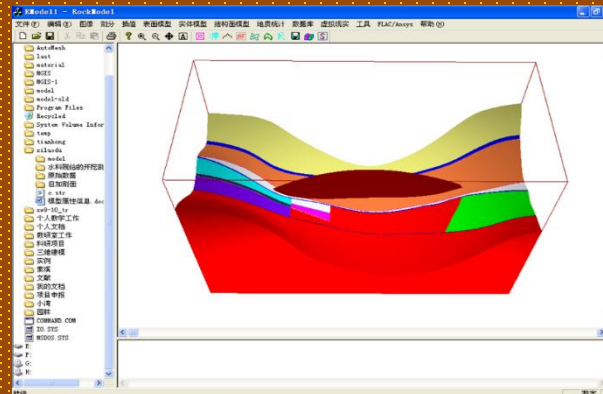
(a) Plane Intersecting



(b) Line Frame

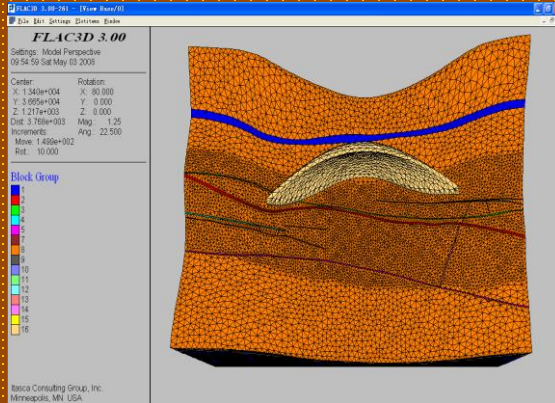


(c) Reform Triangle curves

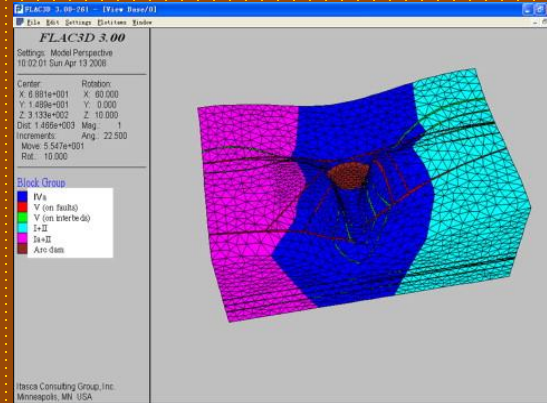


(d) Search Blocks to form Model

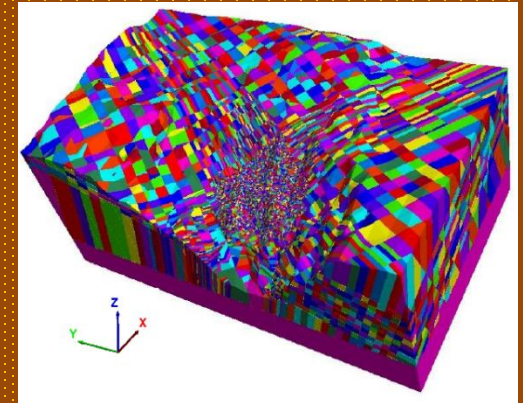




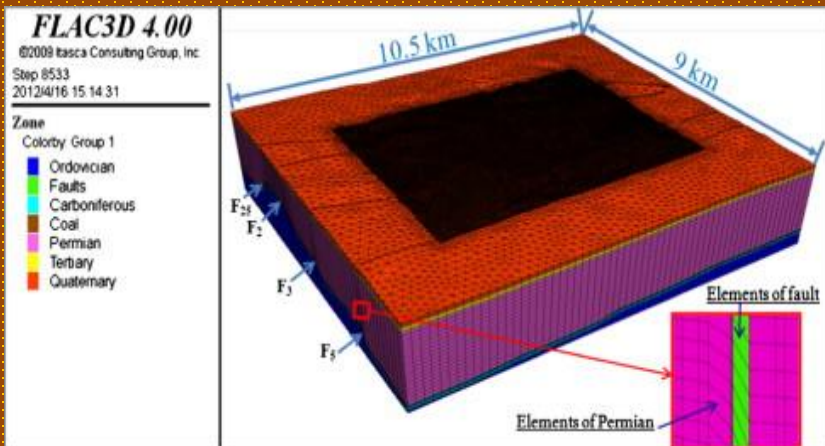
Xiaowan Hydropower Stat.



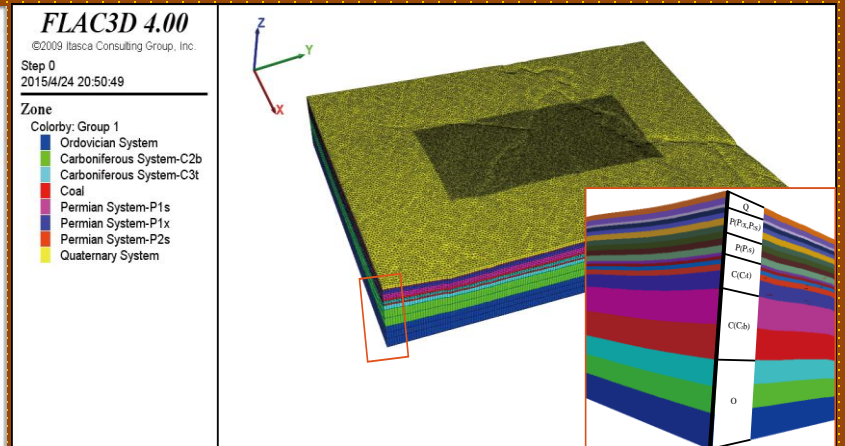
Suoxi Hydropower Stat.



Yanqianshan Model



Wutongzhuang Mine

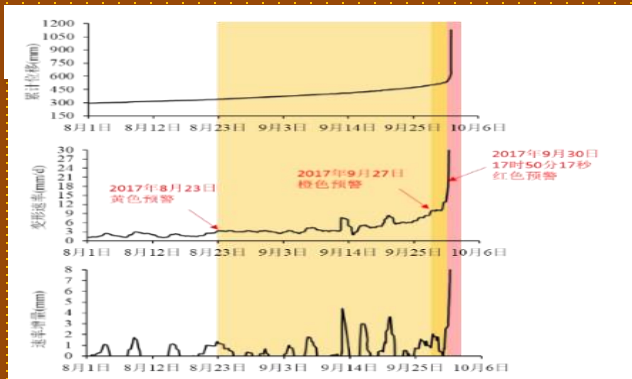


Antaipu Mining Well

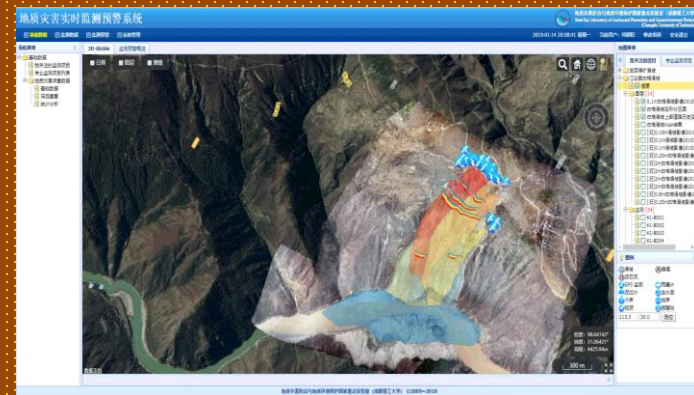
# 5. Geo-monitoring

## ◆ Landslide monitoring and prewarning

----Chengdu University of Technology



Loess landslide in Heifangtai, Gansu, warned 8 hours in advance



Rockslide in Xingyi, Guizhou, predicted 1 hour in advance

• **IoT monitoring** -----Ruhr IoT Tech.

**A series of sensors and applications to bridge and railway structure deformation monitoring.**



Level gauge



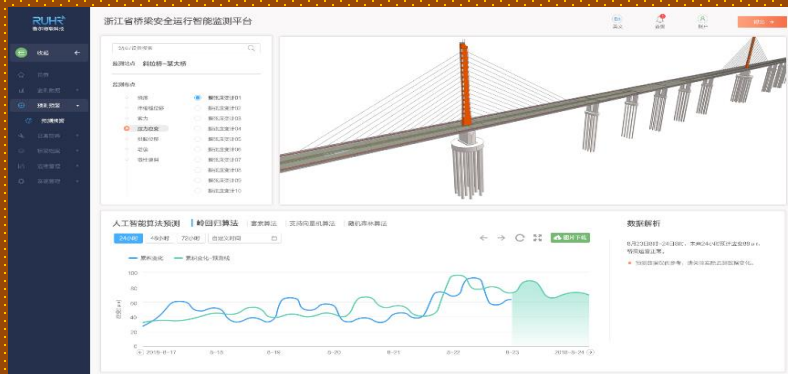
Biaxial Inclinometer



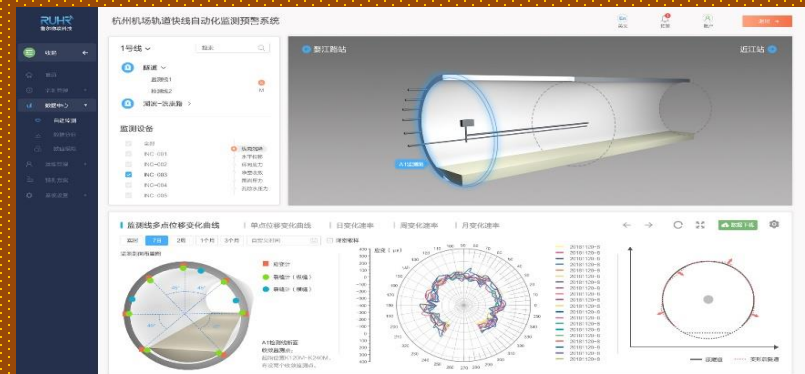
Vibration Meter



Intelligent Data Collectors



Bridge Monitoring

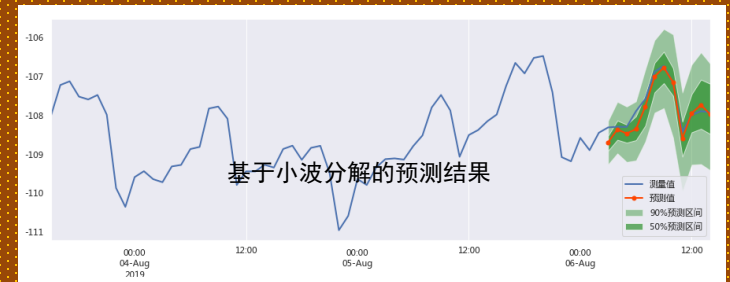
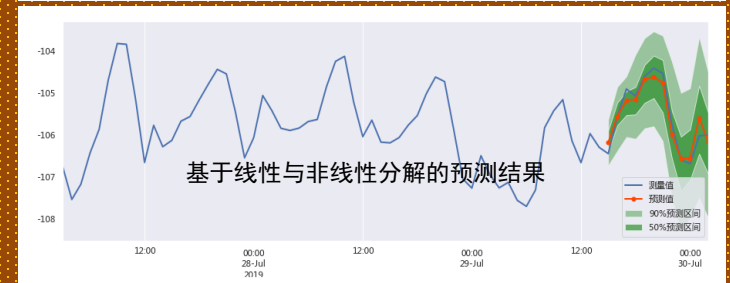
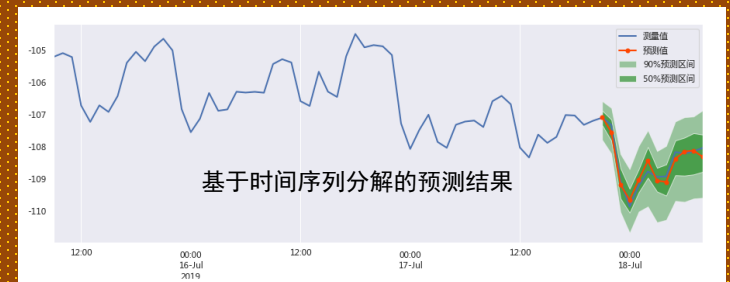
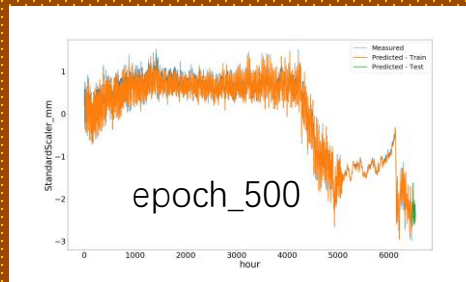
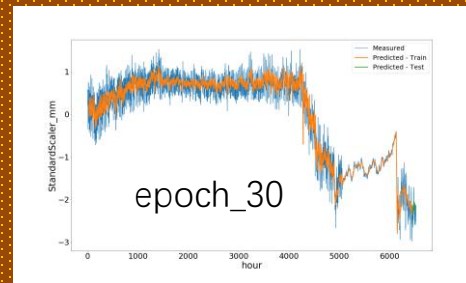
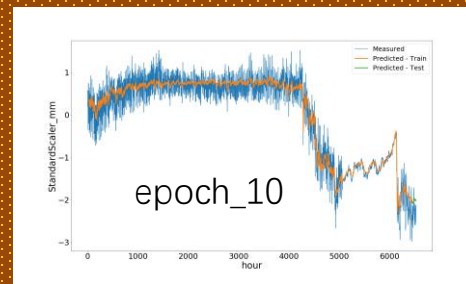


Railway Structure Monitoring

# Landslide prediction with deep learning and AI tech: time series, non-linear analysis and wavelet analysis.



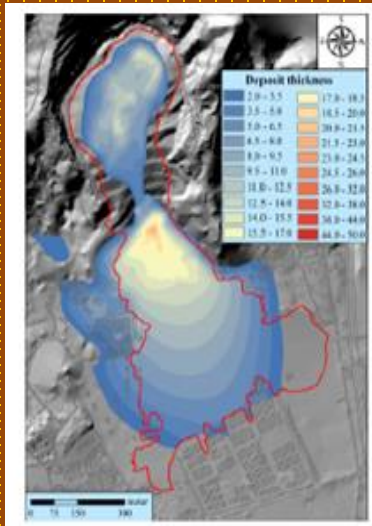
Guang'an village landslide



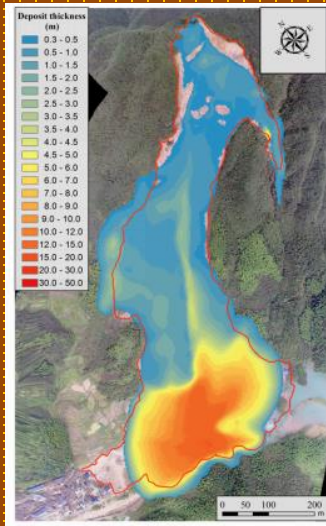
# 7. Numerical simulation

## ◆ Process of Landslides & disaster chain

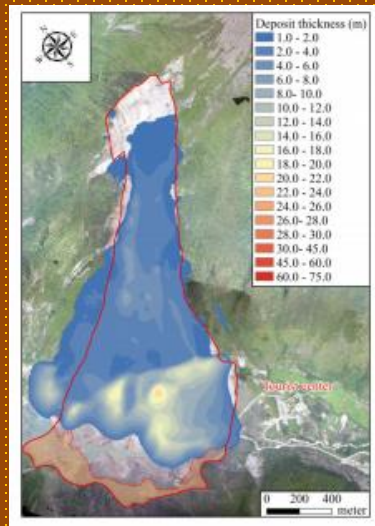
-----Institute of Mountain hazards and Environment, CAS



Shenzhen



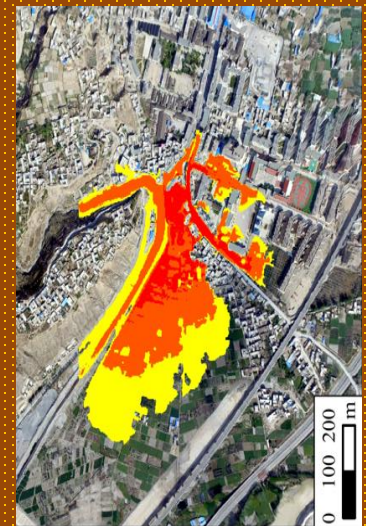
Lishui



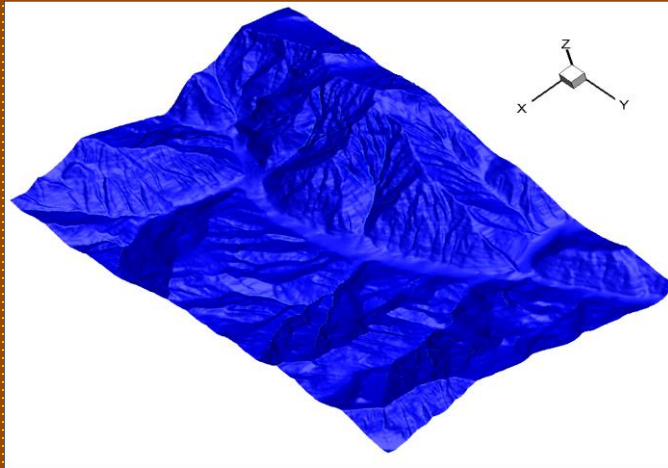
Maoxian



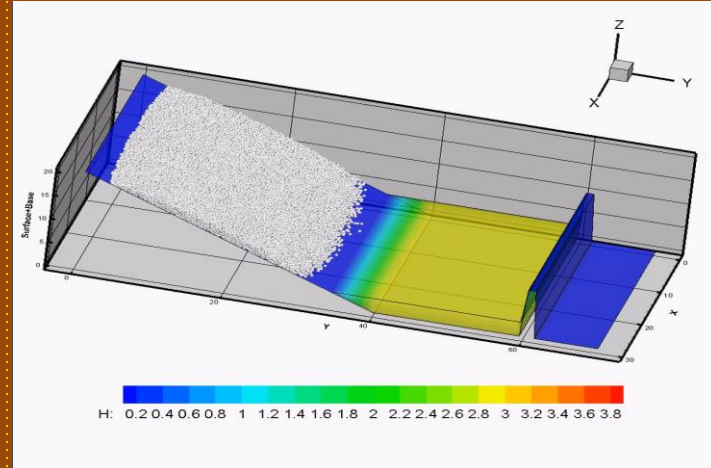
Baige



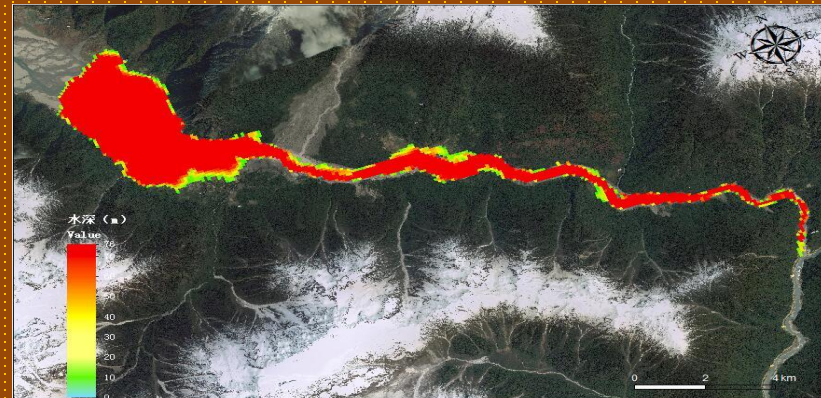
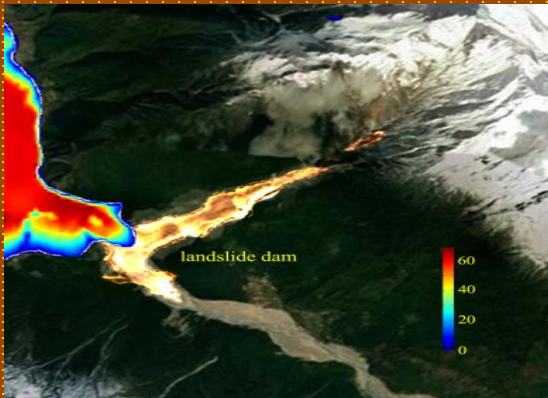
Debris Flow



Flood



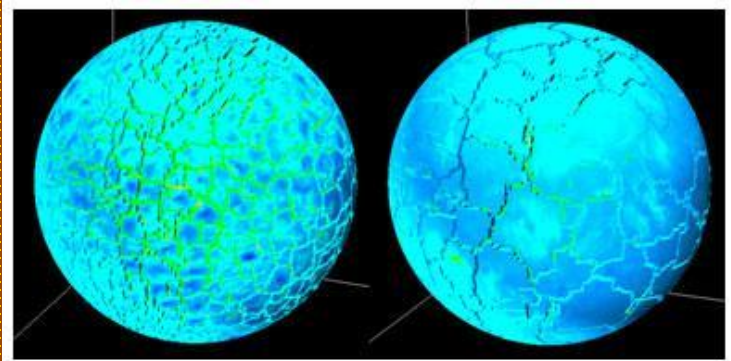
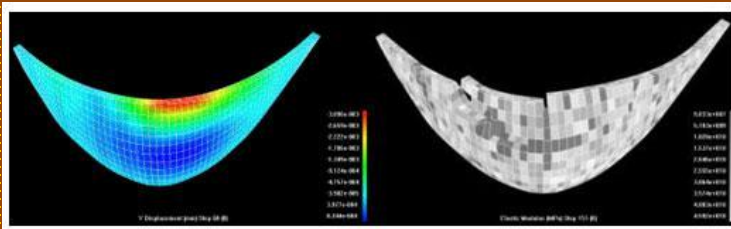
Surge by landslide



Yigong landslide, barrier lake and brokering

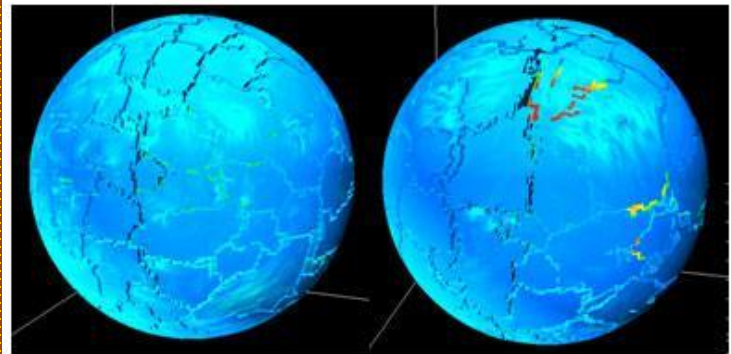
# ◆ Rock failure process

---Dalian University of Technology



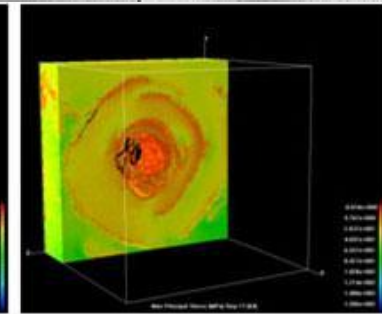
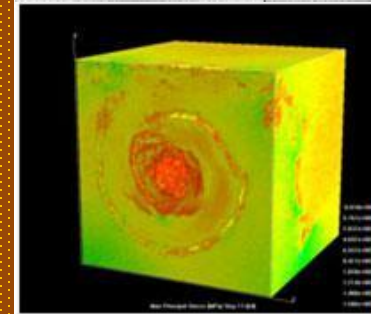
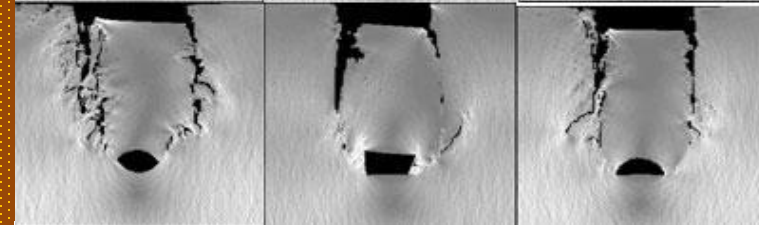
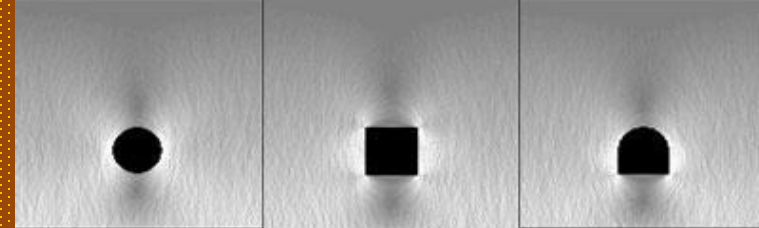
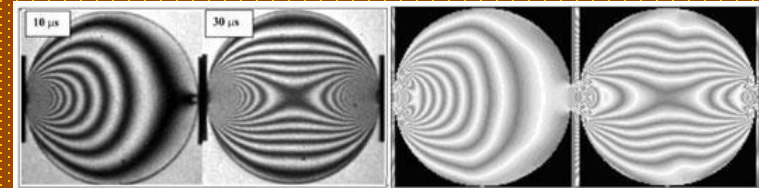
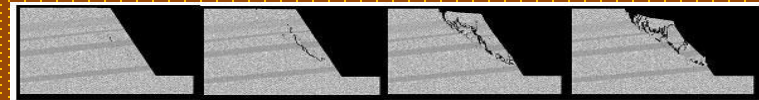
(a) r3-r2=5mm

(b) r3-r2=10mm



(c) r3-r2=15mm

(d) r3-r2=30mm



# 7. Digital engineering and intelligent city

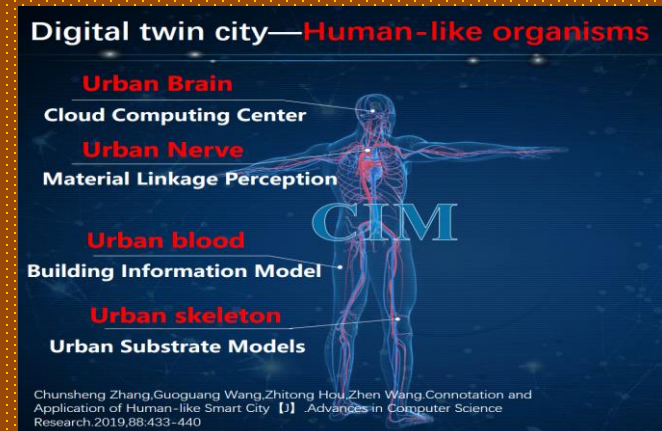
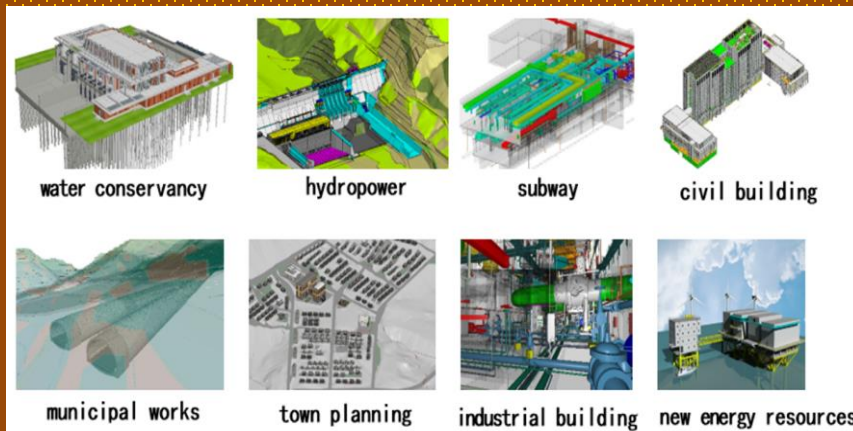
----PowerChina Huadong Engineering Co. Ltd

## GeoStation :

- One Platform, One Model and One Data Architecture
- Hydro Station, iEPC, and iELM

## Intelligent City

- Human-like Smart City
- Co-growth and Symbiosis: the virtual city and the real city

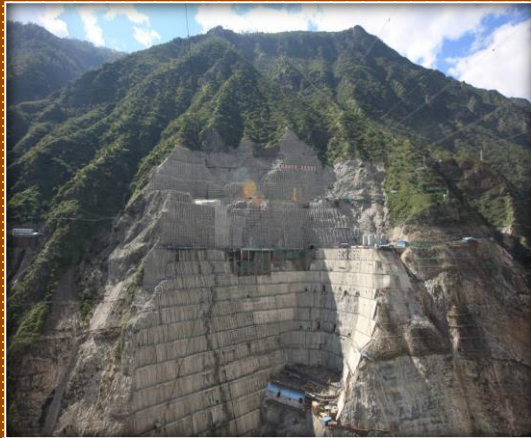




# 8. Geo-Hazard Prevention

## ◆ Materials of Grouting Reinforcement

----Chengdu University of Technology



The left bank of Jinping-1 hydropower station



Mila Tunnel



Jiuzhai Valley World Natural Heritage Site



Desertify Control of Grassland

# Conclusion:

- The technology of EG is lagged much more behind the demand of the industry than the theory.
- A proposal for technical innovation has been initiated by IAEG China and big enterprises.
- The main techs innovation including mapping, in-situ testing, prospection, computation, IoT monitoring, tech standards and education.
- There have been great progress in tech innovation which will be the solid basis of our action.

**Thank you!**