# APPLIED GEOPHYSICS: HONG KONG EXPERIENCE

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SAPIENTIA · ET · VIRTUS

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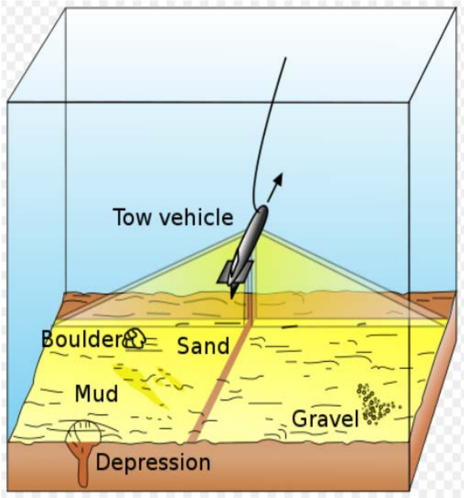
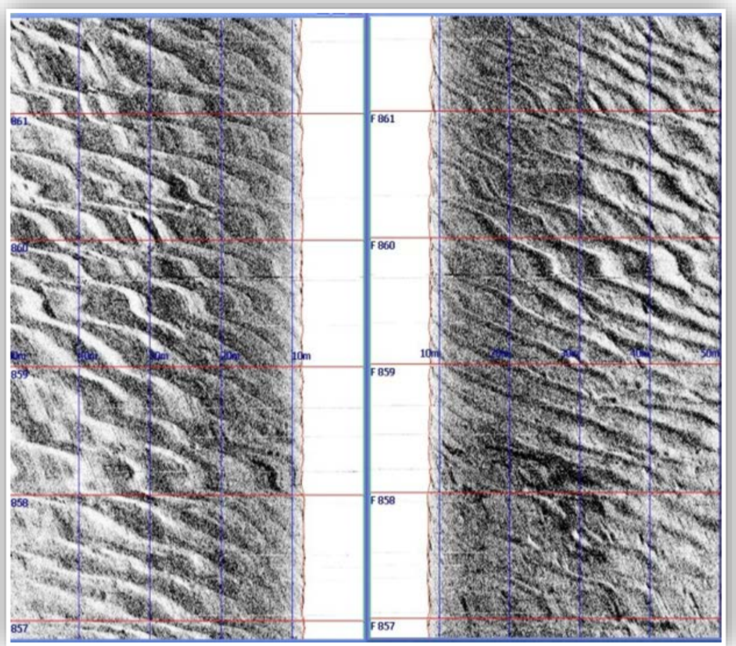
# Use of geophysics in Hong Kong?

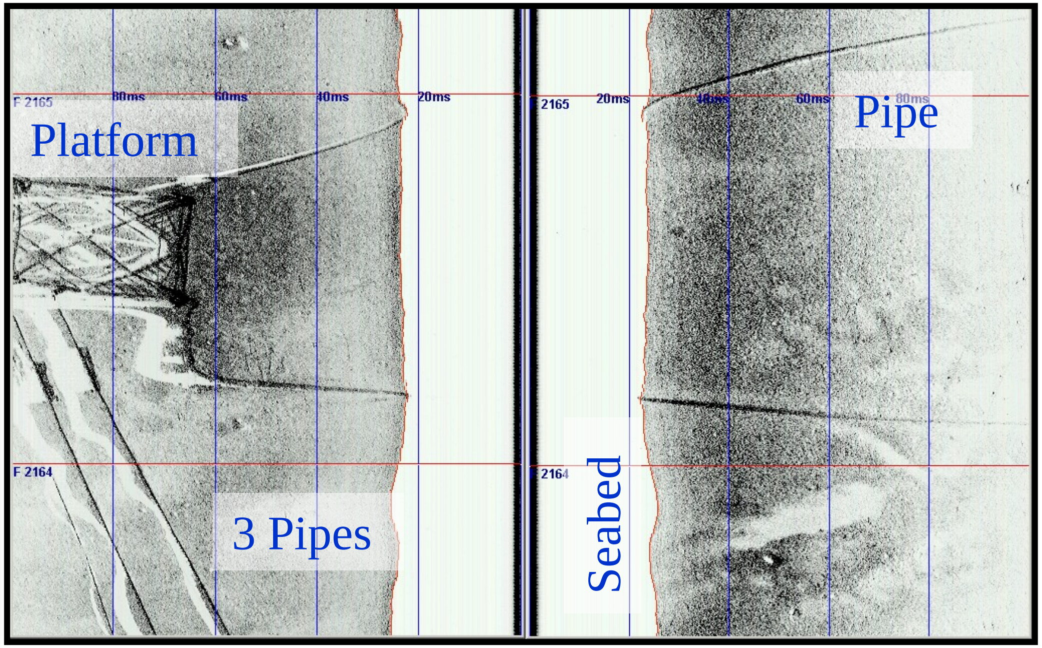
- Marine and geological investigations
- Geotechnical & Engineering applications
- Environmental assessment

# Marine geophysics

- Seabed bathymetry
- Seabed stratigraphy
- Hazardous objects mapping



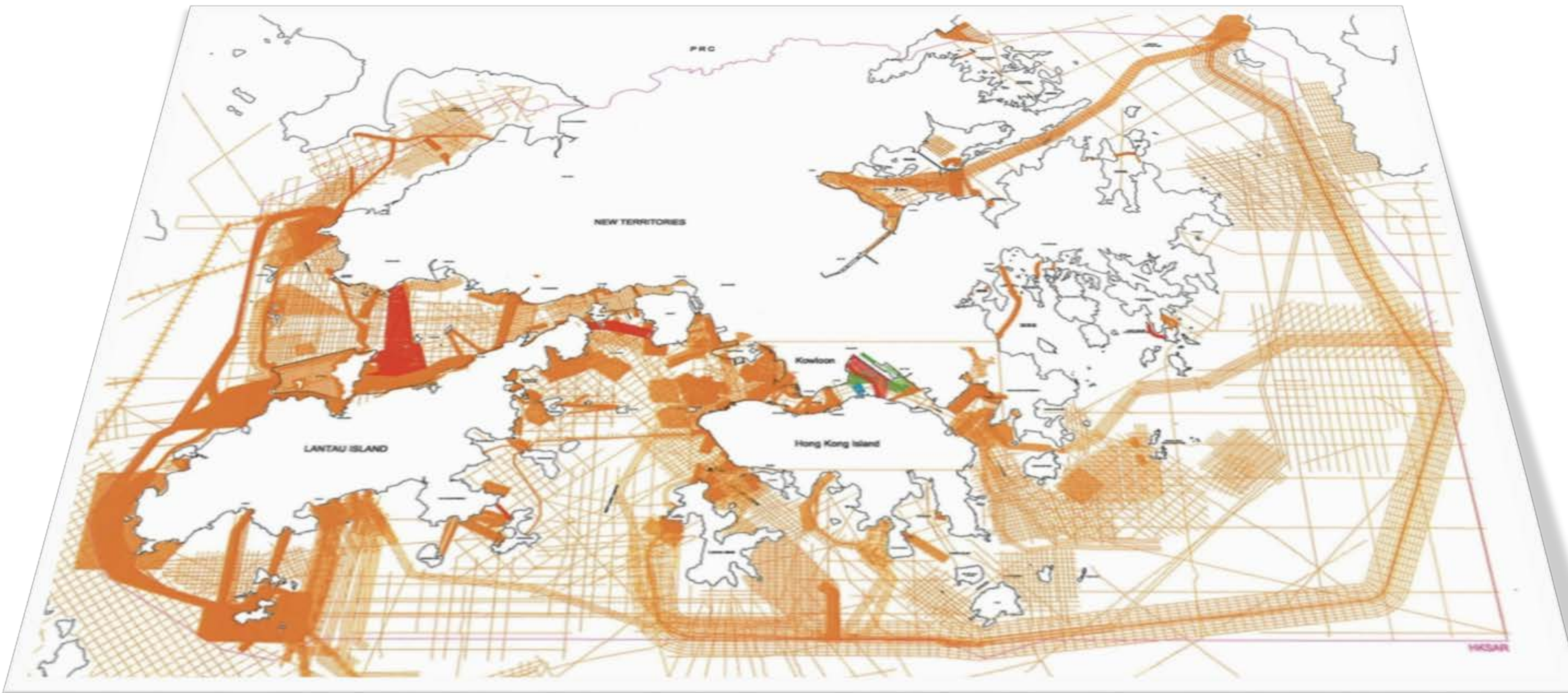





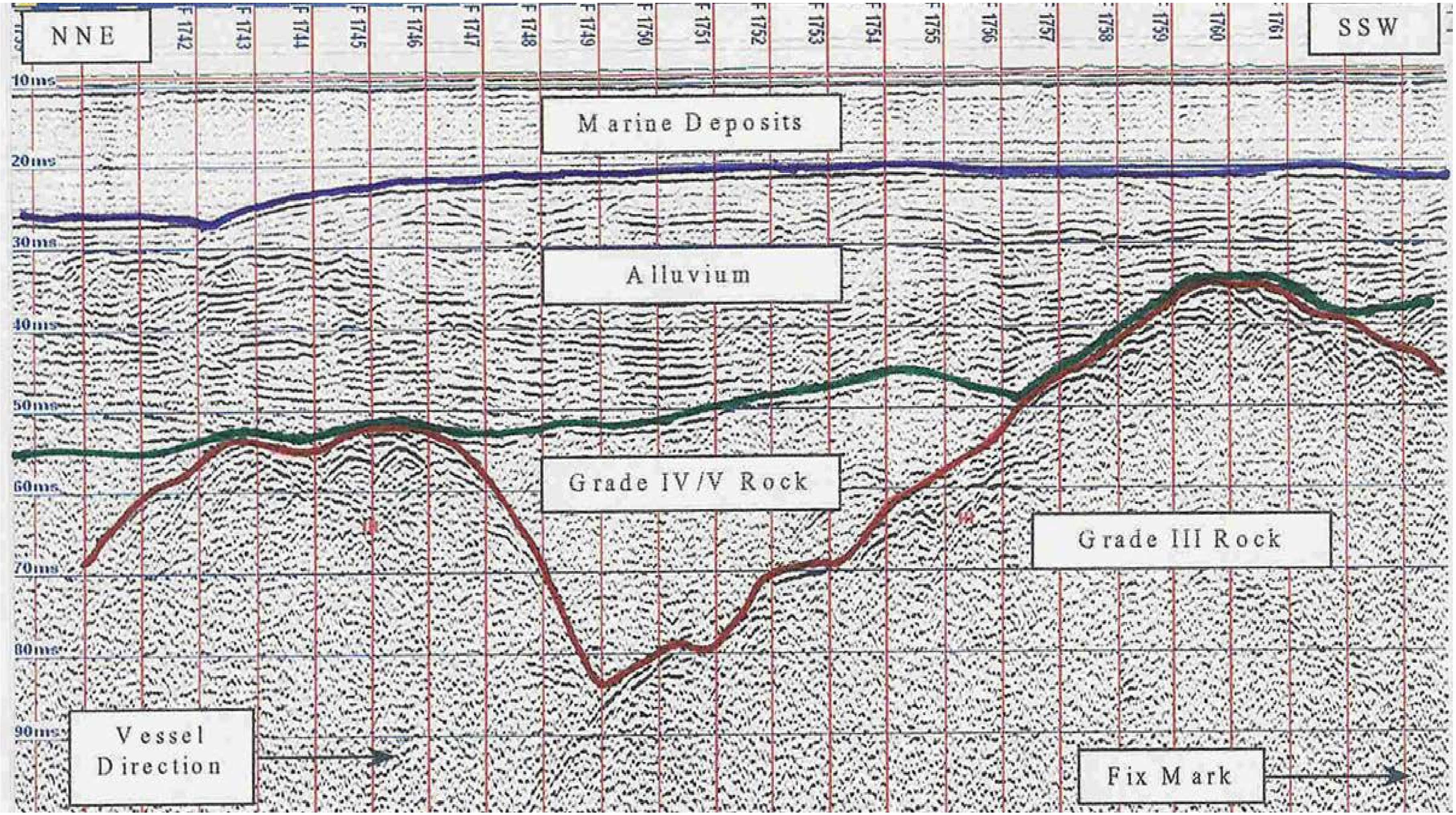

Credits: EGS

EGS
EARTH SCIENCES & SURVEYING

## Seismic lines in HK Waters



# Marine Seismic Reflection Survey



## Marine Studies:

- Fill management for reclamation
- Marine projects, tunnel alignment, bridges, sewage outfalls
- Fibre optic cable routing

# Land Geophysics

Mechanical - seismic methods, surface wave dispersion, downhole seismic, acoustic televiewer, microgravity, hydro-fracturing, ultrasonic systems, impact echo

Electrical - resistivity, self potential, induced polarization, electrical cylinder

Electromagnetic - ground penetrating radar, crosshole radar, locators, electromagnetic, conductivity meter, permittivity

Magnetic - magnetometer, locator

Radiometric - natural gamma spectroscopy, gamma density and neutron porosity

Thermal - infrared thermography

## Urban Geophysics - Hong Kong Experience

# Prior to 1995

- Few studies - retaining wall survey using GPR, microgravity work to detect underground caverns
- Developments of geophysical techniques for subsurface utility and water leakage detection

# Geotechnical application:

## Slope and retaining wall assessment

1994 Kwun Lung Lau
Retaining Wall Collapse

1995 Shum Wan Landslide

1995 Chai Wan Landslide
(Source of pics: civcal.media.hku.hk)

## 1995-1999

Collapse of retaining wall in 1994 & 2 major landslides in 1995

3 Phases of Geophysical Site Characterisation Study to study the feasibility of use of non-invasive geophysical methods to assess slope and retaining wall stability

# Government Geophysical Site Characterisation Studies1995-1999

Geophysical surveys of slope and retaining wall

## Urban Geophysics - Hong Kong Experience

**Since 2000**

New Research Methods (surface wave, gamma spectroscopy, GEOTEK system etc)

Developments of applied geophysics capabilities:

HKU: resistivity, shallow seismic, gamma ray spectroscopy, gravimetrics, magnetics, infrared thermography, downhole geophysics;

HK Polytechnic U: GPR; smart ball technology

HK U Sci & Tech: electrical imaging - Ohmapper

# Factors to be considered in selection of methods:

1. Ability to identify contrasting physical properties in subsurface ground;
2. Non-invasive;
3. Ability to produce a continuous section;
4. Fast and inexpensive;
5. The method should give some indications on the depth, size and extent of the target;
6. No significant disruption to traffic;
7. Not affected by electromagnetic interferences and radio noises in city.

# Seismic Methods

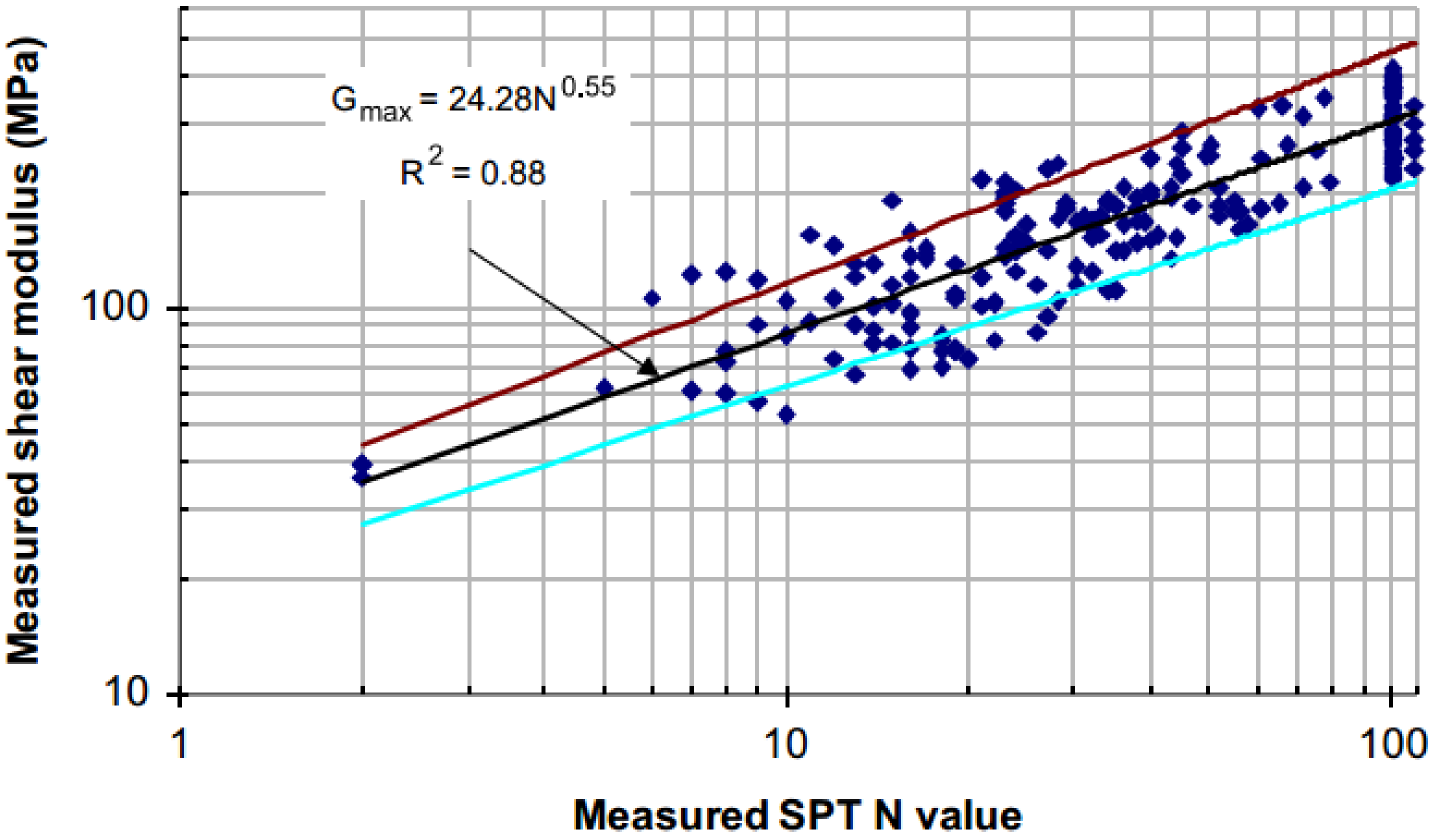
$$V_P = \sqrt{\frac{k + 4/3\,\mu}{\rho}} = \sqrt{\frac{\lambda + 2\mu}{\rho}}$$

$$V_S = \sqrt{\frac{\mu}{\rho}}$$

In-situ elastic parameters can be estimated from seismic velocities

# Relation between shear modulus and S-wave velocity

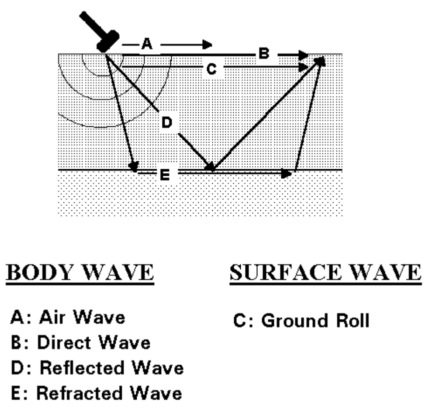
$$G = Vs^2 \rho$$

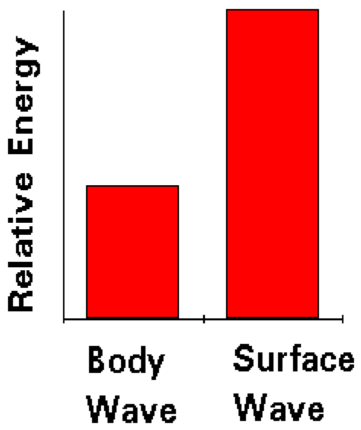


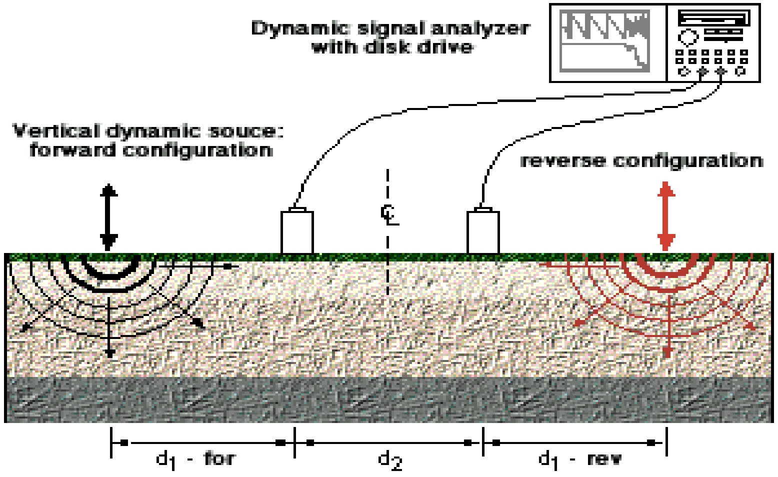

Review of correlations between SPT *N* and shear modulus: A new correlation applicable to any region

P. Anbazhagan*, Aditya Parihar, H.N. Rashmi

# Spectral Analysis of Surface Wave (SASW)



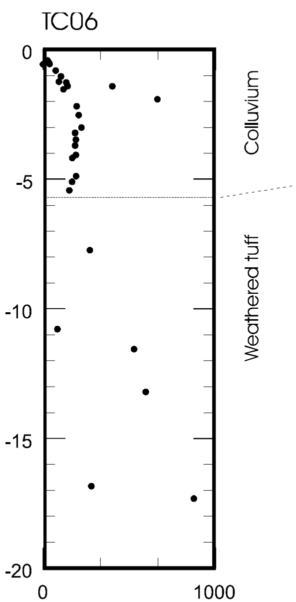



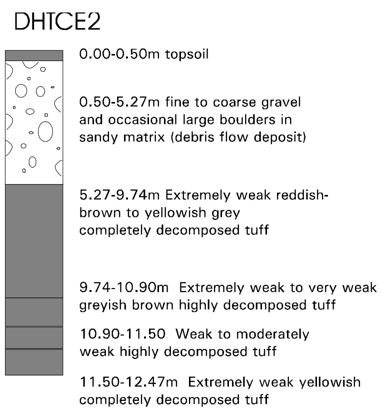



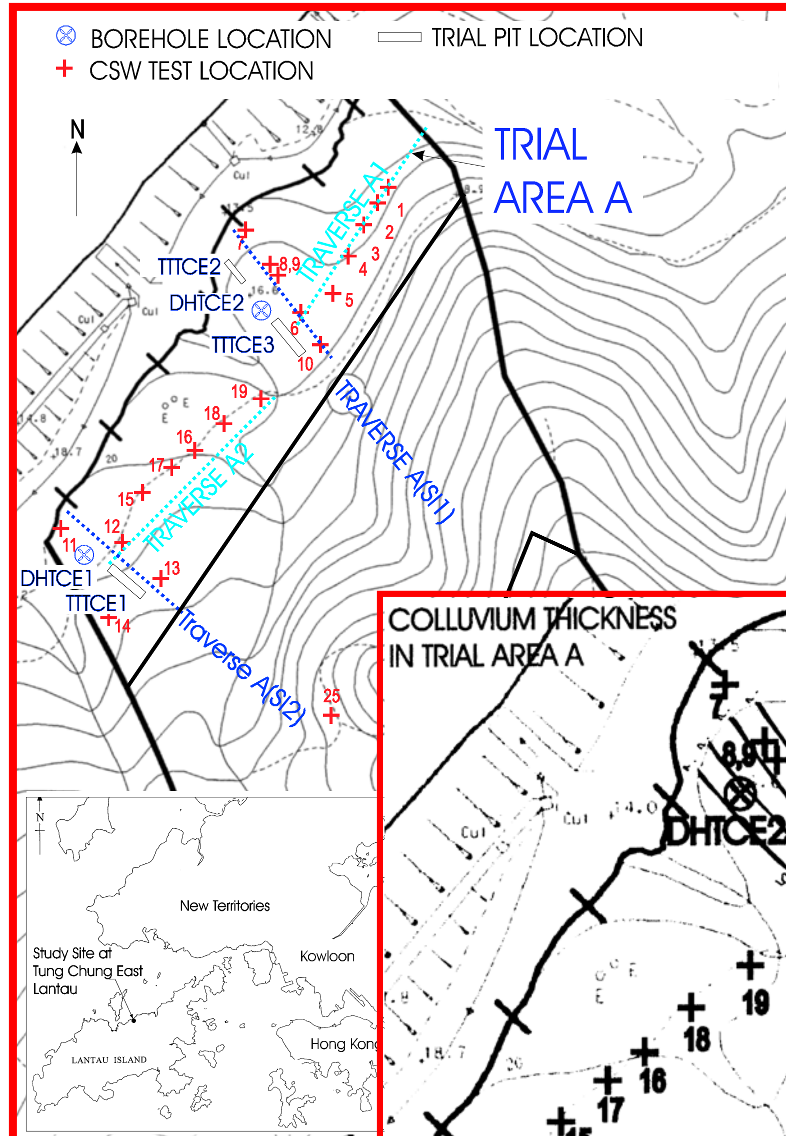

- Surface wave is dispersive: Rayleigh wave (LR) velocity depends on frequency
- SASW to determine Rayleigh wave (LR) dispersion profile
- Vs obtained from LR velocities
- G obtained from Vs
- Depth estimated from LR wavelength

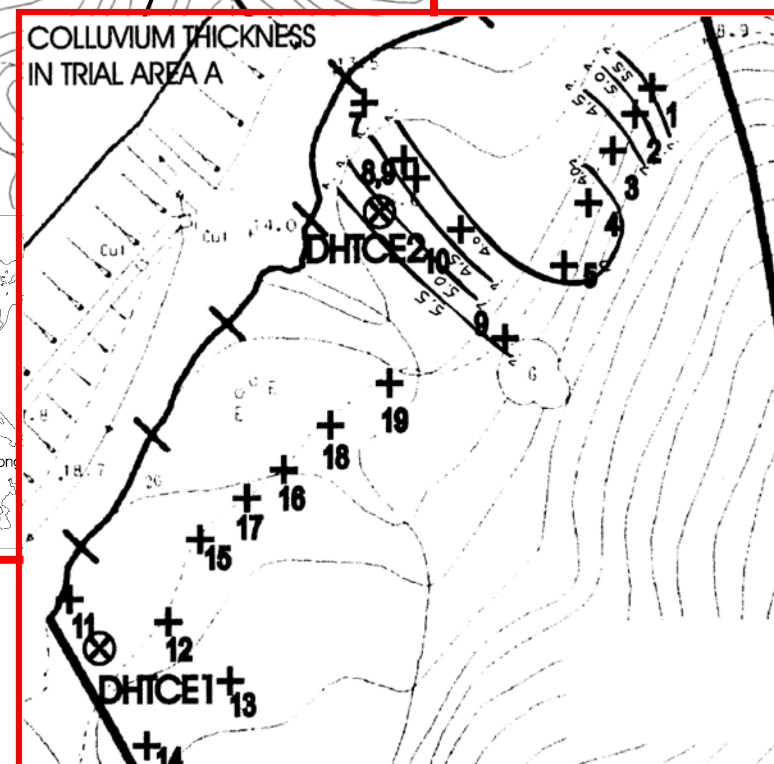
# Continuous Surface Wave System

Tung Chung East colluvium thickness mapping



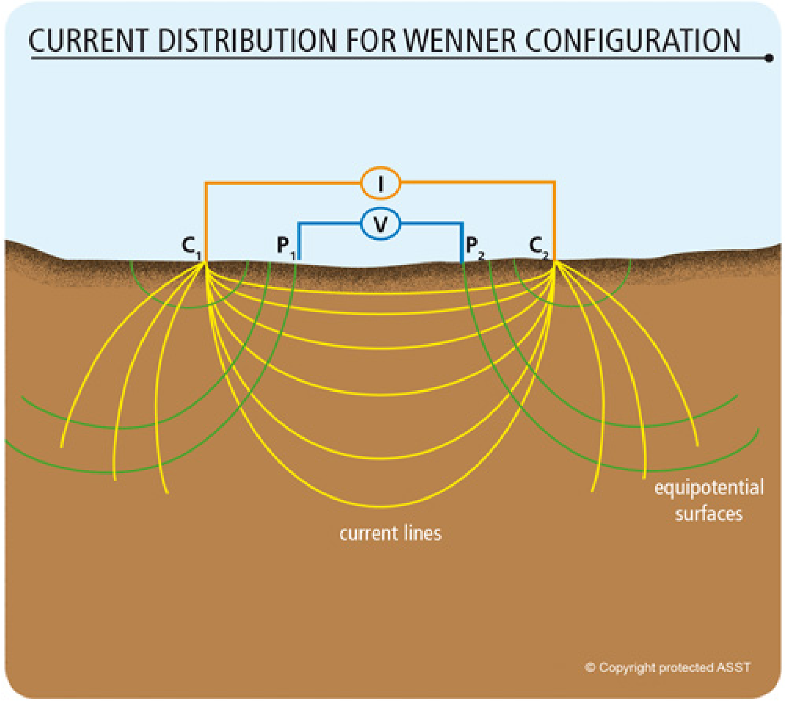

# Shear modulus profile

# Electrical imaging method

A set amount of current in injected into the ground through a pair of current electrodes

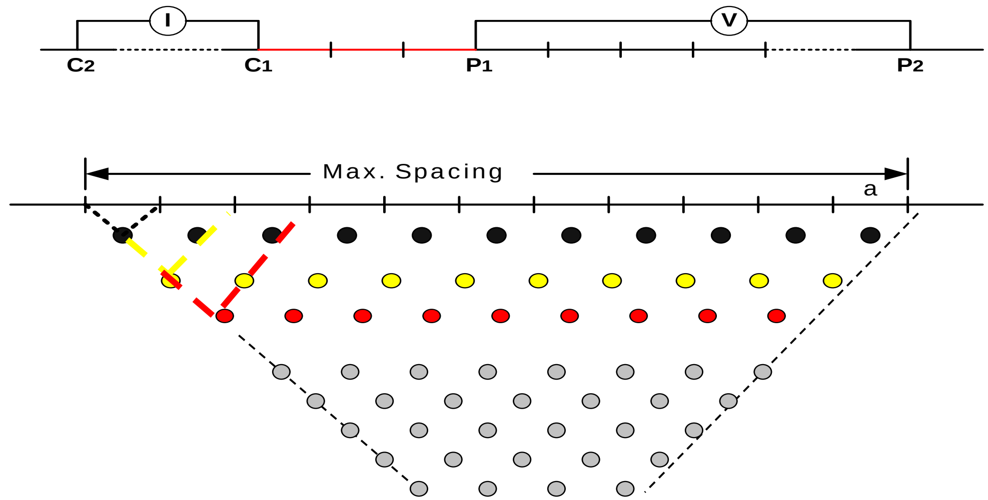
Potential differences between a pair of potential electrodes are measured with a resistivity meter

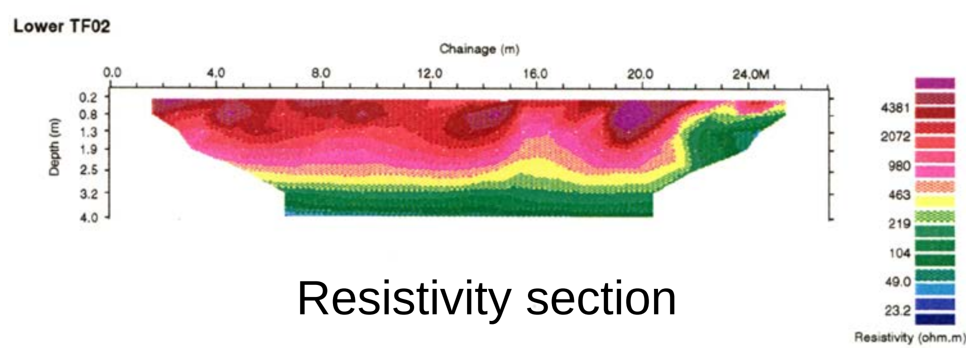
Electrodes are moved to achieve various depth of penetration

# Electrode configurations

The arrangement of current and potential electrodes in a resistivity survey




Resistivity section

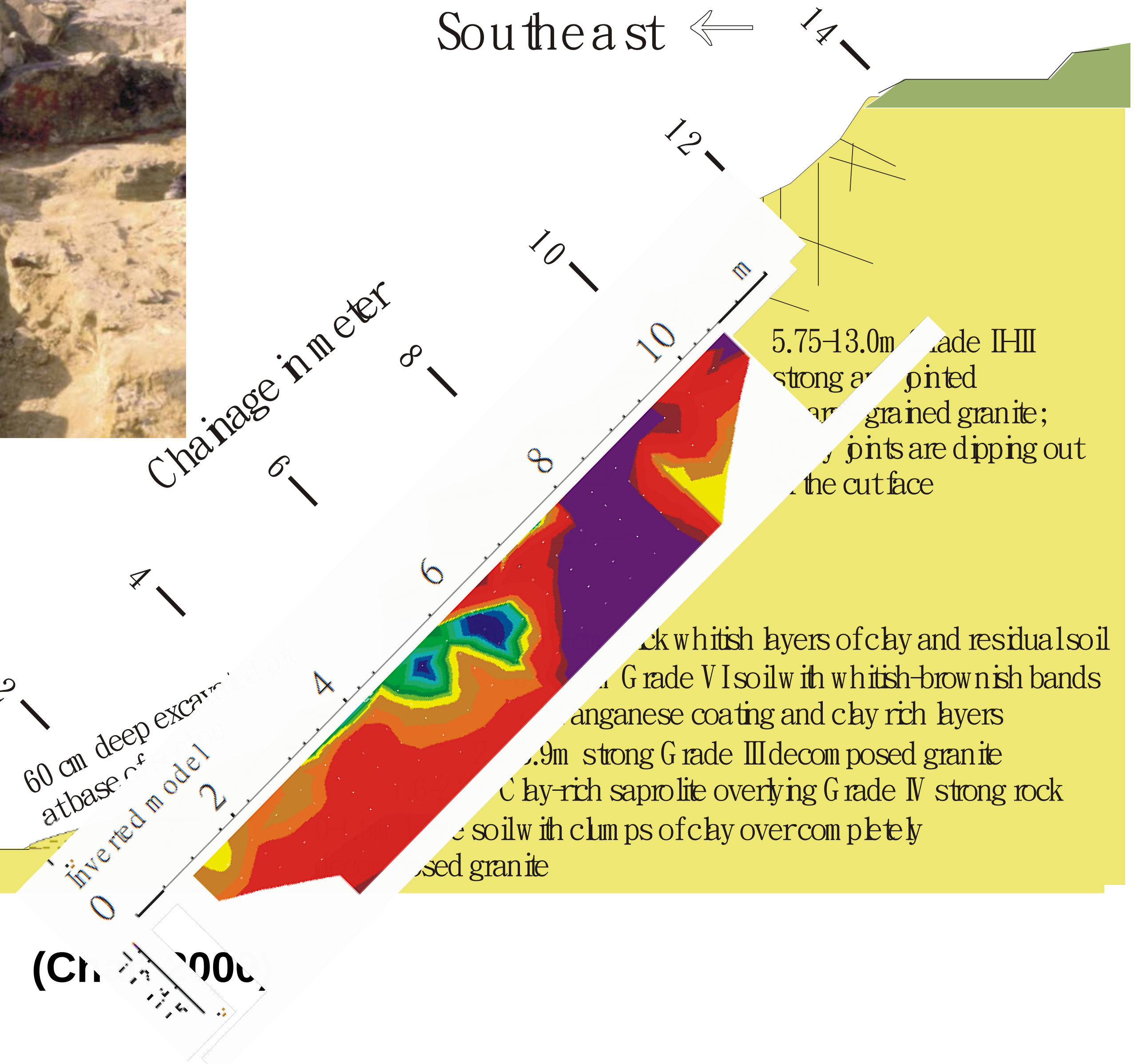
Field collection of data

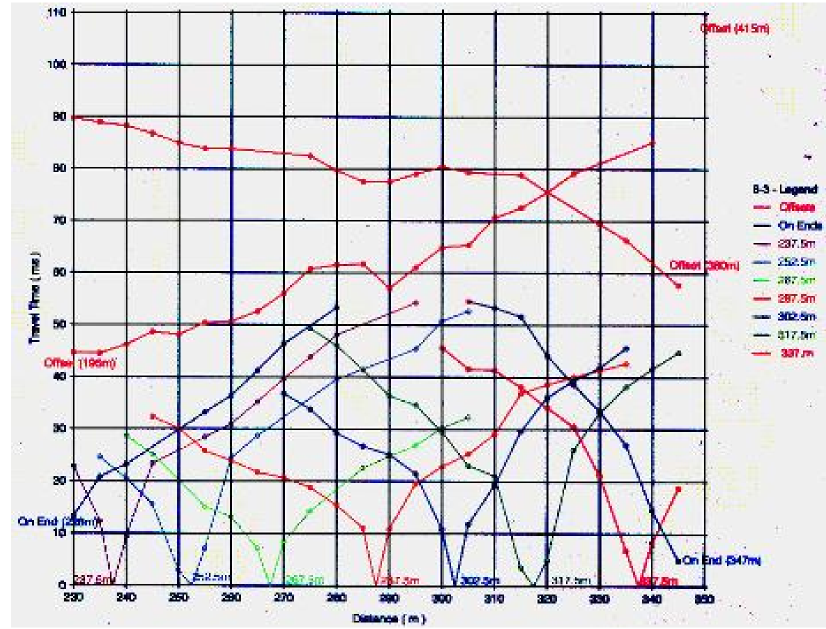
- Ground profile
- Voids and moisture zone
- Water table
- Clay layers
- Contaminated ground
- Metallic objects

# Approximate Values of Resistivity

| | |
|---|---|
| Grade I granite/tuff | >2000 Ωm |
| Grade III-IV (Dry) | 500-5000 Ωm |
| Grade III-IV (Saturated) | 200-500 Ωm |
| Grade V (Saturated) | 100-300 Ωm |
| Clay-rich soil | 30-200 Ωm |

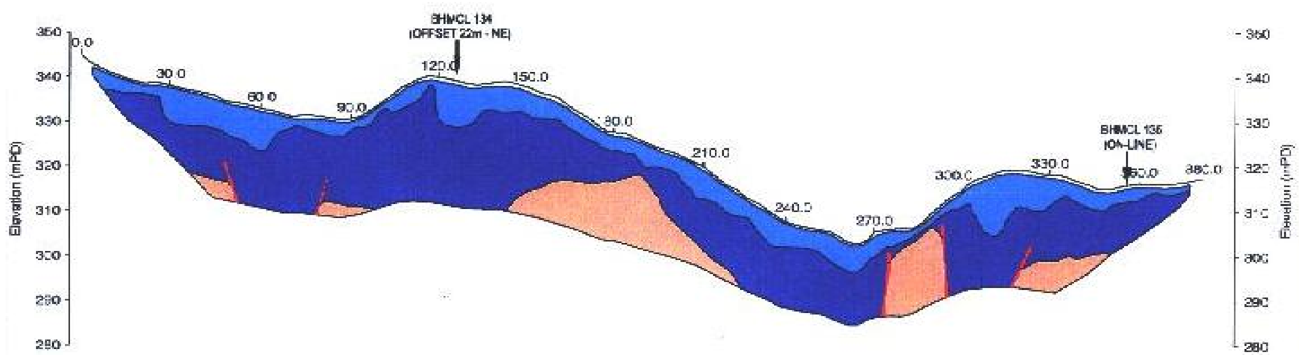
# Resistivity survey at Tiu Keng Leng





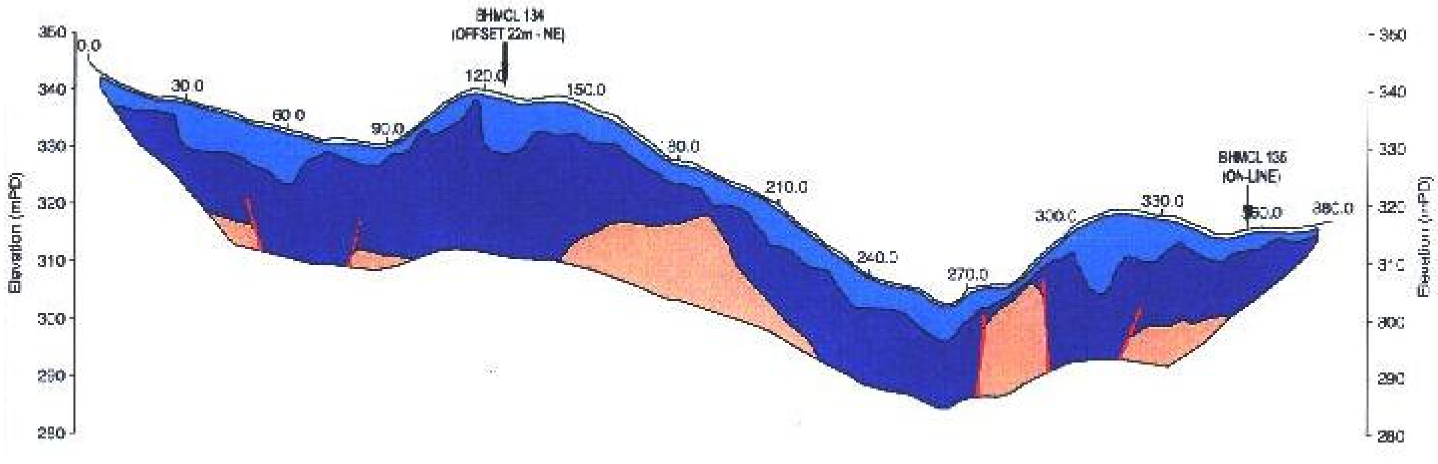

Picture from internet source

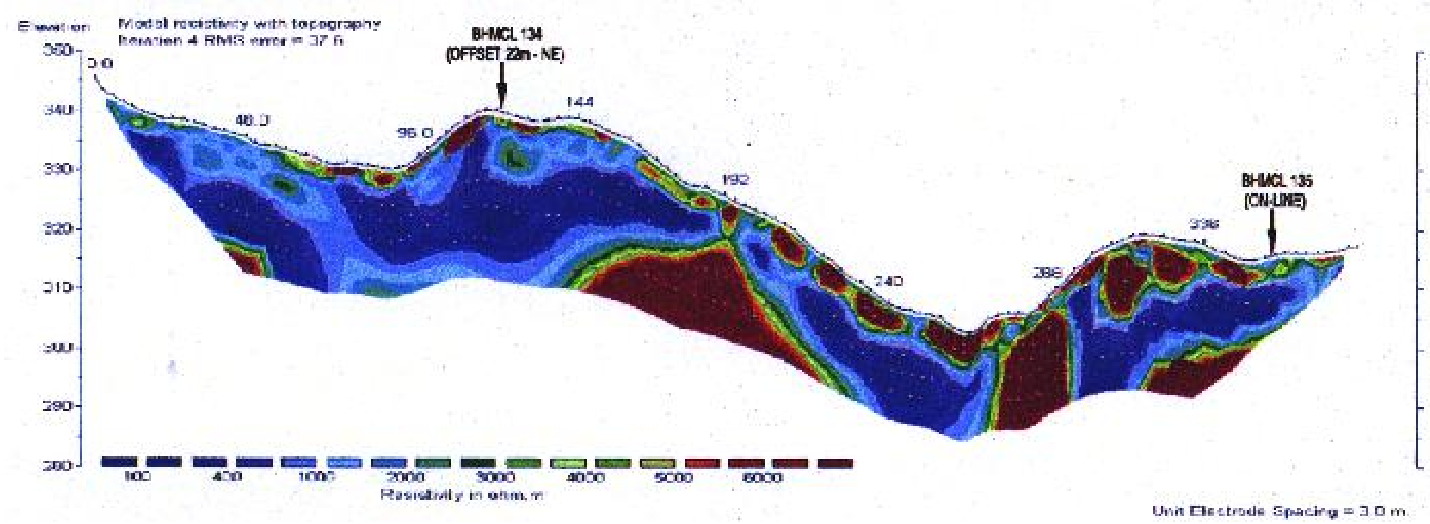
Tung Chung Road, Lantau Is. Widening Project




Fugro Geotechnical Services

# Comparison of seismic and electrical imaging results



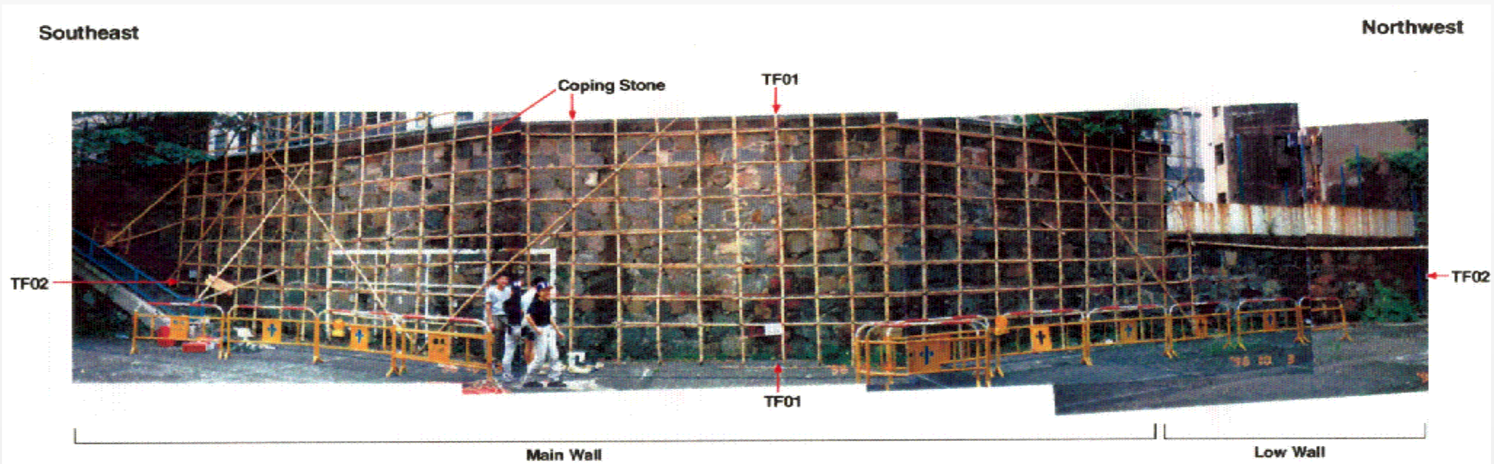



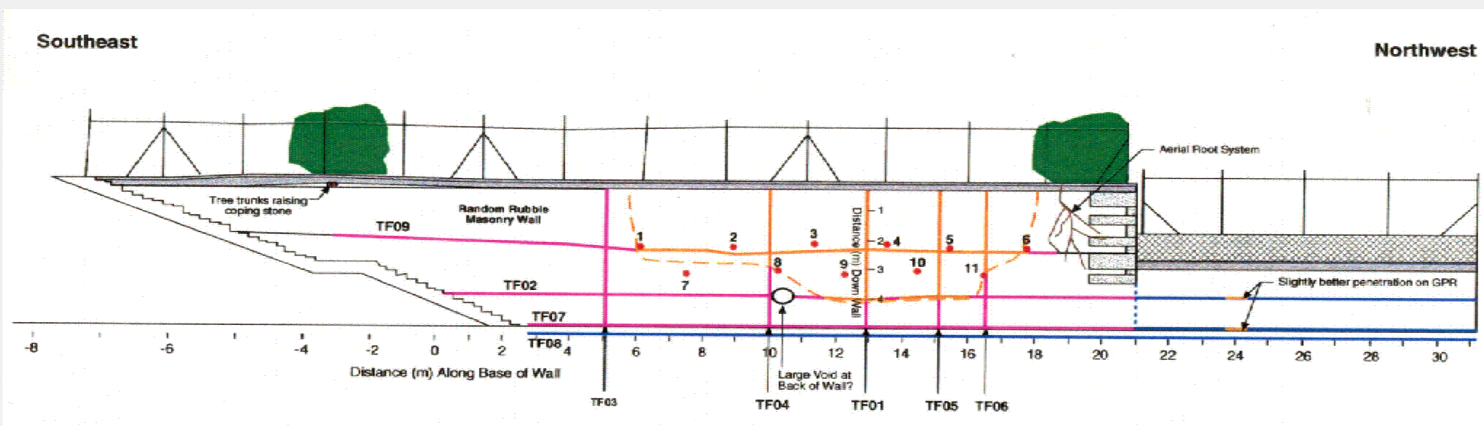

Fugro Geotechnical Services

# Comparison of electrical and ground radar imaging result

## Geophysical Results from TF02 (Golder Associates, 1996)

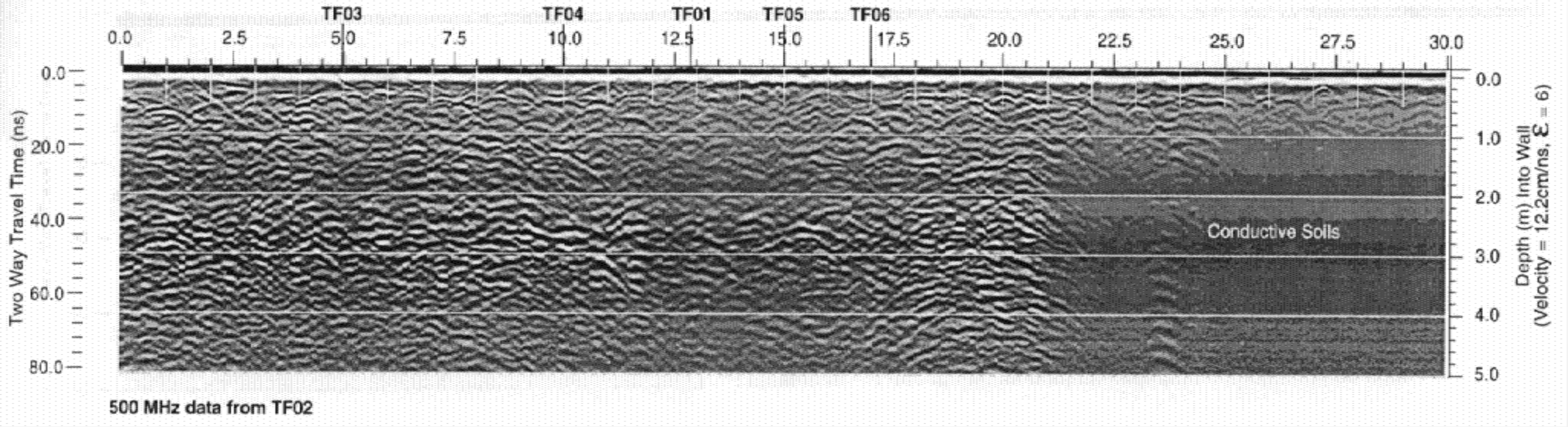
### Retaining Wall at Hollywood Road Police Staff Quarter



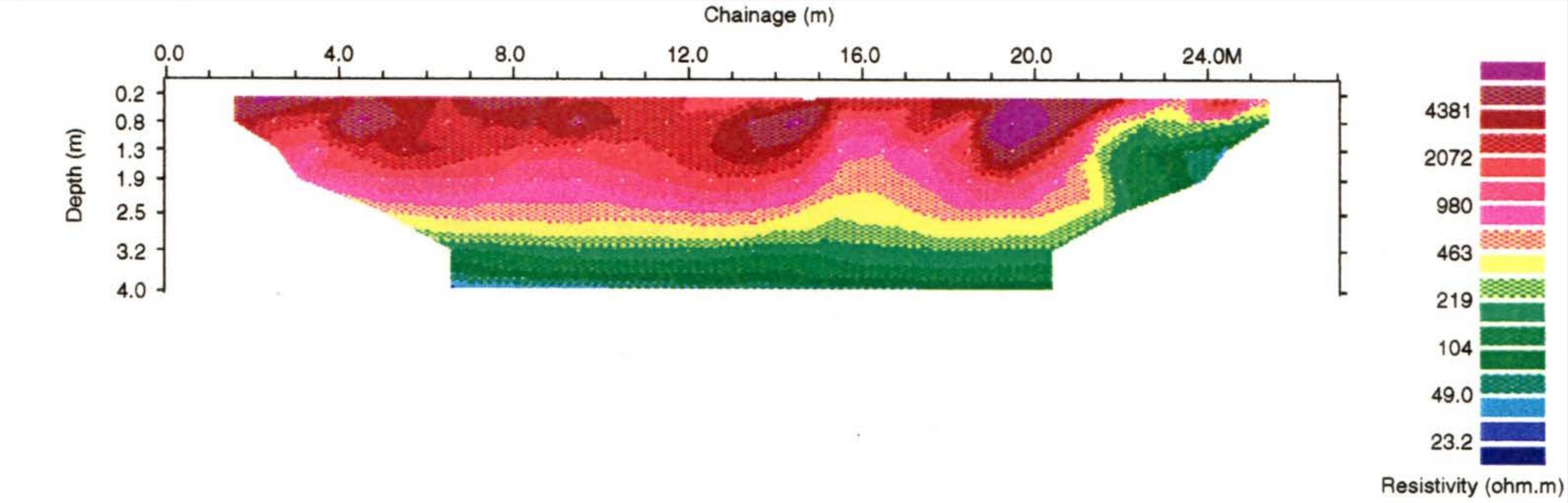



# Geophysical Results from TF02 (Golder Associates, 1996)

**GPR, 500 MHz, SIRII**

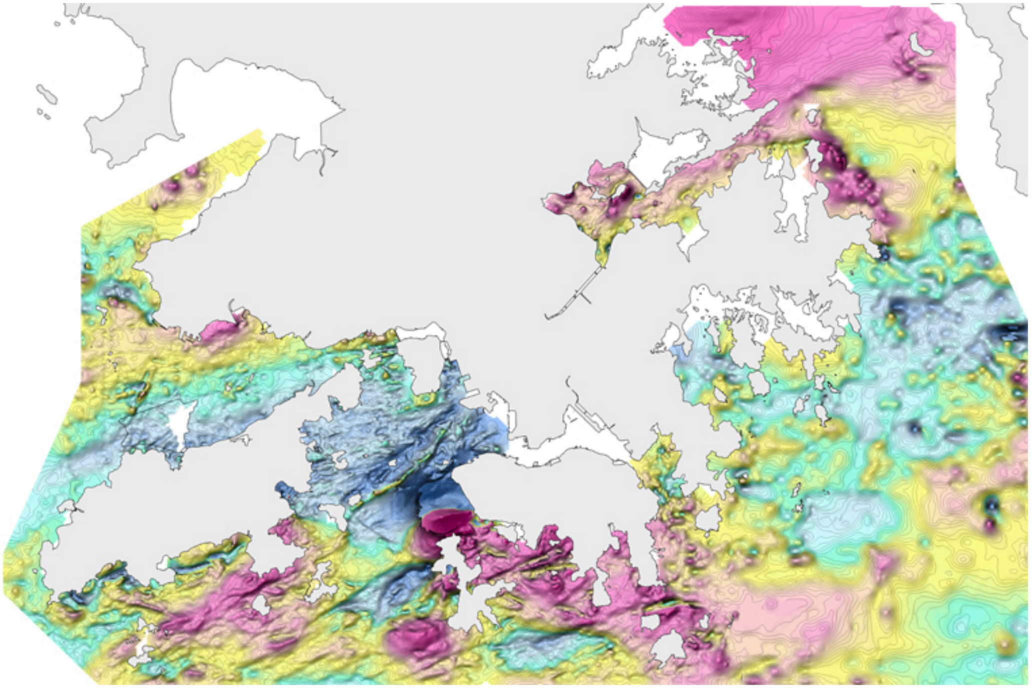



**Inverted resistivity section**



# Other methods: Magnetometer Survey

Magnetic anomaly map showing major structural lineaments in Hong Kong Harbour (GEO)



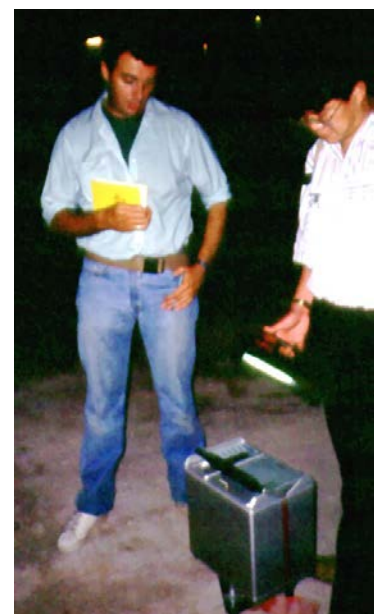
# Microgravity

Microgravity survey to detect adverse ground conditions such as subsurface cavities

$$g = \frac{G\,m}{R^2}$$

gravity meter resolution: 0.001 mgal
precision: 0.01 mgal

Micro-gravity survey at proposed site for new KCRC Central Station

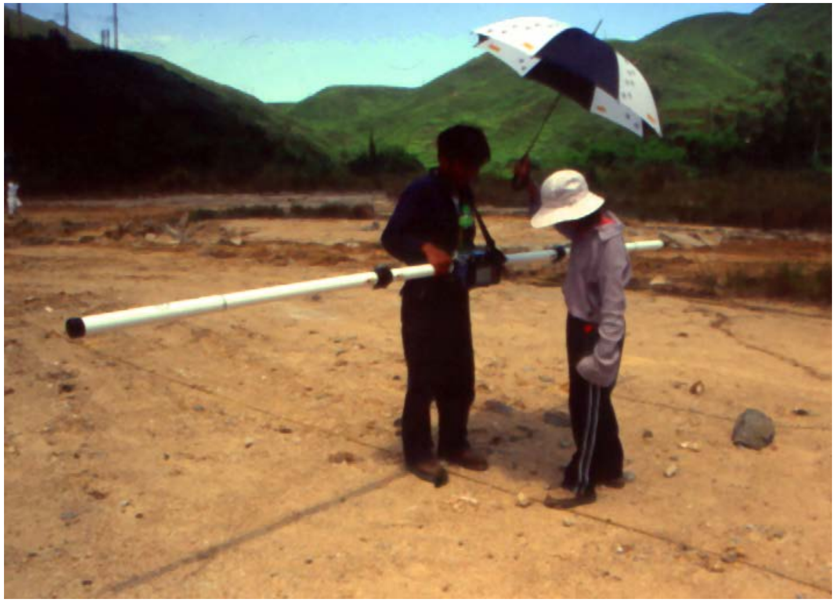


# Electromagnetic survey

Choy Lee Ship Yard

Penny's Bay Power Station

## Environemental survey at Penny's Bay using conductivity meter



Camela Wong (rt. 1999, EGS) undertaking EM survey at Penny's Bay

# Permittivity and GPR mapping

Pavement Survey at Airport Runway


GPR survey at runway

Permittivity survey

# Downhole geophysical methods used in Hong Kong

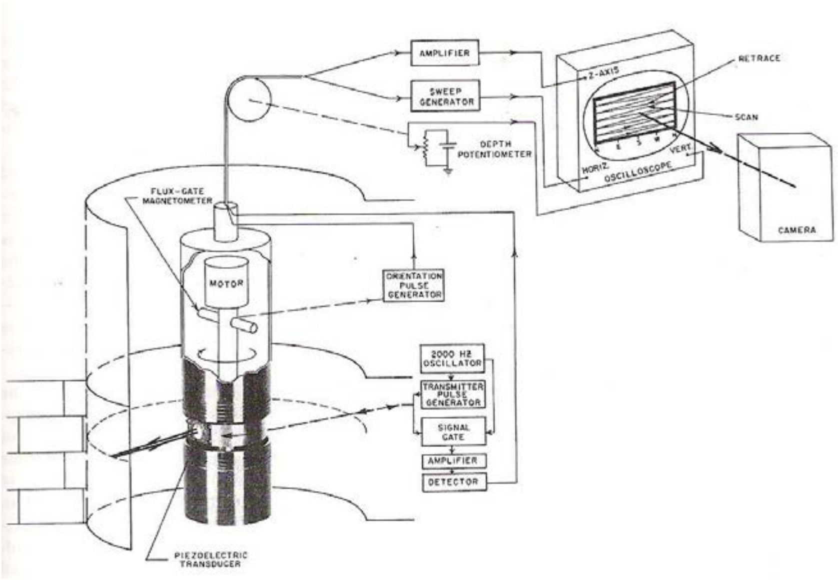
Downhole resistivity
Gamma density
Natural gamma intensity
Low rate heat flow
Magnetic susceptibility
Spectral gamma
Crosshole radar
Crosshole and downhole seismic
Electrical cylinder
Neutron porosity
Acoustic televiewer
Borehole CCTV
Magnetic vector

# Acoustic Televiewer

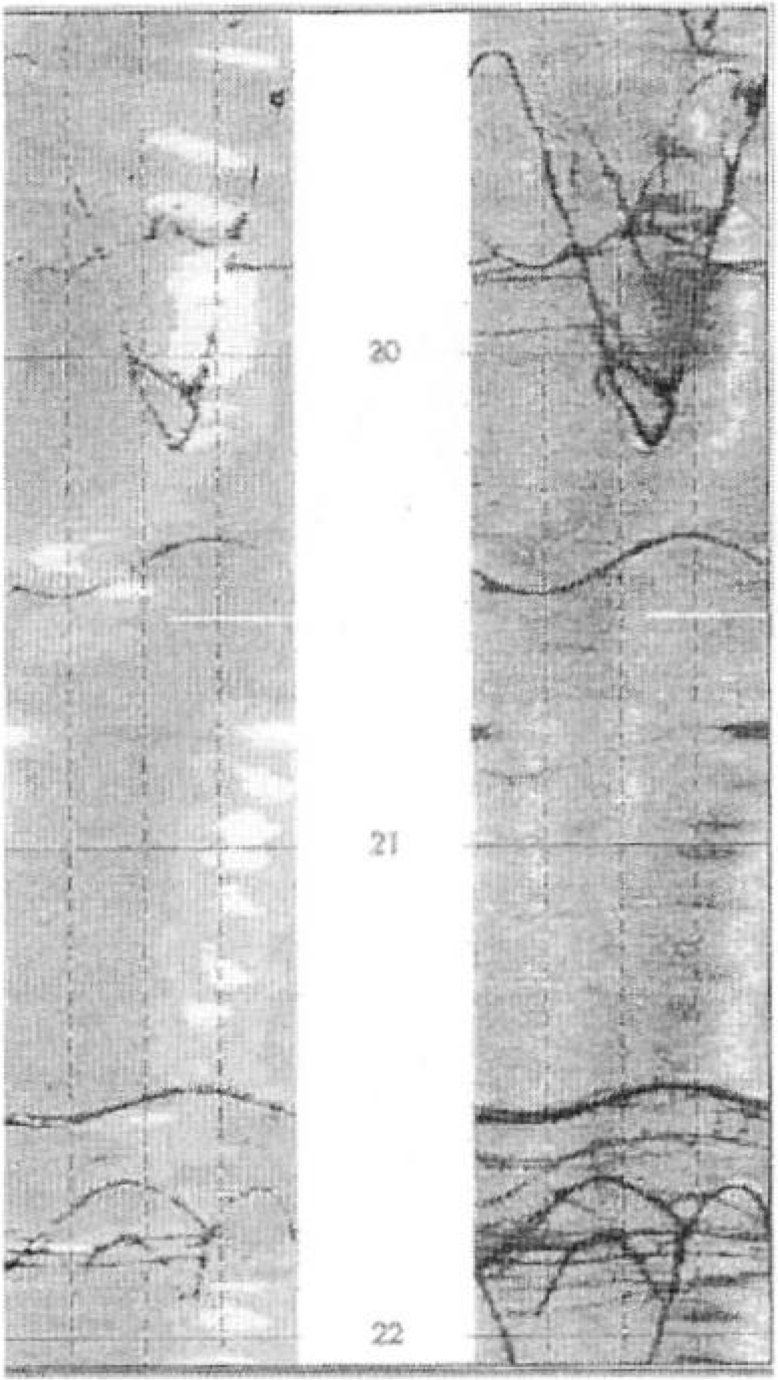
Principle: transmitting ultrasound pulses from a rotating sensor and recording the amplitude and travel time of the signals reflected from wall.

Specifications: 250KHz up to ~2 MHz

- Fracture zones
- Clay beds
- Casing evaluation



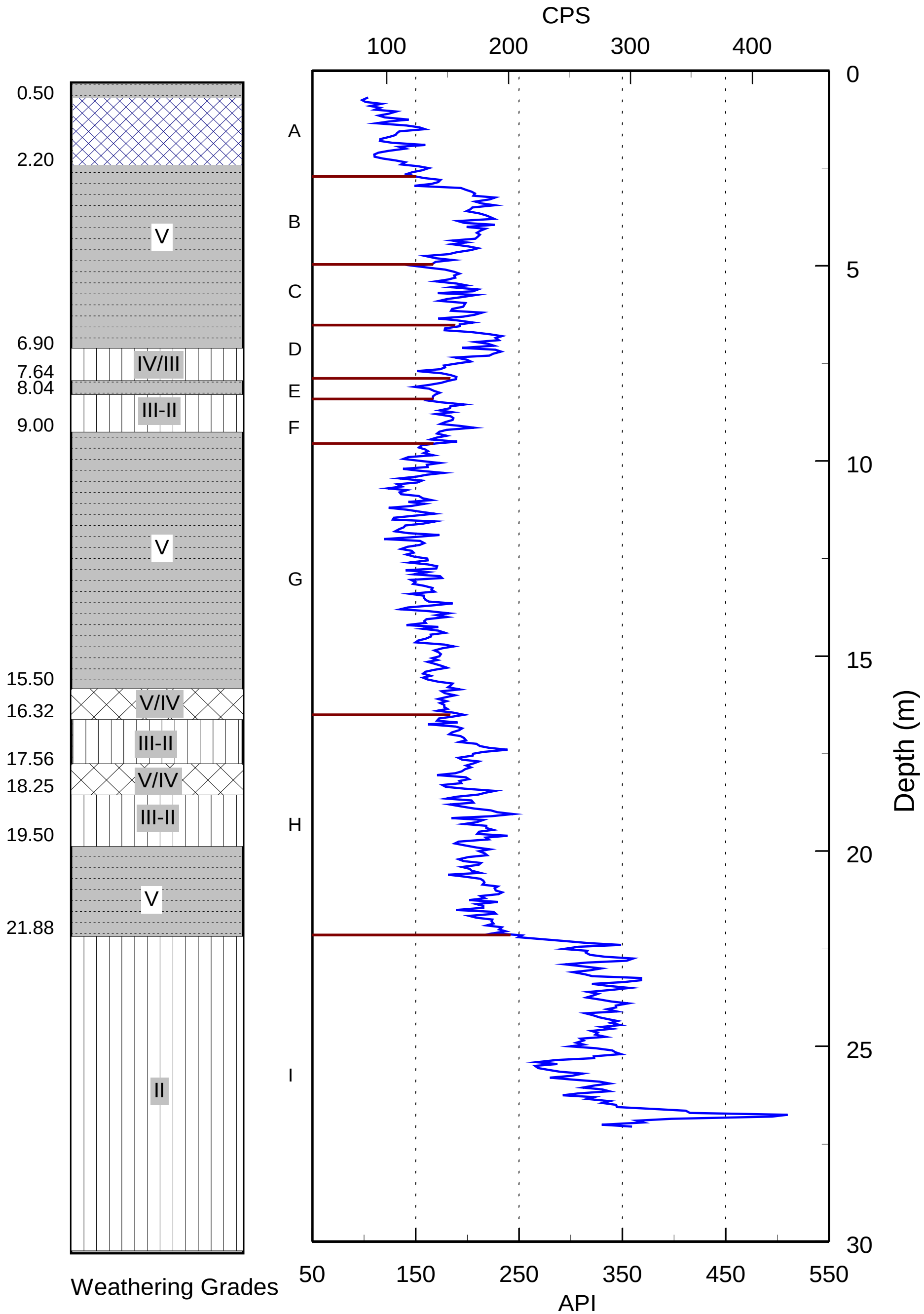

Hearst et al., Well Logging, 2000




Travel time display indicates geometry of irregularities

Dipping continuities appear as sinusoidal features

Gamma spectroscopy survey: in search of subsurface clay seams




(Chan & Chen, 2000)

Correlation between Weathering Grade and Natural Gamma Intensity of Drillhole TT2A

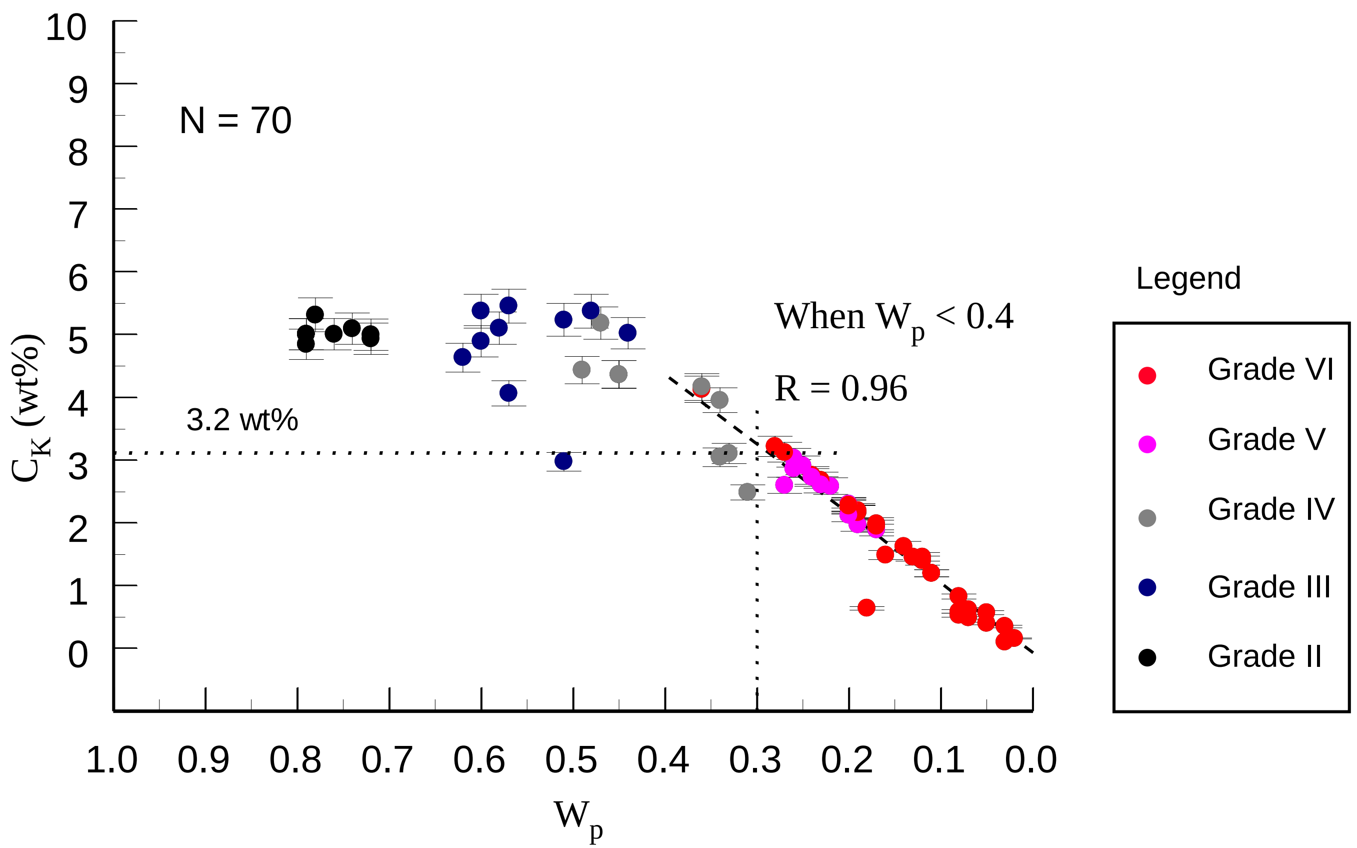
## Chemical weathering of k-feldspar

$$2KAlSi_3O_8 + 2H^+ + 9H_2O \longrightarrow Al_2Si_2O_5(OH)_4 + 2K^+ + 4H_4SiO_4$$

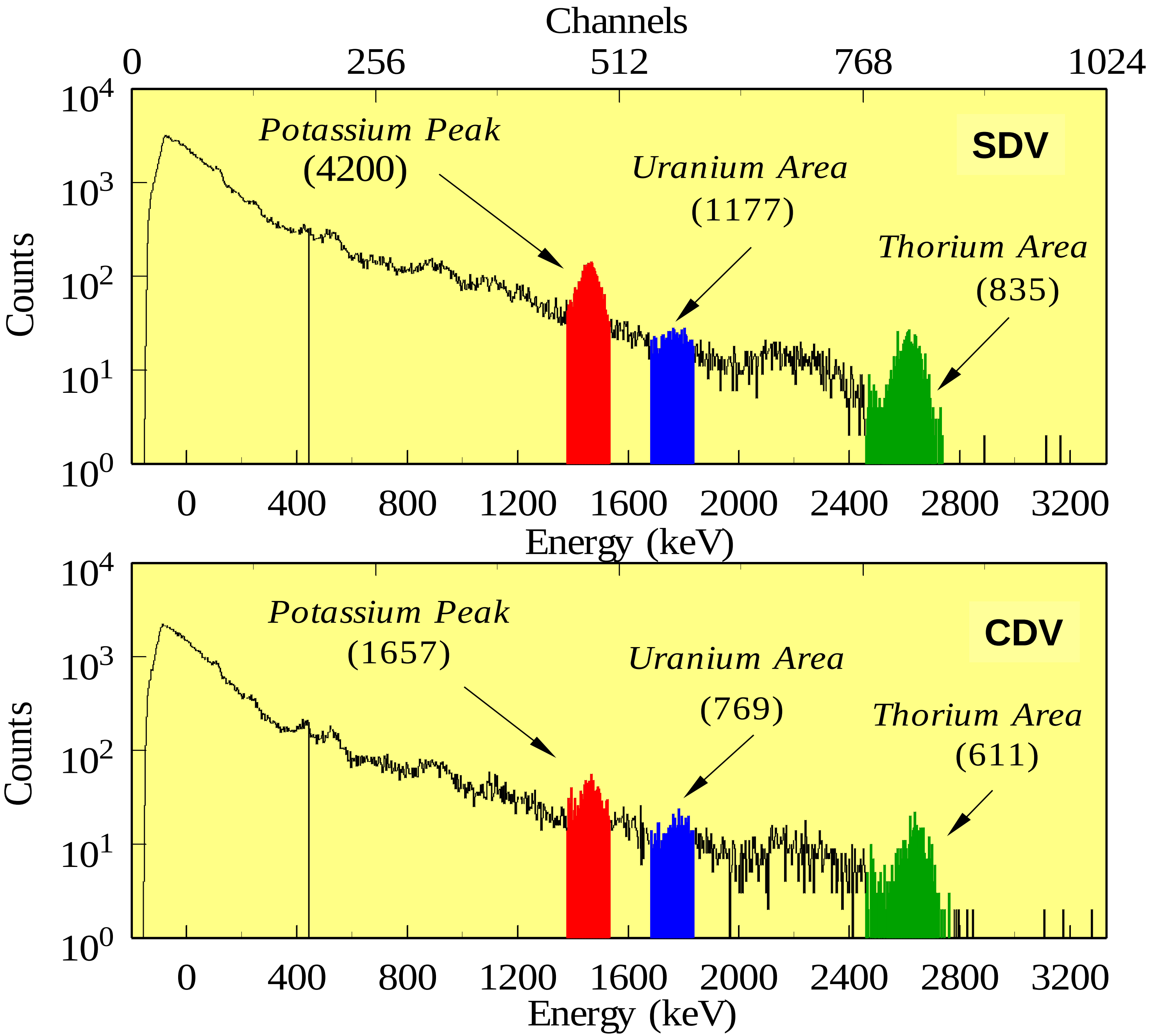
orthoclase → kaolinite

(Selby, 1993)

Three major sources of naturally occurring radioactivity: $^{40}K$, $^{238}U$ series and $^{232}Th$ series.




Variation of K content with weathering grade (Chen & Chan, 2002)



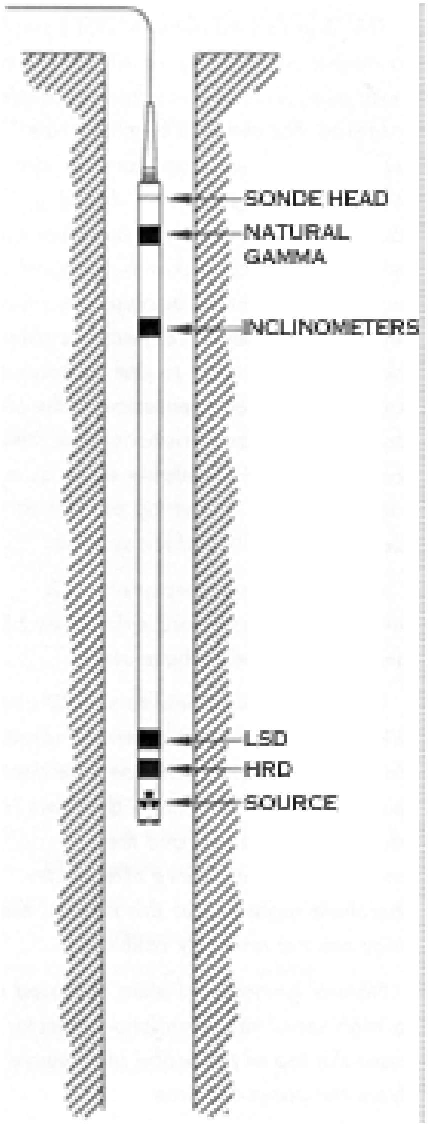
Channels
0
256
512
768
1024
Counts
Potassium Peak
(4200)
Uranium Area
(1177)
Thorium Area
(835)
SDV
0
400
800
1200
1600
2000
2400
2800
3200
Energy (keV)
Counts
Potassium Peak
(1657)
Uranium Area
(769)
Thorium Area
(611)
CDV
0
400
800
1200
1600
2000
2400
2800
3200
Energy (keV)

# Gamma density survey

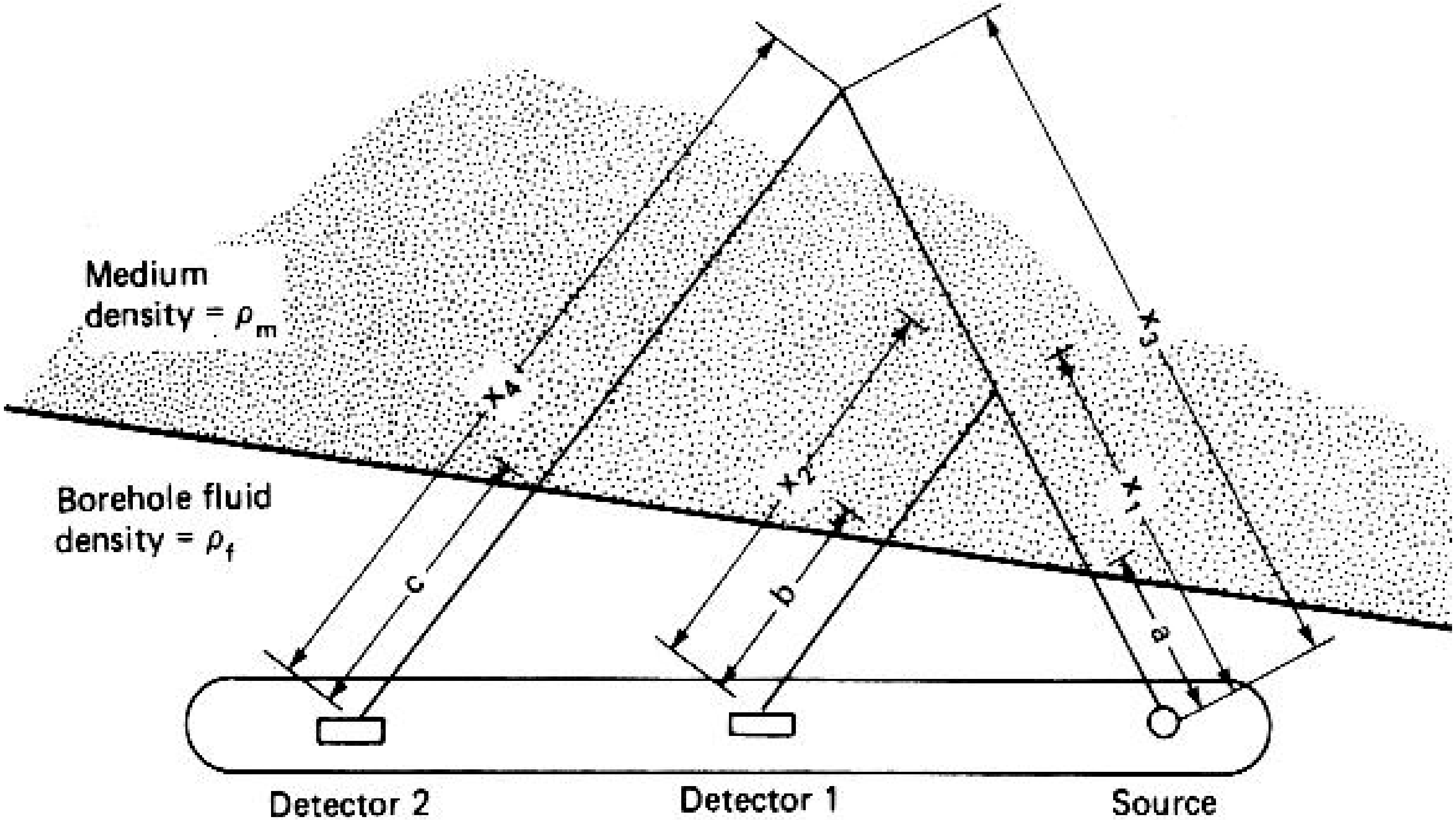
Use active Cs source and 2 detectors

Detect backscattered gamma radiation

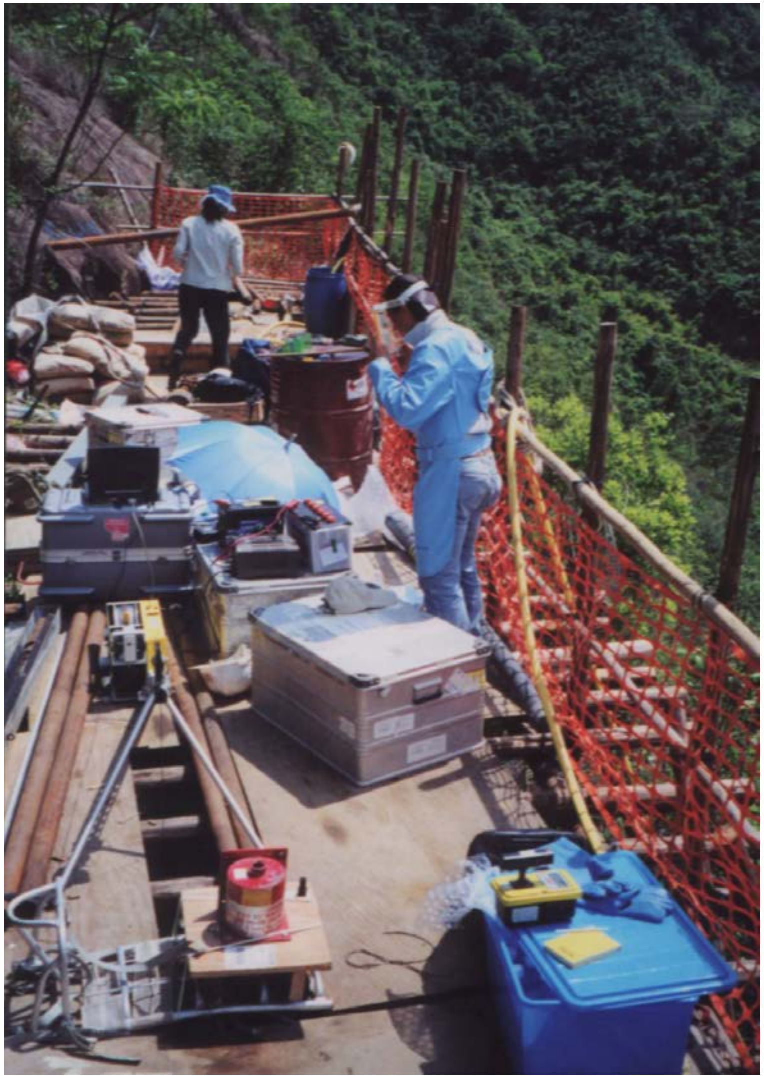
Uses two detector readings to compute density



# Gamma density method



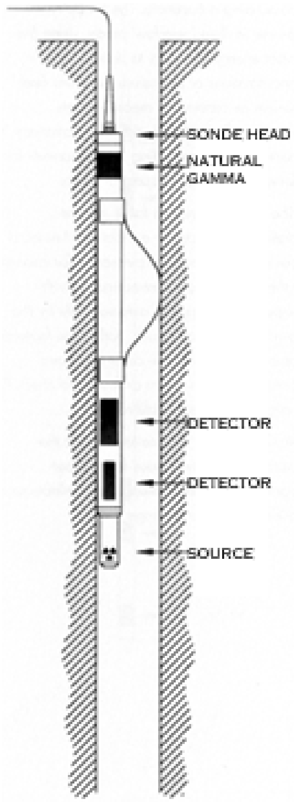
# Downhole gamma density



# Neutron porosity

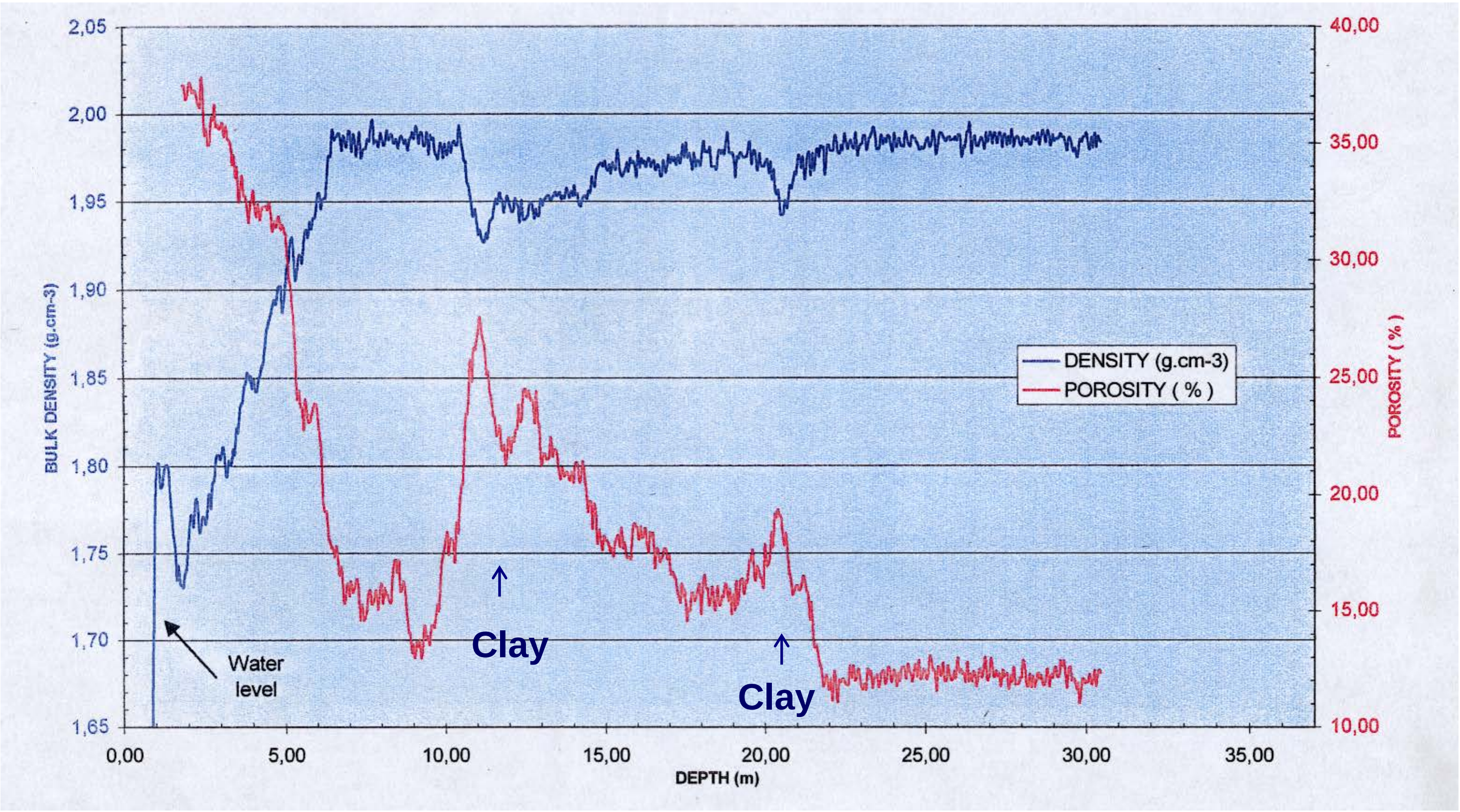
Uses an Americium source to produce neutrons which are scattered and slowed by hydrogen.

Lower counts indicate a greater porosity



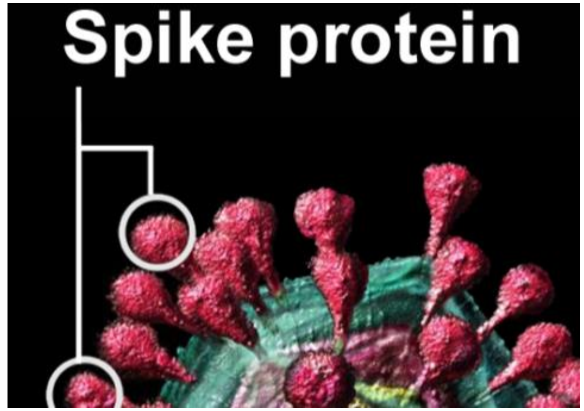

http://www.geologging.com/english/products/probes/dual_neutron.htm

# gamma density and neutron porosity surveys



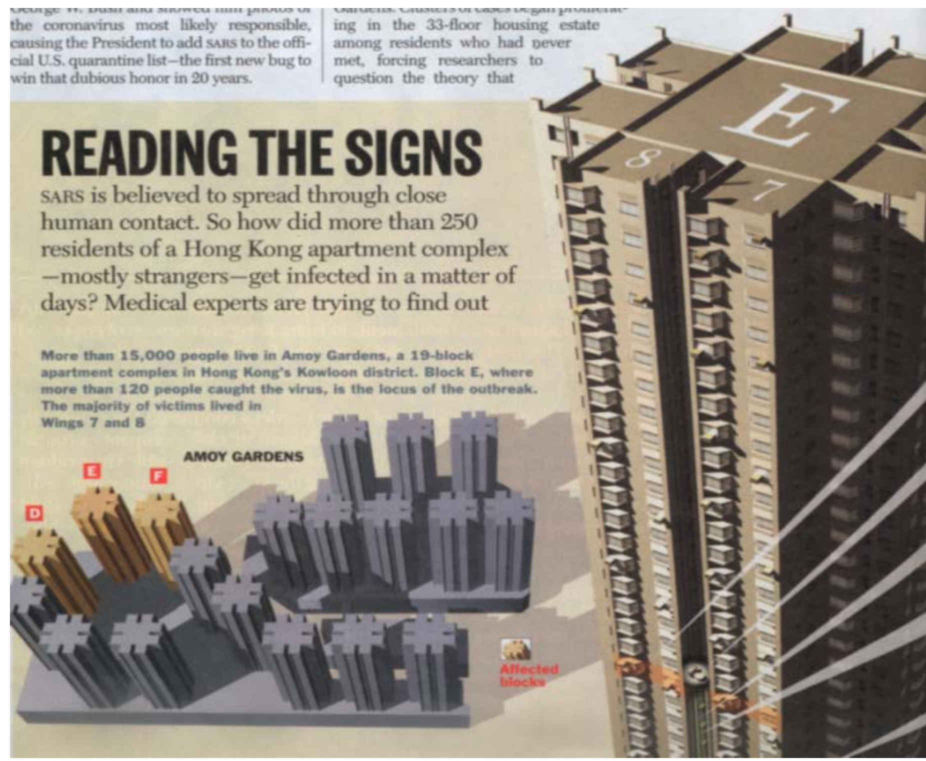

Data from E.D.G.

SARS coronavirus genome project





# SARS Outbreak 2003



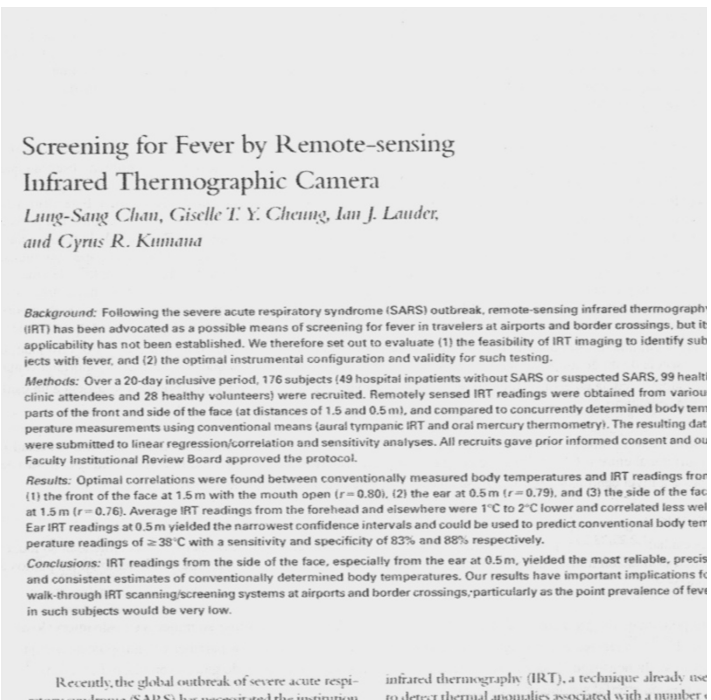
the coronavirus most likely responsible, causing the President to add SARS to the official U.S. quarantine list—the first new bug to win that dubious honor in 20 years.

Gardens. Clusters of cases began proliferating in the 33-floor housing estate among residents who had never met, forcing researchers to question the theory that

## READING THE SIGNS

SARS is believed to spread through close human contact. So how did more than 250 residents of a Hong Kong apartment complex —mostly strangers—get infected in a matter of days? Medical experts are trying to find out

**More than 15,000 people live in Amoy Gardens, a 19-block apartment complex in Hong Kong's Kowloon district. Block E, where more than 120 people caught the virus, is the locus of the outbreak. The majority of victims lived in Wings 7 and 8**



# Screening for Fever by Remote-sensing Infrared Thermographic Camera

*Lung-Sang Chan, Giselle T. Y. Cheung, Ian J. Lauder, and Cyrus R. Kumana*

*Background:* Following the severe acute respiratory syndrome (SARS) outbreak, remote-sensing infrared thermograph
(IRT) has been advocated as a possible means of screening for fever in travelers at airports and border crossings, but it
applicability has not been established. We therefore set out to evaluate (1) the feasibility of IRT imaging to identify sub
jects with fever, and (2) the optimal instrumental configuration and validity for such testing.

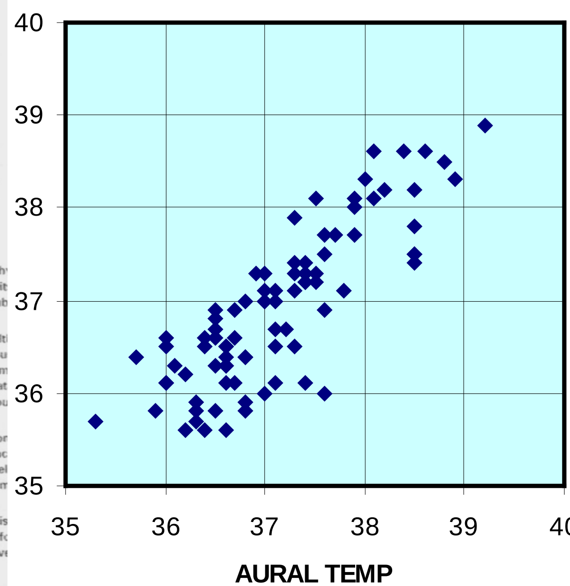
*Methods:* Over a 20-day inclusive period, 176 subjects (49 hospital inpatients without SARS or suspected SARS, 99 healt
clinic attendees and 28 healthy volunteers) were recruited. Remotely sensed IRT readings were obtained from variou
parts of the front and side of the face (at distances of 1.5 and 0.5 m), and compared to concurrently determined body tem
perature measurements using conventional means (aural tympanic IRT and oral mercury thermometry). The resulting dat
were submitted to linear regression/correlation and sensitivity analyses. All recruits gave prior informed consent and ou
Faculty Institutional Review Board approved the protocol.

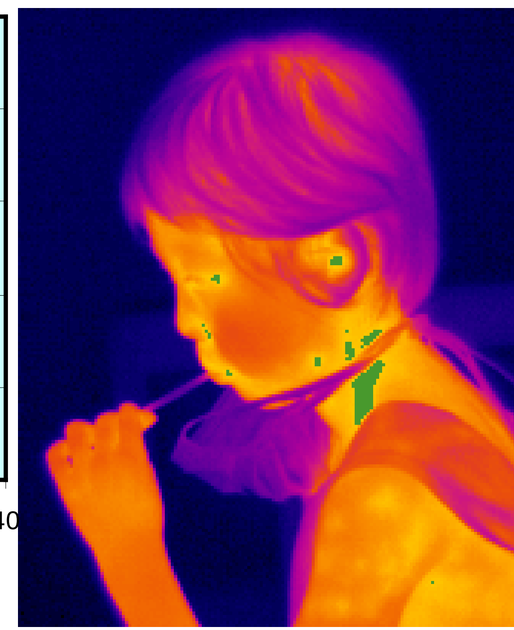
*Results:* Optimal correlations were found between conventionally measured body temperatures and IRT readings fror
(1) the front of the face at 1.5 m with the mouth open ($r = 0.80$), (2) the ear at 0.5 m ($r = 0.79$), and (3) the side of the fac
at 1.5 m ($r = 0.76$). Average IRT readings from the forehead and elsewhere were 1°C to 2°C lower and correlated less wel
Ear IRT readings at 0.5 m yielded the narrowest confidence intervals and could be used to predict conventional body tem
perature readings of ≥38°C with a sensitivity and specificity of 83% and 88% respectively.

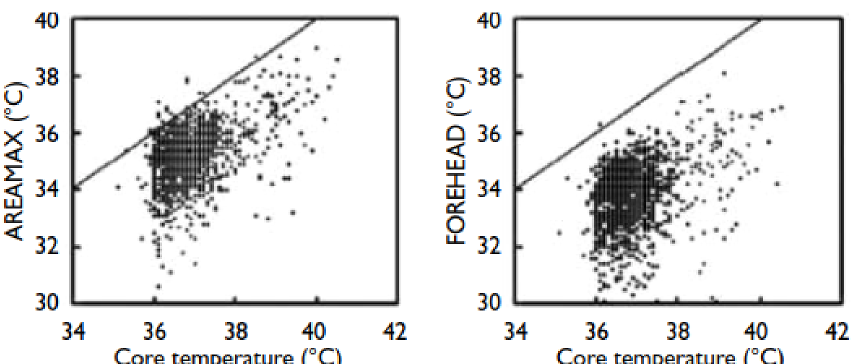
*Conclusions:* IRT readings from the side of the face, especially from the ear at 0.5 m, yielded the most reliable, precis
and consistent estimates of conventionally determined body temperatures. Our results have important implications fc
walk-through IRT scanning/screening systems at airports and border crossings, particularly as the point prevalence of feve
in such subjects would be very low.

Recently, the global outbreak of severe acute respi-
ratory syndrome (SARS) has necessitated the institution

infrared thermography (IRT), a technique already use
to detect thermal anomalies associated with a number






ORIGINAL ARTICLE

# Utility of infrared thermography for screening febrile subjects

LS Chan 陳龍生
Jessica LF Lo 盧玲芬
Cyrus R Kumana 顧崇仁
Bernard MY Cheung 張文勇

**Objective** To assess the utility of remote-sensing infrared thermography as a screening tool for fever.

**Design** Cross-sectional study comparing body temperatures measured by remote-sensing infrared thermography (maximum for frontal, forehead, or lateral views) with core temperatures measured by aural or oral methods.

**Setting** Accident and Emergency Department, Queen Mary Hospital, Hong Kong.

**Participants** A total of 1517 patients (747 men, 770 women) with or without fever; 34 of whom entered a substudy to measure the effects of distance on recorded temperature.

**Main outcome measures** The proportions of subjects with fever (core temperature of 38°C or above) detected by remote-sensing infrared thermography compared with the proportion detected by conventional thermometry.

**Results** The correlations between infrared thermography temperatures and core temperature were only moderate ($r$=0.36-0.44), albeit statistically significant. The temperature recorded by infrared thermography was inversely proportional to the distance from the camera. There were 113 (7.4%) subjects with a core temperature of 38°C or above. The areas under the receiver operating characteristic curves for the three infrared thermography measurements were around 0.8. However, the maximum sensitivity achieved at a low cut-off temperature of 35°C was only 0.87 (for frontal and lateral infrared thermography views), resulting in 13% of febrile subjects being missed. The maximum forehead temperature in general had the poorest performance among the three infrared thermography views.

**Conclusions** Forehead infrared thermography readings from a distance should be abandoned for fever screening. Although maximum lateral or frontal infrared thermography temperatures have reasonable correlations with core temperatures and areas under the receiver operating characteristic curves, the sensitivity-specificity combination might still not be high enough for screening febrile conditions, especially at border crossings with huge numbers of passengers.

**Key words**
Body temperature; Fever; Infrared rays; Sensitivity and specificity; Thermography

*Hong Kong Med J 2013;19:109-15*

**New knowledge added by this study**

- Although maximum lateral and/or frontal infrared thermography temperatures correlate with core temperatures, the sensitivity and specificity of these measurements might still not be high enough for screening febrile conditions.

**Implications for clinical practice or policy**

- Checking body temperature at border crossing using infrared thermography in its present form (on the face) is of questionable value and its continued use should be reviewed.

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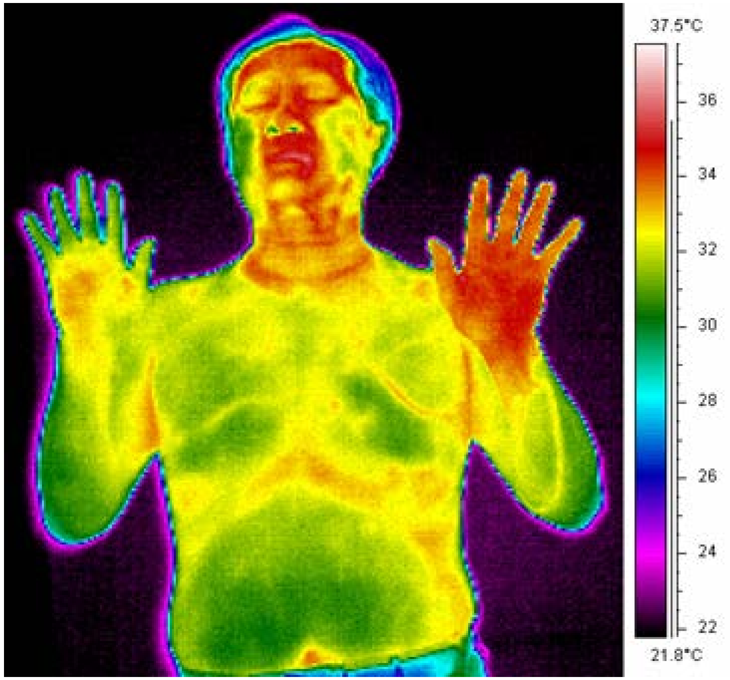
## Introduction

Since the global outbreak of severe acute respiratory syndrome in 2003, infrared thermographic (IRT) instruments ranging from single-point infrared probes to full-image IRT cameras have been introduced at many airports and border crossings for screening travellers with elevated body temperatures. These systems are either IRT imaging cameras

# Medical applications of IR technique

Infrared thermography as a medical diagnostic tool

(with Dr. Winsor Mak, Medicine Faculty, HKU)




Left palm: 34.2 ±0.5

Right palm: 32.3±0.8

# Conclusions

- HK has much experience with applications of various geophysical techniques
- Validation and ground-truthing is necessary
- Careful selection of methods as well as contractor

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