尋找和管理香港砂資源

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香港地質學會前專業部主席

英國地質學會香港區前主席

香港早年已有用海砂作填料

- 舊啟德機場跑道(7.5Mm3)(紅磡灣，青衣南等)1956
- 船灣淡水瑚霸(2Mm3)(大水坑，丁角)1963
- 6號貨櫃碼頭 (8.6Mm3)(汲水門)1988
- 7號貨櫃碼頭 (16.4Mm3)(青衣)1988
- 天水圍新市鎮(24Mm3)(后海灣/深圳灣)1987
- 共用海砂為5仟8佰萬立方米

Reclamation	Sand Volume Mm^3	Main borrow areas	Project Dates
Kai Tak Runway Extension	7.5	Hung Hom, South Tsing Yi, Fa Peng, Joss House Bay	1956 - 1959
Plover Cove Main Dam	2.0	Tai Shui Hang, Ting Kok, Chung Pui, Three Fathoms Cove	1960 - 1968
Tuen Mun New Town	3.5	Tung Chung, Sha Chau, Chek Lap Kok, Lung Kwu Chau, So Kwun Tan	1968 - 1973
Container Terminal No. 6	8.6	Kap Shui Mun	1986 - 1989
Container Terminal No. 7	16.4	South Tsing Yi	1986 - 1989
Tin Shui Wai	24.0	Outer Deep Bay	1986 - 1988
West Kowloon Reclamation South	33.0	Tathong Channel, East Tung Lung Chau & West Po Toi	12/90 - 05/95
West Kowloon Reclamation North	33.6	East Tung Lung Chau & East Po Toi	11/91 - 06/94
Tseung Kwan O	17.4	Tathong Channel & East Tung Lung Chau	01/91 - 07/96
Container Terminal No. 8	25.5	South Tsing Yi	03/92 - 01/95
Chek Lap Kok Airport	72.0	East Sha Chau, South Tsing Yi, West Po Toi & Brothers	11/92 - 01/96
Tung Chung New Town - Phase I	9.3	West Sokos	08/92 - 12/93
SENT Landfill	3.32	Tathong Channel	10/92 - 04/94
North Lantau Expressway	18.5	Tathong Channel, Kap Shui Mun & North of Lantau	11/92 - 01/95
Central and Wanchai Reclamation	3.6	Tathong Channel & East Po Toi	09/93 - 09/96
Stonecutters Island	1.0	South Tsing Yi	06/96 - 09/96

Table 13.1 - Examples of some major reclamations using offshore fill

土木工程署內有一海洋填料委員會

主席:土木工程拓展署署長

成員；

運輸及房屋局局長

發展局局長 - 工務科

漁農自然護理署署長

渠務署署長

環境保護署署長

路政署署長

土木工程拓展署土木工程處副處長(工程及環境管理)

非經常性成員：發展局局長 -規劃地政科及地政總署署長

委員會職權

1. 就主要的發展政策問題，有關管理及使用海洋填料儲備、
2. 及疏浚 / 挖掘沉積物卸置設施的管理及運作
3. 制定策略以：

找出海洋填料資源以滿足需求。
找出海上卸置設施的容量以滿足需求。

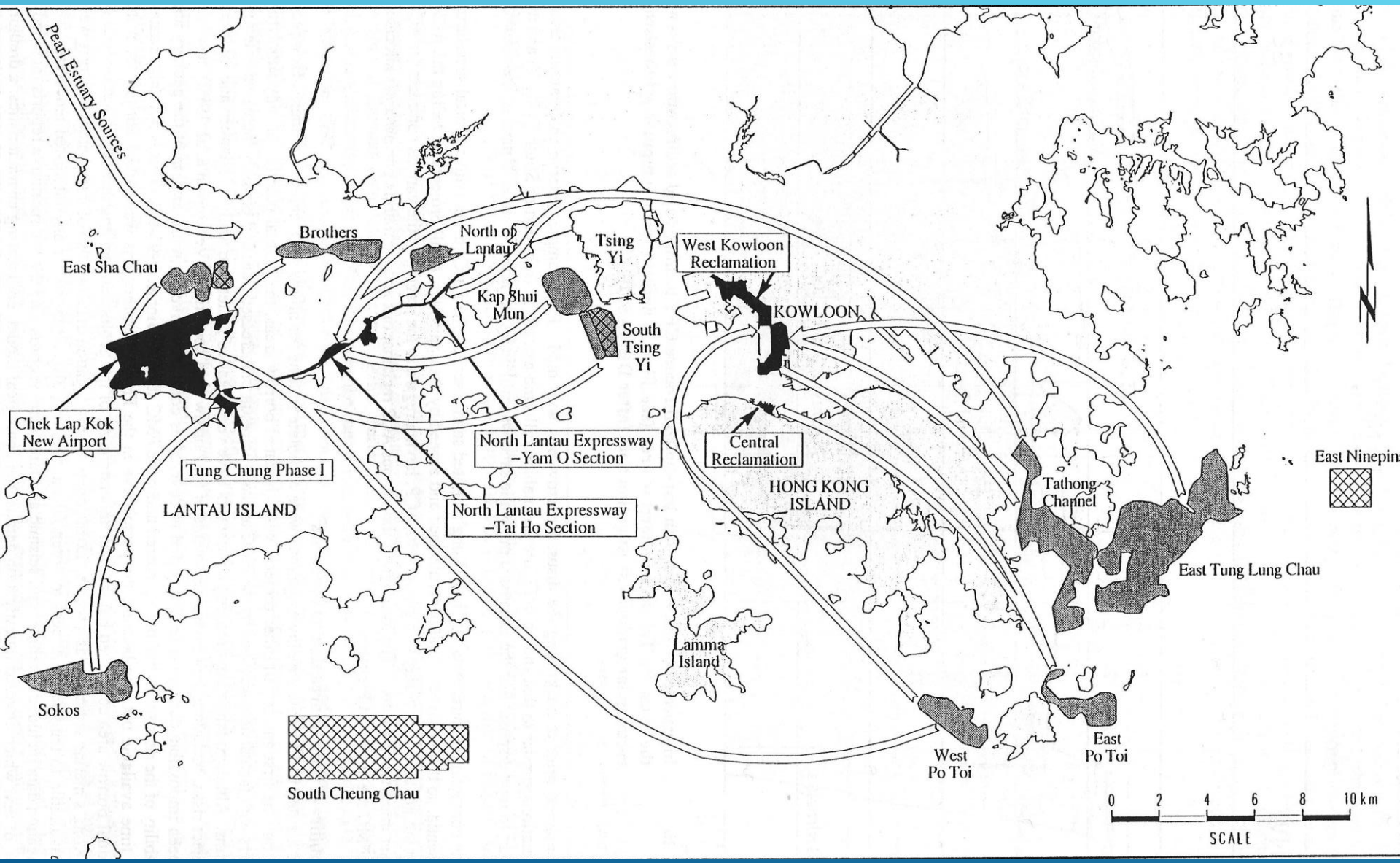
1982年土力工程處開始詳細 進行海上地質調查。

1987年在青衣島南面海域找到1億立方米的海砂源。

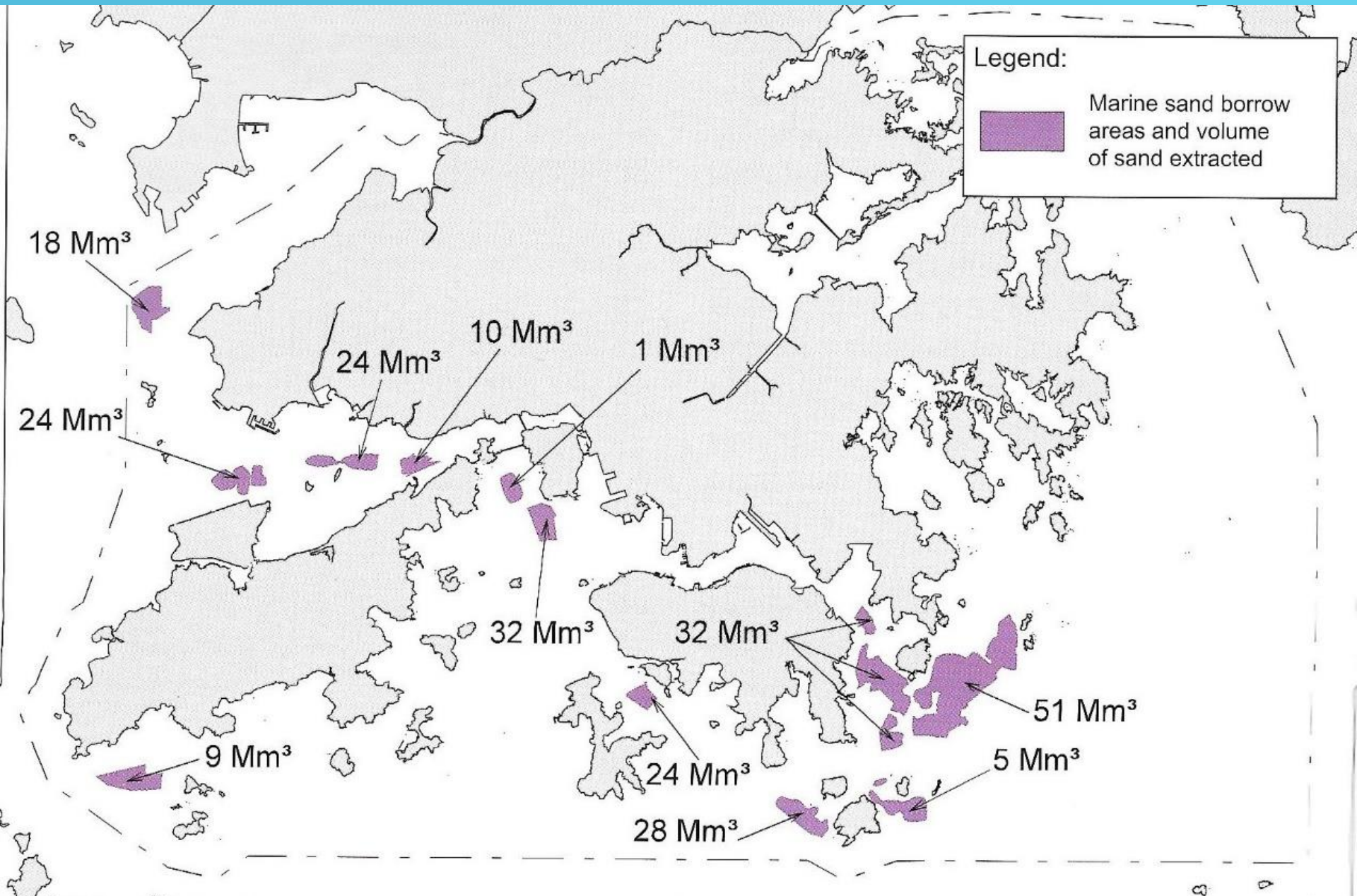
1988年展開分階段全港海上區域地質調查。


820 E
840 E
860 E
Guangdong Province
840 N
New Territories
N
Kowloon
820 N
Lantau Island
Hong Kong Island
0
5
10 km

分配採砂區給各填海項目



各採砂區開採量


Legend:
Marine sand borrow areas and volume of sand extracted
18 Mm³
24 Mm³
24 Mm³
10 Mm³
1 Mm³
32 Mm³
32 Mm³
51 Mm³
9 Mm³
24 Mm³
5 Mm³
28 Mm³

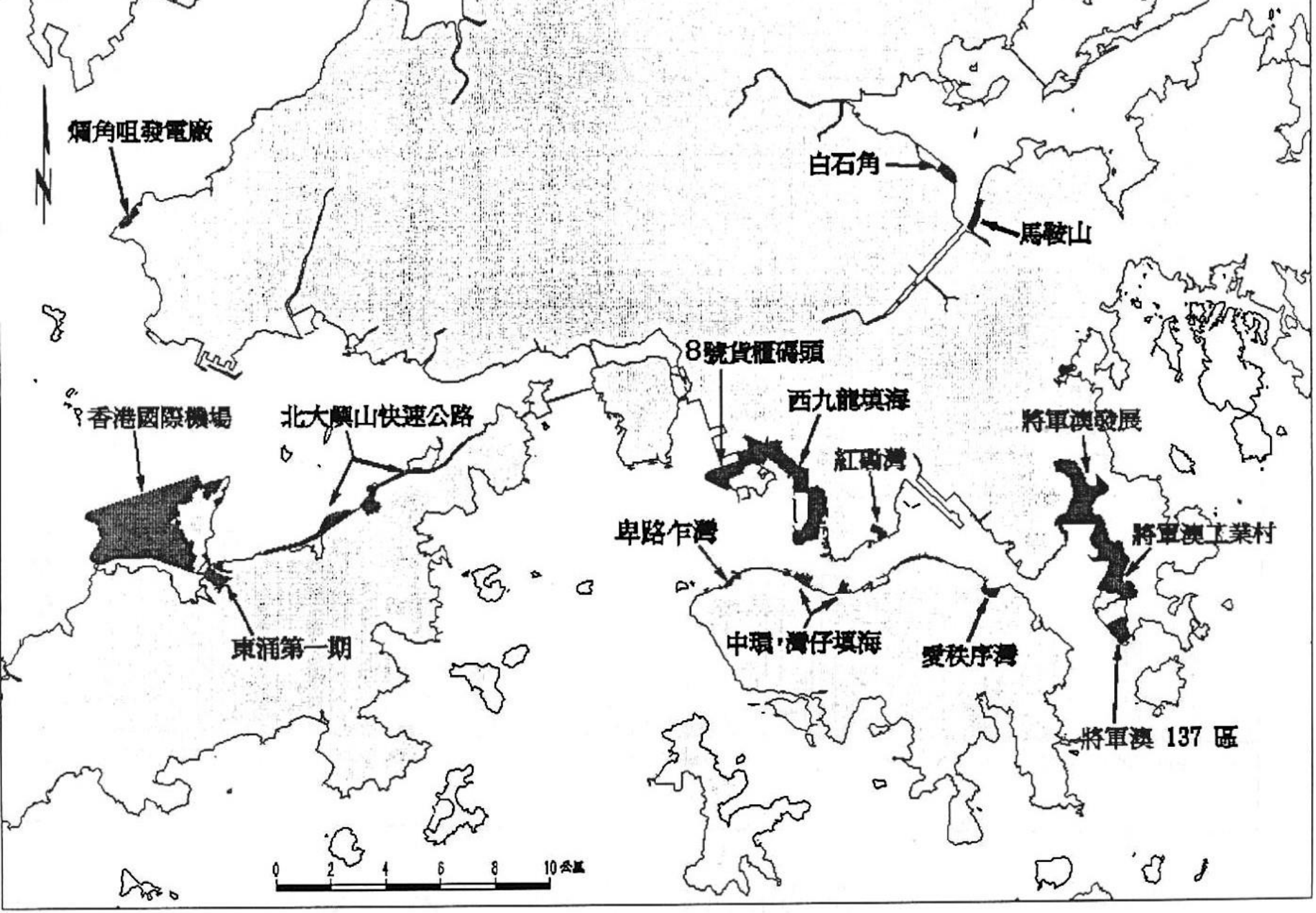


圖 1 -1989至1999年間的填海區

灣仔會議展覽中心

竹篙灣迪士尼填海

西九龍填海


ClubONE Repulse Bay
Metered Parking Spaces
S Bay Rd
Repulse Bay Beach
Limewood
The Pulse
S Bay Rd
Beach Rd
Repulse Bay Rd
Repulse Bay
Repulse Bay
The Lily
Tin Hau and Kwun Yum Statues
Repulse Bay
Image © 2021 Maxar Technologies
Google Earth


1984

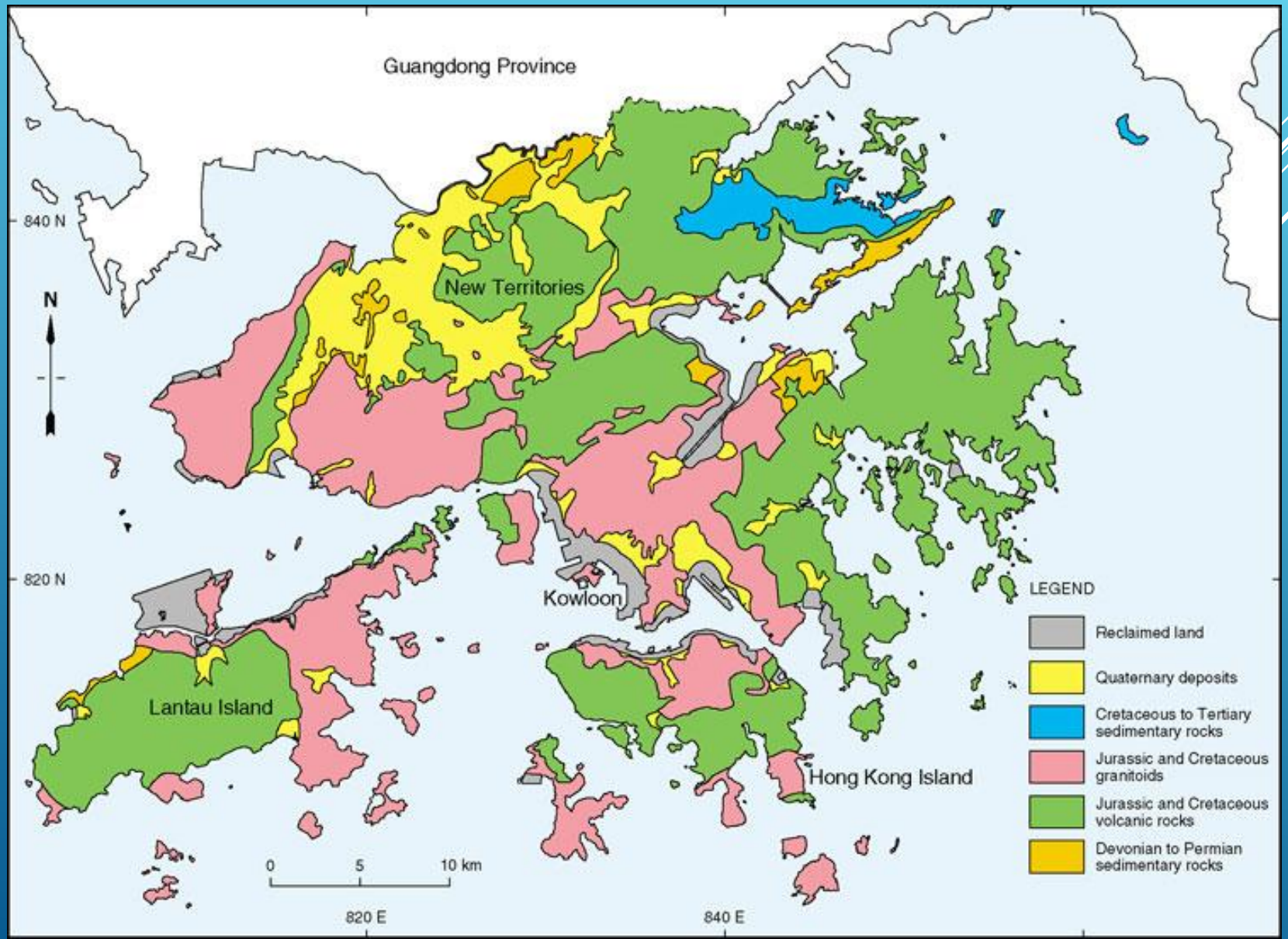
各主要工程項目從不同採砂區採填料

- 香港國際機場 (72Mm3) 東沙洲，青衣南，西蒲台，大小磨刀 **(92-96)**
- 北大嶼山公路(18.5Mm3) 藍塘海峽，汲水門，大嶼山北 **(92-95)**
- 西九龍南填土(33Mm3) 藍塘海峽，東龍洲東，西蒲台 **(90-95)**
- 西九龍北填土(33.6Mm3) 東龍洲東，東蒲台 **(91-94)**
- 將軍澳填土(17.4Mm3) 藍塘海峽，東龍洲東 **(91-96)**

尋找砂源的方法

1.查閱資料

香港地質圖


Guangdong Province
840 N
820 N
N
New Territories
Kowloon
Lantau Island
Hong Kong Island
0
5
10 km
820 E
840 E
LEGEND
Reclaimed land
Quaternary deposits
Cretaceous to Tertiary sedimentary rocks
Jurassic and Cretaceous granitoids
Jurassic and Cretaceous volcanic rocks
Devonian to Permian sedimentary rocks

海床設施包括電纜和各種管道

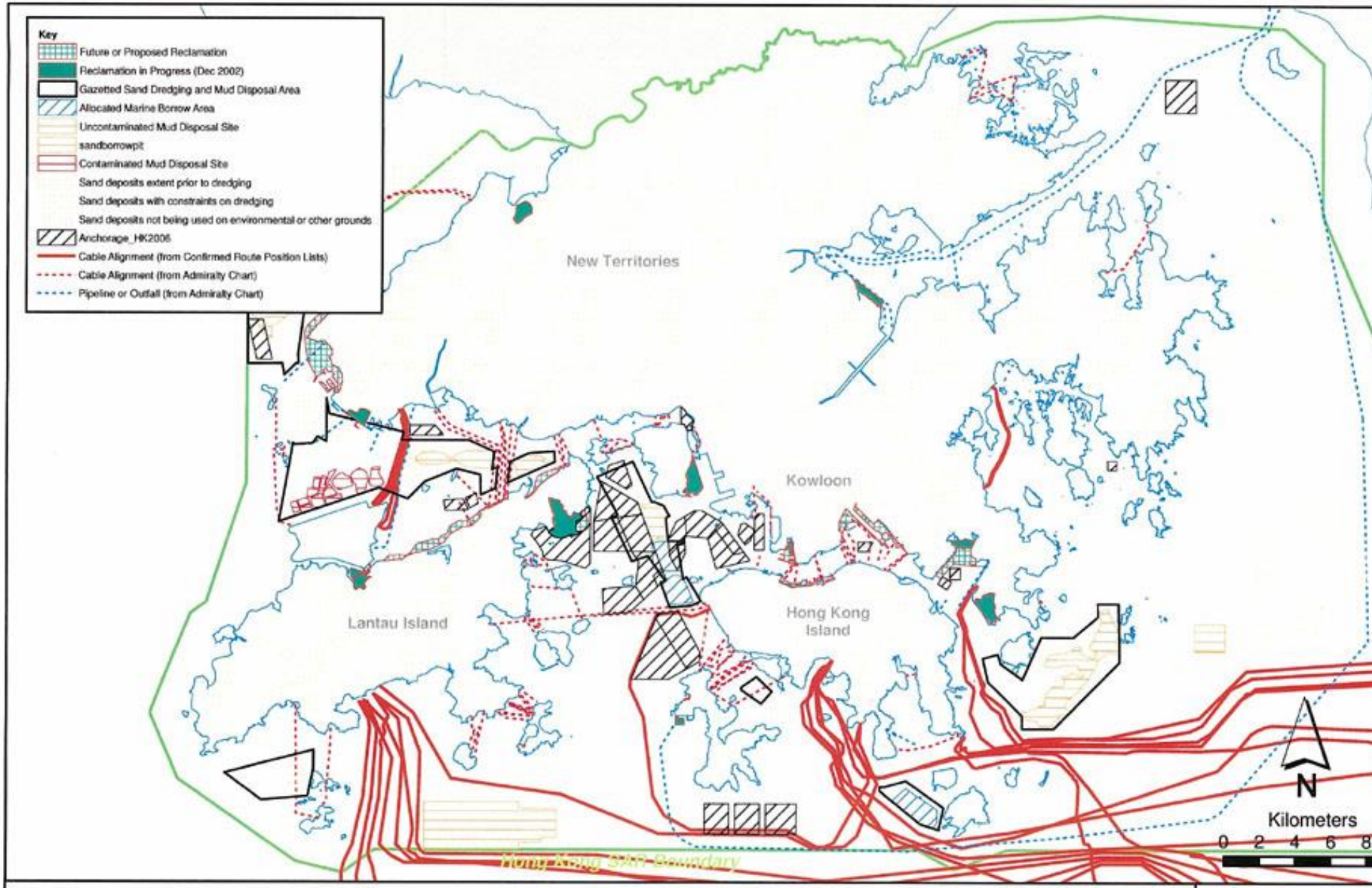


Figure 4.5

Environmental

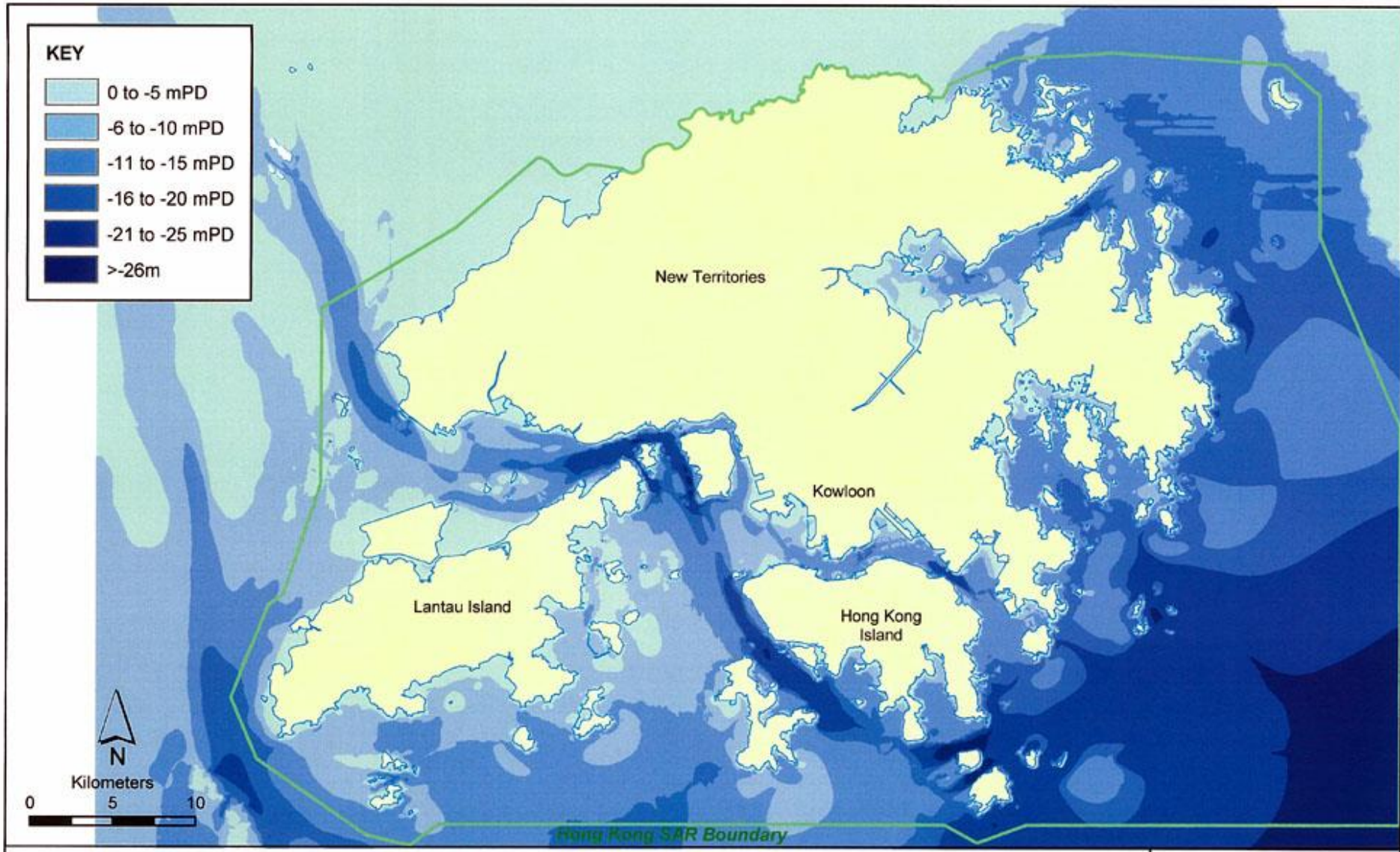


Figure 4.7

Water Depth within the
Hong Kong Special Administrative Region

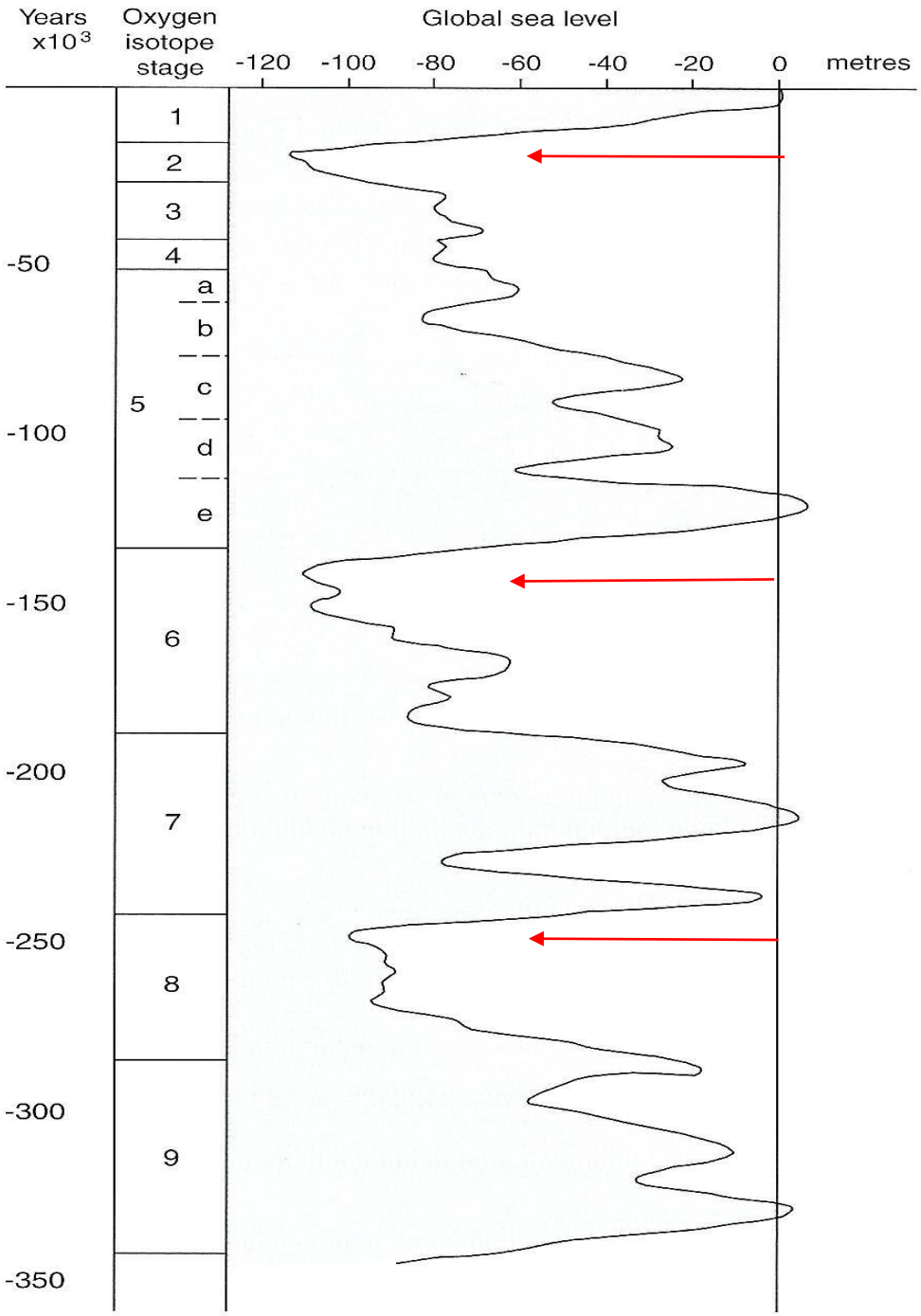
(Civil Engineering Department, 1999)

File: 0018180_water_depth_2.mxd
Date: 04/11/2005

Environmental
Resources
Management

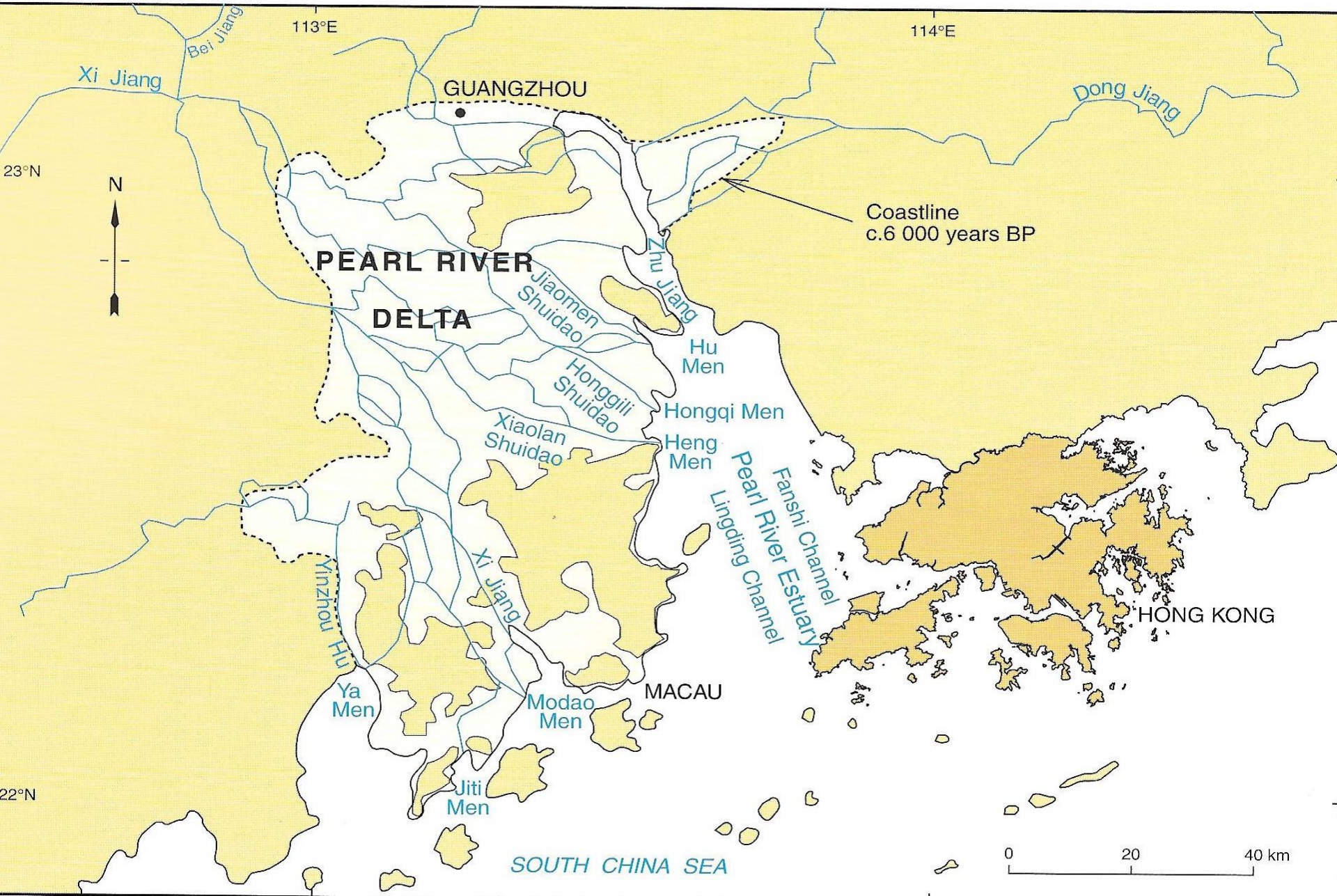
ERM


青衣
TSING YI
赤鱲角
CHEK LAP KOK
大嶼山
LANTAU ISLAND
南丫島
LAMMA ISLAND
九
KOWL
HONG



18,000年前末冰期時海平面比現在低120米

香港地理位置


113°E
114°E
Bei Jiang
Xi Jiang
GUANGZHOU
Dong Jiang
23°N
N
Coastline
c.6 000 years BP
PEARL RIVER
DELTA
Jiaomen
Shuidao
Zhu Jiang
Hu
Men
Honggili
Shuidao
Hongqi Men
Xiaolan
Shuidao
Heng
Men
Pearl River Estuary
Fanshi Channel
Lingding Channel
HONG KONG
Yinzhou Hu
Xi Jiang
Ya
Men
Modao
Men
MACAU
Jiti
Men
22°N
SOUTH CHINA SEA
0
20
40 km

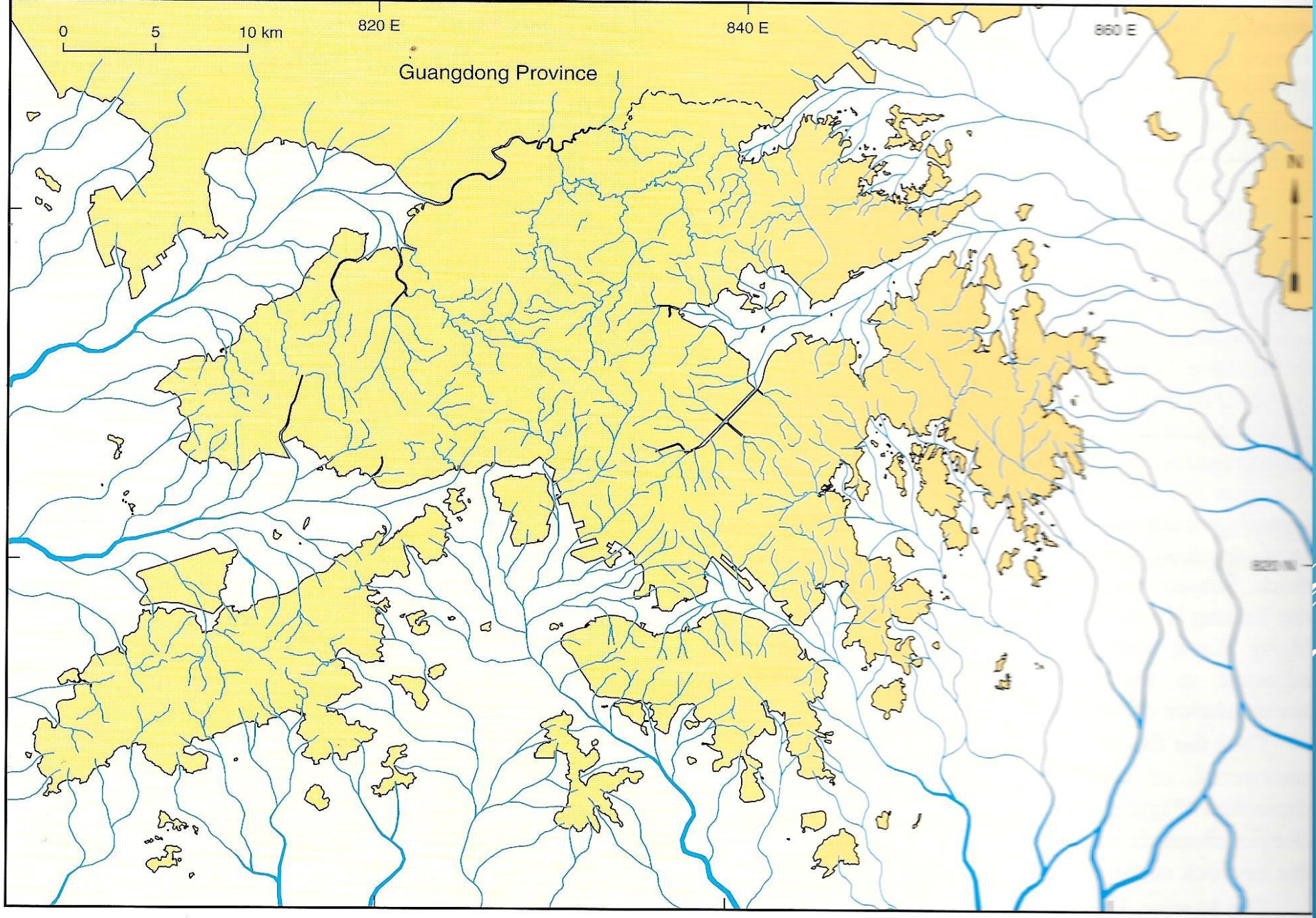
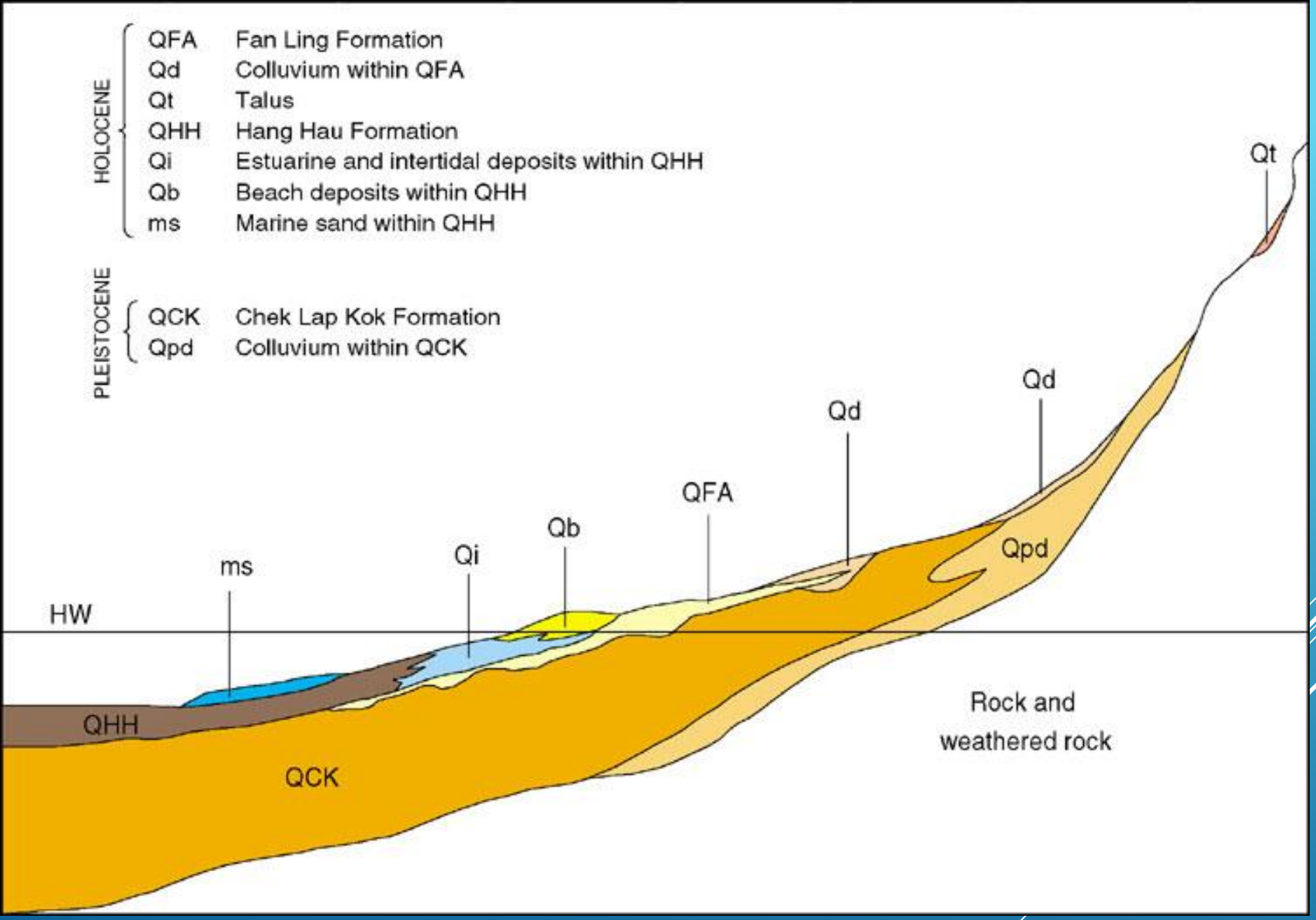
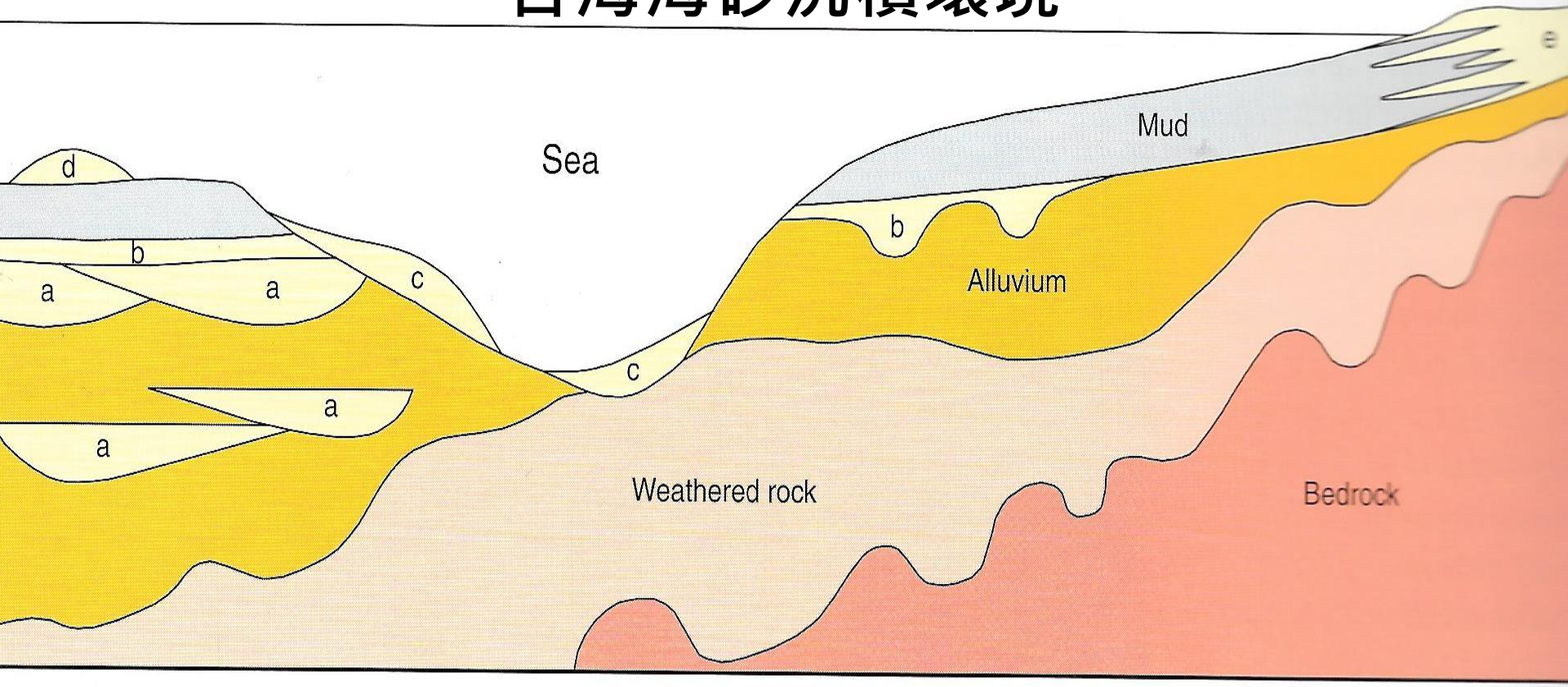


Figure 12.4 - Schematic reconstruction of the Late Pleistocene drainage pattern


HOLOCENE
QFA Fan Ling Formation
Qd Colluvium within QFA
Qt Talus
QHH Hang Hau Formation
Qi Estuarine and intertidal deposits within QHH
Qb Beach deposits within QHH
ms Marine sand within QHH
PLEISTOCENE
QCK Chek Lap Kok Formation
Qpd Colluvium within QCK
Qt
Qd
Qd
QFA
Qb
Qi
ms
Qpd
HW
QHH
QCK
Rock and
weathered rock

各海海砂沉積環境



Pleistocene

a - alluvial channel sands

Holocene

b - basal transgressive sands

Holocene & Recent

c - marine channel sands

d - seabed residual sands

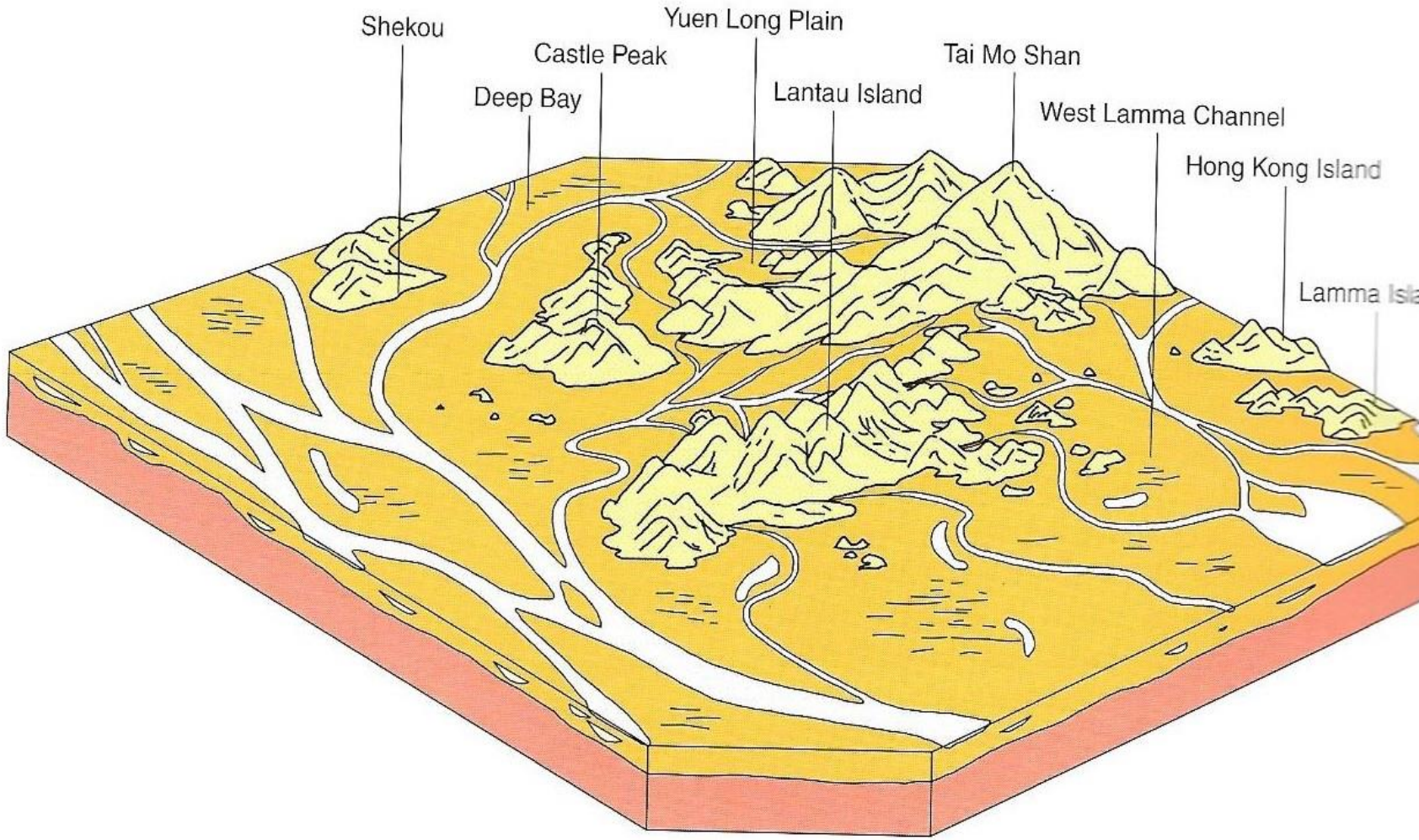
e - littoral and sub-littoral sands

Figure 12.3 - Schematic representation of the modes of offshore sand occurrence (after Shaw, 1988)

MODEL OF SAND OCCURRENCES

- Holocene, River channels sands (modern onshore rivers)
- Littoral and sublittoral sands (coastal)
- Seabed residual sands (sands sheets and sand banks)
- Marine channel sands below present day tidal channels (have or no mud overburden)
- Pleistocene alluvial sands (buried deposits)

重組低海平面時的地理環境
(砂源在古河道內)



尋找砂源的方法

2.根據海砂的沉積環境進行廣範的地球物理探測

有系統的全港砂源勘查

- 第1期先進行海上高解像度反射地球物理測量(Boomer, 3公里間距方格)
- 連續12至18米震孔並取樣去對比各震測層
- 修改地質模型並選定砂源
- 第2期海上高解像度反射地球物理測量的間距為350米,並有連續取樣(平均每平方公里有10個鑽探孔或圓錐貫入儀)

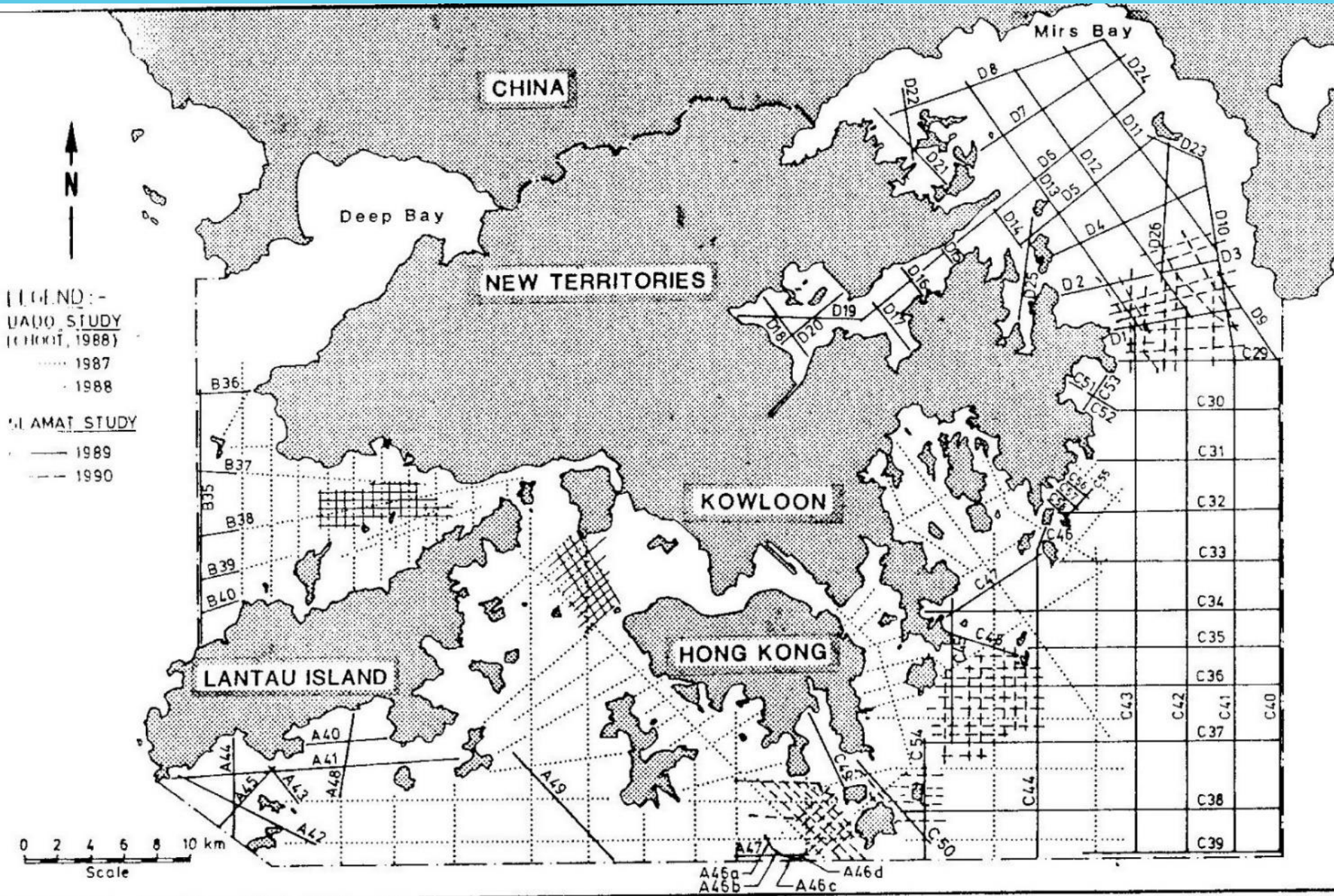
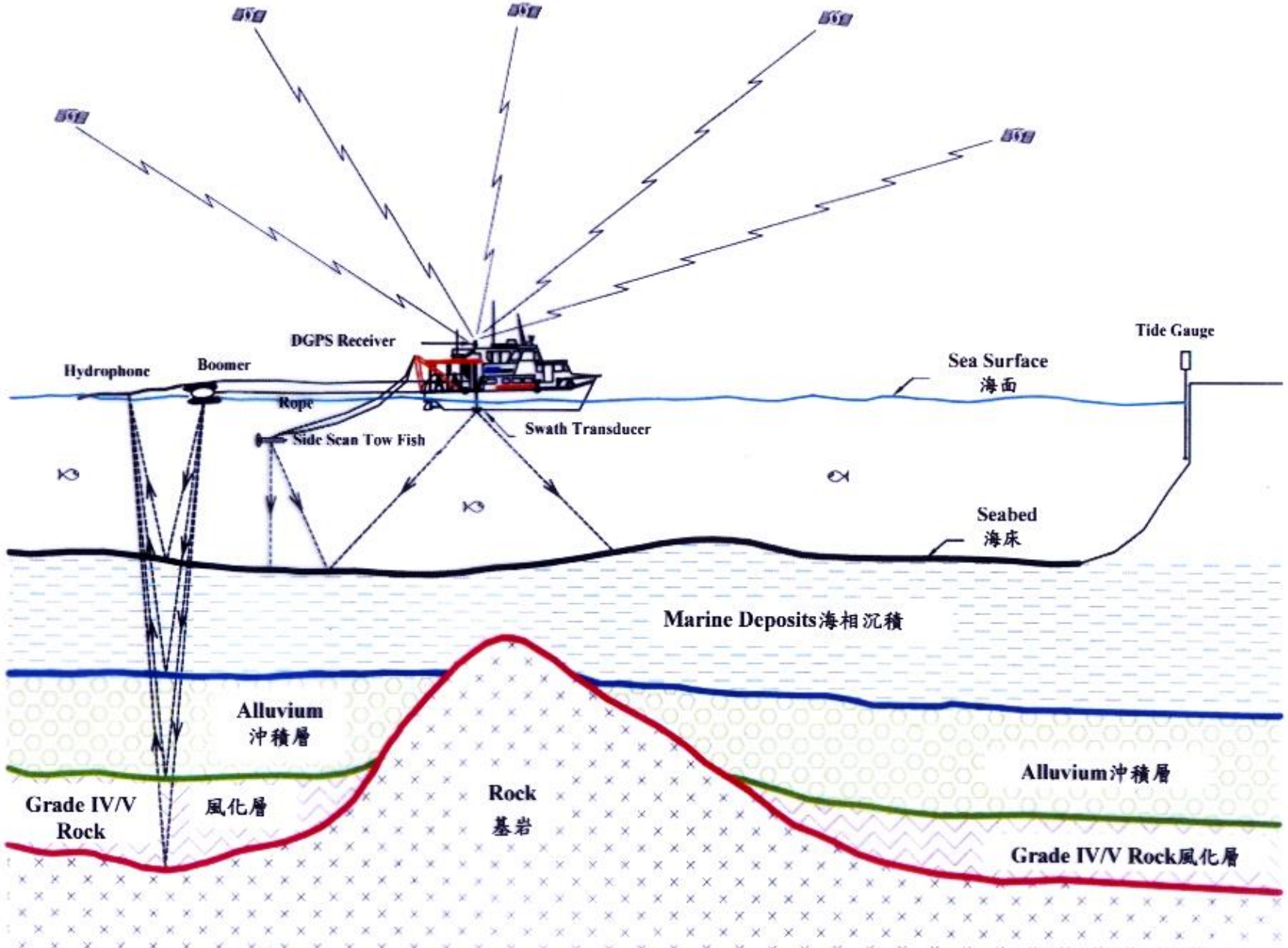
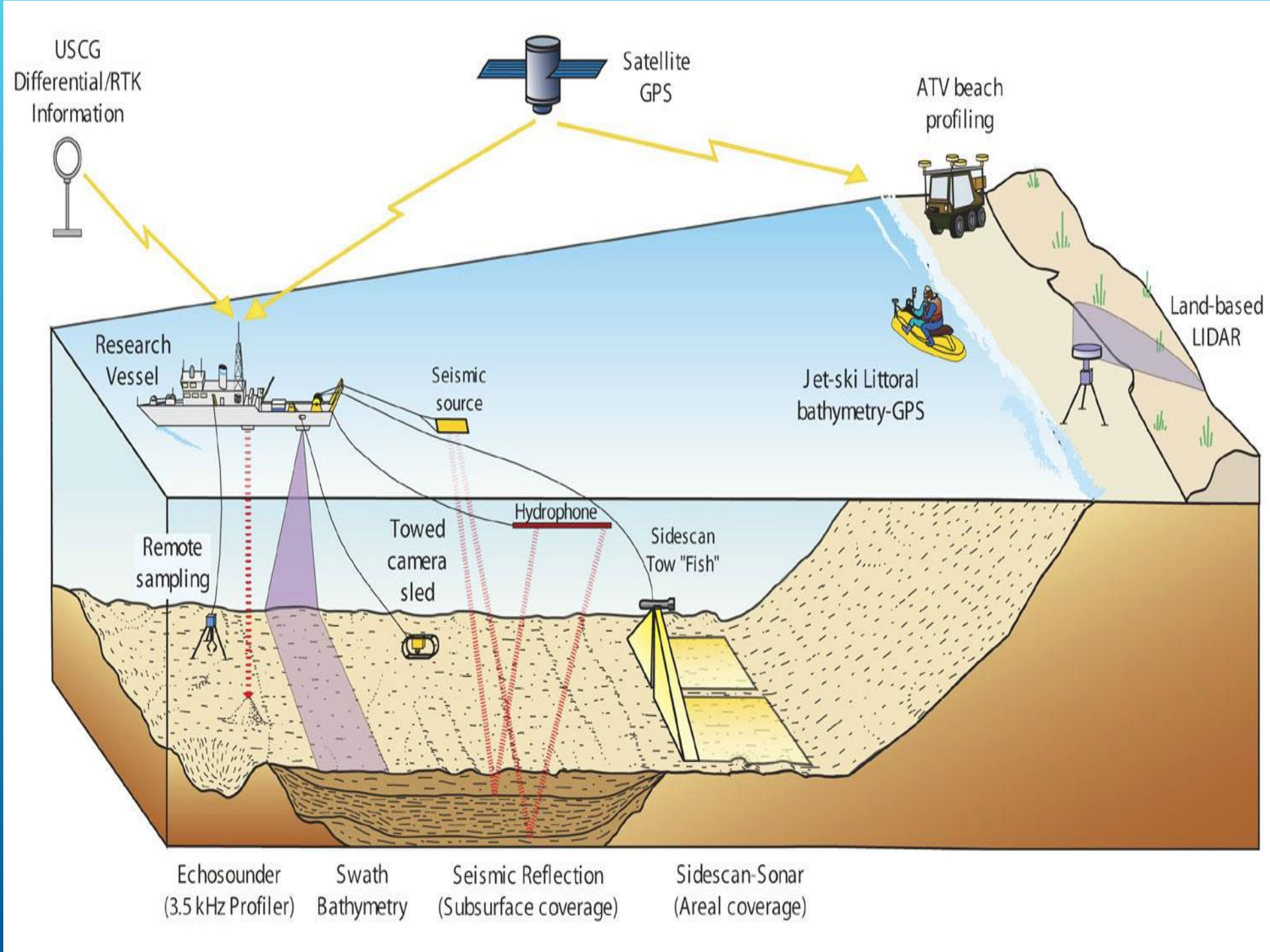


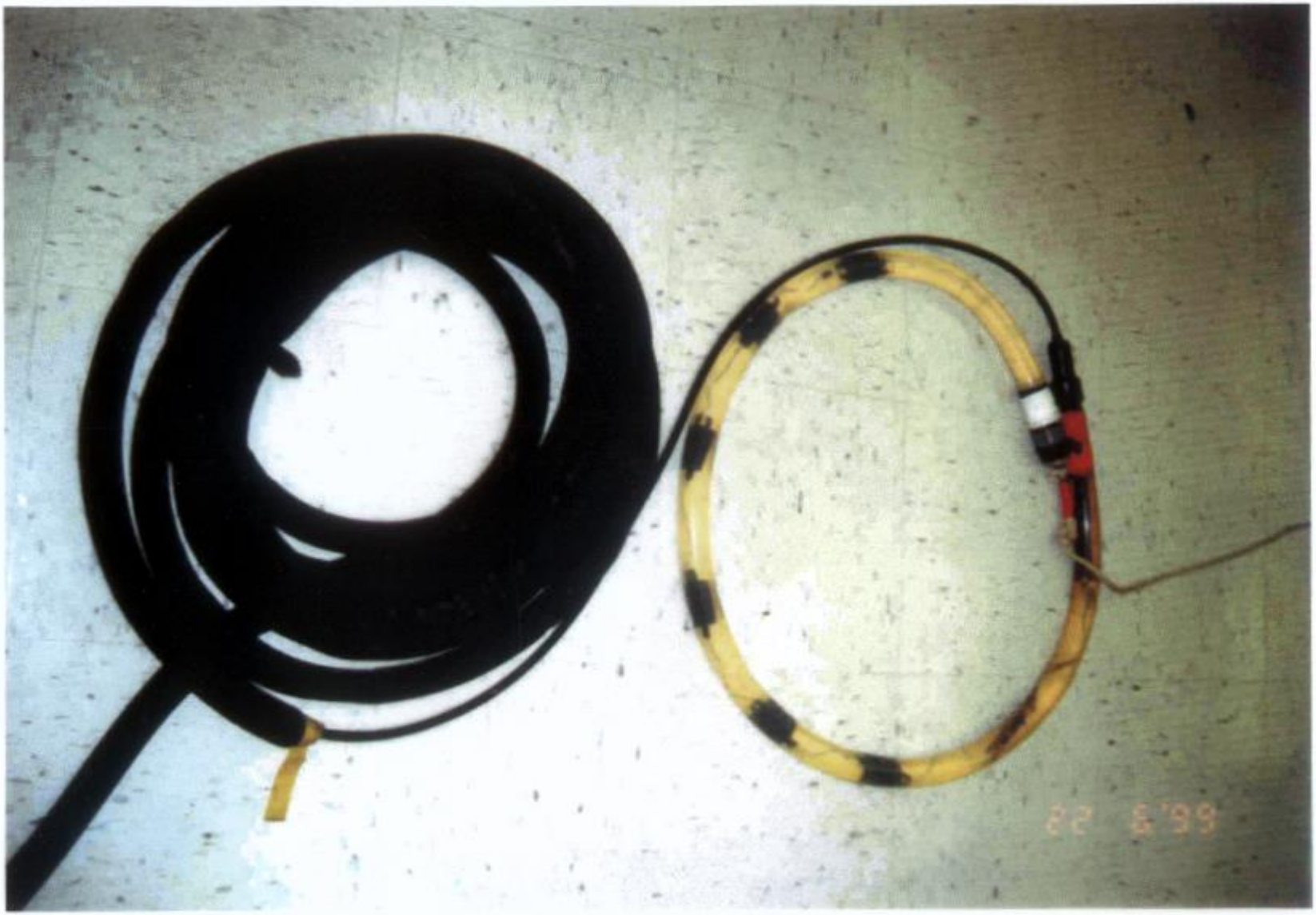
Figure 3 - Seismic Traverses carried out during UADO and SEAMAT Studies


DGPS Receiver
Tide Gauge
Hydrophone
Boomer
Sea Surface
海面
Rope
Side Scan Tow Fish
Swath Transducer
Seabed
海床
Marine Deposits海相沉積
Alluvium
沖積層
Alluvium沖積層
Grade IV/V
Rock
風化層
Rock
基岩
Grade IV/V Rock風化層


USCG
Differential/RTK
Information
Satellite
GPS
ATV beach
profiling
Land-based
LIDAR
Research
Vessel
Seismic
source
Jet-ski Littoral
bathymetry-GPS
Hydrophone
Towed
camera
sled
Sidescan
Tow "Fish"
Remote
sampling
Echosounder
(3.5 kHz Profiler)
Swath
Bathymetry
Seismic Reflection
(Subsurface coverage)
Sidescan-Sonar
(Areal coverage)

水面拖行地震反射發振器

Surface Tow Boomer for Seismic



水中地震反射檢波器

BOMMER

Effective penetration depth is 80m below the seabed

Poisition fixes by 5 accurately-positioned shore stations Plus swell filter

EGS (ASIA) LIMITED

Project Title : PROPOSED SIU LAM TYPHOON SHELTER GEOPHYSICAL SURVEY

Contract Number : GE/97/12

Works Order Number : GE/97/12.09

Client : Geotechnical Engineering Office

Survey Date : 27-29 November 1997

Survey Area : Siu Lam

Line Number : 1235-26 Fix Number : 1184-1208

Source : Boomer

Power : 100 Joules

Fix Interval : 10 Seconds

Sweep : 80ms

Scale Lines : 10ms

Firing Intervals : 4/secs.

Filter Passband : High 2500 Hz to Low 600 Hz

Signal Processing : EGS TVG, Band Pass Filter

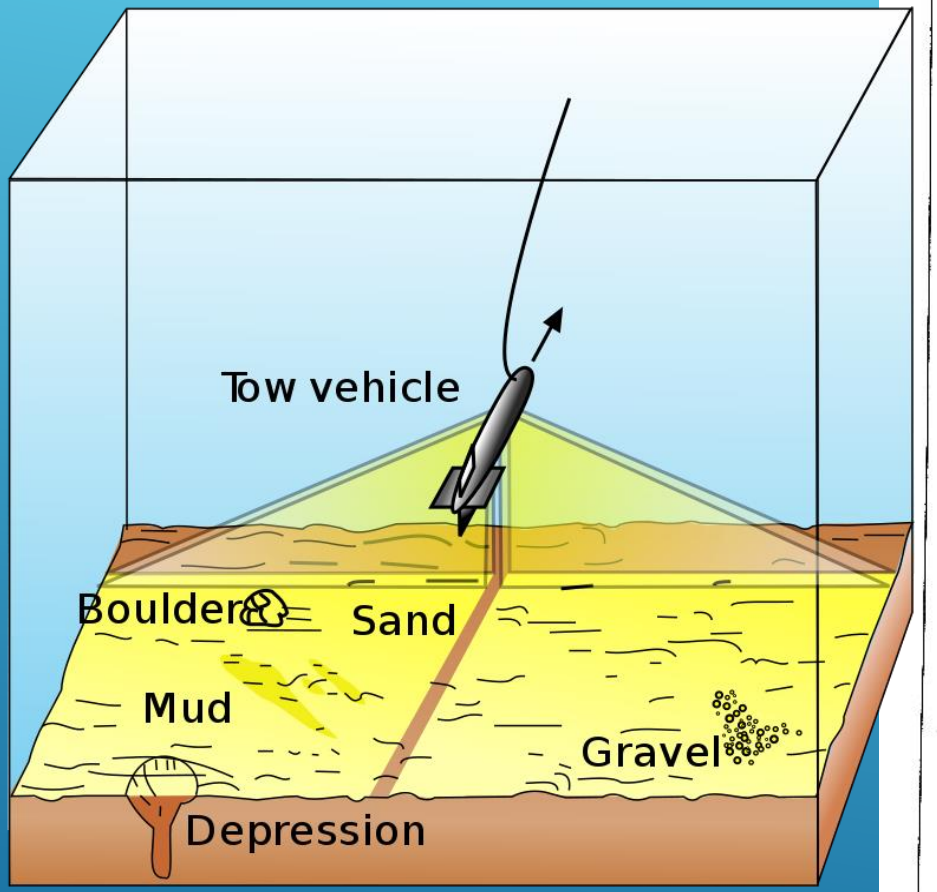
Hydrophone : EGS Hydrophone

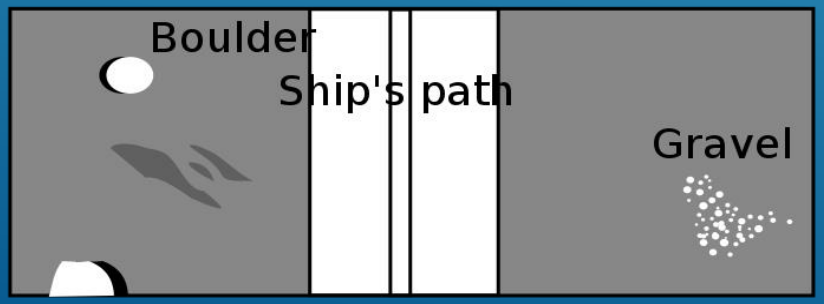
Recorder : Waverly Thermal

Contractor's Job Number : HK 123597

Run Direction : [redacted] / N to S

SIDE SCAN SONAR
側掃聲納





ELECTRONIC AND GEOPHYSICAL SERVICES LTD

Project : East of Po Toi Geophysical Survey

CED Contract Number : GE/95/05

Works Order Number : GE/95/05.23

Client : Geotechnical Engineering Office

Line Number : CEN–10

Survey Area : East of Po Toi

Survey Date : 15–18/01/1996 & 01–05/02/1996

Towfish : Klein 2000 system

Frequency : 500 kHz

Fixing Interval : 20 sec

Slant Range : 50m

Scale Lines : 10m

Recorder : Klein 2000 system

Contractor's Job Number : EGS HK104896

Side Scan Sonar Record The Quaternary Geology of Hong Kong, 144

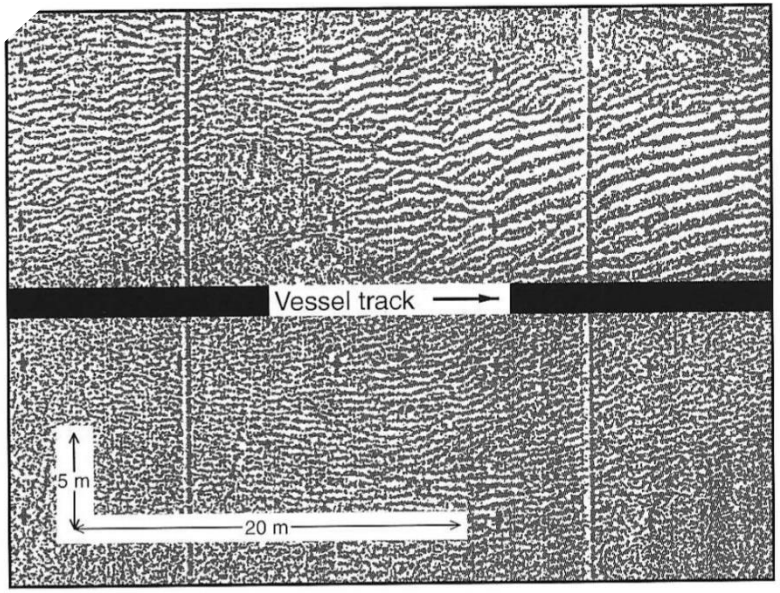


Figure 10.20 - Sidescan sonar record showing sand waves from north of Lantau Island (大嶼山)

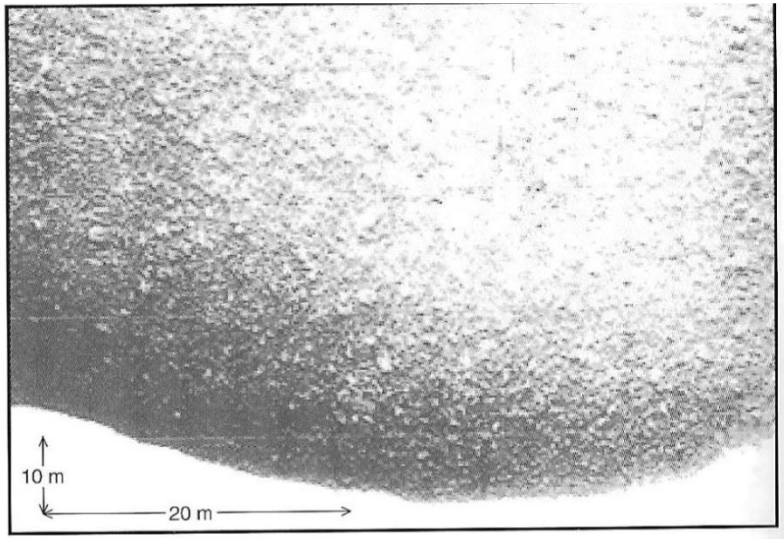


Figure 10.21 - Sidescan sonar record showing gravel lag on rock surface north of Kap Shui Mun (汲水門)

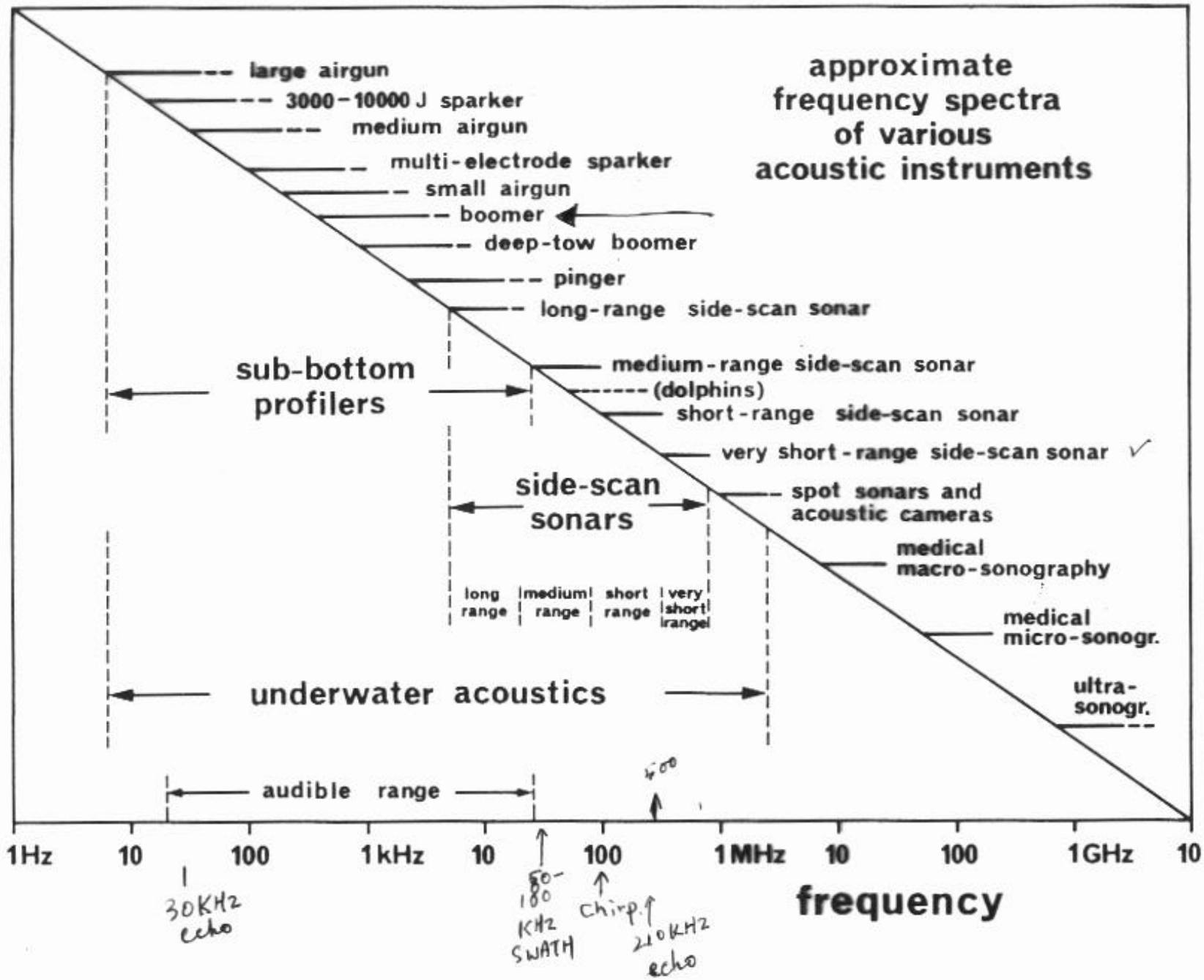
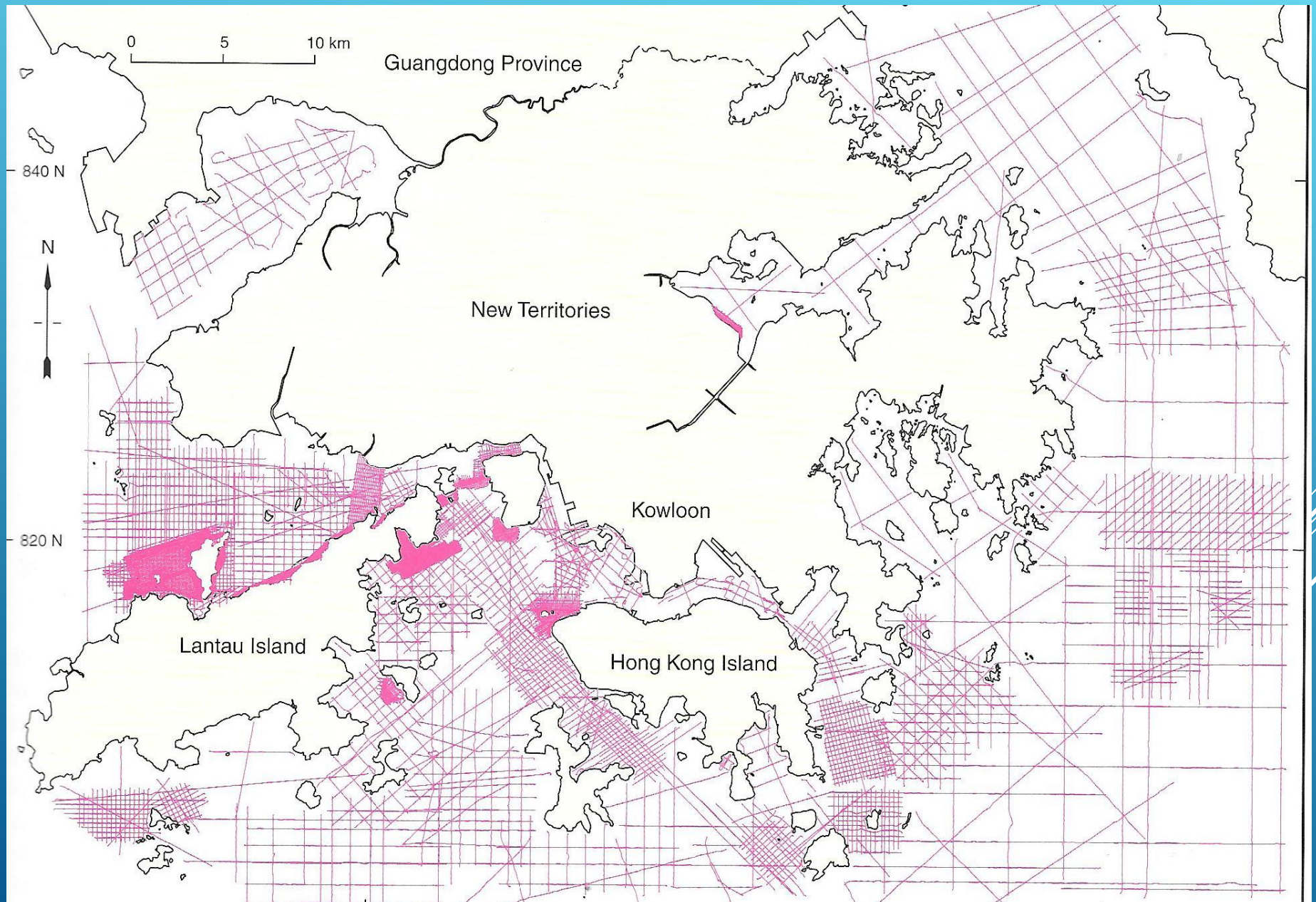


Fig. 2. Frequency spectra of various acoustic imaging methods with special reference to underwater applications.

Seismic Reflection (Pinger, Chirp(digital), Sparker, airgun profiling)

1. Various type of survey, Pinger(light energy source) to high energy source (airgun for oil exploration).
2. Depth of profile (penetration) varies from few meters to several kilometers (Boomer ranges from 60-100meters).
3. Delination of geological profile (to top of grade III weathered rock (boomer survey).
4. Cross sections along survey lines.
5. Relies drillholes to assist interpretation
6. Some areas "masked" by presence of gas in the top marine deposits(usually at about 10meters below seabed).
7. Minimum water depth is 2meters.

全港海上物理探測


0
5
10 km
Guangdong Province
840 N
N
New Territories
Kowloon
820 N
Lantau Island
Hong Kong Island

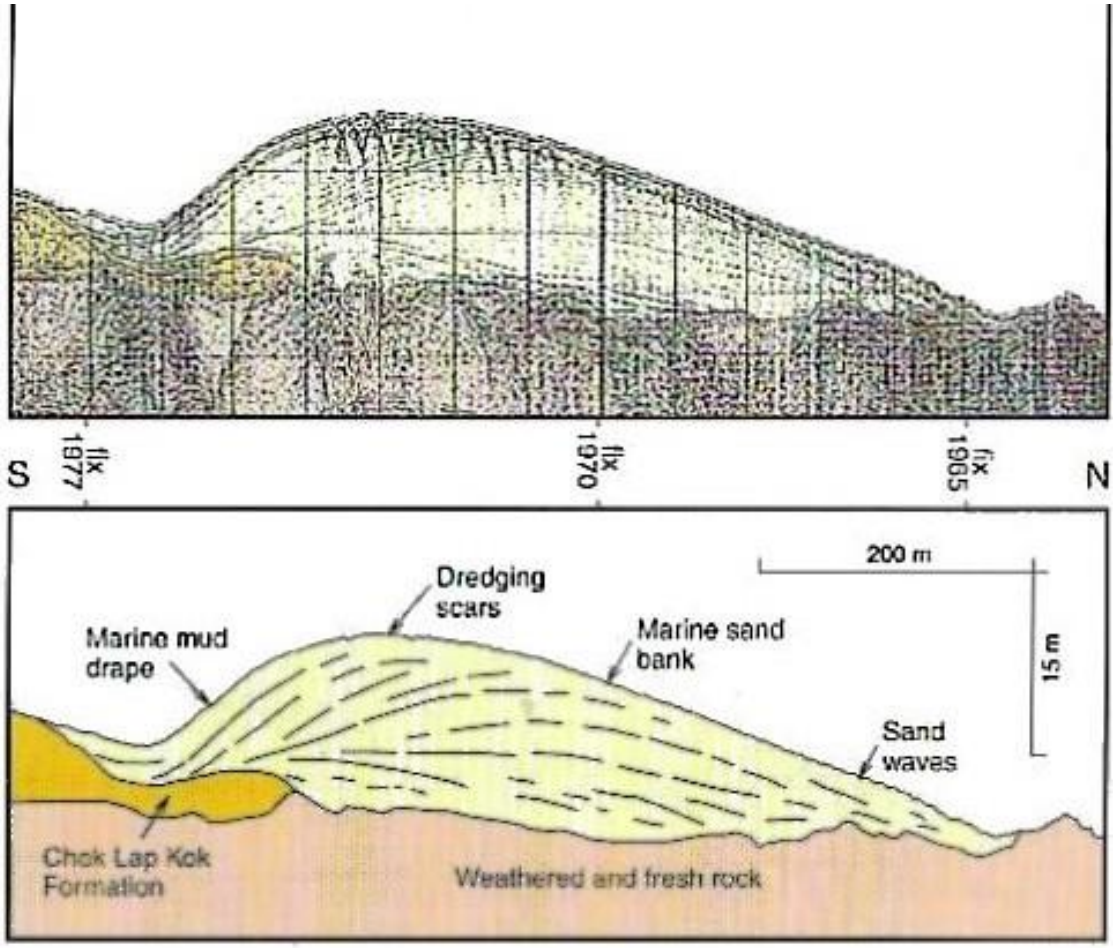
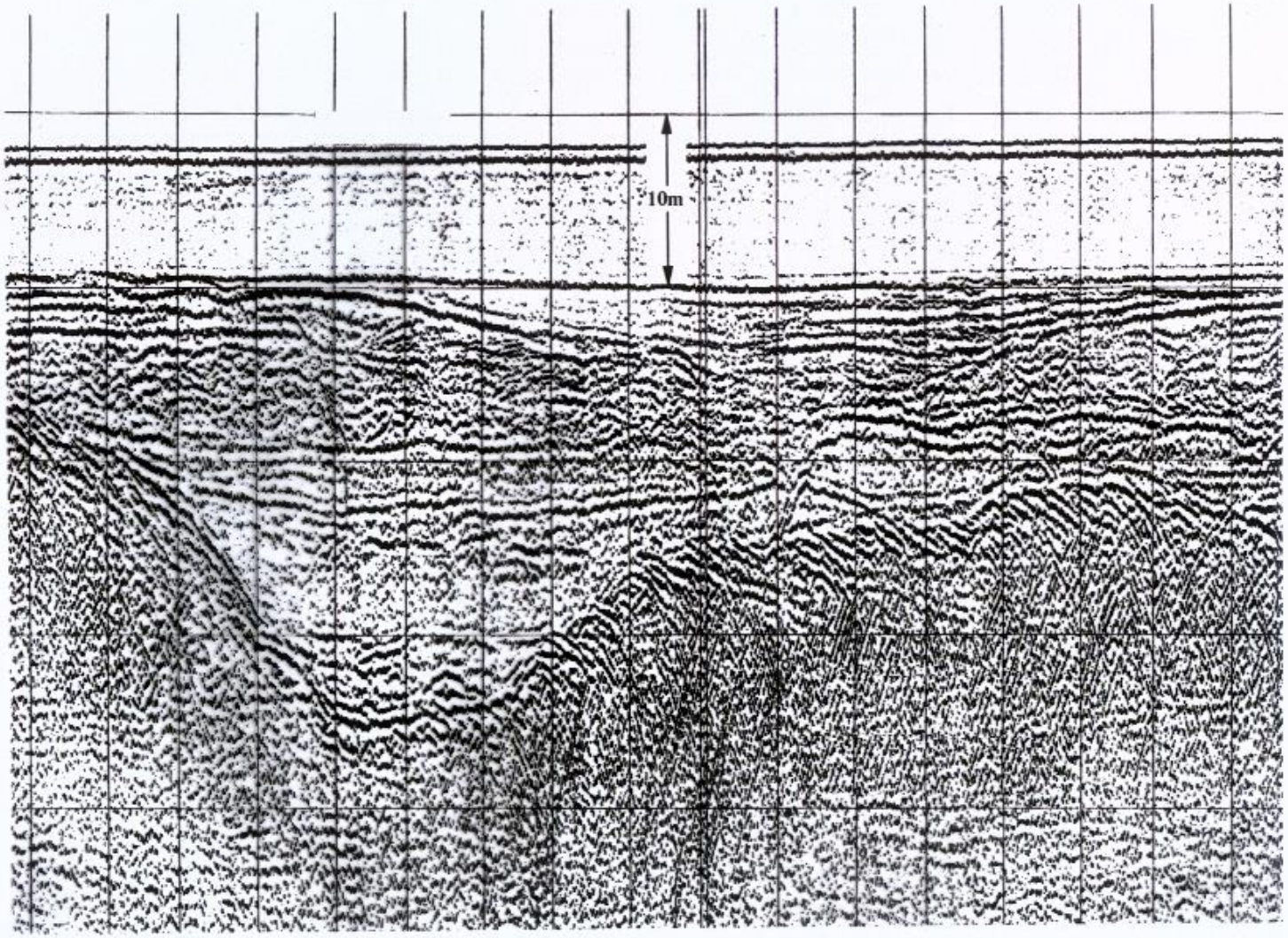


Figure 10.19 - Profile showing a moribund sand bank north of Lantau Island (大嶼山)

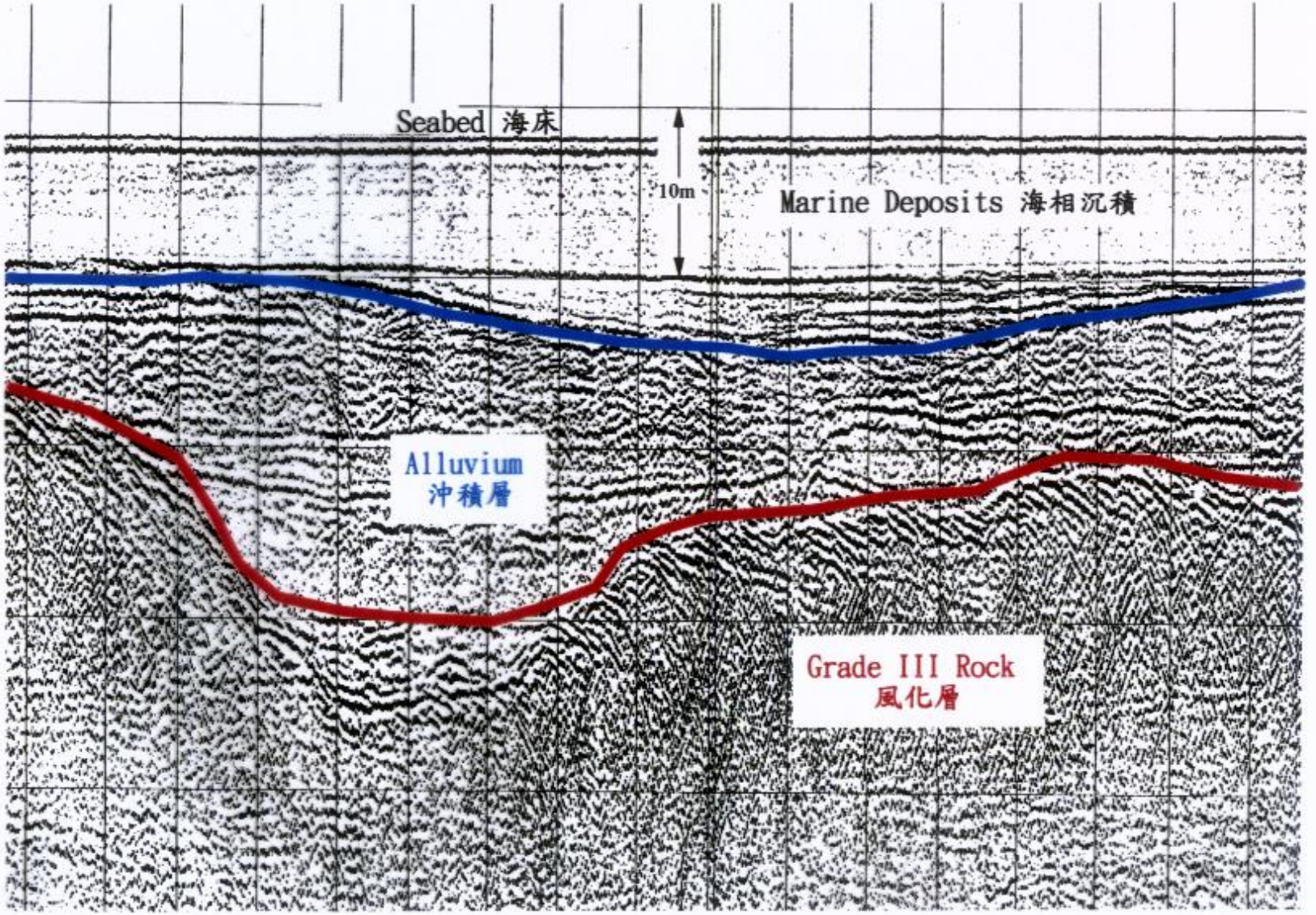
震波可
達海床
下80米



來回速
度每秒
125毫
米
沉積物
平均速
是每秒
1600米

地震反射剖面記錄

Seismic Reflection Profile Record



已分析地震的地震反射剖面

Interpreted Seismic Reflection Profile Record

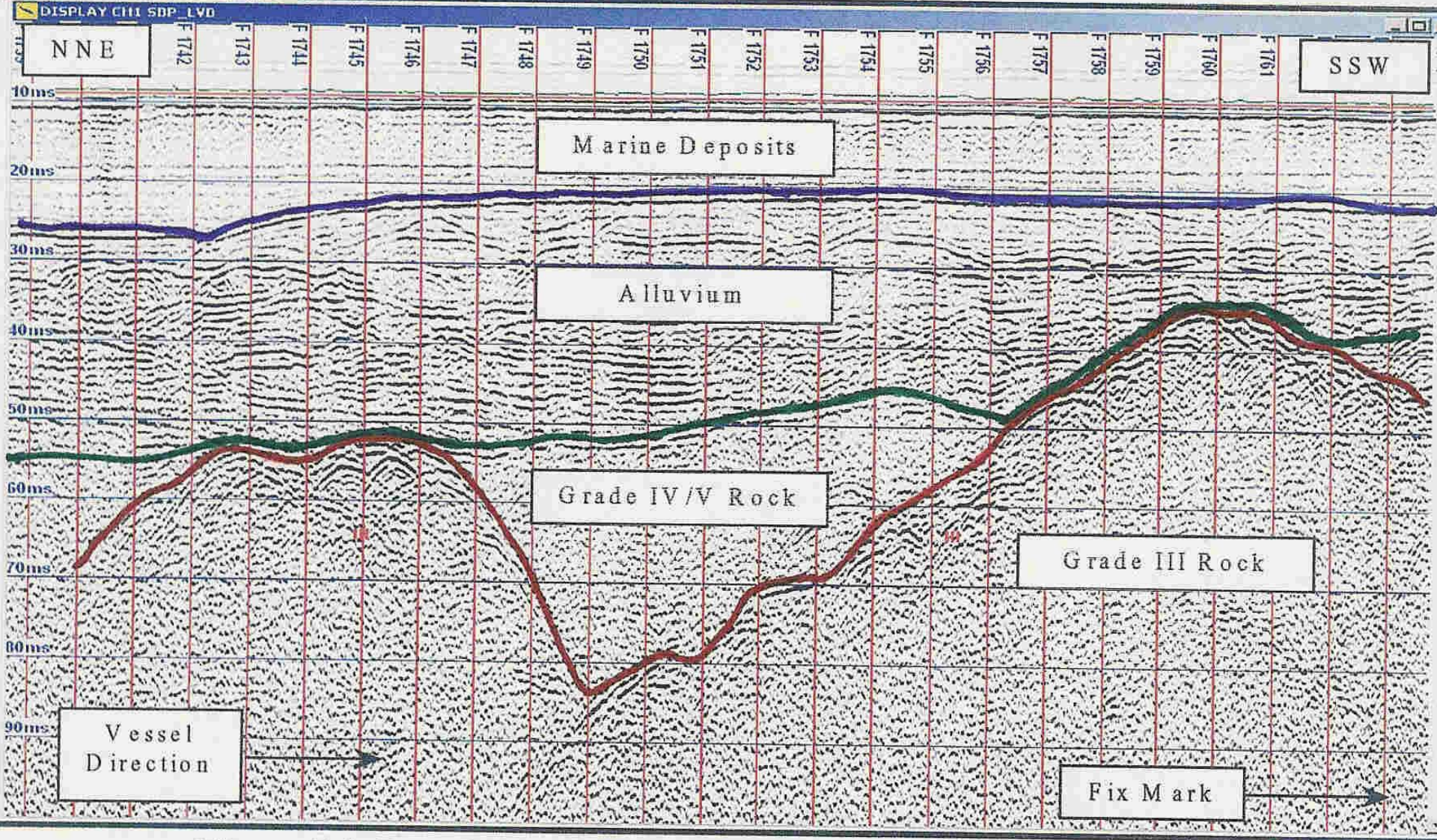


Figure 7.1: Low Voltage Boomer data example of seismic sequence

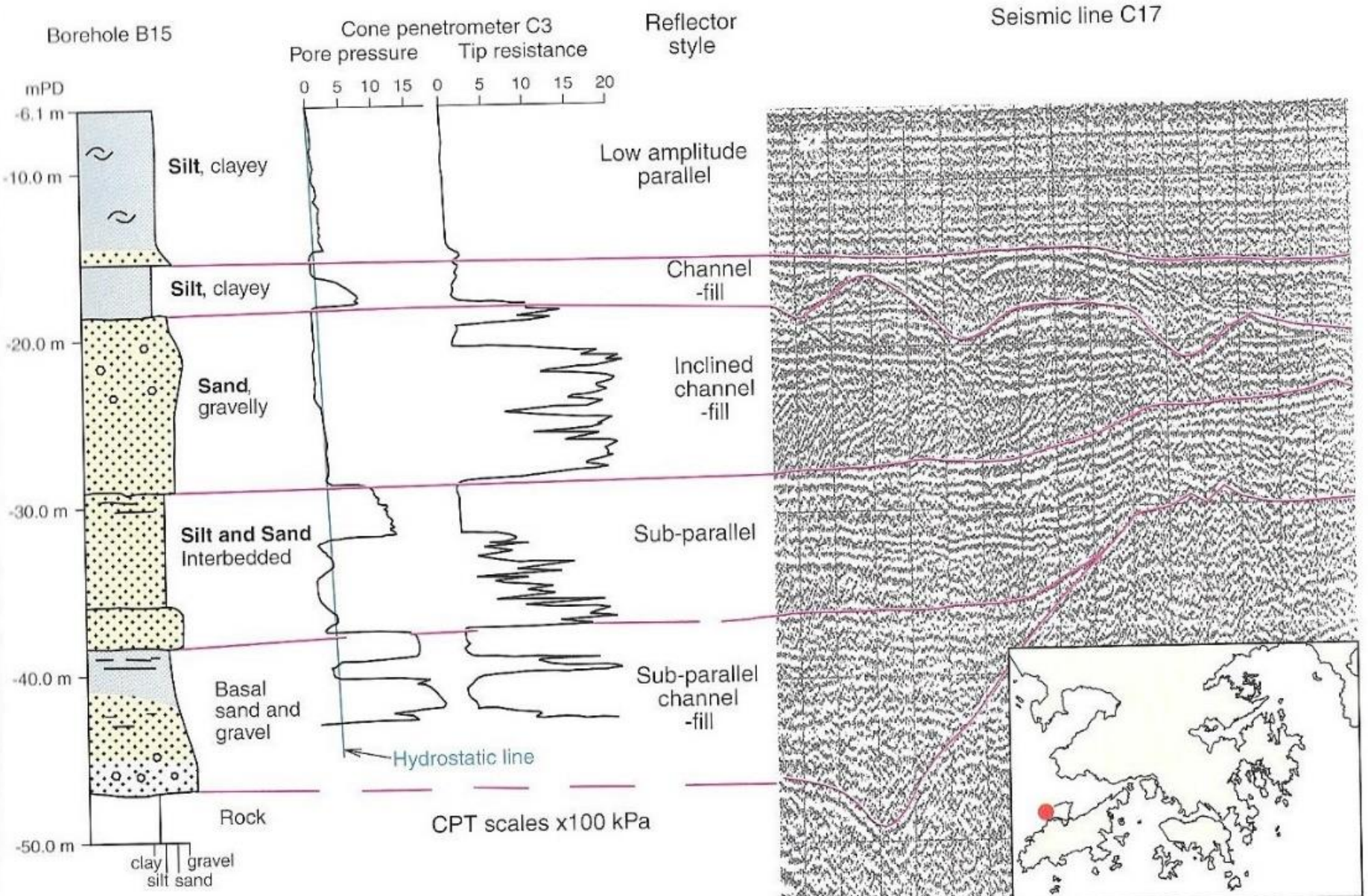
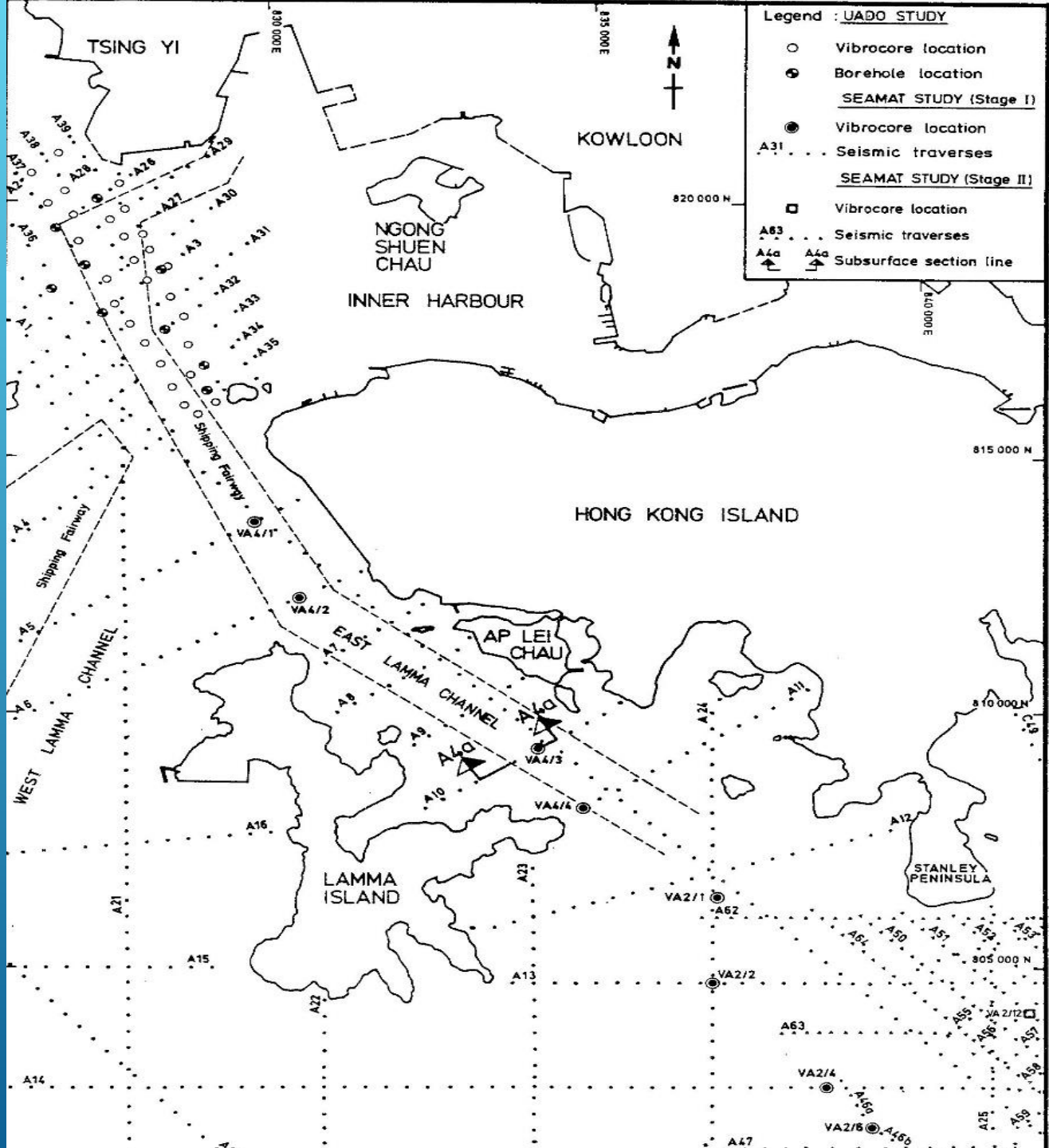
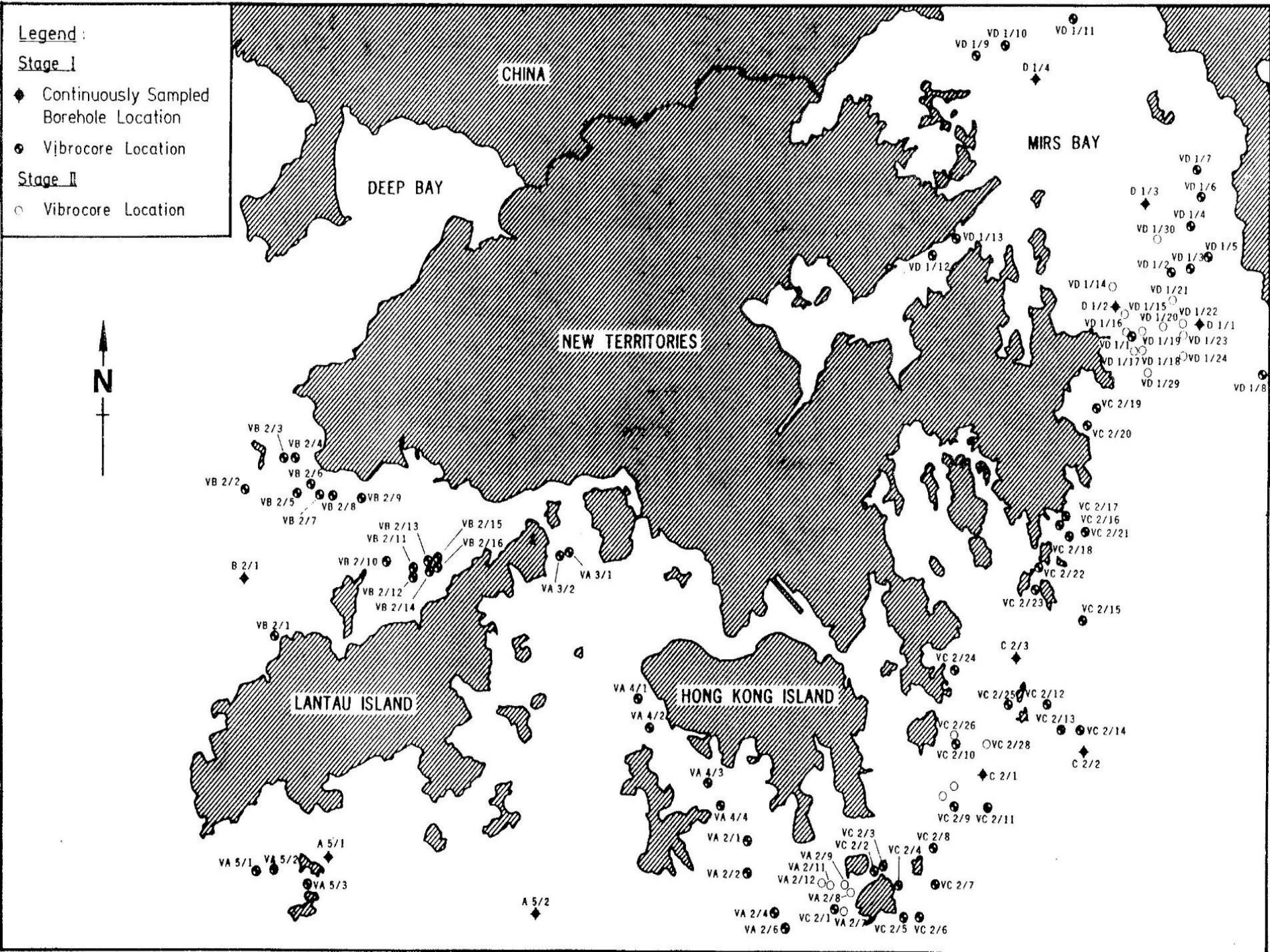


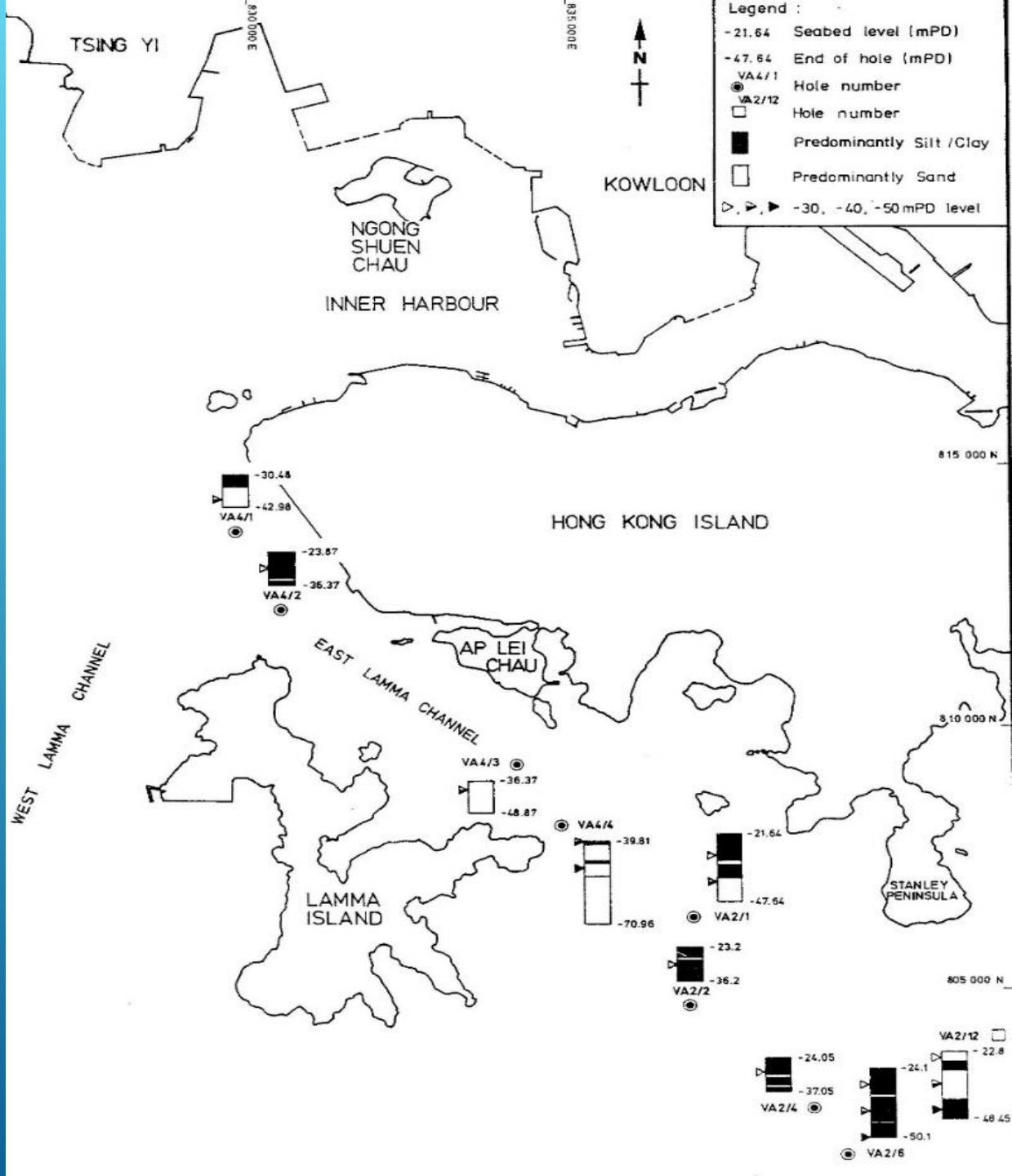
Figure 4.11 - Correlation between borehole log, cone penetrometer curves and seismic profile

物探測線，振孔及鑽孔位置(青衣南及東博寮海峽)

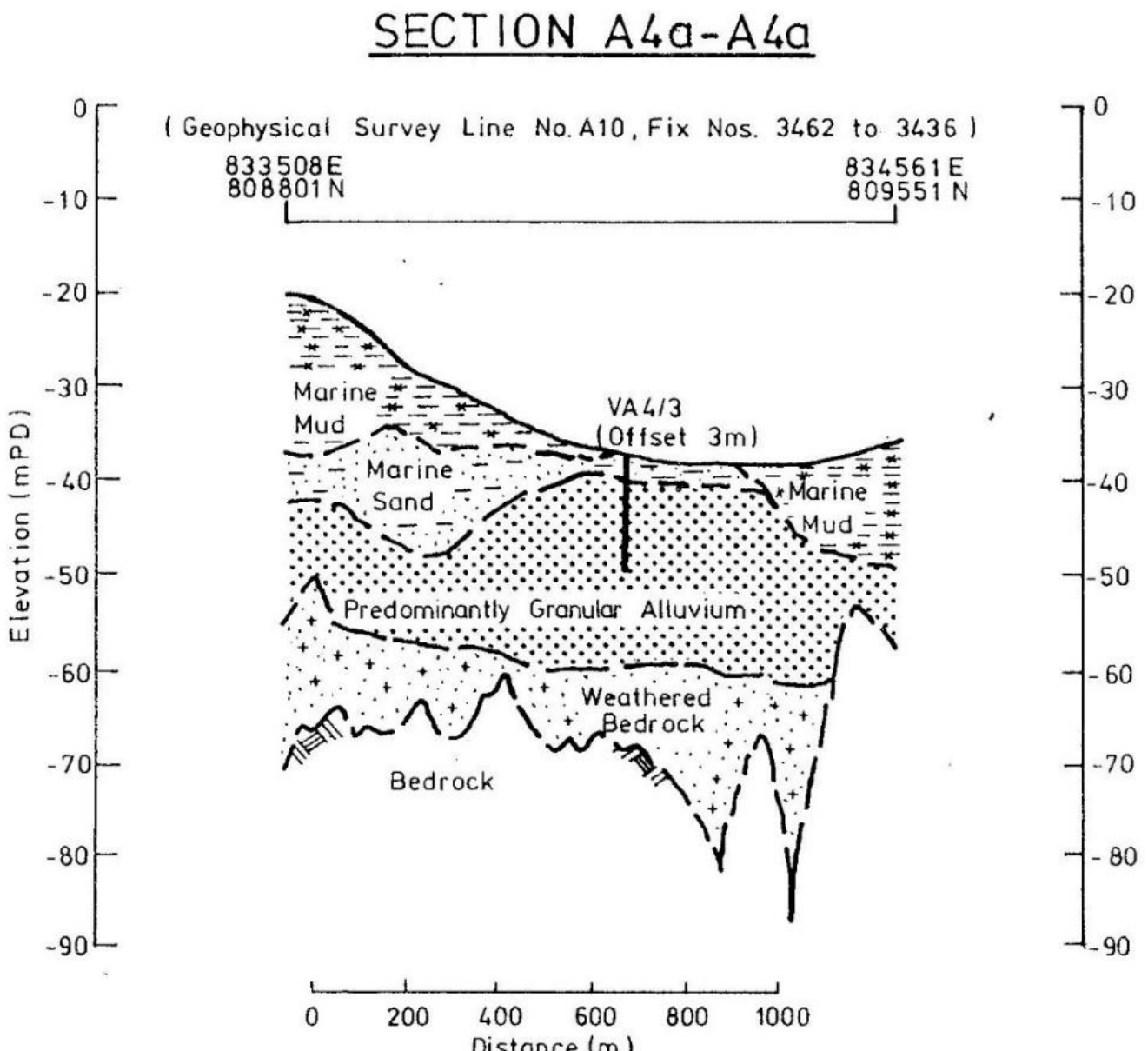


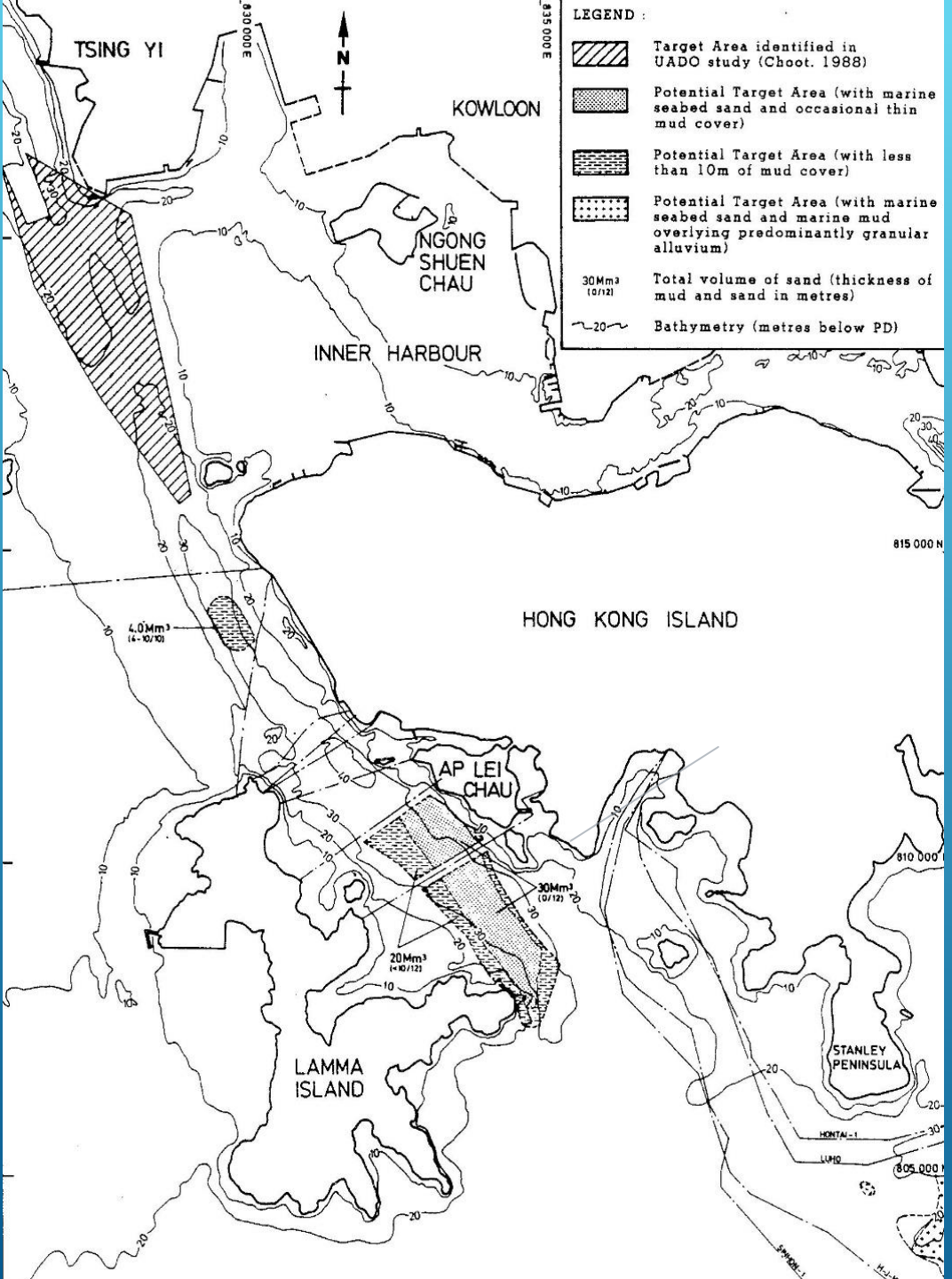

Legend :
Stage I
Continuously Sampled Borehole Location
Vibrocore Location
Stage II
Vibrocore Location
CHINA
DEEP BAY
MIRS BAY
NEW TERRITORIES
LANTAU ISLAND
HONG KONG ISLAND
N
VD 1/10
VD 1/11
VD 1/9
D 1/4
VD 1/7
VD 1/6
D 1/3
VD 1/4
VD 1/30
VD 1/5
VD 1/2
VD 1/3
VD 1/13
VD 1/12
VD 1/14
VD 1/21
D 1/2
VD 1/15
VD 1/22
VD 1/16
VD 1/20
D 1/1
VD 1/1
VD 1/19
VD 1/23
VD 1/17
VD 1/18
VD 1/24
VD 1/29
VD 1/8
VC 2/19
VC 2/20
VB 2/3
VB 2/4
VB 2/6
VB 2/2
VB 2/5
VB 2/8
VB 2/9
VB 2/7
VB 2/13
VB 2/11
VB 2/15
VB 2/16
VB 2/10
B 2/1
VB 2/12
VB 2/14
VA 3/2
VA 3/1
VC 2/17
VC 2/16
VC 2/21
VC 2/18
VC 2/22
VC 2/23
VC 2/15
VB 2/1
C 2/3
VC 2/24
VA 4/1
VA 4/2
VC 2/25
VC 2/12
VC 2/13
VC 2/14
VC 2/26
VC 2/28
VC 2/10
C 2/2
C 2/1
VA 4/3
VA 4/4
VC 2/9
VC 2/11
VA 2/1
VC 2/3
VC 2/2
VC 2/8
VC 2/4
VA 2/9
VA 2/11
VA 2/12
VA 2/2
VC 2/7
VA 2/8
A 5/1
VA 5/1
VA 5/2
VA 5/3
A 5/2
VA 2/4
VA 2/6
VC 2/1
VA 2/7
VC 2/5
VC 2/6

簡單振孔的泥砂記錄


TSING YI
KOWLOON
NGONG SHUEN CHAU
INNER HARBOUR
HONG KONG ISLAND
AP LEI CHAU
EAST LAMMA CHANNEL
WEST LAMMA CHANNEL
LAMMA ISLAND
STANLEY PENINSULA
N
Legend :
-21.64 Seabed level (mPD)
-47.64 End of hole (mPD)
VA4/1 Hole number
VA2/12 Hole number
Predominantly Silt /Clay
Predominantly Sand
-30, -40, -50 mPD level
815 000 N
810 000 N
805 000 N
VA4/1 -30.48 -42.98
VA4/2 -23.87 -36.37
VA4/3 -36.37 -48.87
VA4/4 -39.81 -70.96
VA2/1 -21.64 -47.64
VA2/2 -23.2 -36.2
VA2/4 -24.05 -37.05
VA2/6 -24.1 -50.1
VA2/12 -22.8 -48.45

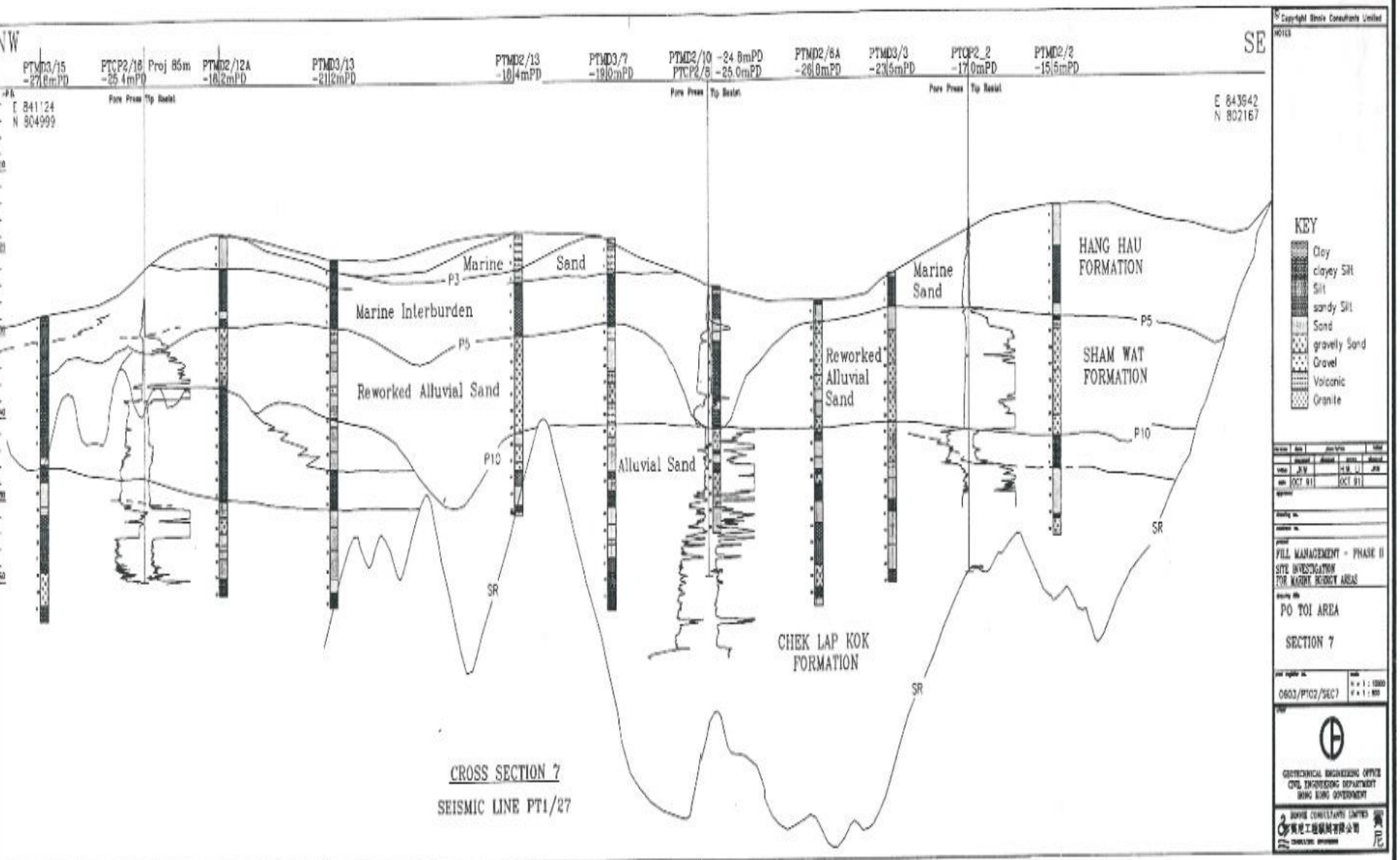
用振孔資料確定已分析的地震剖面





東博寮海峽採砂區
30Mm3(0泥/12砂
(計算至水下50米))
20Mm3
(<10泥/12砂)

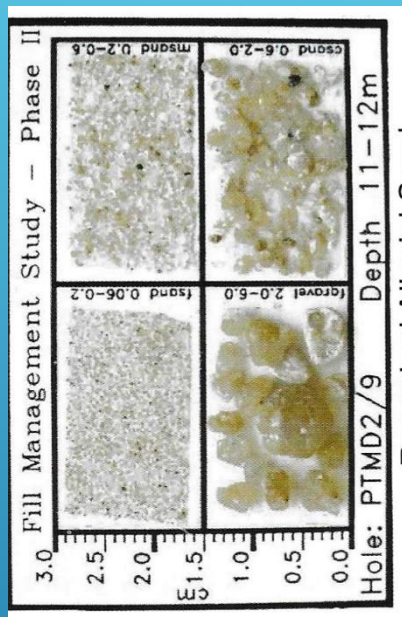
西蒲台採砂區



CROSS SECTION 7

SEISMIC LINE PT1/27

蒲台採砂區



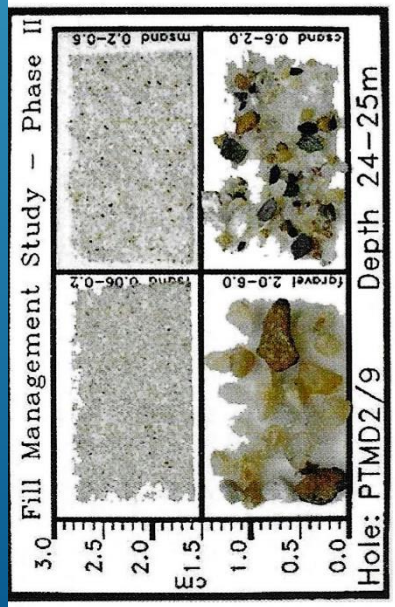
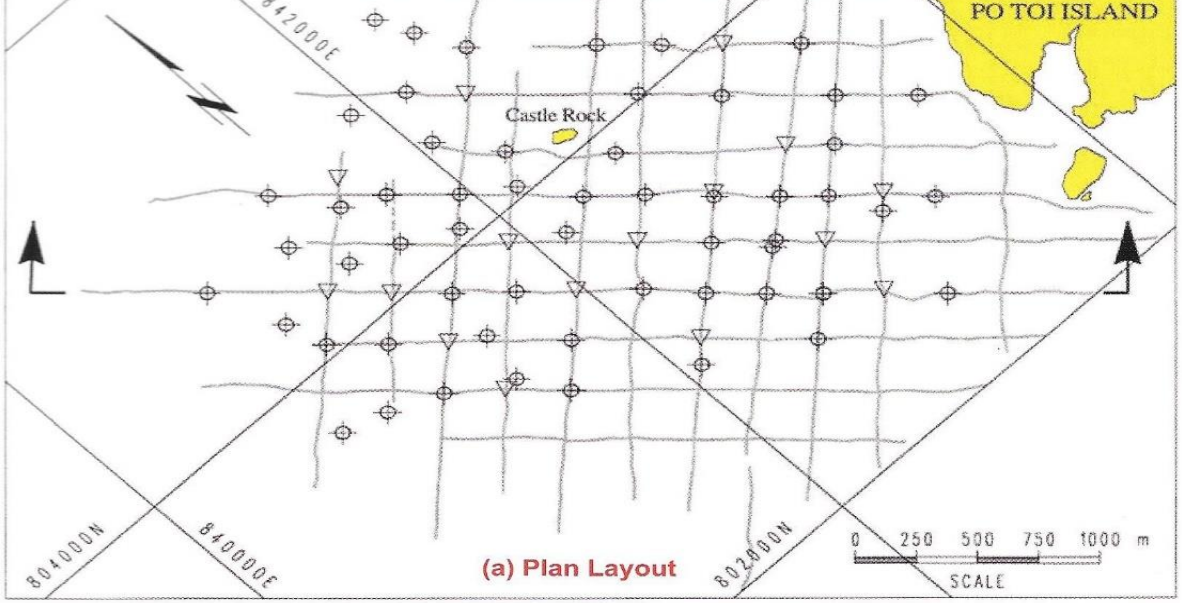


Figure 6.10.6 – Photograph of alluvial sand and reworked alluvial sand from West Po Toi marine borrow area (BCL, 1991-93)



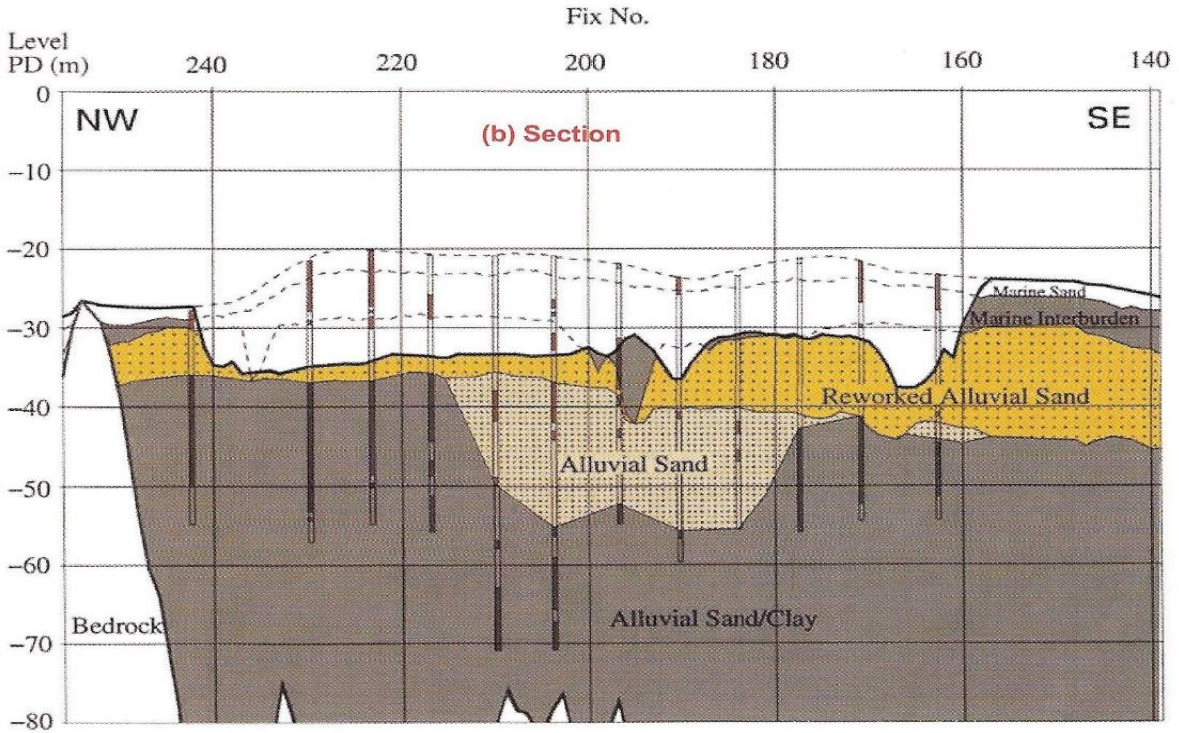
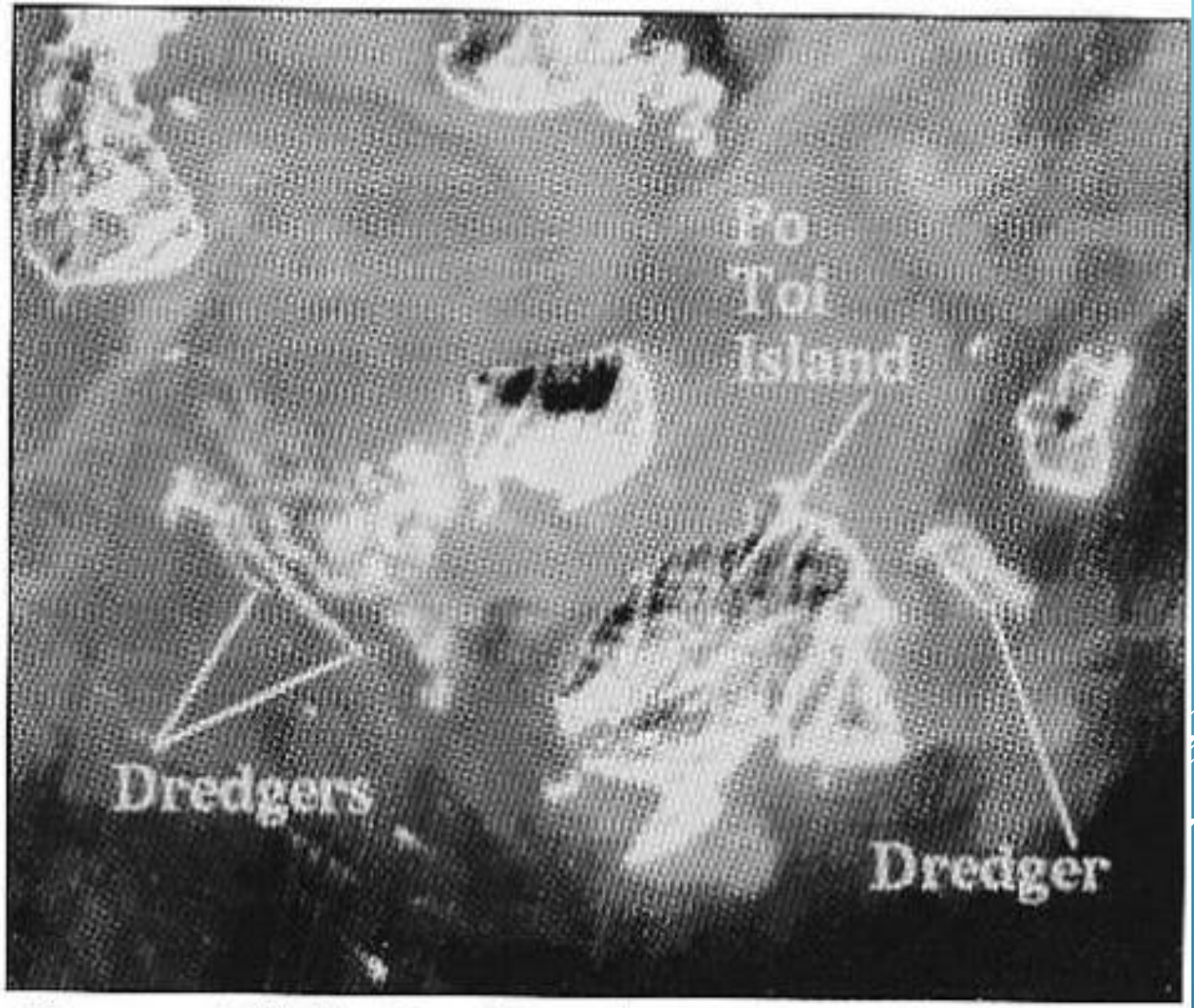


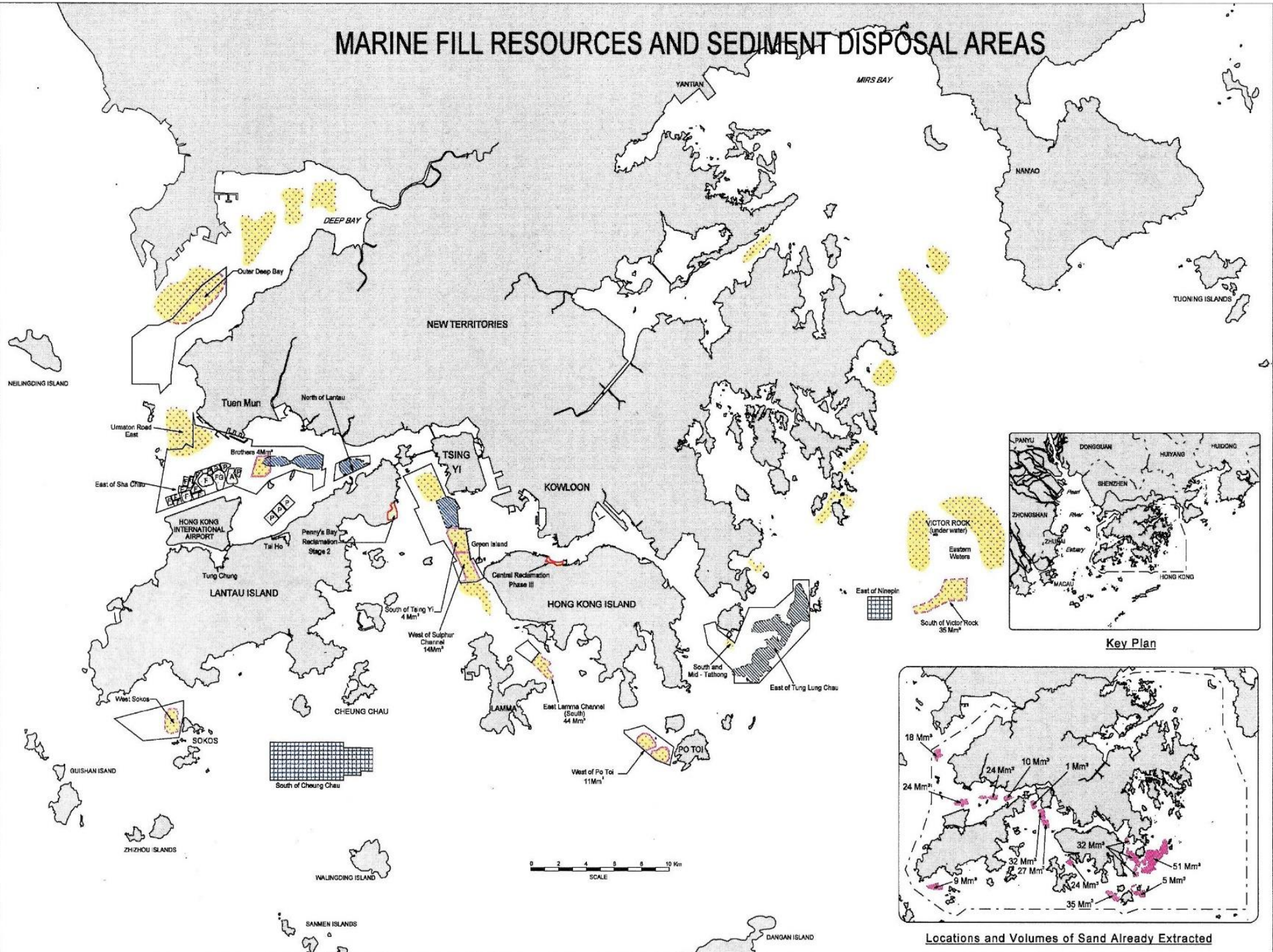
Figure 6.10.5 – Plan layout and section through the West Po Toi marine borrow area (after DEMAS, 1996)

Dredging plumes generated by 3 dredgers around Po Toi Islands



Figures 6.10.7 – Satellite photograph of dredging plumes around the Po Toi Islands

MARINE FILL RESOURCES AND SEDIMENT DISPOSAL AREAS



選定有經濟價值的砂源的條件

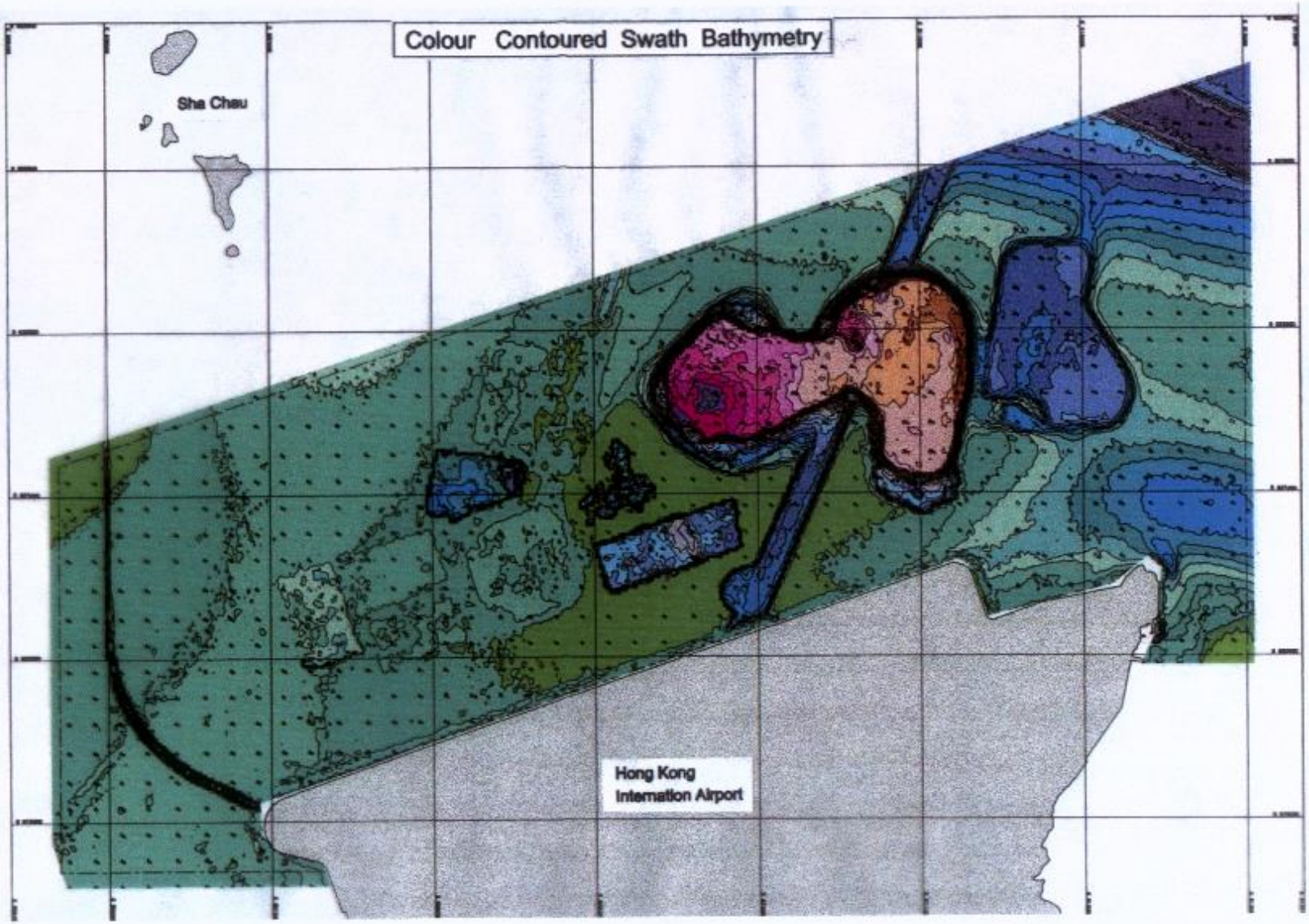
1.排除海底設施的地區
2.海泥覆蓋層厚度(少於10米)、
3.覆蓋泥層與砂層厚度比不大於1
4.標準貫入試驗值N不大於45
5.砂料總泥沙量不超百分之40
6.砂源深度不超基準面下50(80)米
7.砂層中的夾泥層不超50公分
8.環境影響評估

環境影響評估

懸浮物

水質調查

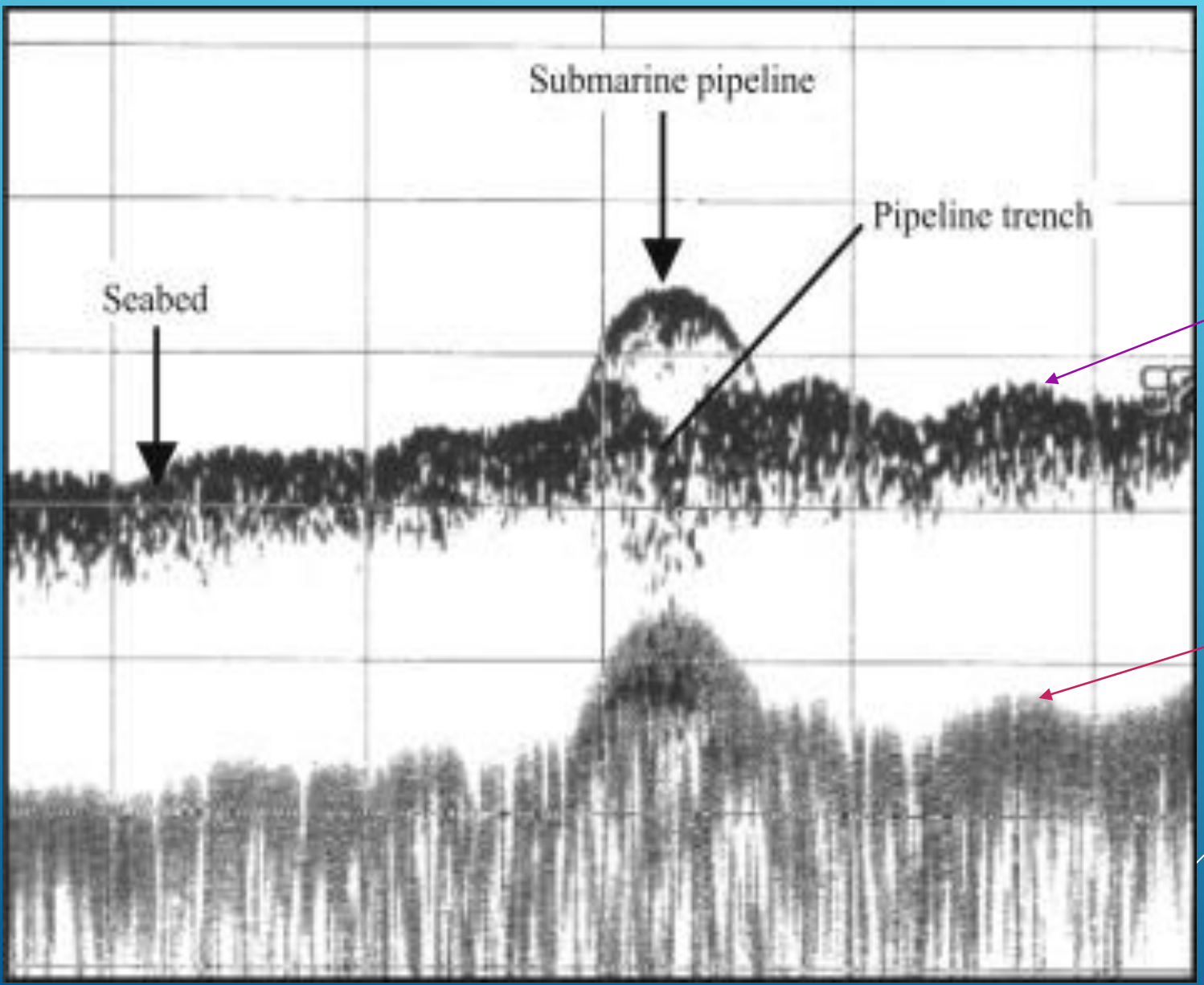
Collecting Water Sample



多聲度海床測量記錄

Multi-beam Bathymetry Record

Dual Frequency Chirp Survey (Echo sounding)



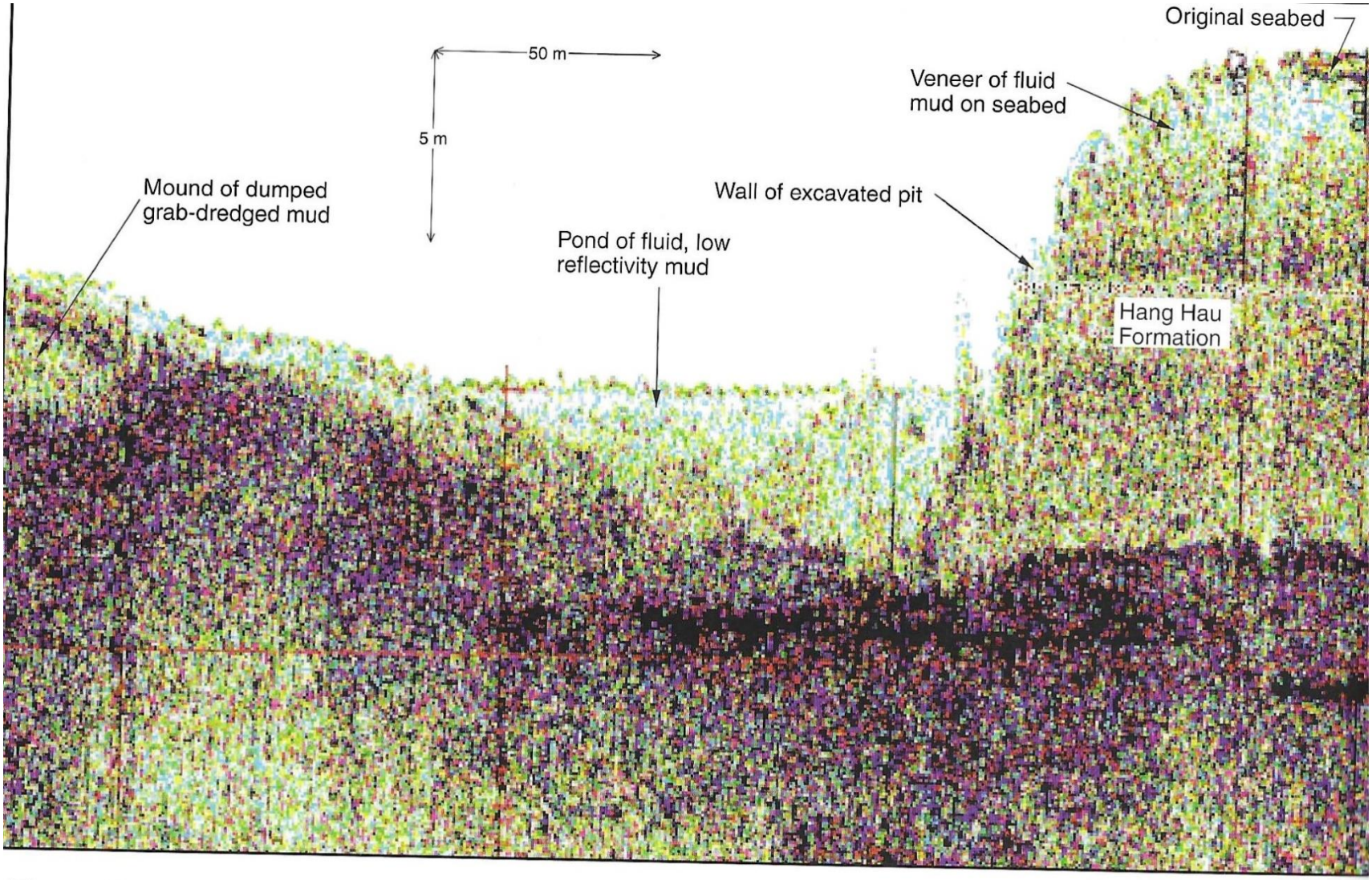
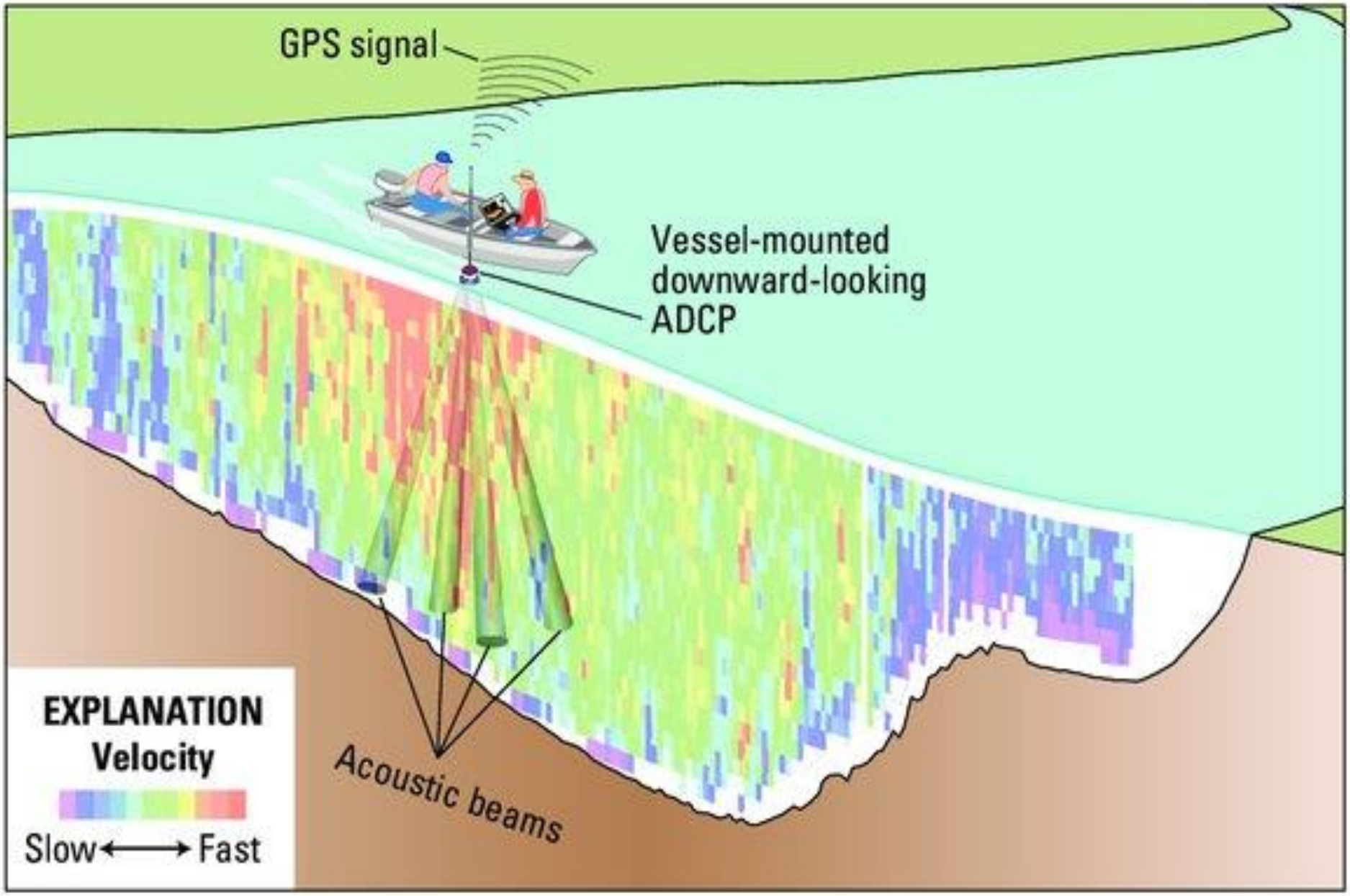


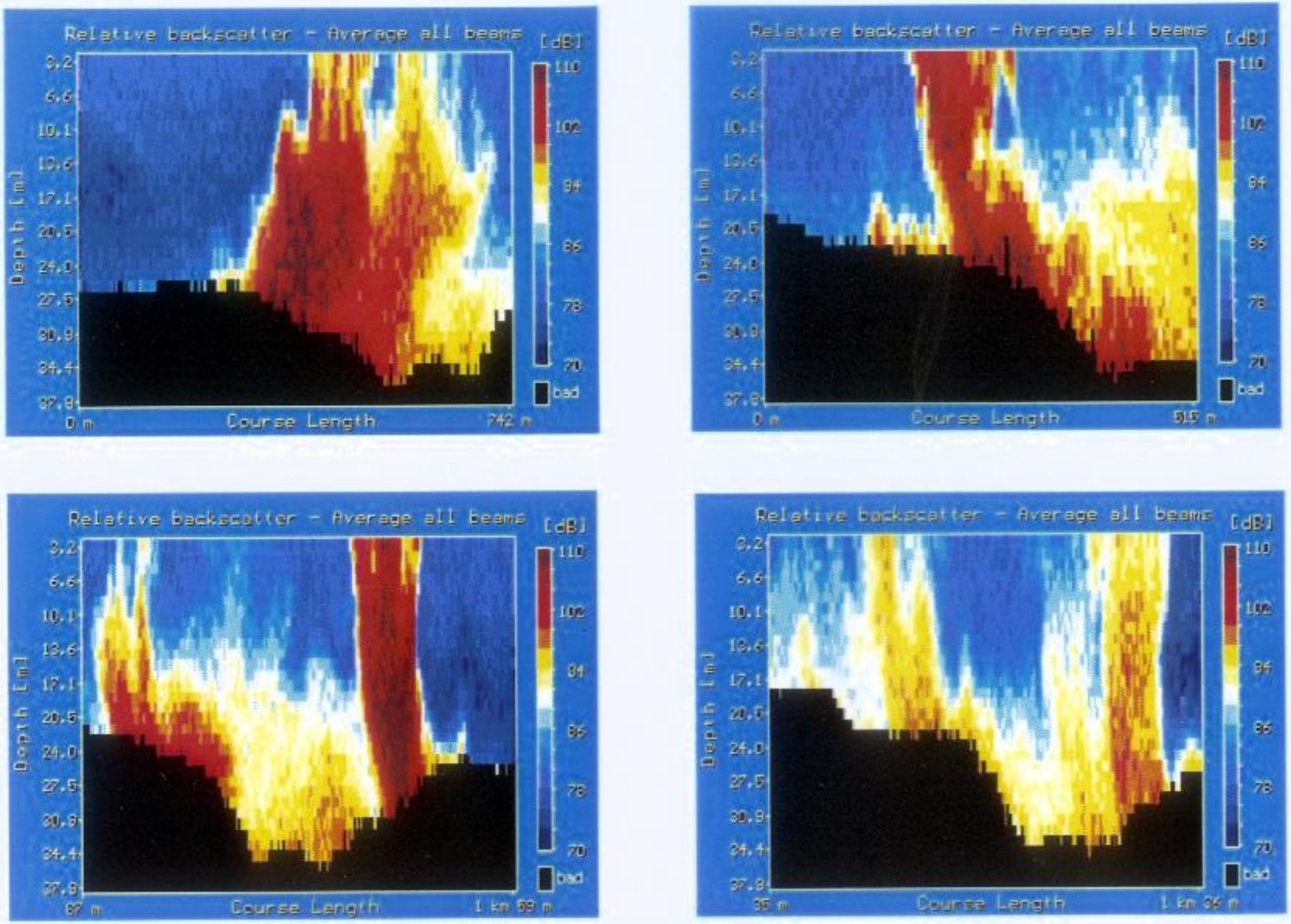
Figure 10.17 - Chirp record from an excavated pit near Sha Chau (沙洲), showing a layer of suspended mud

Acoustic Doppler Current Profiler (ADCP)



音波多譜勒水流計

Acoustic Doppler Current Profiler



監察在卸泥時的懸浮固體濃度

Monitoring of Suspended Solid Concentration during Mud Disposal

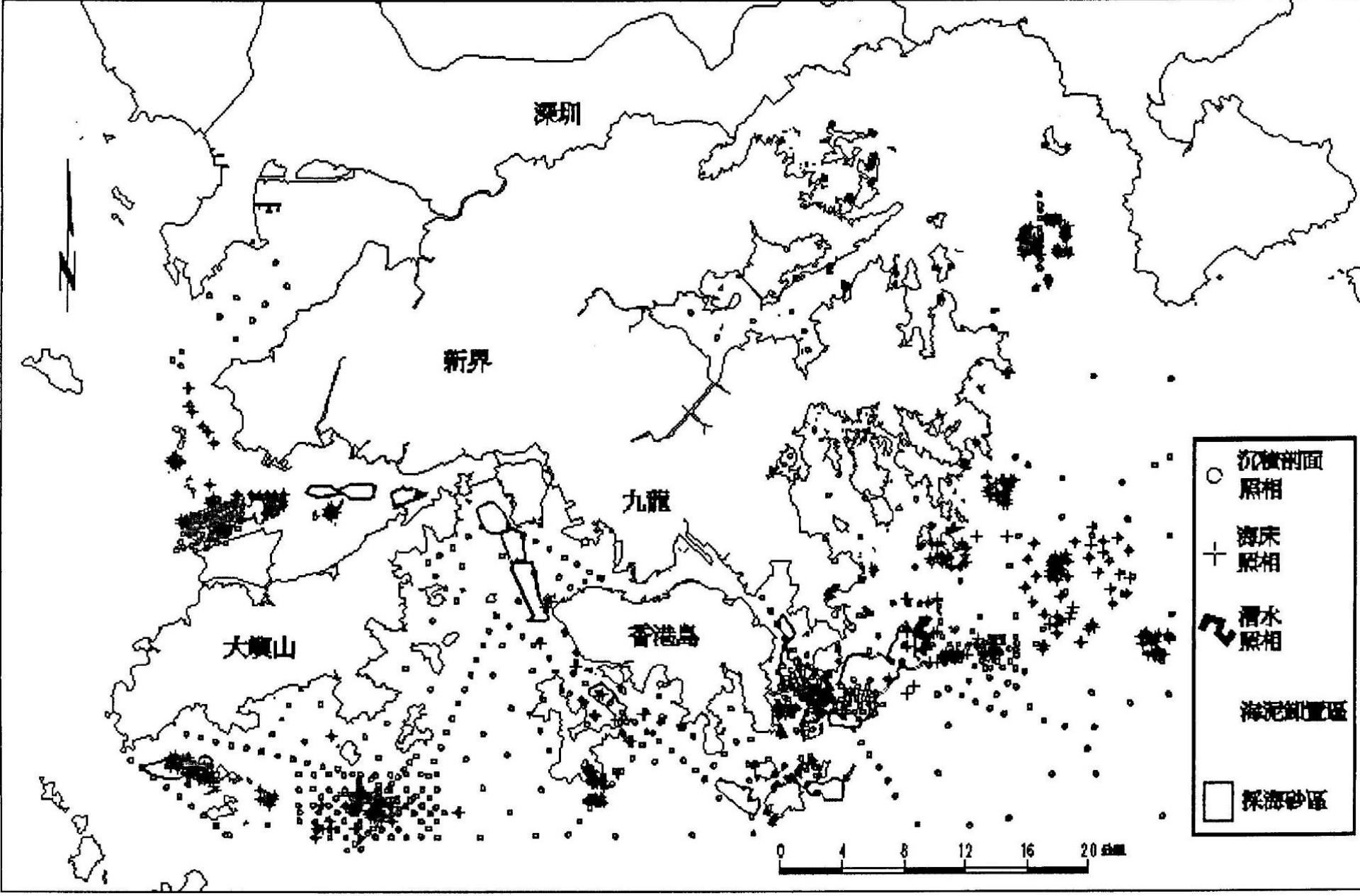
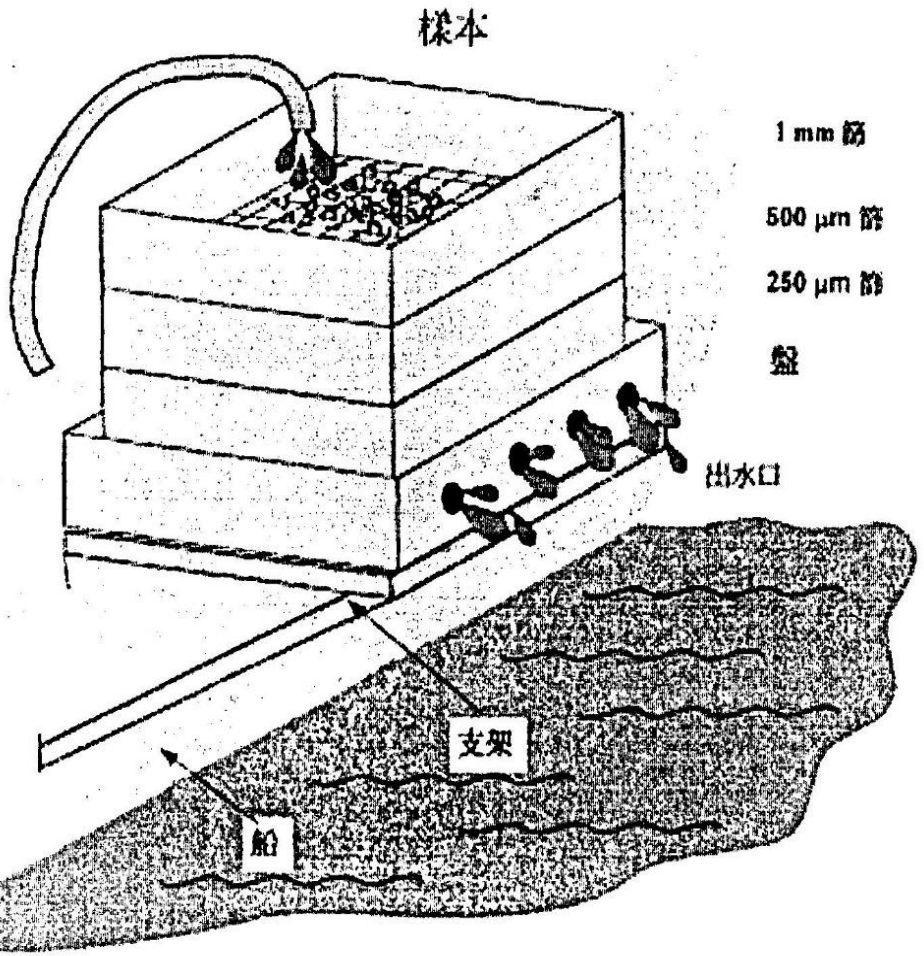


圖 11 – 海洋生態調查(潛水,海床及沉積剖面照相)位置

採海砂時有小量粉砂流回海床

篩選方法



乙) 沉積剖面照相方法

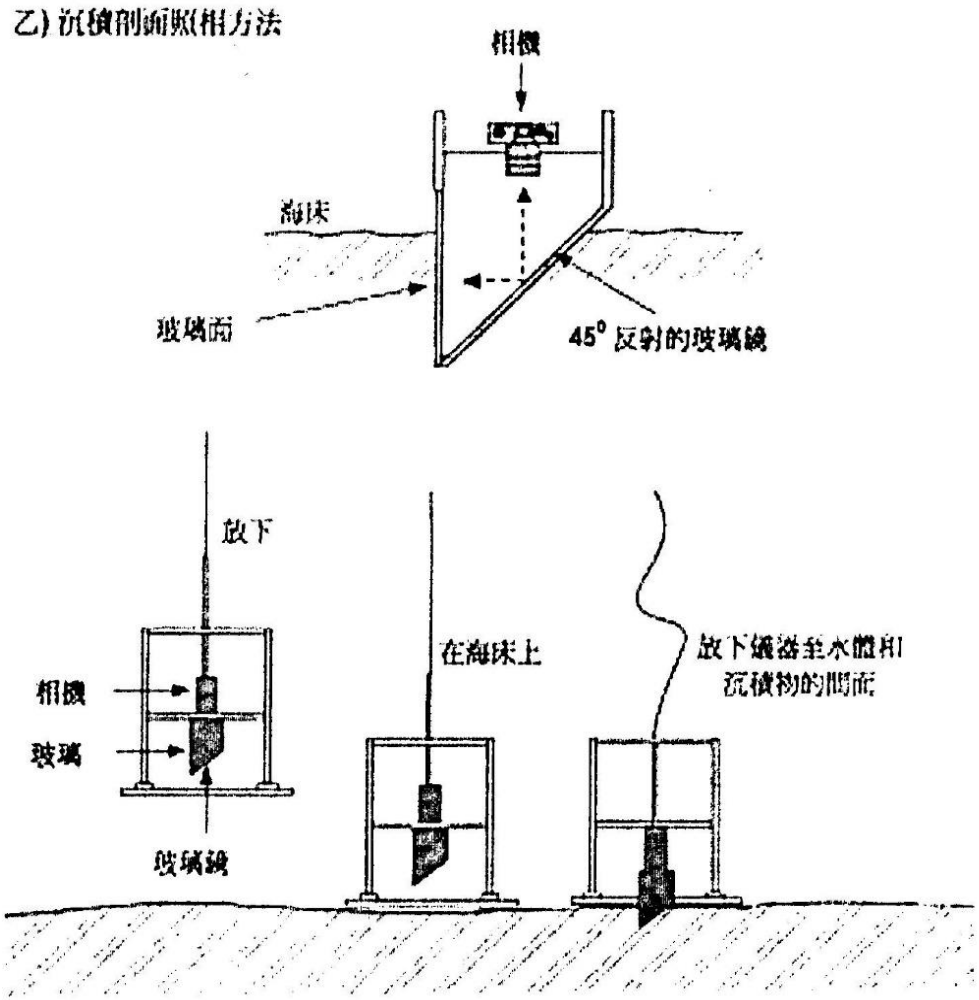


圖 12 - 甲) 篩選方法, 乙) 沉積剖面照相方法

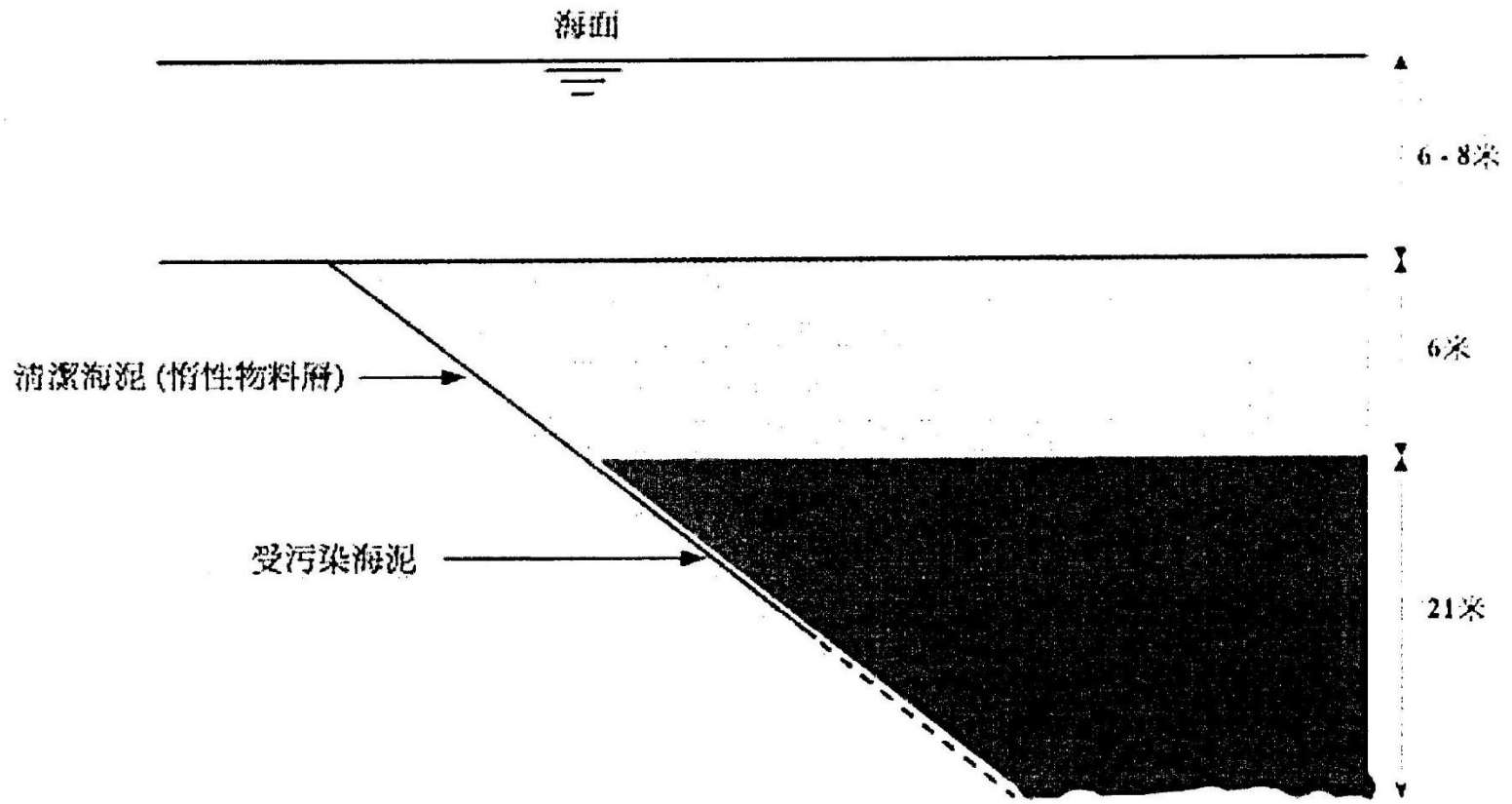
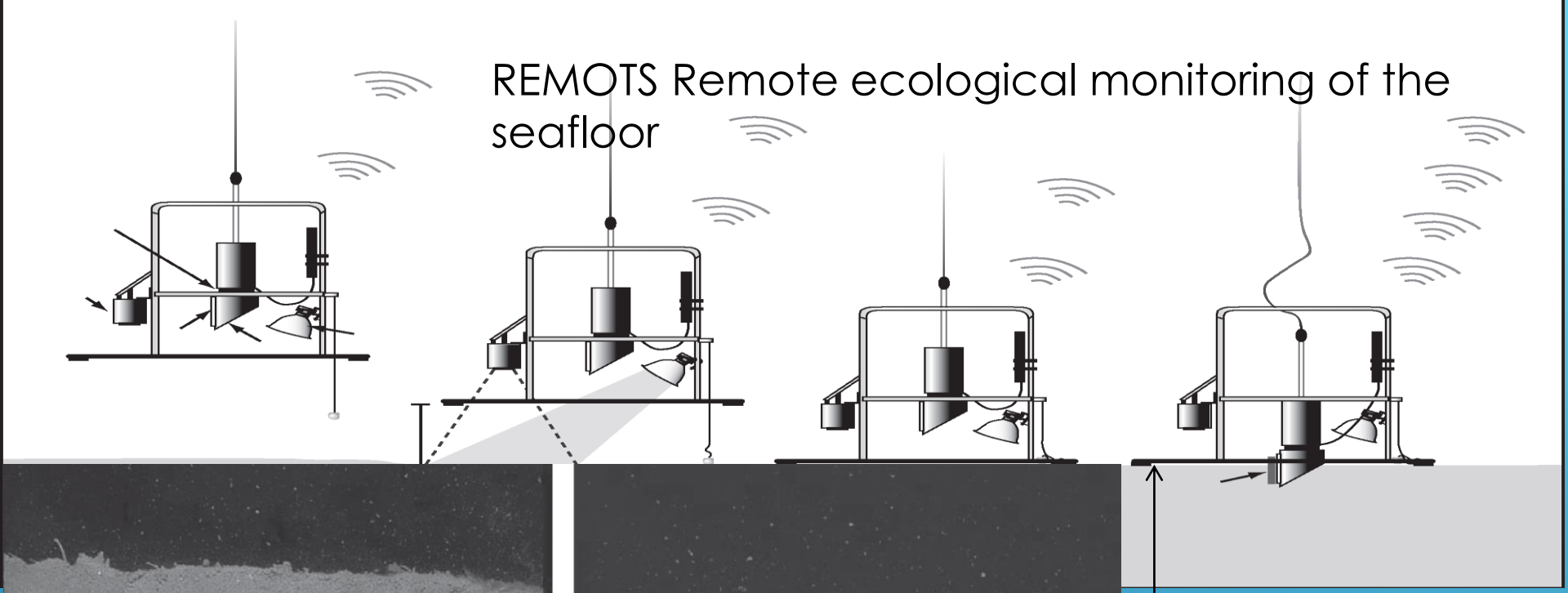
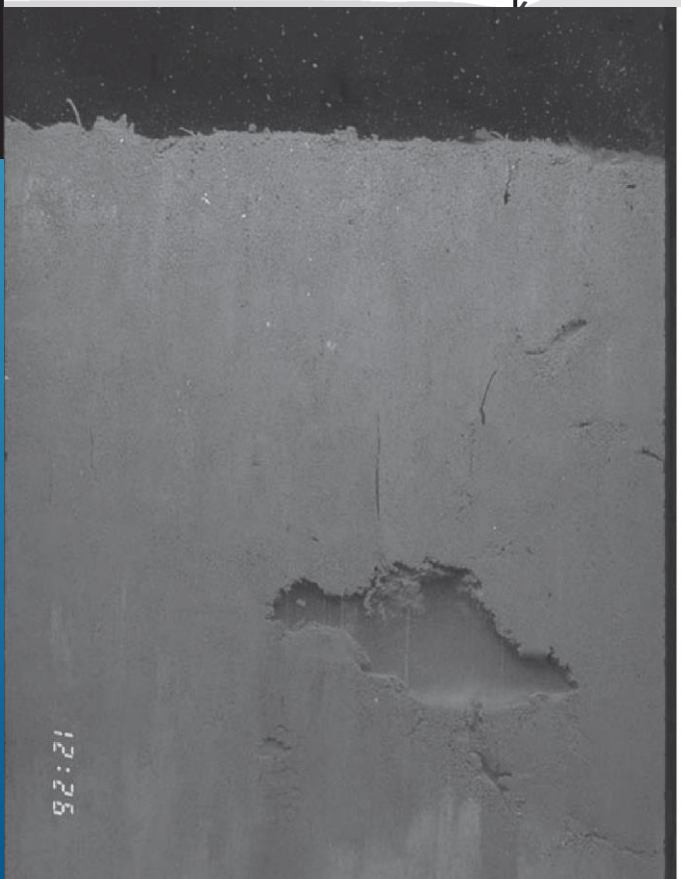


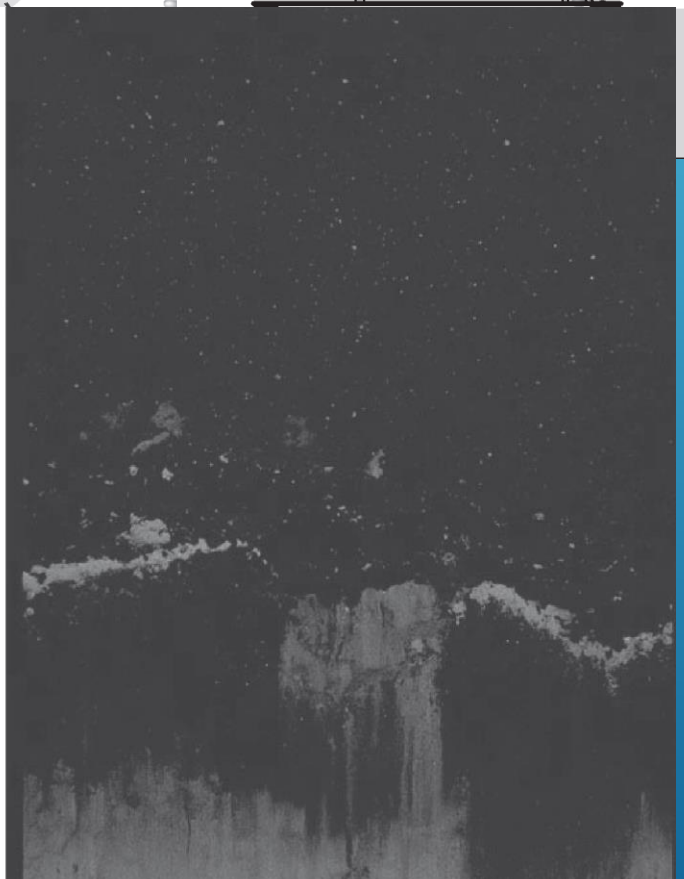
圖 13 - 本港受污染泥坑的大綱

Plate 13.2 - The REMOTS system and photographs: a. REMOTS seabed camera b. a muddy seabed c. the abandoned disposal ground in Mirs Bay (大鵬灣)

REMOTS Remote ecological monitoring of the seafloor



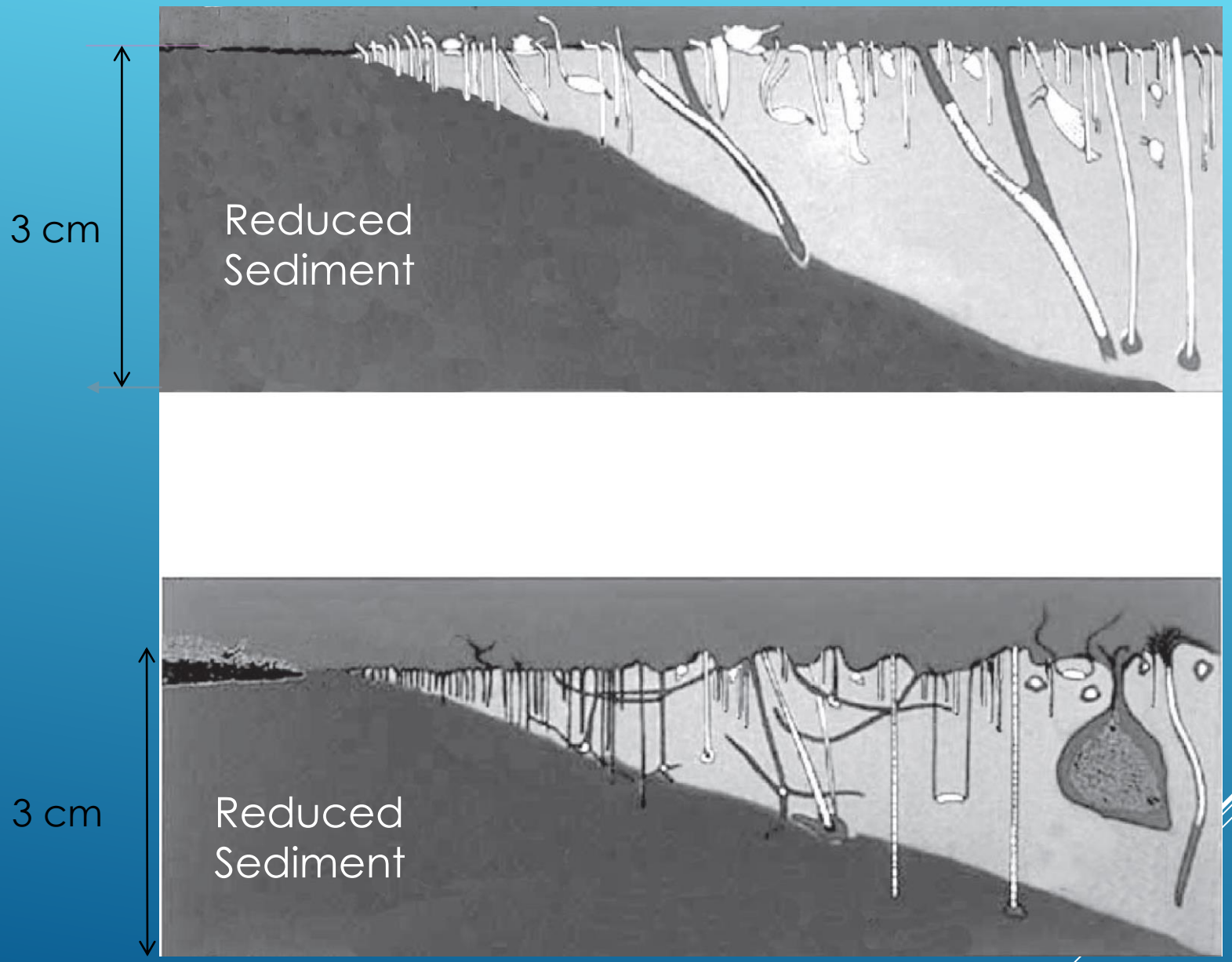




5 cm

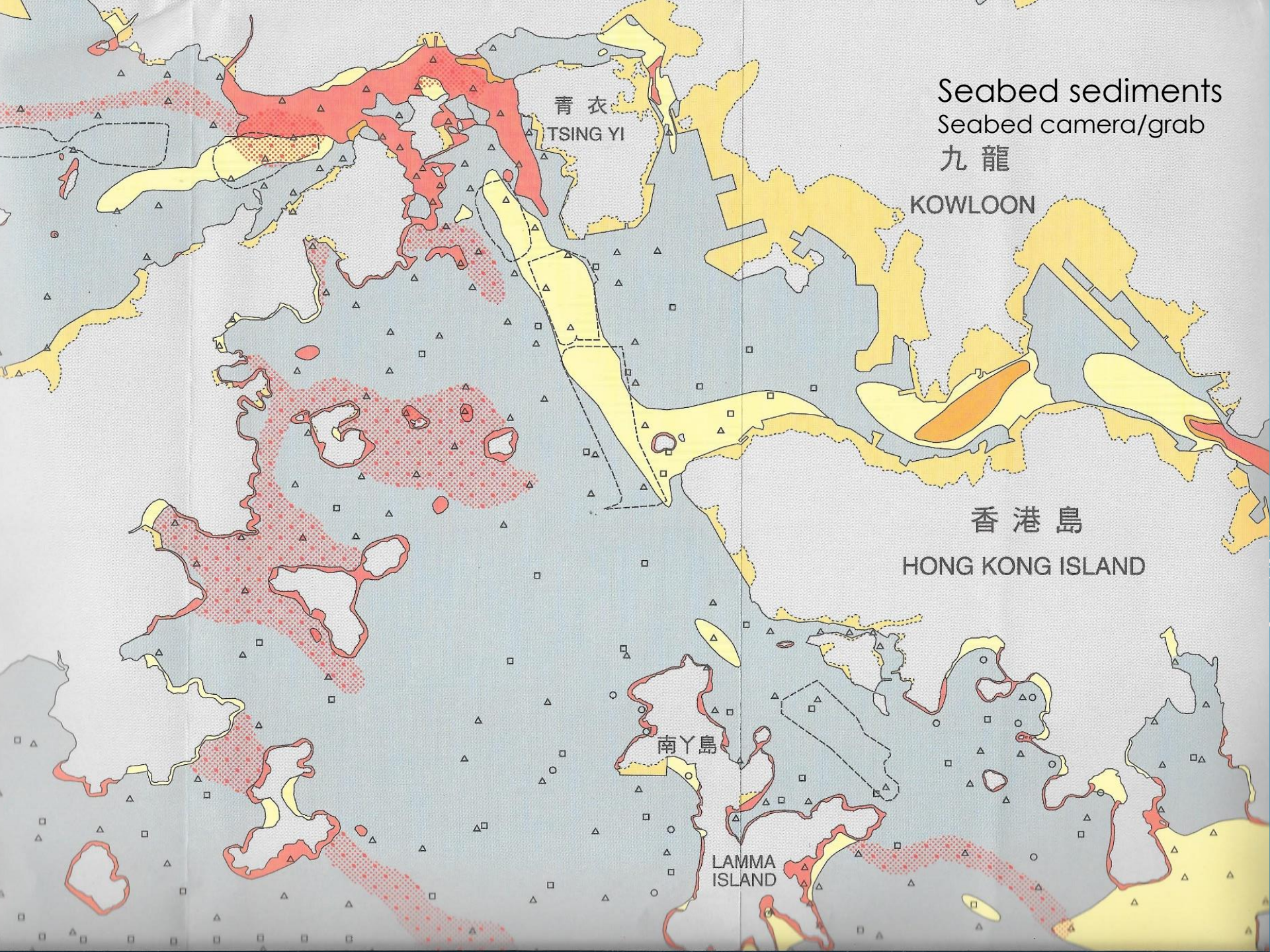
Healthy, undisturbed organically seabed

Sediment profile imaging for EIA assessment and monitoring

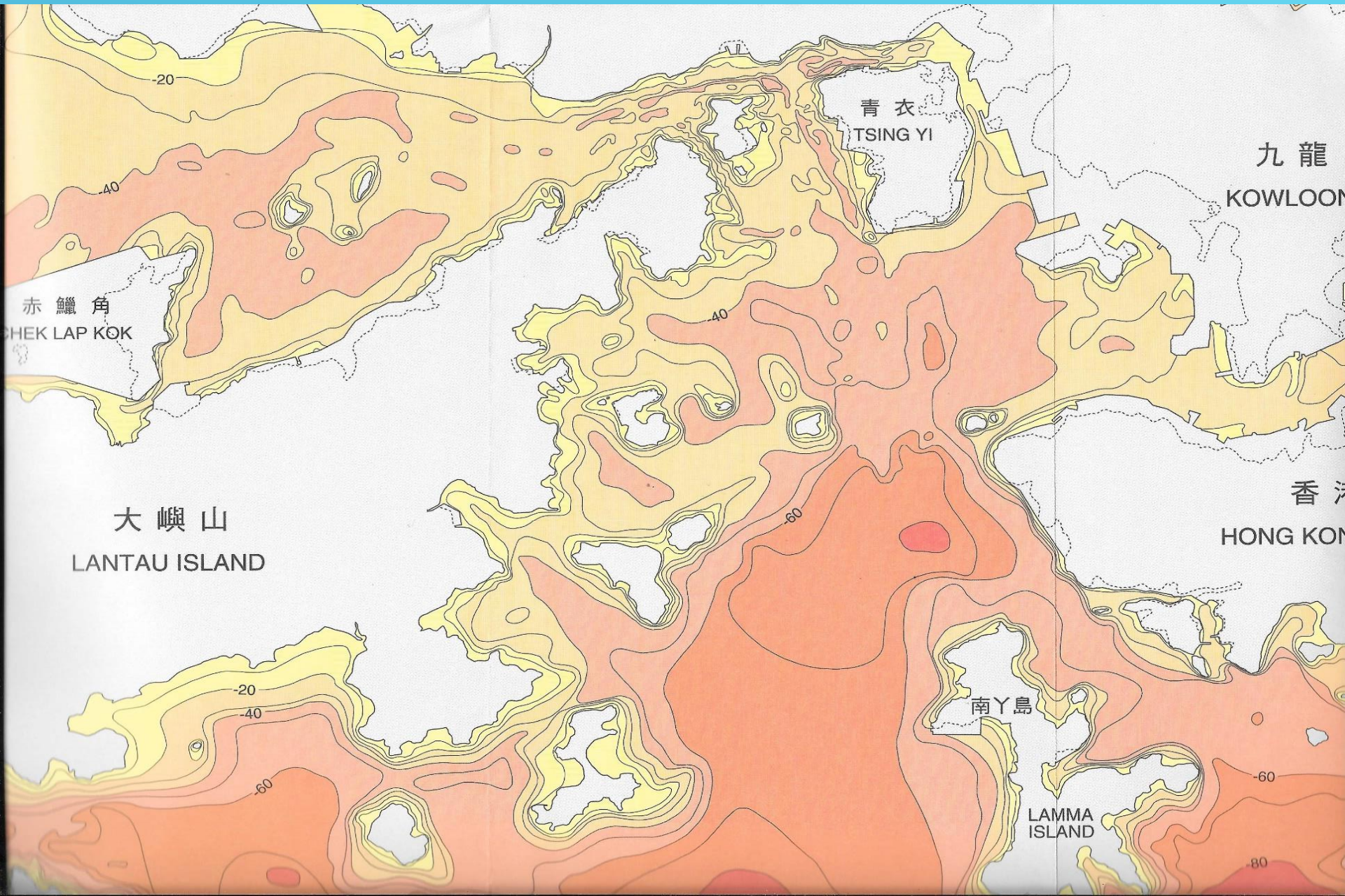


Germano et. Al, 2011 Oceanography and Marine Biology


Bathymetry
青衣
TSING YI
赤鱲角
CHEK LAP KOK
大嶼山
LANTAU ISLAND
南丫島
LAMMA ISLAND
KOWL
HONG
-10
-20
-30
-40


Seabed sediments
Seabed camera/grab
九 龍
KOWLOON
青 衣
TSING YI
香 港 島
HONG KONG ISLAND
南丫島
LAMMA
ISLAND

全風化至未風化岩的深度



Methane within the Marine Mud, Hang Hau Formation

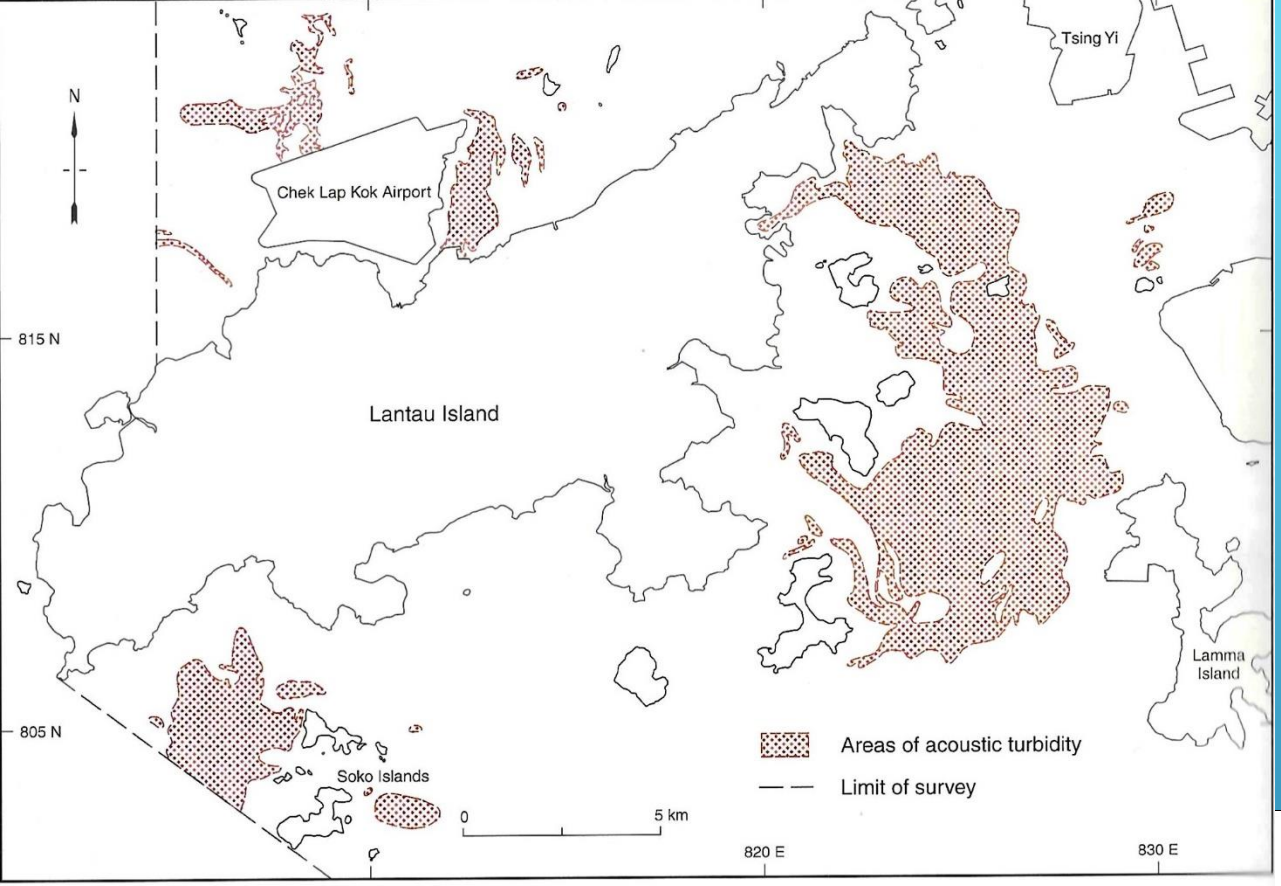


Figure 10.10 - Distribution of acoustic turbidity in Hong Kong waters

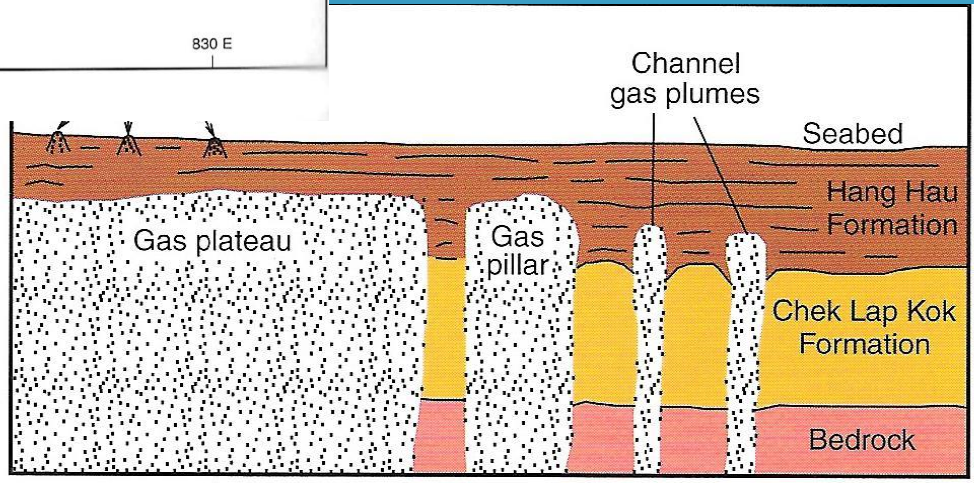


Figure 4.7 - Styles of acoustic turbidity seen on boomer profiles in Hong Kong (after Evans, 1988a)

TRAILER SUCTION HOPPER (7,000M3) DREDGER

HOPPER CONTAINING SANDS

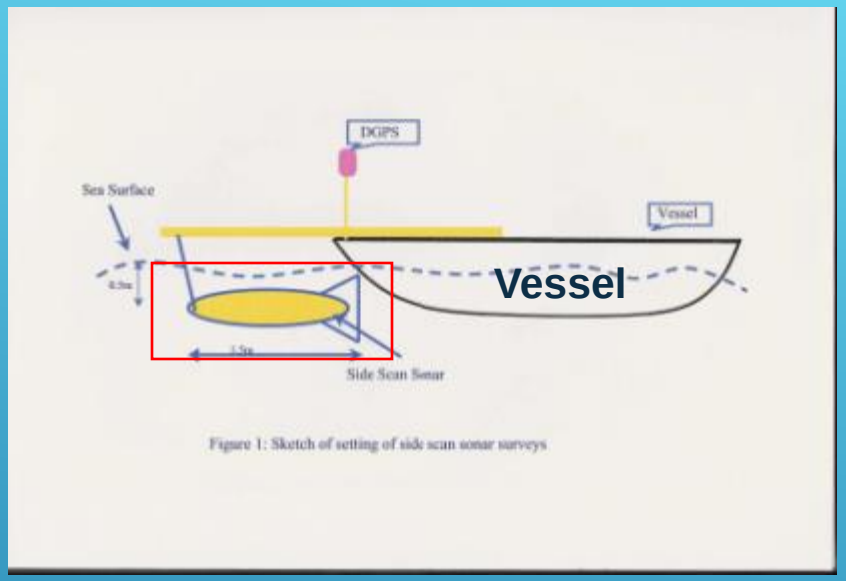
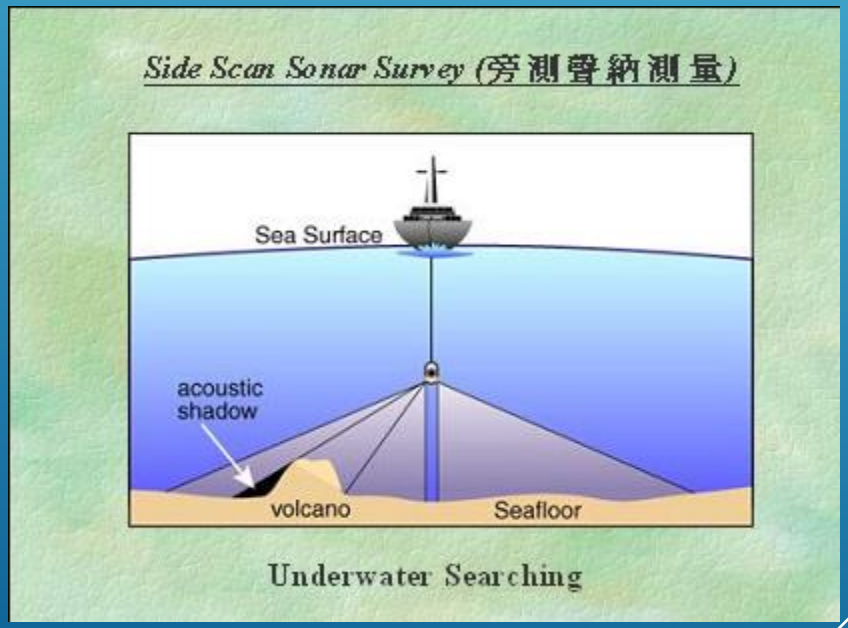


Figure 1: Sketch of setting of side scan sonar surveys



Tow-fish

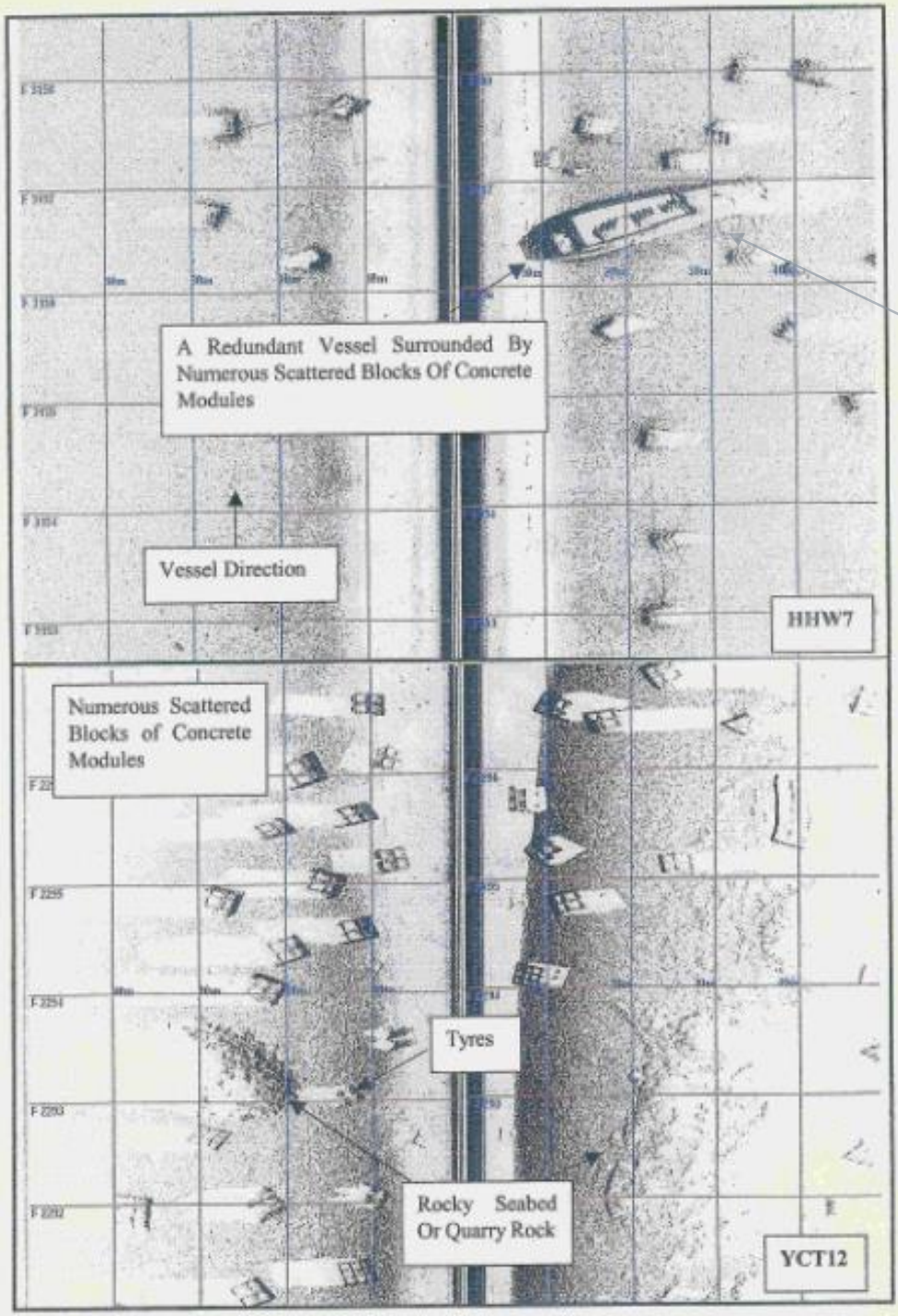
Side Scan Sonar

MARINE GEOPHYSICAL SURVEY

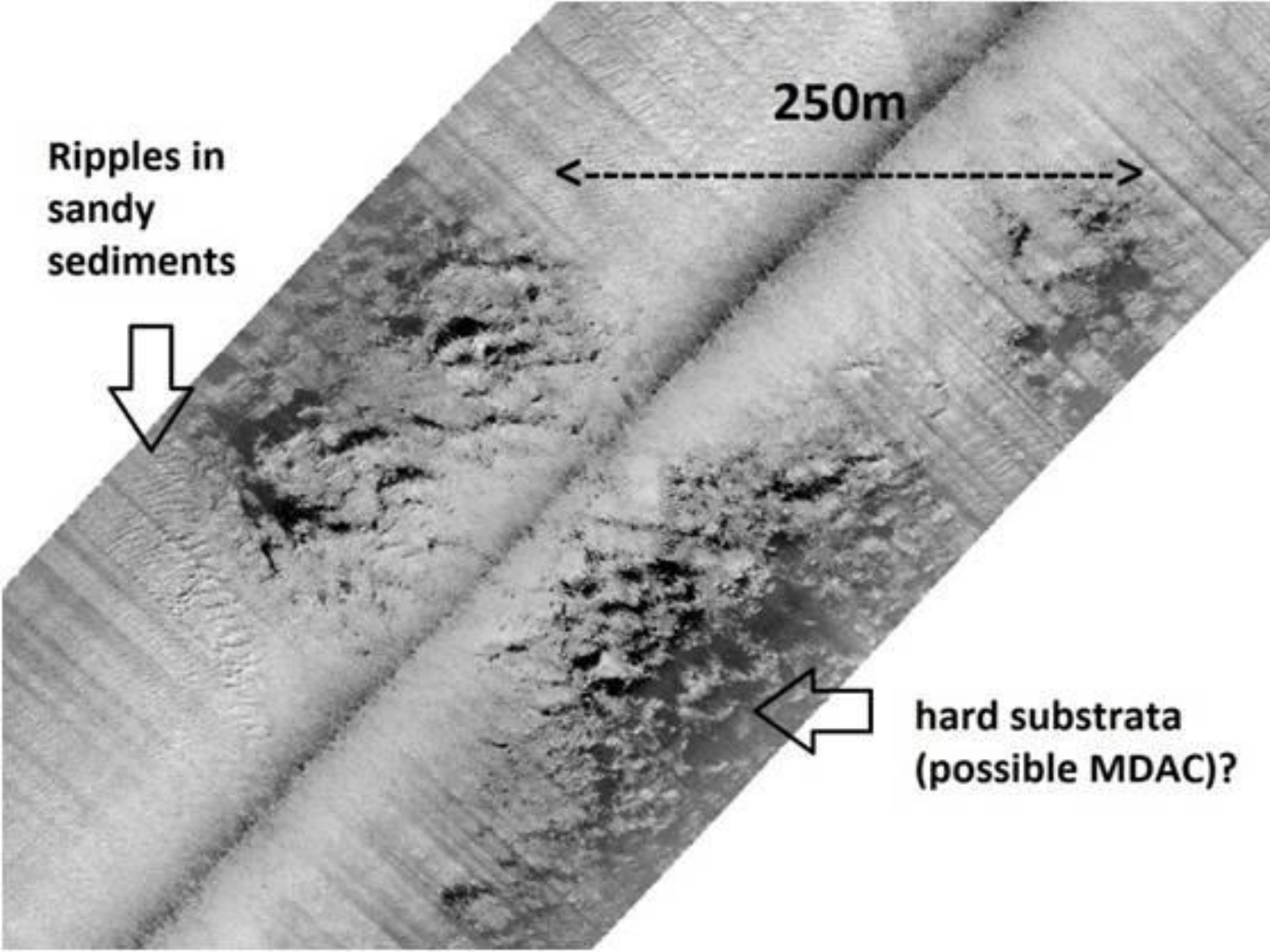
旁測聲納拖魚

Side Scan Sonar Tow Fish

旁測聲納記錄


A Redundant Vessel Surrounded By Numerous Scattered Blocks Of Concrete Modules
Vessel Direction
HHW7
Numerous Scattered Blocks of Concrete Modules
Tyres
Rocky Seabed Or Quarry Rock
YCT12

沉船


250m
Ripples in sandy sediments
hard substrata (possible MDAC)?

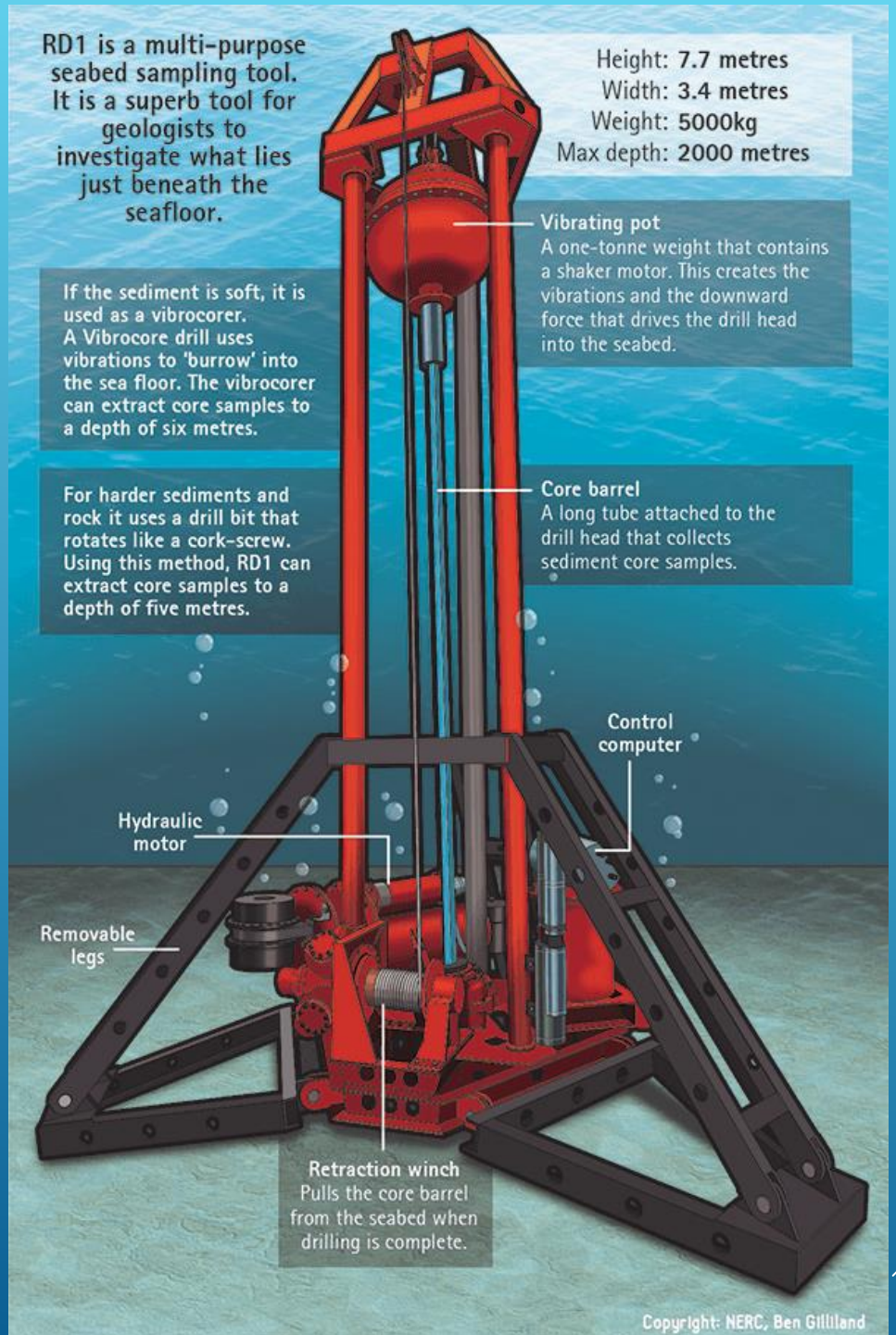
海上鑽探

U76mm

取砂器

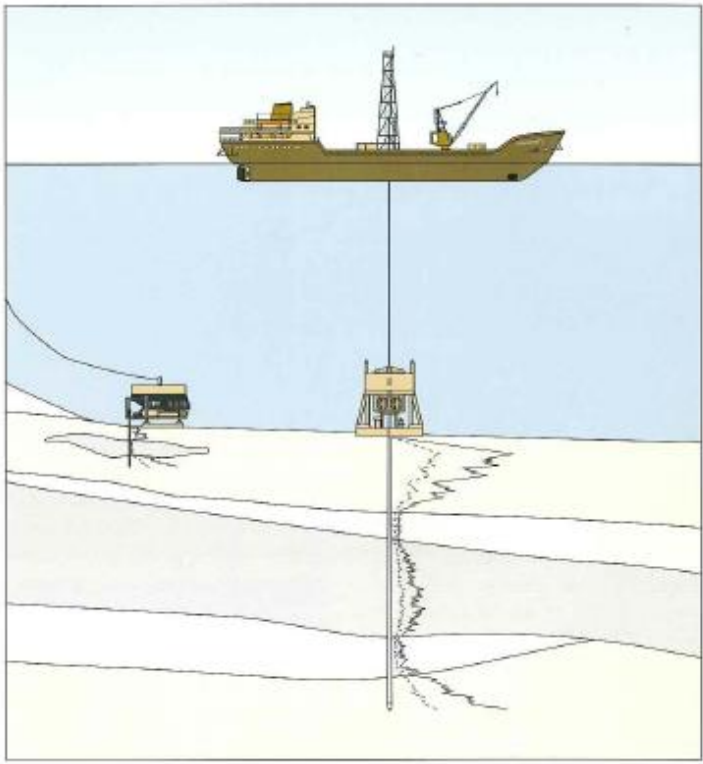

Gammon

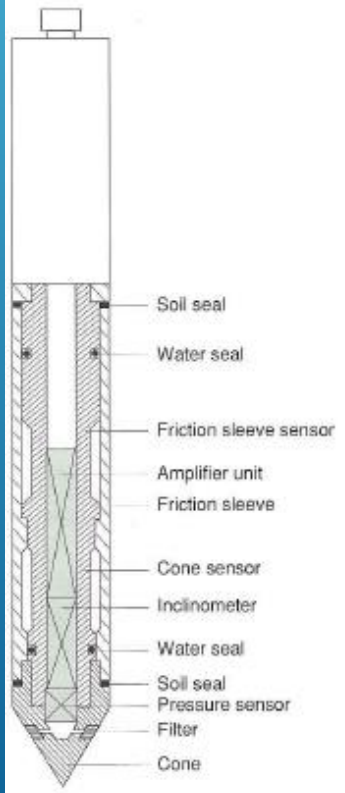
振孔

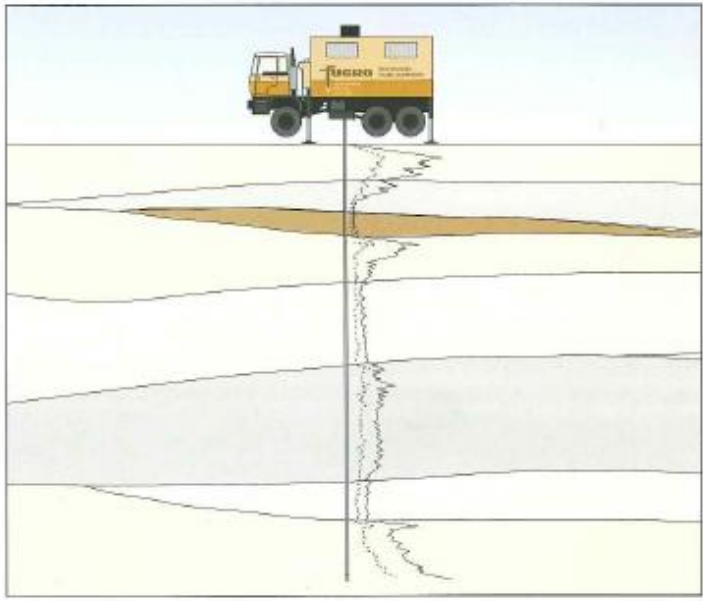

RD1 is a multi-purpose seabed sampling tool. It is a superb tool for geologists to investigate what lies just beneath the seafloor.
Height: 7.7 metres
Width: 3.4 metres
Weight: 5000kg
Max depth: 2000 metres
Vibrating pot
A one-tonne weight that contains a shaker motor. This creates the vibrations and the downward force that drives the drill head into the seabed.
If the sediment is soft, it is used as a vibrocorer. A Vibrocore drill uses vibrations to 'burrow' into the sea floor. The vibrocorer can extract core samples to a depth of six metres.
Core barrel
A long tube attached to the drill head that collects sediment core samples.
For harder sediments and rock it uses a drill bit that rotates like a cork-screw. Using this method, RD1 can extract core samples to a depth of five metres.
Control computer
Hydraulic motor
Removable legs
Retraction winch
Pulls the core barrel from the seabed when drilling is complete.
Copyright: NERC, Ben Gilliland

圓錐貫入儀 CONE PENETRATION TEST

Since 1964 Fugro have successfully developed and modified the electric cone penetrometer as an in-situ testing technique for use in site investigations. The cone penetrometer forms the basis of a variety of tools and equipment used by Fugro for soil surveys both onshore and offshore. The electric cone penetrometer supersedes the mechanical cone penetrometer, such as the Delft or Begemann types. It offers a number of advantages: namely that continuous and direct recording of cone resistance, sleeve friction and pore pressure is obtained with a high degree of resolution, accuracy and reliability. The method whether employed onshore or offshore provides a fast and efficient investigation technique.







Reference

1. Whiteshide, P.G.D. & Cheung, P.C.T. (1996) Exploration for Offshore Sand in Hong Kong: Detailed Surveys, Dredging and Environmental Assessments *Hong Kong Geologist,* 2 (Spring), 28-36

2. Rhoads, D.C. & Germano, J.D. (1982) Characterisation of benthic processes using sediment profile imaging: An efficient method of remote ecological monitoring of the seafloor (REMOTS TM System), *Marine Ecology Progress Series,* 8, 115-128

- 3. Germano, J.D., Rhoads, D.C., Valente, R.M., Carey, D.A. & Solan, M. (2011 The use of sediment profile imaging (SPI) for environmental impact assessments and monitoring studies: Lessons learned from the past four decades, *Oceanography and Marine Biology*: An Annual Review, 49, 235-298

- 4. Engineering Geological Practice in HONG KONG GEO Publication No. 1/2007, 245-255
- 5. The Quaternary Geology of Hong Kong, (2000) 159-173

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