Coastal changes in Hong Kong and Southern China

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Volume two
(figures and tables)

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The second of two volumes

Figures and tables

List of Figures

5.10 Reproduction of the 1:10,000 map of part of the study area

5.11 Relative altitudes of sea levels and land in the Zhujiang Delta

5.12 Population and altitude maps of the study area

5.13 Communication routes in the study area

5.14 Estimates of future sea level rise

5.15 Estimates of future sea level rise added to the highest recorded sea level at Shanbanzhou

5.16 Sea level rise scenarios for the Zhujiang Delta, according to Hoffman et al (1986)

5.17 Sea level rise scenarios for Shanbanzhou, combined with an estimate of subsidence of 2 mm/year

5.18 Sea-level rise scenarios for the Zhujiang Delta, combined with an estimate of land subsidence of 2mm/year

5.19 Possible increase in population for the Zhujiang Delta (10 counties) 1983-2100

5.20 Possible increase in population for the Zhujiang Delta (19 counties) 1983-2100

5.21 Possible increase in population of the Flood Risk Zone, Bao'an County, 1983-2100

List of Tables

5.15 Medium and high sea level rise estimates added to highest recorded sea levels

5.16 The effects of scenarios of future sea level change combined with estimates of subsidence in the Zhujiang Delta of 2 mm per year

5.17 Projected population growth in 10 counties in the Zhujiang Delta 1983-2100

Figures and tables

Figure 1.1 The south coast of China and the location of the study area

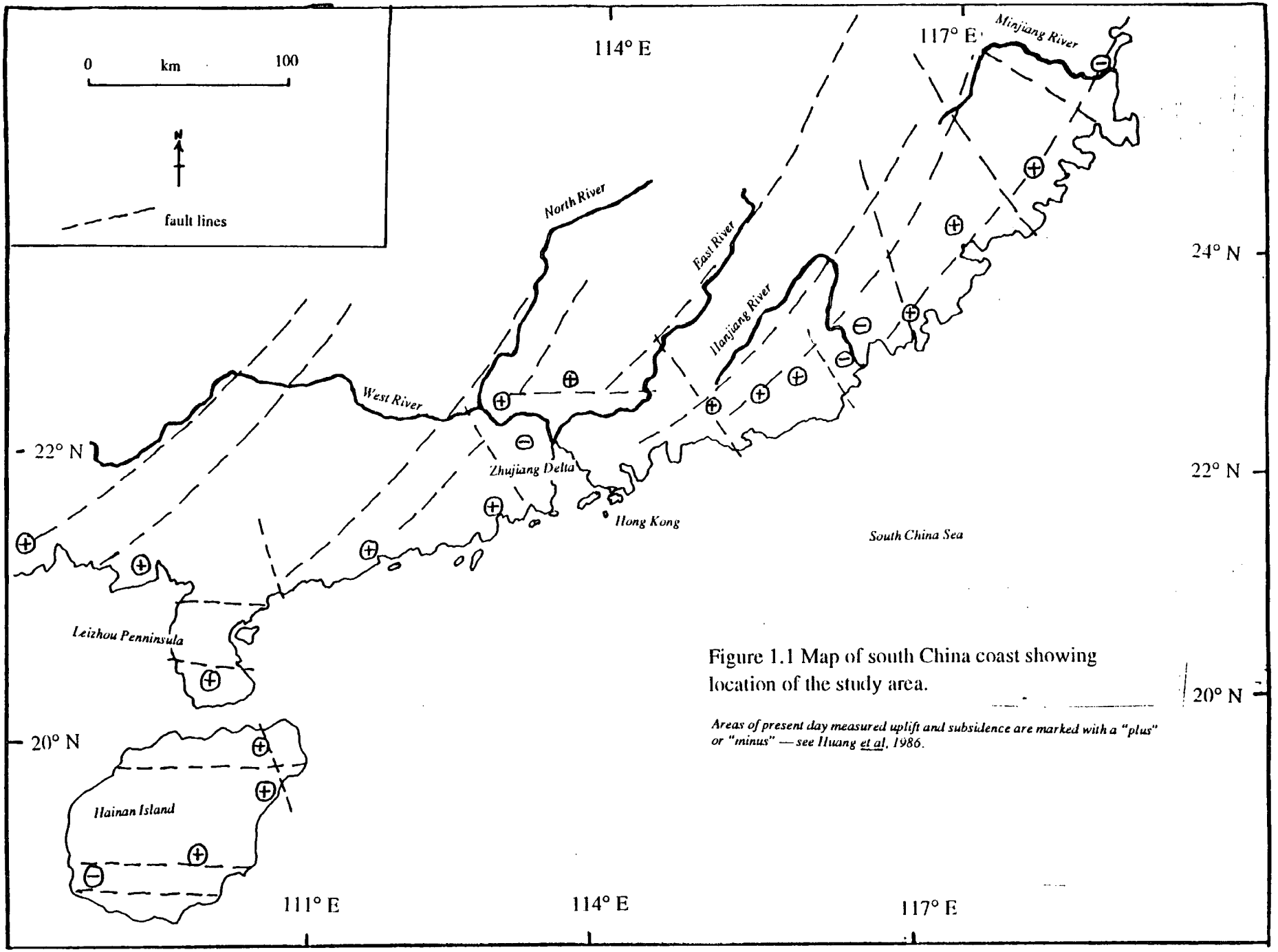

Figure 1.1 Map of south China coast showing location of the study area.

Areas of present day measured uplift and subsidence are marked with a "plus" or "minus" — see Huang et al, 1986.

Figure 1.2 Tentative Quaternary stratigraphy from Hong Kong (after Yim et al 1988)

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Stratigraphic unit	Estimated age in years BP	Age	Maximum thickness in m
Upper Marine	<8,520	Holocene/Postglacial	21.5
d			
Upper Terrestrial	8,520–<30,560	Last Glacial/Late Wurm	6
Middle Marine	30,560–36,230	Last Interstadial	15.3
d d d			
Middle Terrestrial	40,000–50,000	Middle Wurm	6
Lower Marine	55,000–65,000	Second Last Interstadial	10.3
d d d			
Lower Terrestrial	>65,000	Pre-Second Last Interstadial	14

d - Disconformity

Figure 3.1 Location of sites studied

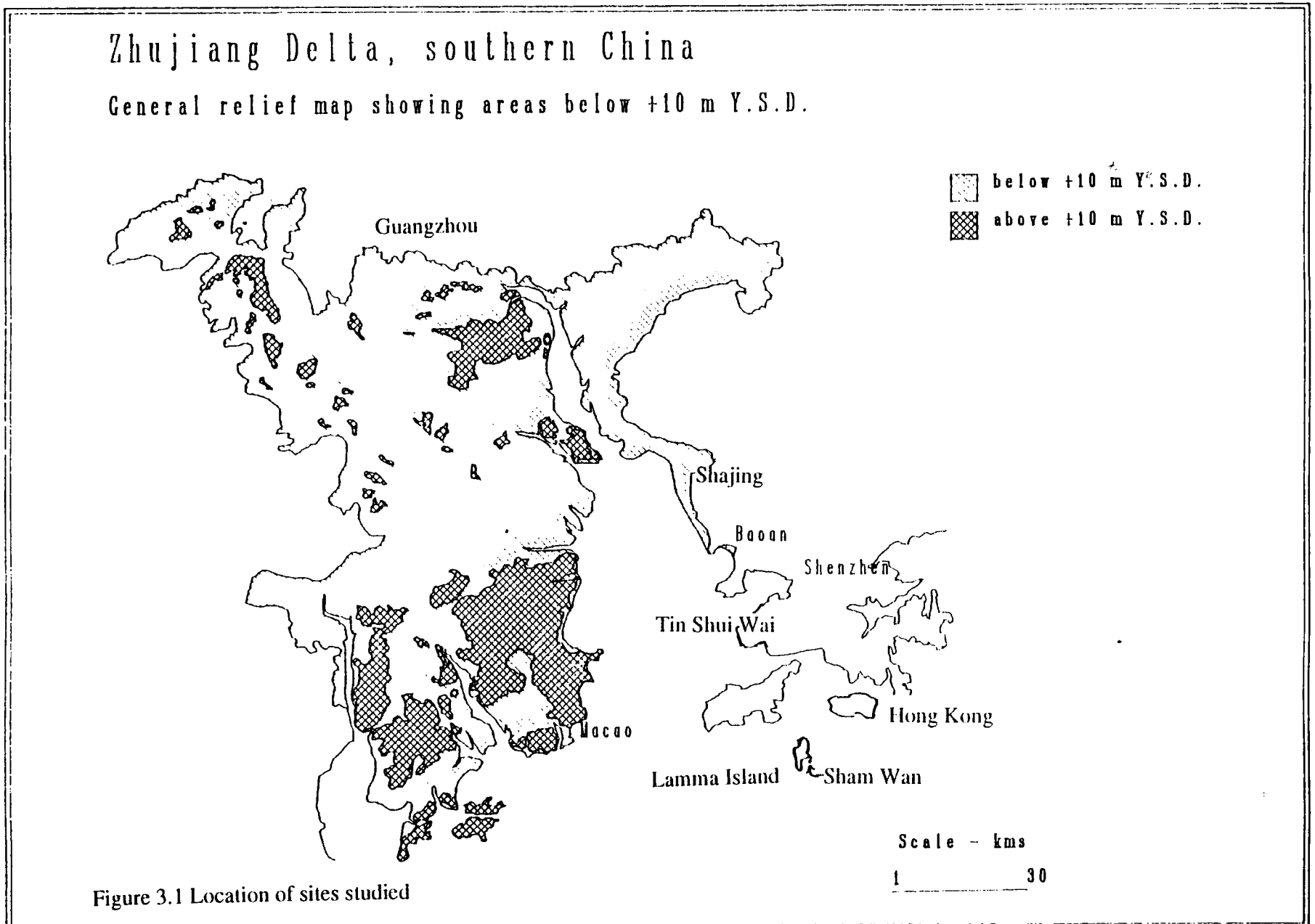

Figure 3.1 Location of sites studied

Figure 3.2 The site at Shajing

Figure 3.2 The site at Shajing, Bao'an County

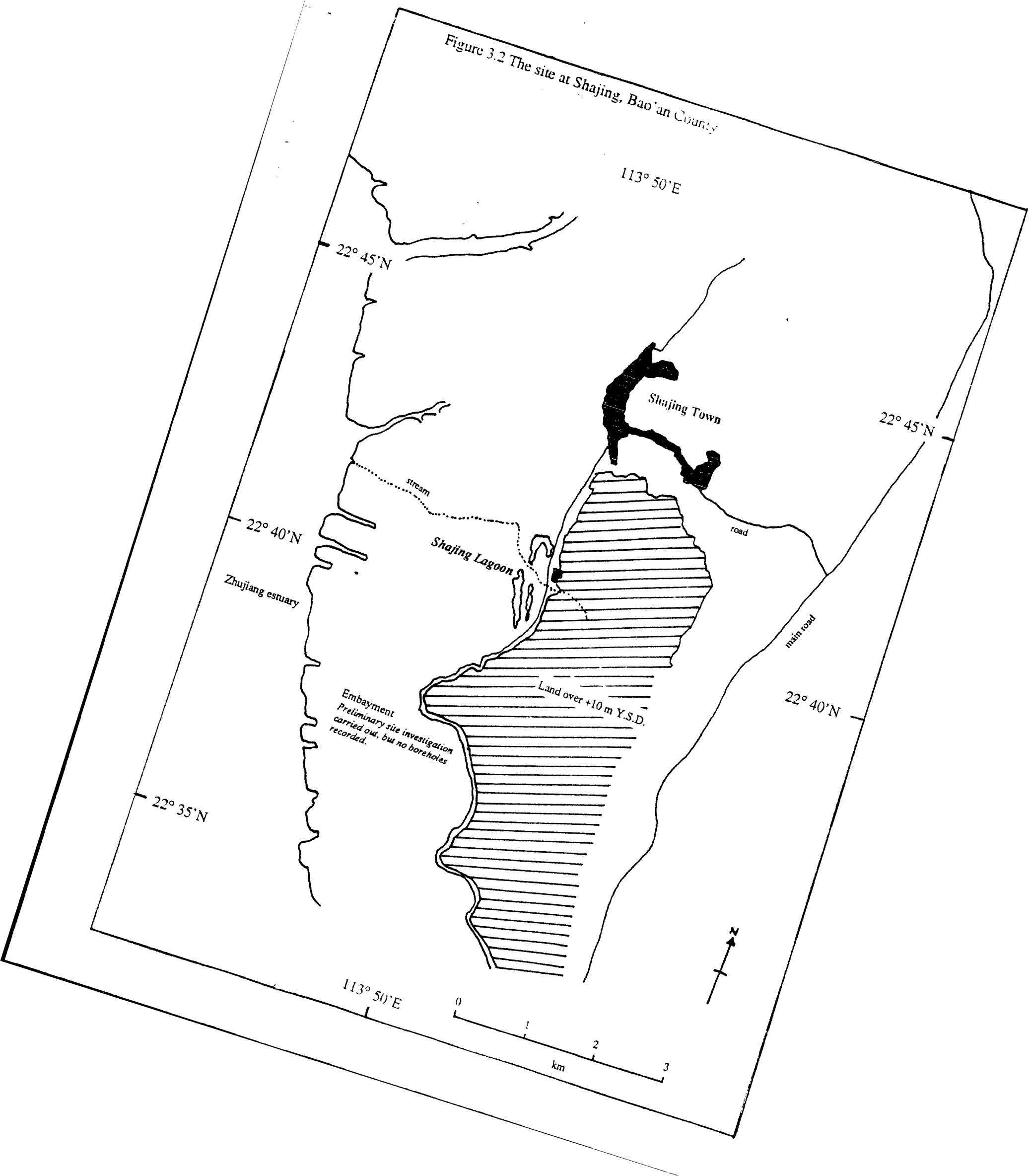

Figure 3.3 The location of bore holes at Shajing Lagoon

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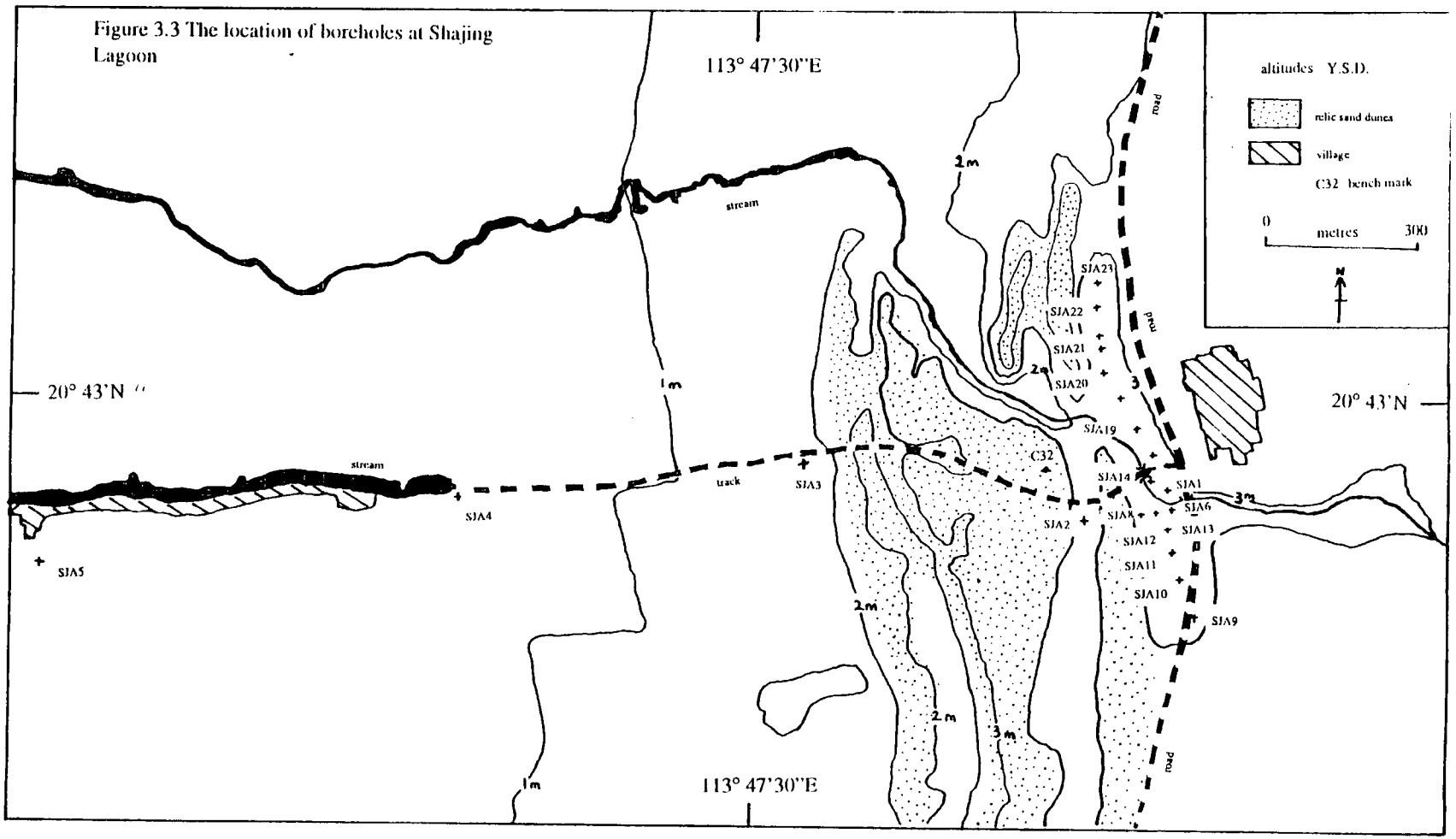

Map based on 1:10,000 map published by Chinese government

Figure 3.4 Stratigraphy at Shajing Lagoon "A"

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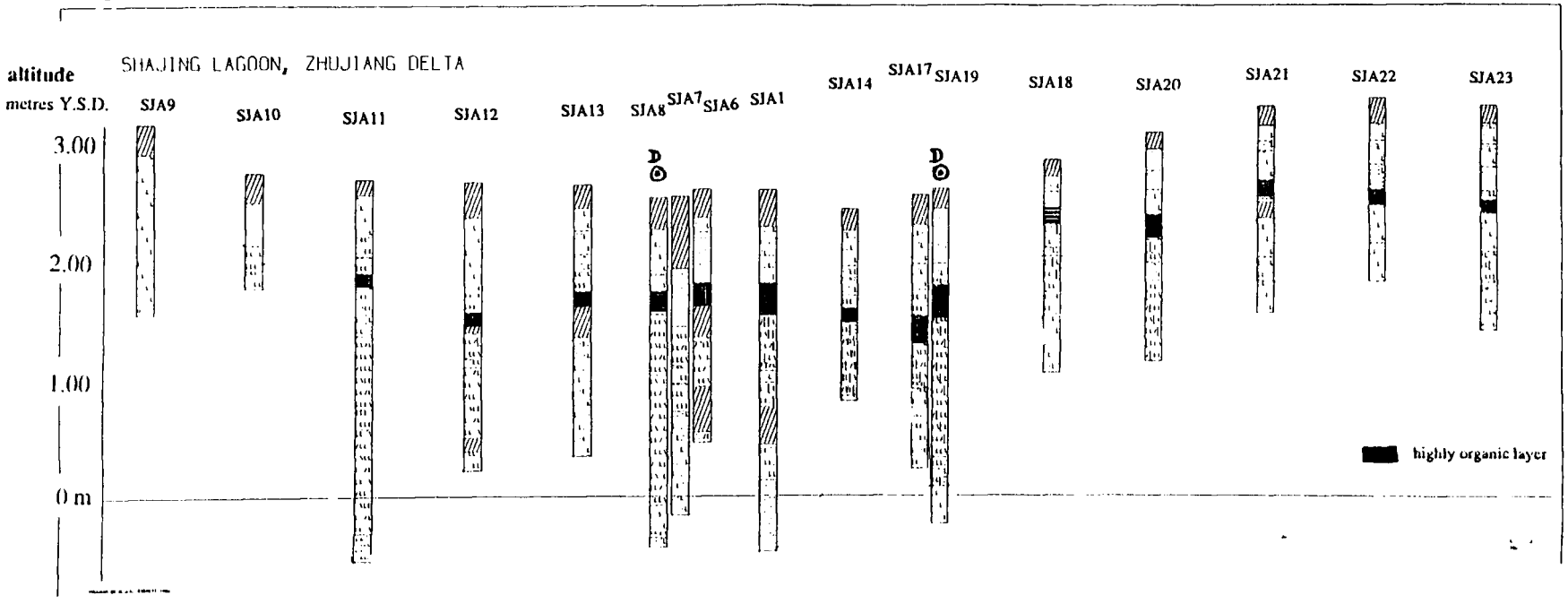

See appendix 1 for details

Figure 3.6 Stratigraphy of bore holes SJA1 - SJA5

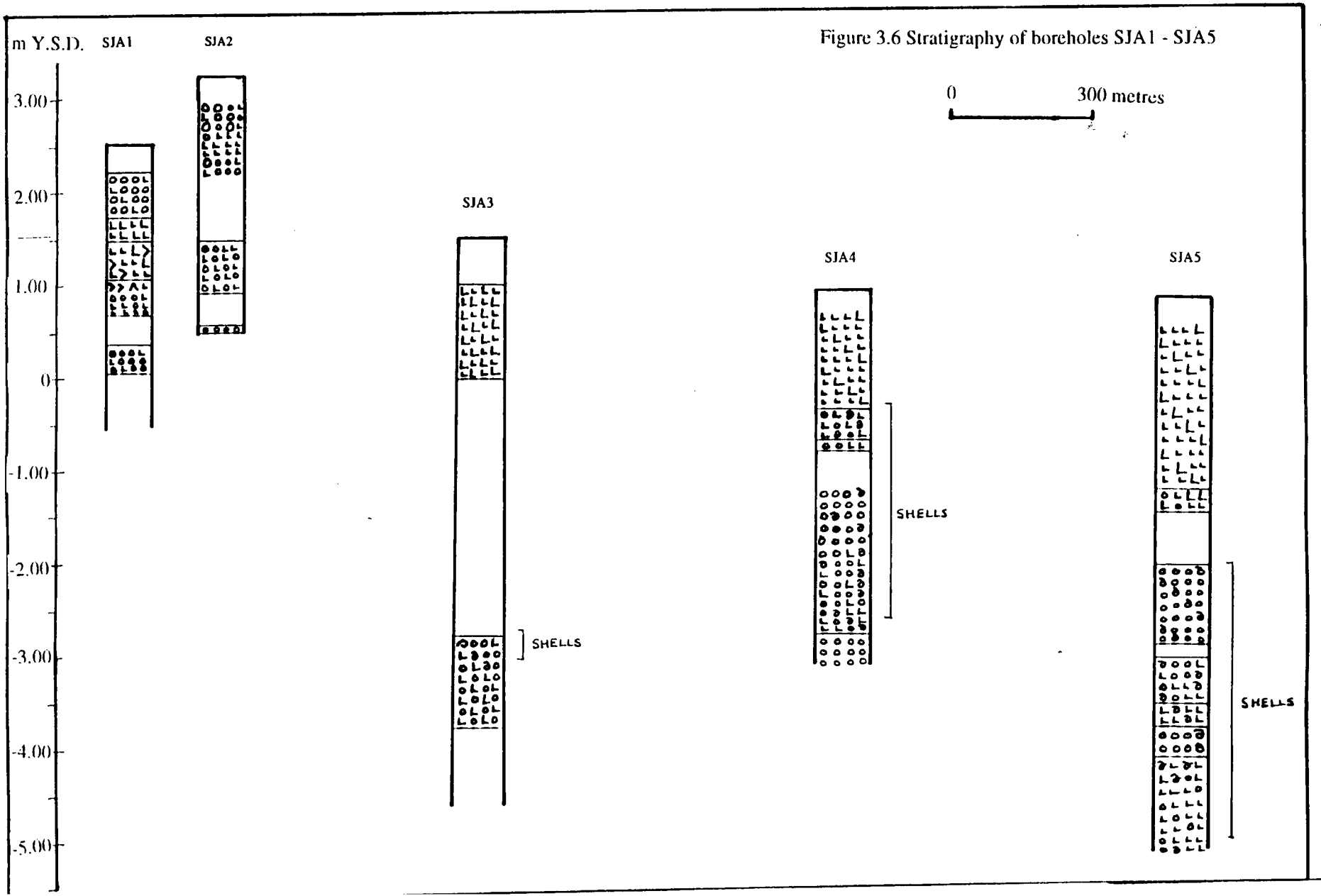

Figure 3.6 Stratigraphy of boreholes SJA1 - SJA5

Figure 3.7 Diatom diagram SJA8

Figure 3.7 Shajing Lagoon: borehole SJA8

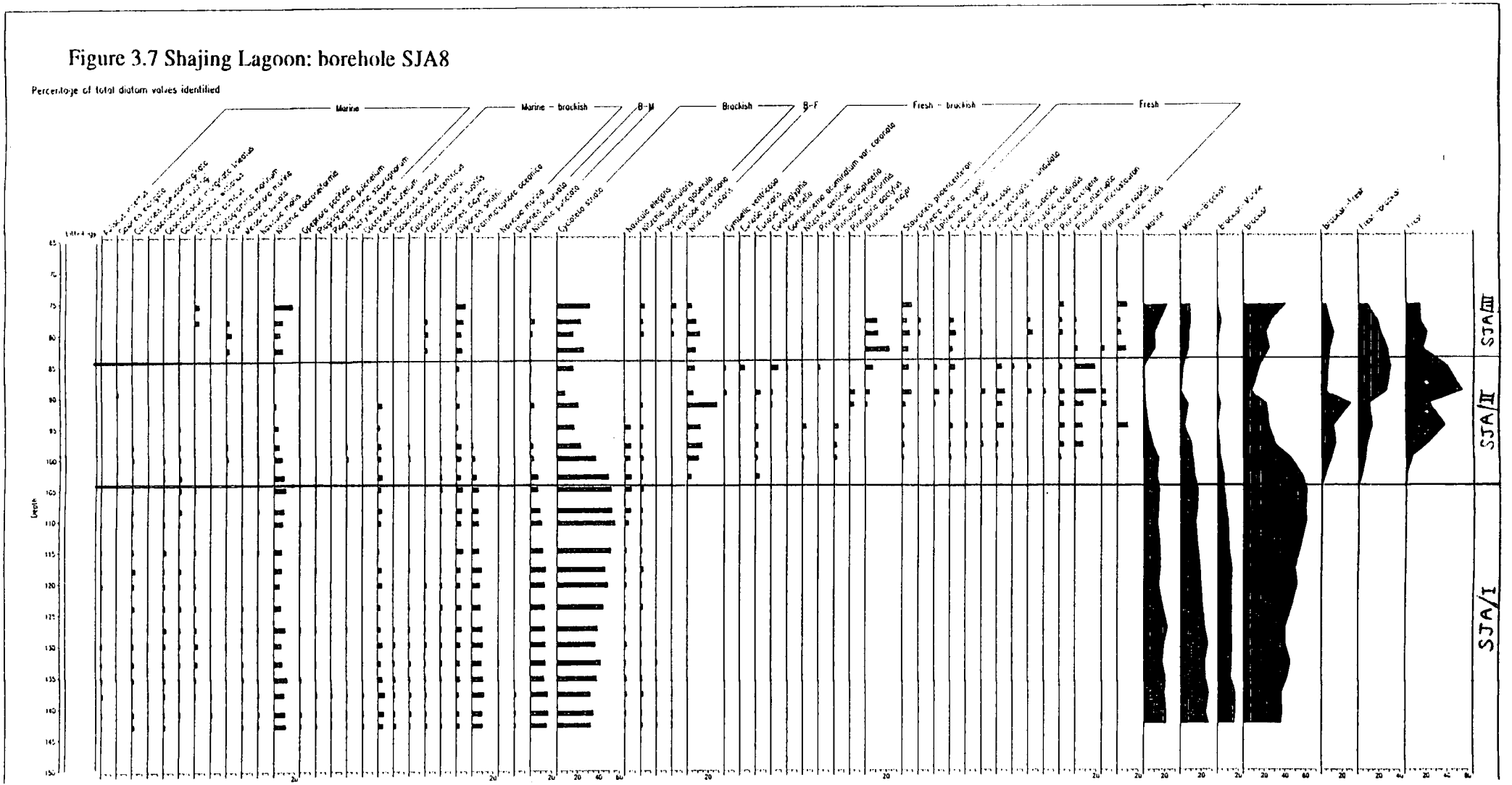

Figure 3.8 Diatom diagram SJA19

Figure 3.8 Shajing Lagoon: borehole SJA19

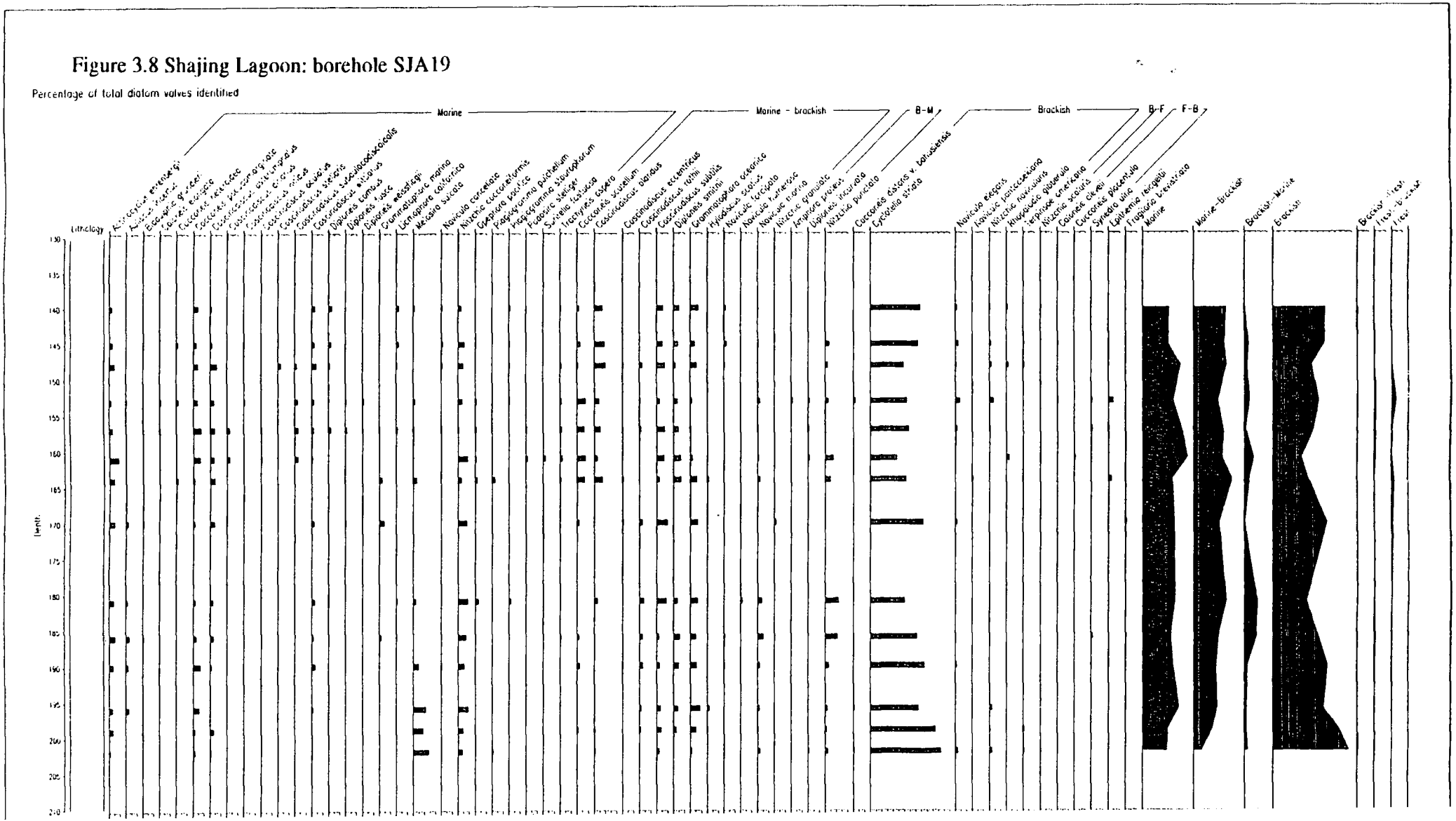

Figure 3.9 The location of the Sham Wan site bore holes, Tung O, Lamma Island

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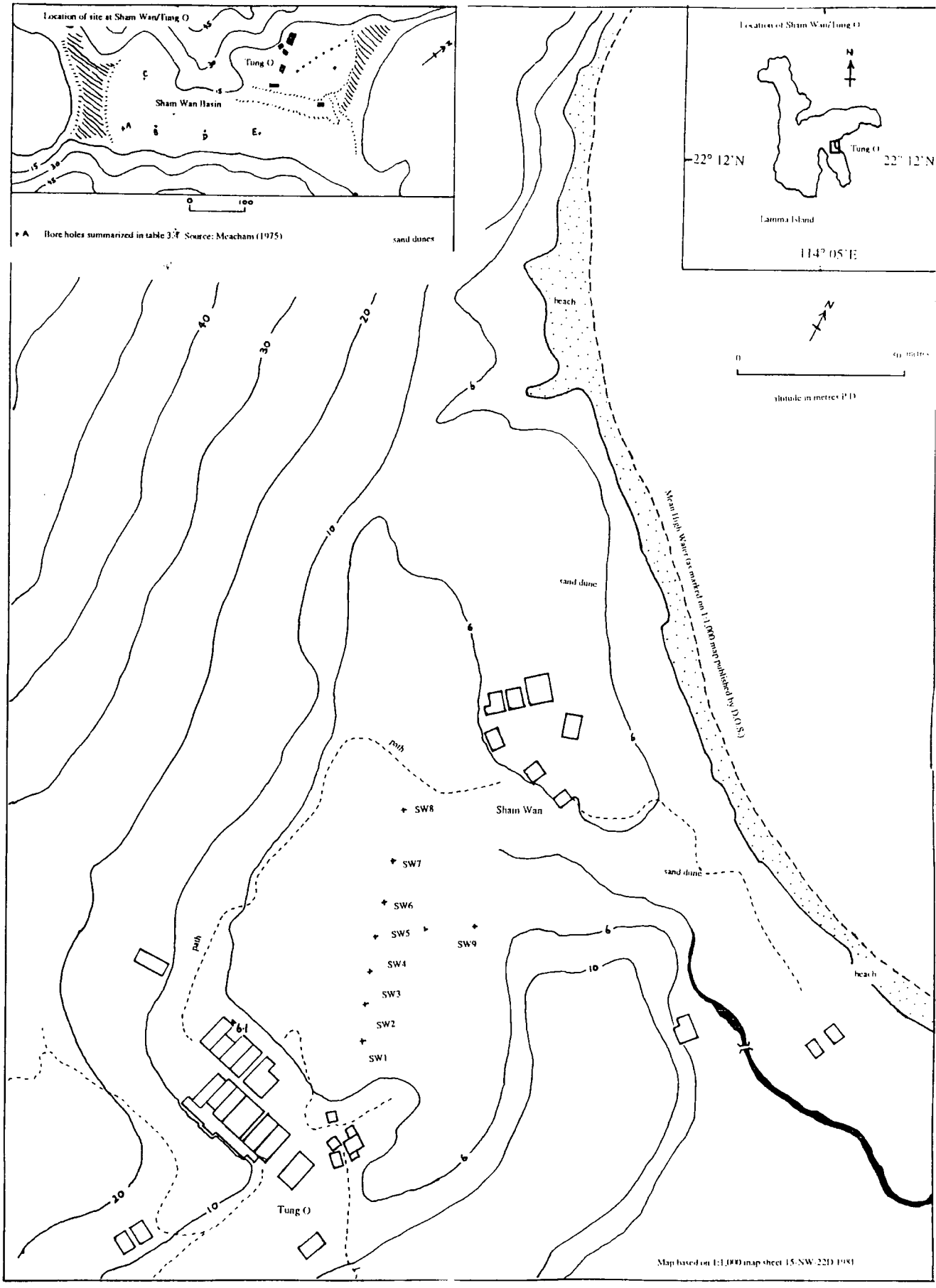
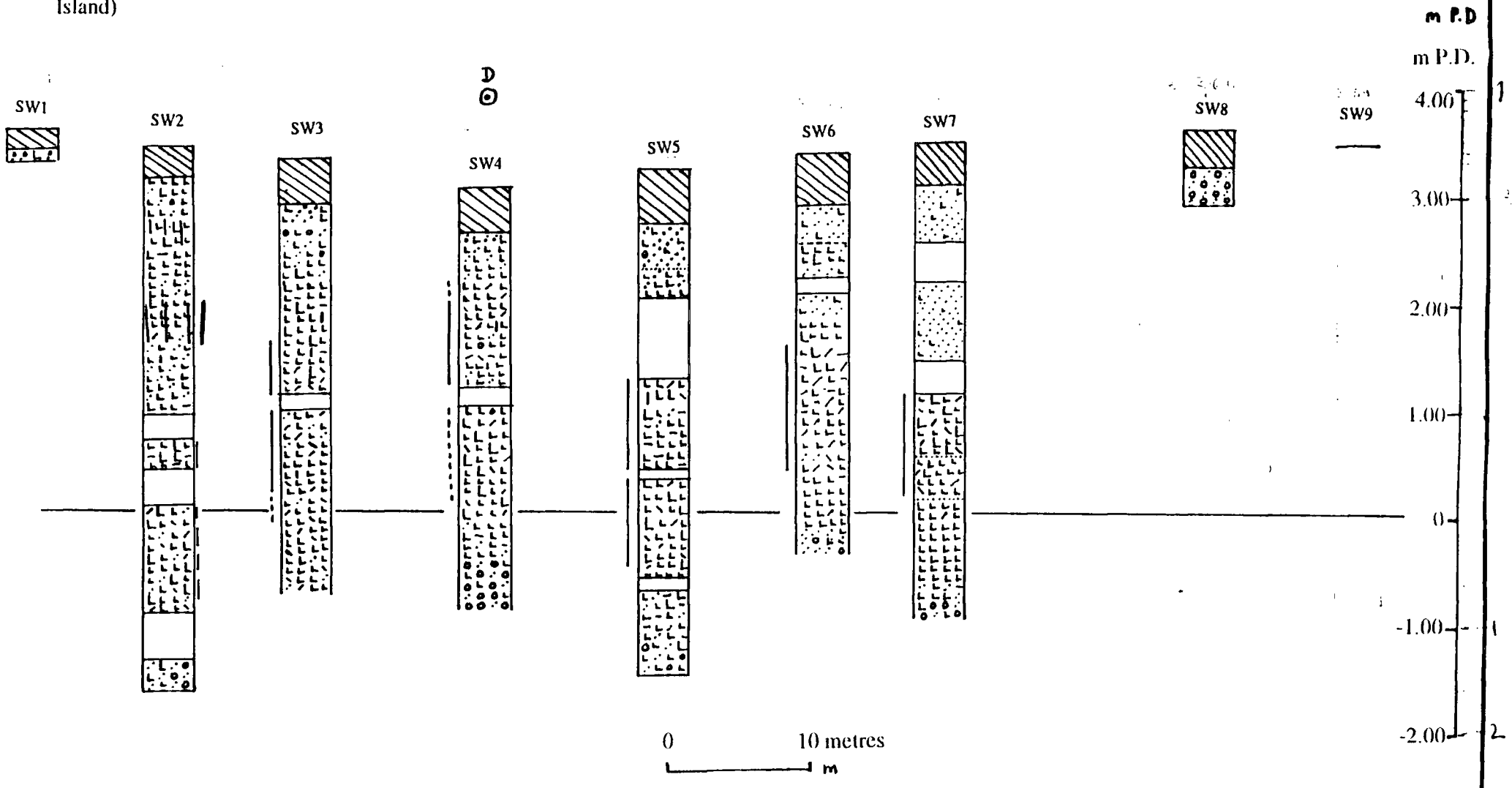


Figure 3.10 Stratigraphy at Sham Wan (Tung O)

Figure 3.10 Stratigraphy at Sham Wan (Lamma Island)



See appendix 1 for details

Figure 3.11 Diatom diagram SW4

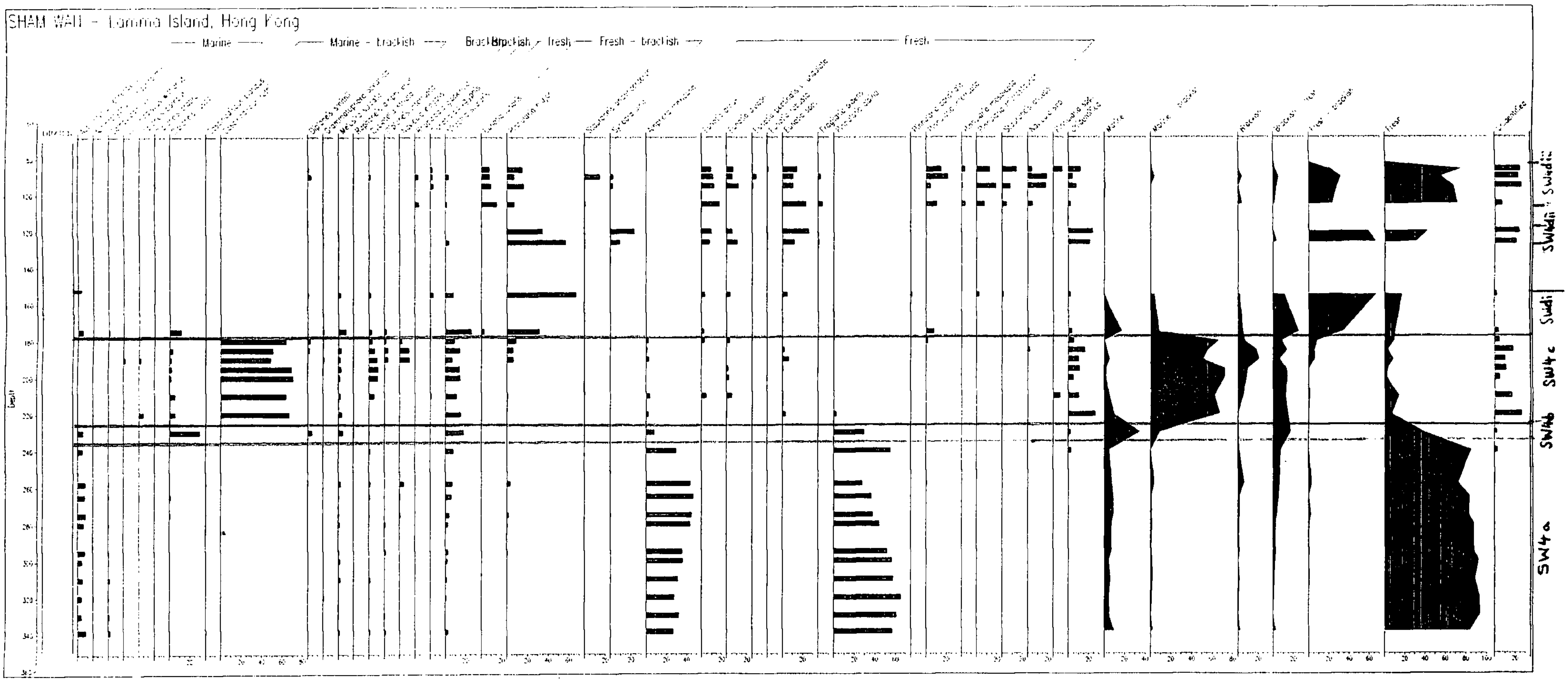

SHAM WAN - Lamma Island, Hong Kong
Marine
Marine - brackish
Brackish - fresh
Fresh - brackish
Fresh
Depth
Marine
Marine - brackish
Brackish
Brackish - fresh
Fresh - brackish
Fresh
SW4d ii
SW4d i
SW4c
SW4b
SW4a

Figure 3.11a Photograph of Sham Wan sediment core SWA4/4i

FIGURE 3.11a: Photograph of sediments sampled from core SW4, Tung O basin, Lamma Island.

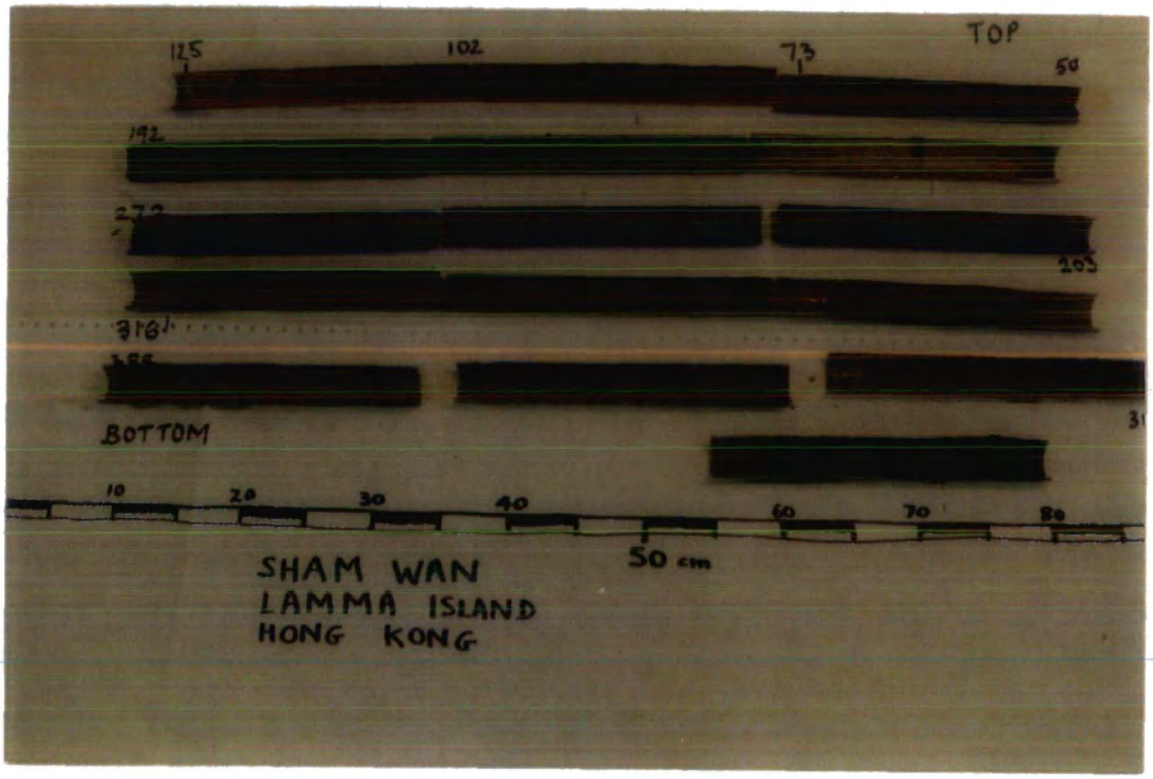


Figure 3.12 The location of the bore holes and sediment sections at Tin Shui Wai

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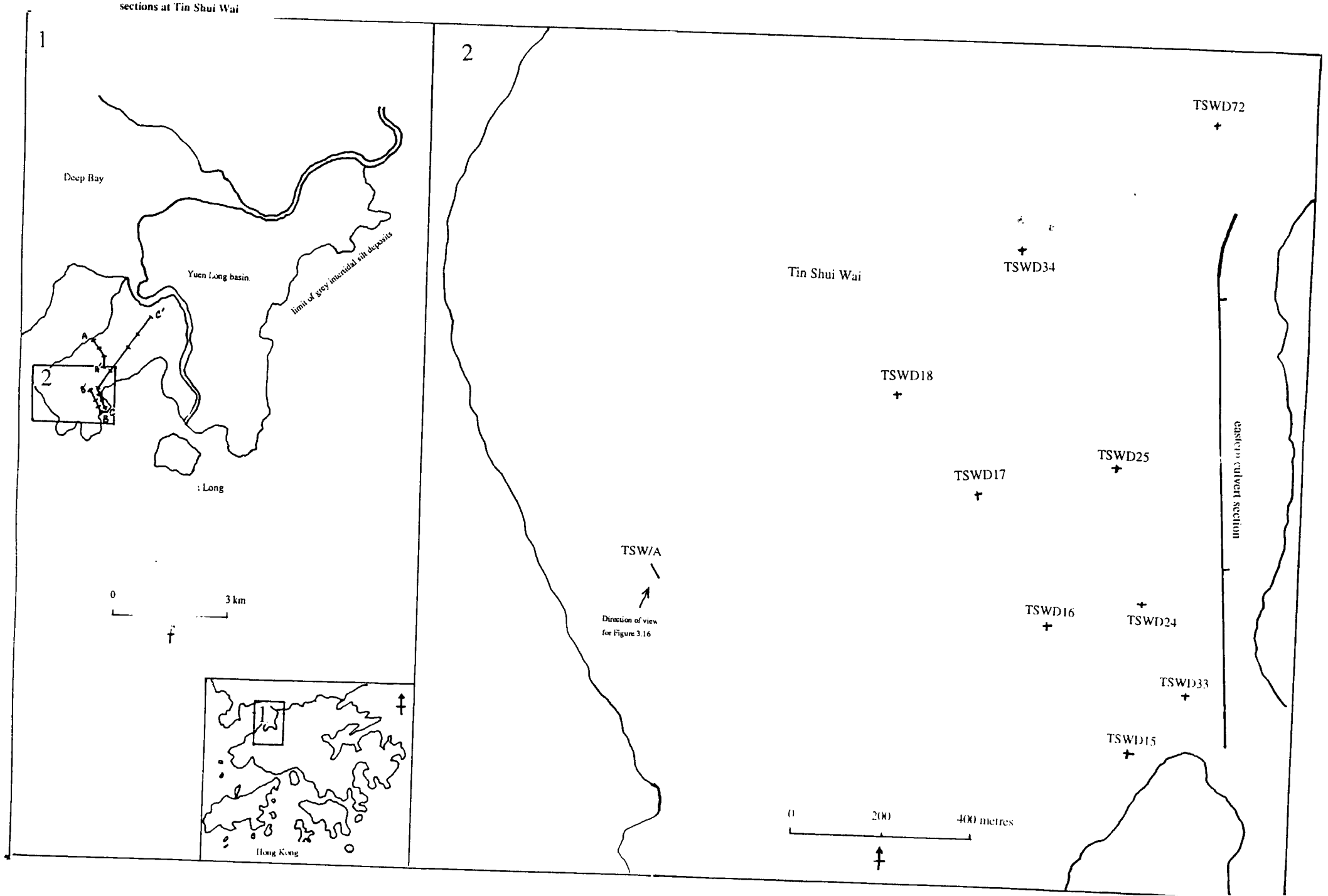

Figure 3.13 Interpreted stratigraphy of "Dutch" bore holes transect A (see figure 3.12)

Figures 3.13

Stratigraphy of transect A-A' (see figure 3.12)

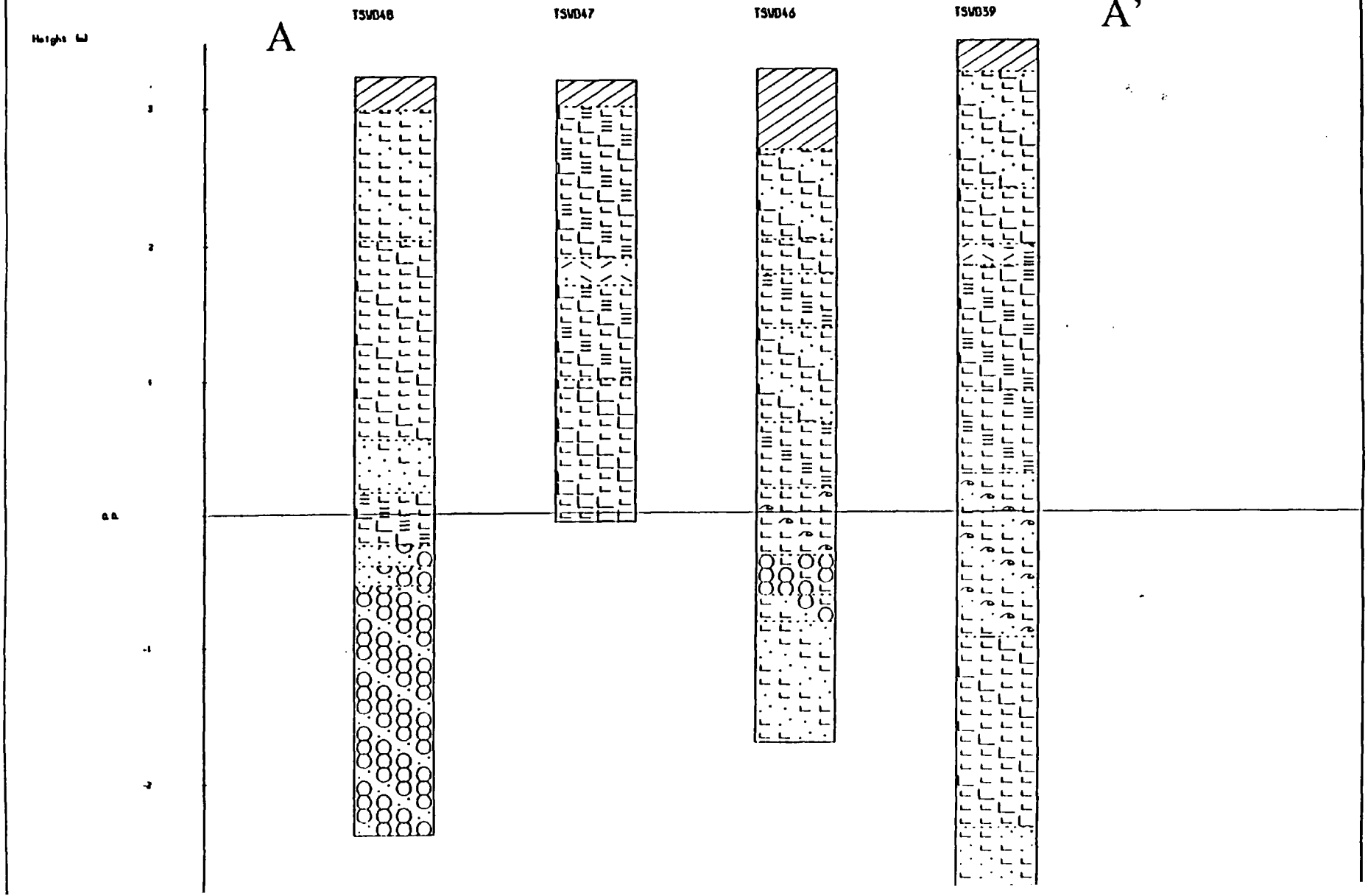

Figure 3.14 Interpreted stratigraphy of "Dutch" bore holes transect B (see figure 3.12)

Figures 3.14

Stratigraphy of transect B-B' (see figure 3.12)

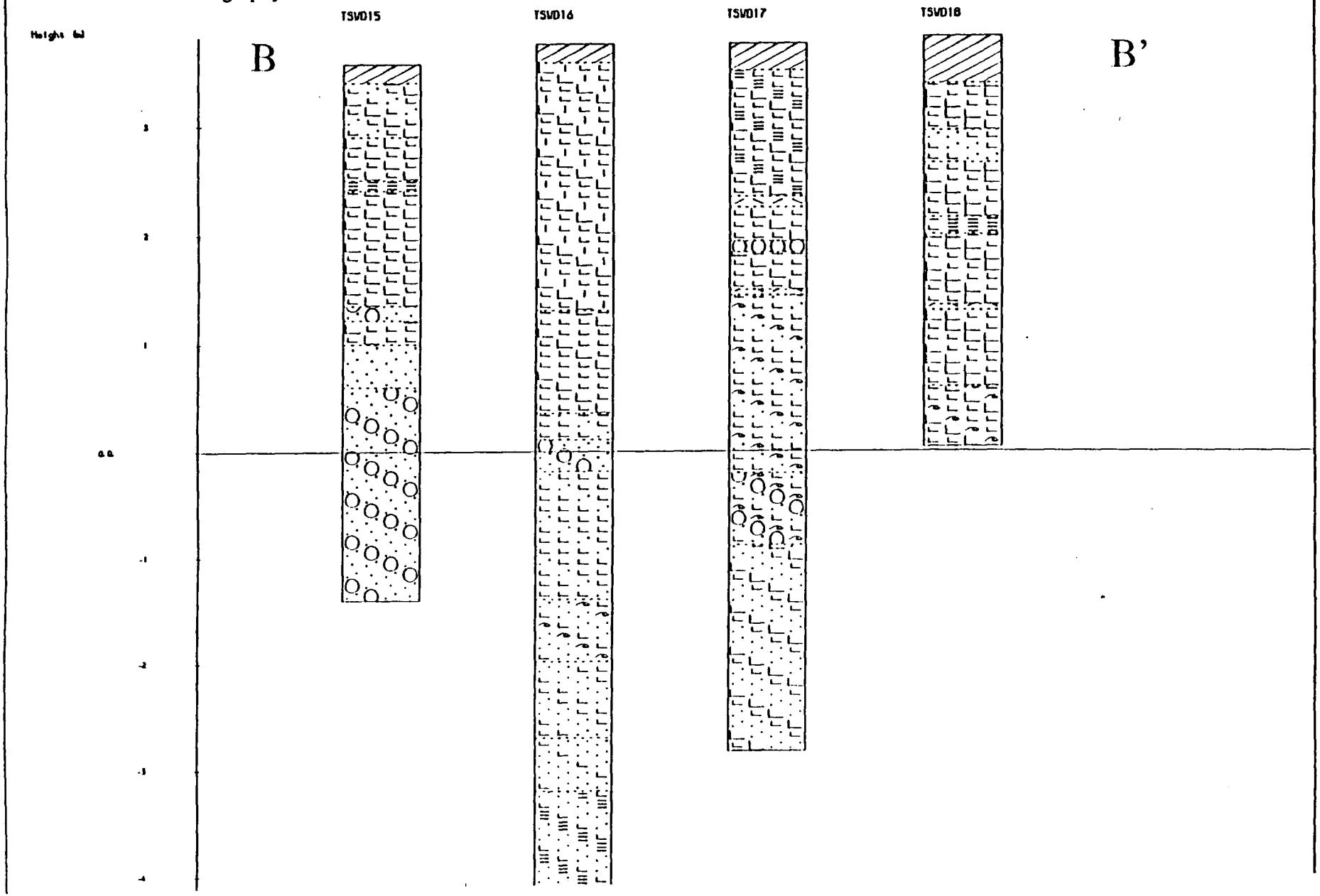

Figure 3.15 Interpreted stratigraphy of "Dutch" bore holes transect C (see figure 3.12)

Figures 3.15

Stratigraphy of transect C-C' (see figure 3.12)

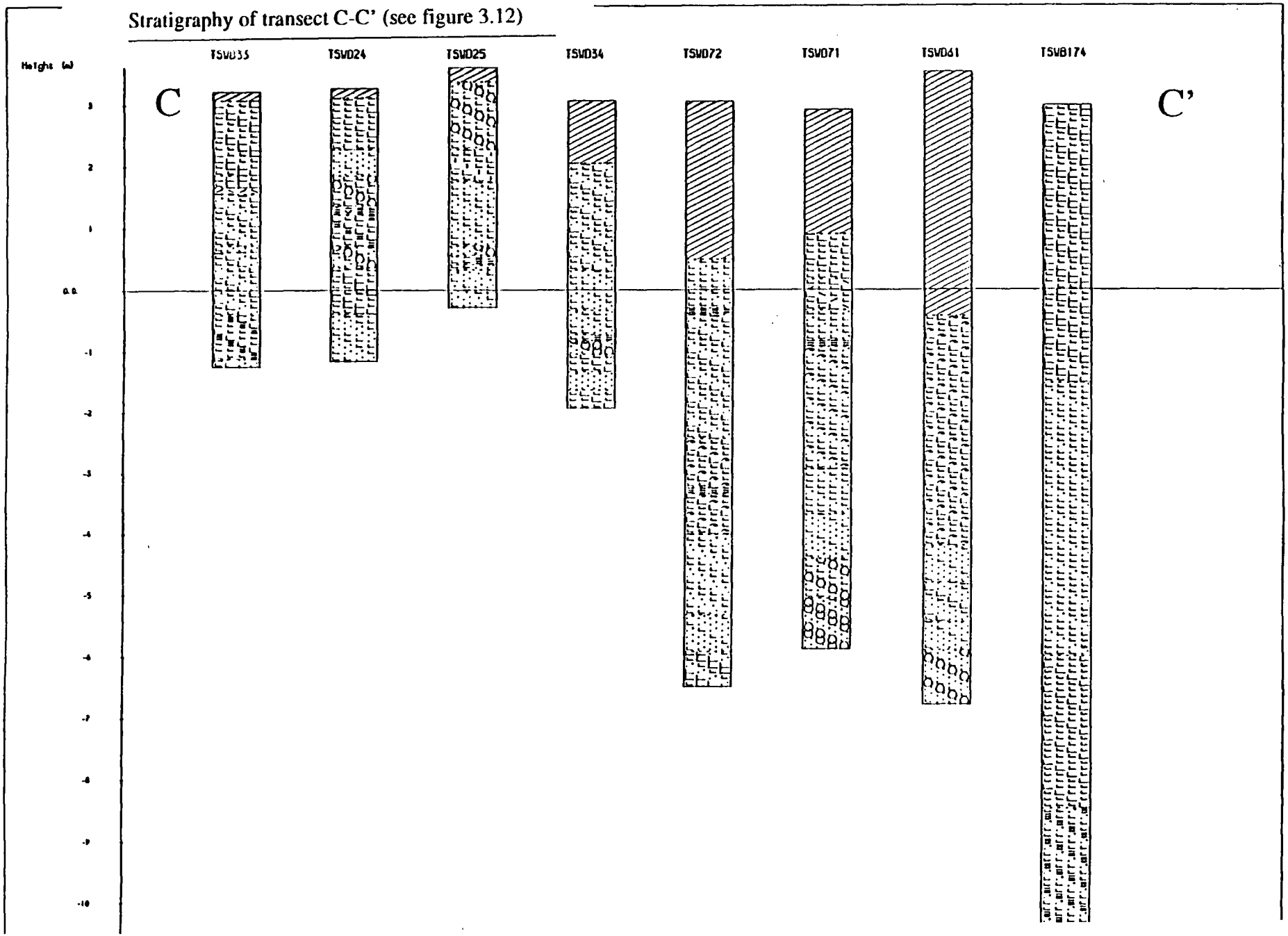

Figure 3.16 Sketch of the TSW/A section

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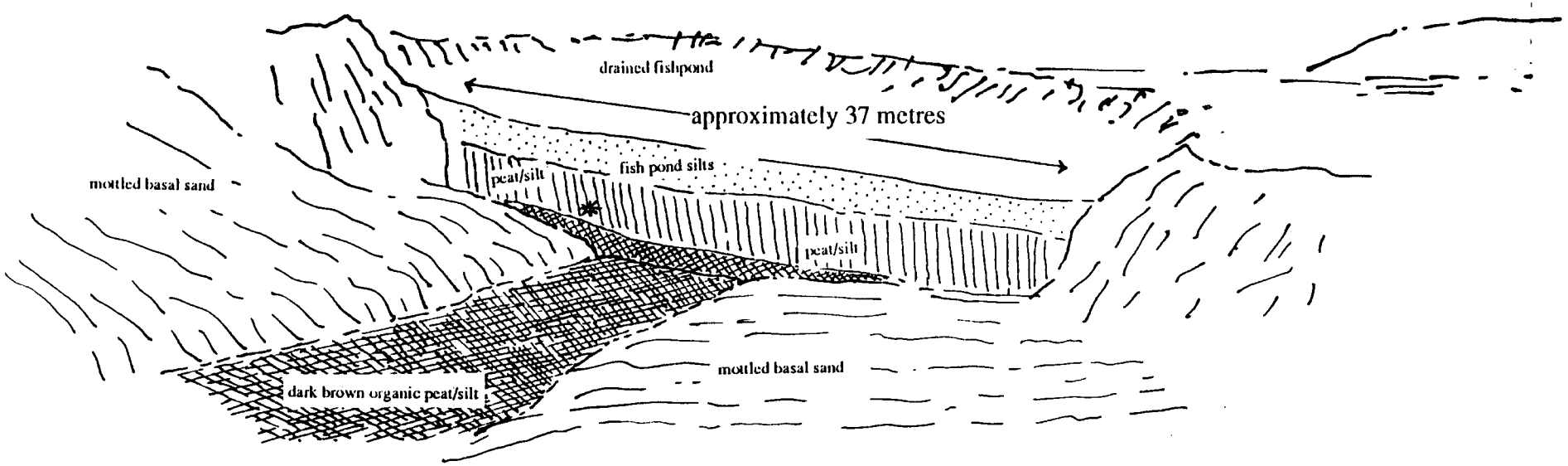

* = position of monolith

See figure 3.17 for diagram of section

Figure 3.17 Stratigraphic diagram of section TSW/A

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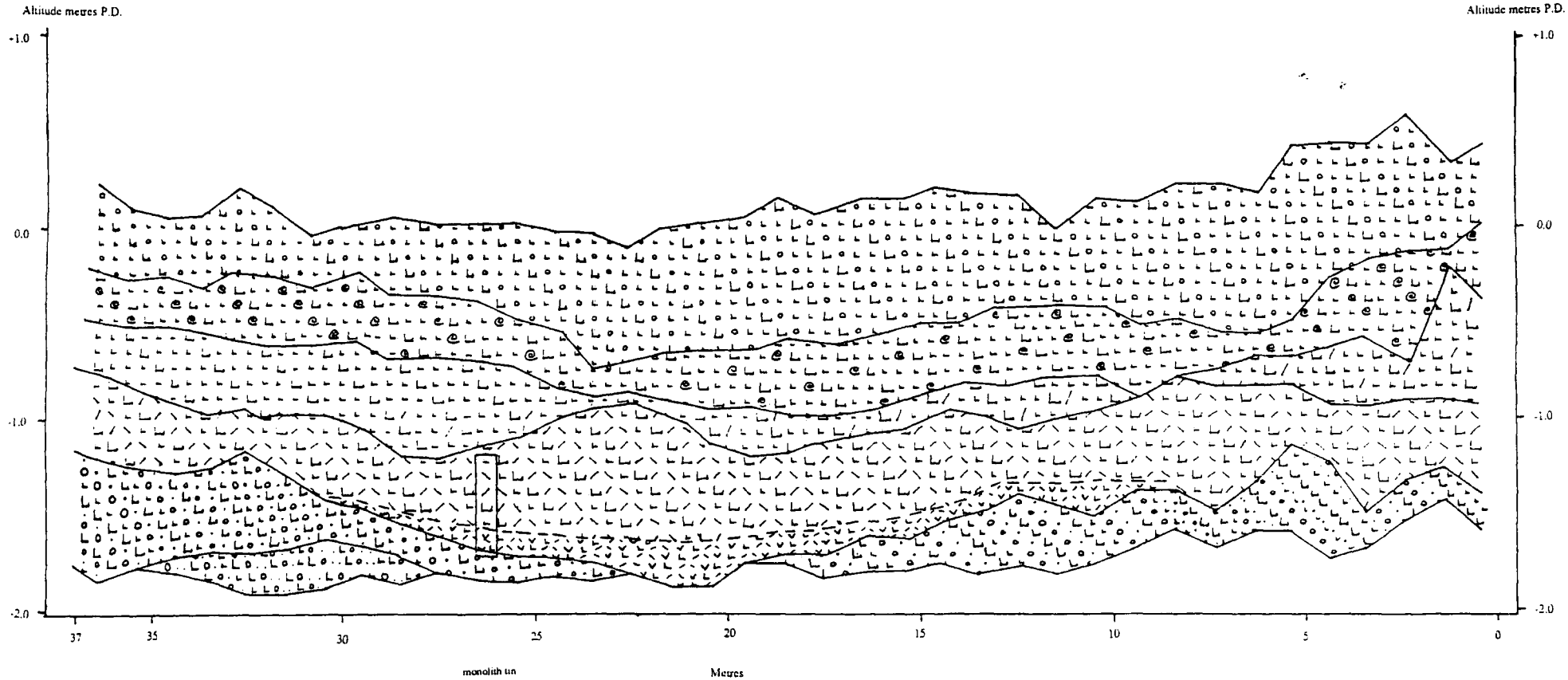


Figure 3.18 Stratigraphy at Tin Shui Wai, eastern culvert - TSW/B

FIGURE 3.18: Transect TSW/B

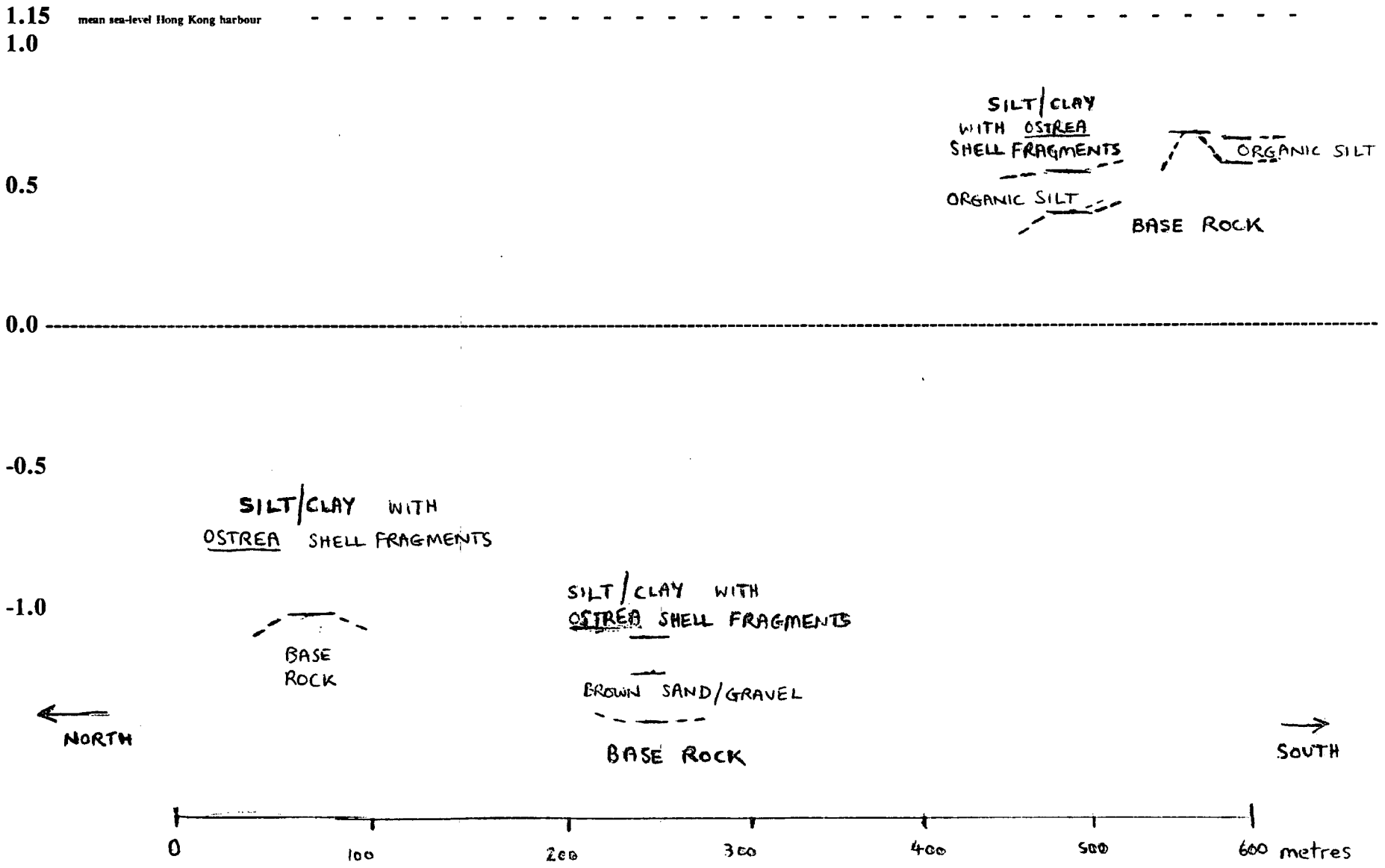


Figure 4.1 Map of south China, and location of sites

Figure 4.1 Map of South China and the location of radiocarbon dated samples

See maps 4.1a, 4.1b and 4.1c for details of data from Zhujiang Delta, Hanjiang Delta and Hong Kong. For details of individual radiocarbon dated samples see appendix 5.

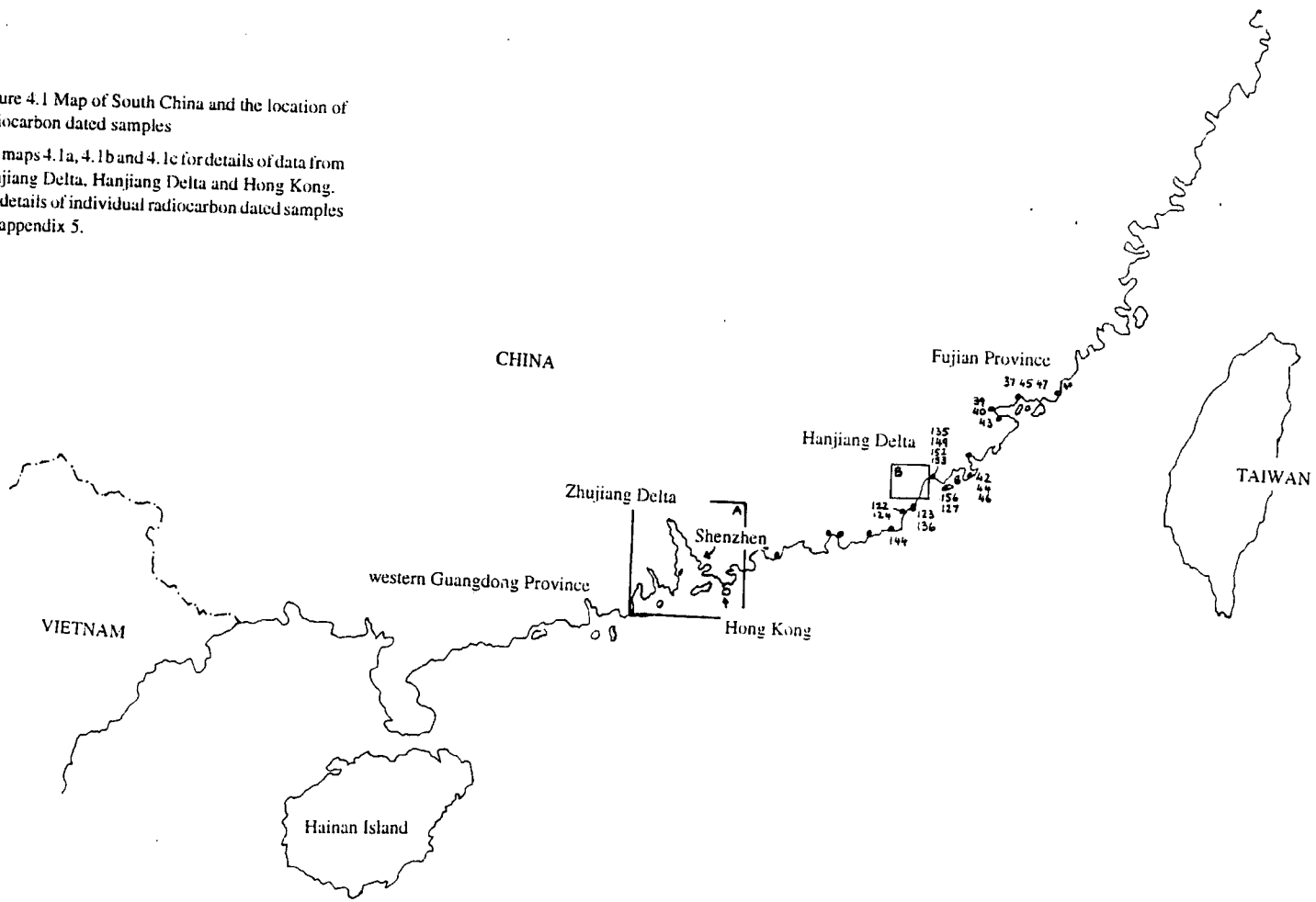


Figure 4.1b Location of sites of radiocarbon dated sea-level indicators in the Hanjiang Delta

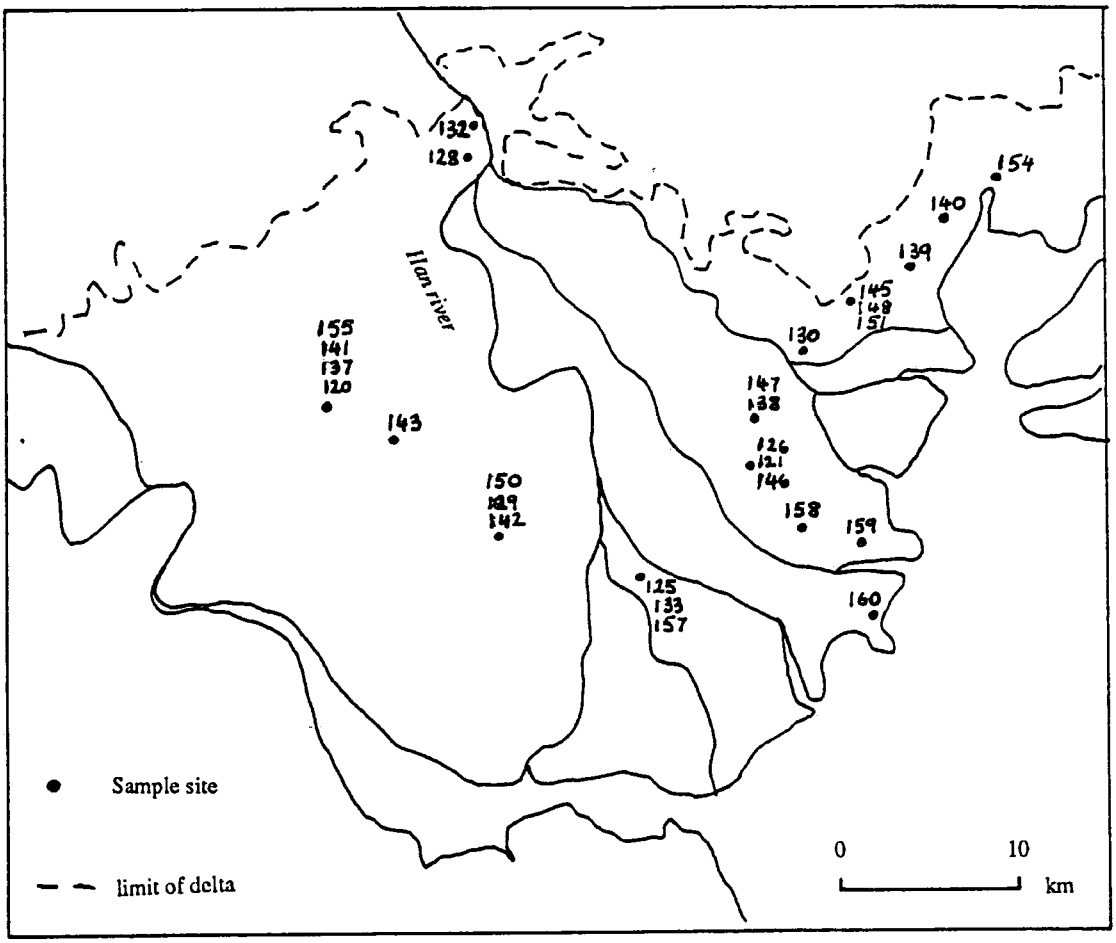
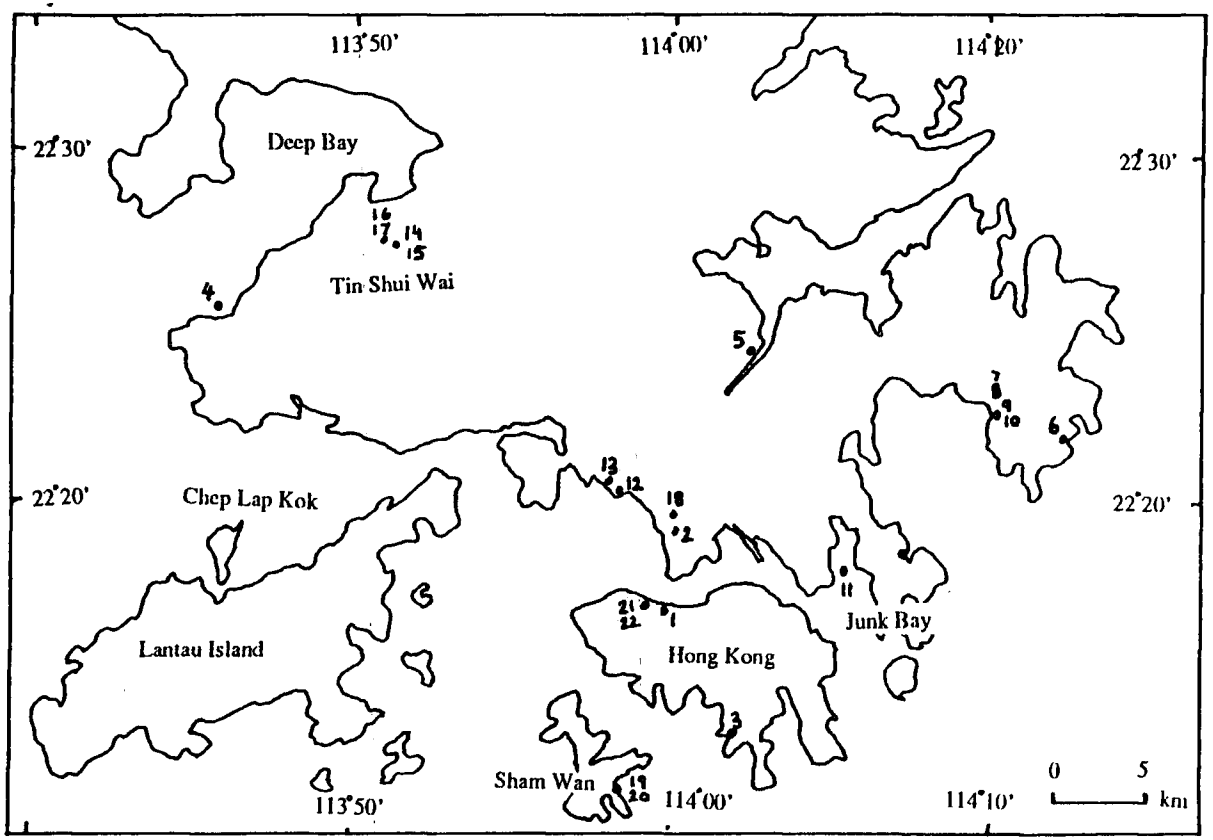


Figure 4.1c Location of sites of radiocarbon dated sea-level indicators in Hong Kong



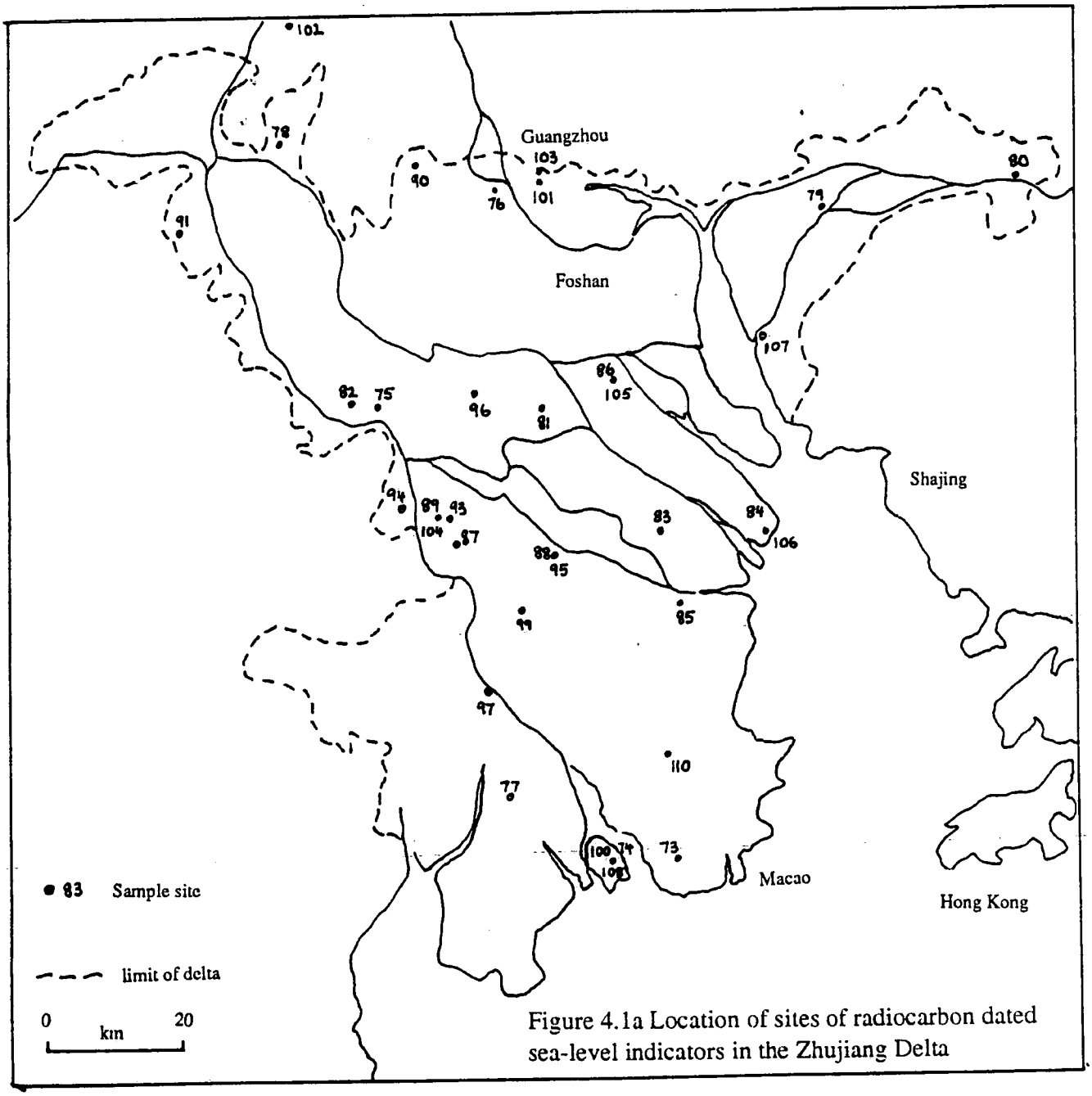


Figure 4.1a Location of sites of radiocarbon dated sea-level indicators in the Zhujiang Delta

Figure 4.2 Time-altitude graph of 217 sea level index points

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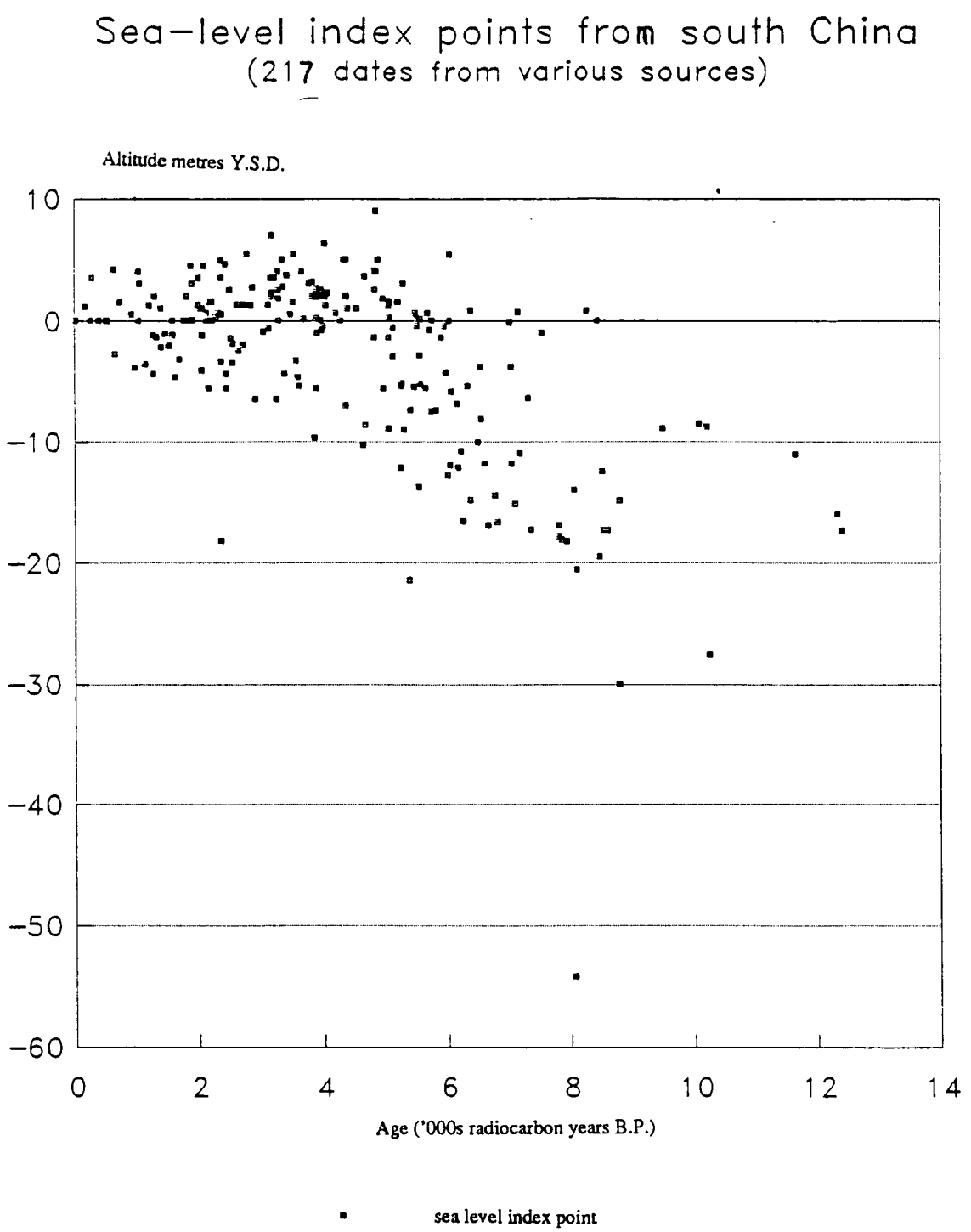

Figure 4.3 Hong Kong sea level index point time-altitude plots

HONG KONG

Figure 4.3 Hong Kong sea-level index point time-altitude plot

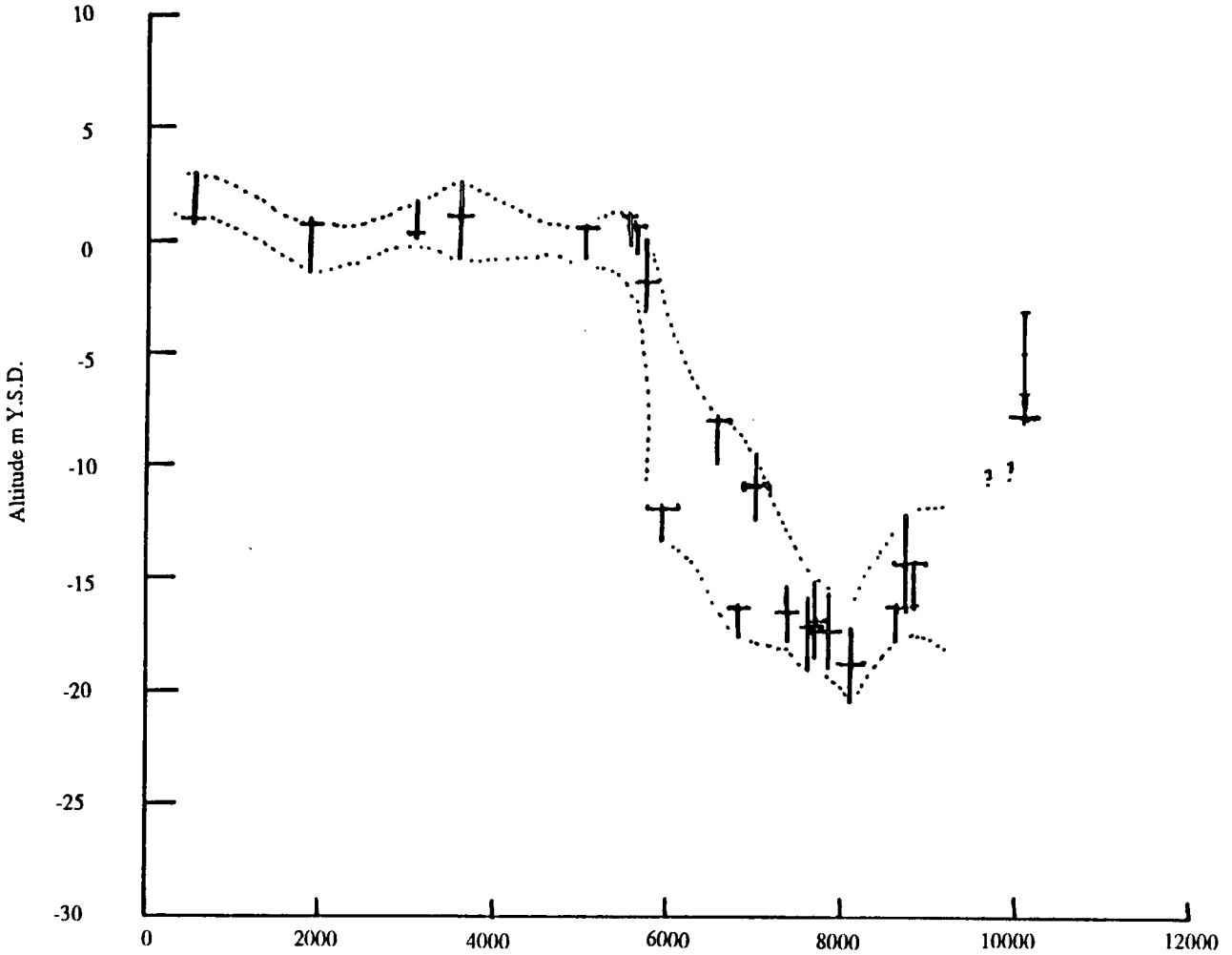

Figure 4.4 Shenzhen sea level index point time-altitude plots

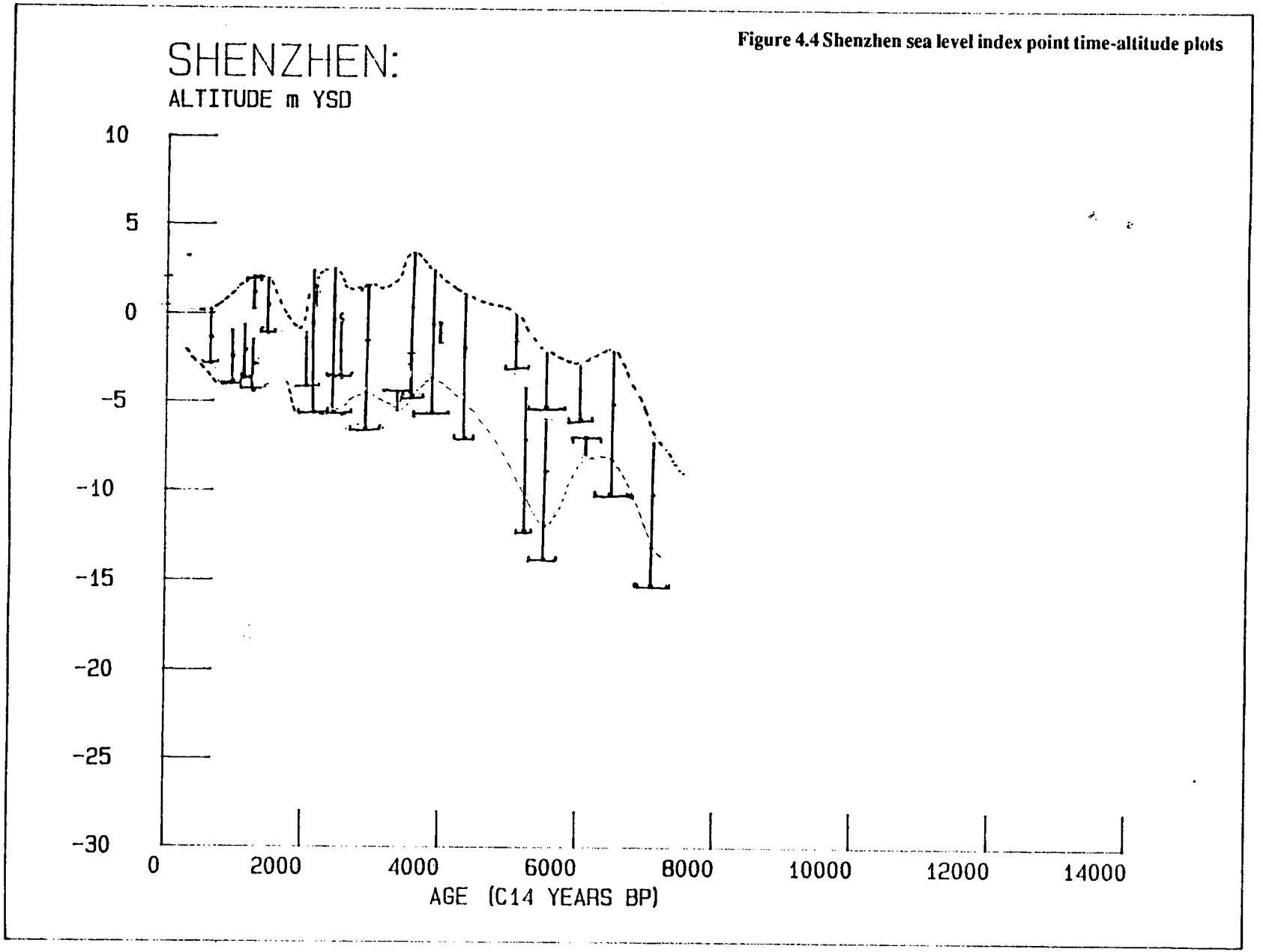

Figure 4.4 Shenzhen sea level index point time-altitude plots

Figure 4.5 Zhujiang Delta sea level index point time-altitude plots

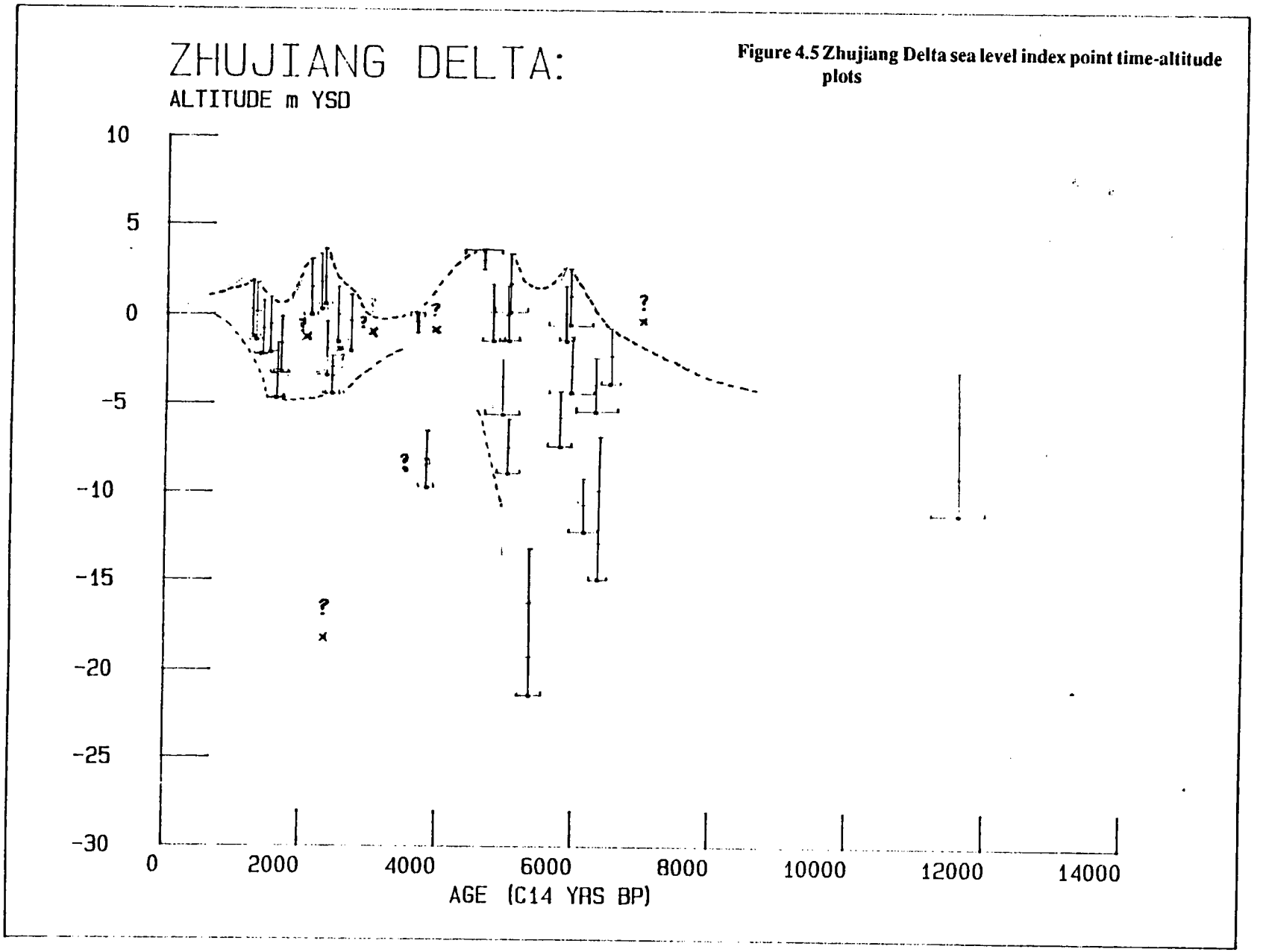

Figure 4.5 Zhujiang Delta sea level index point time-altitude plots

Figure 4.6 Hanjiang sea level index point time-altitude plots

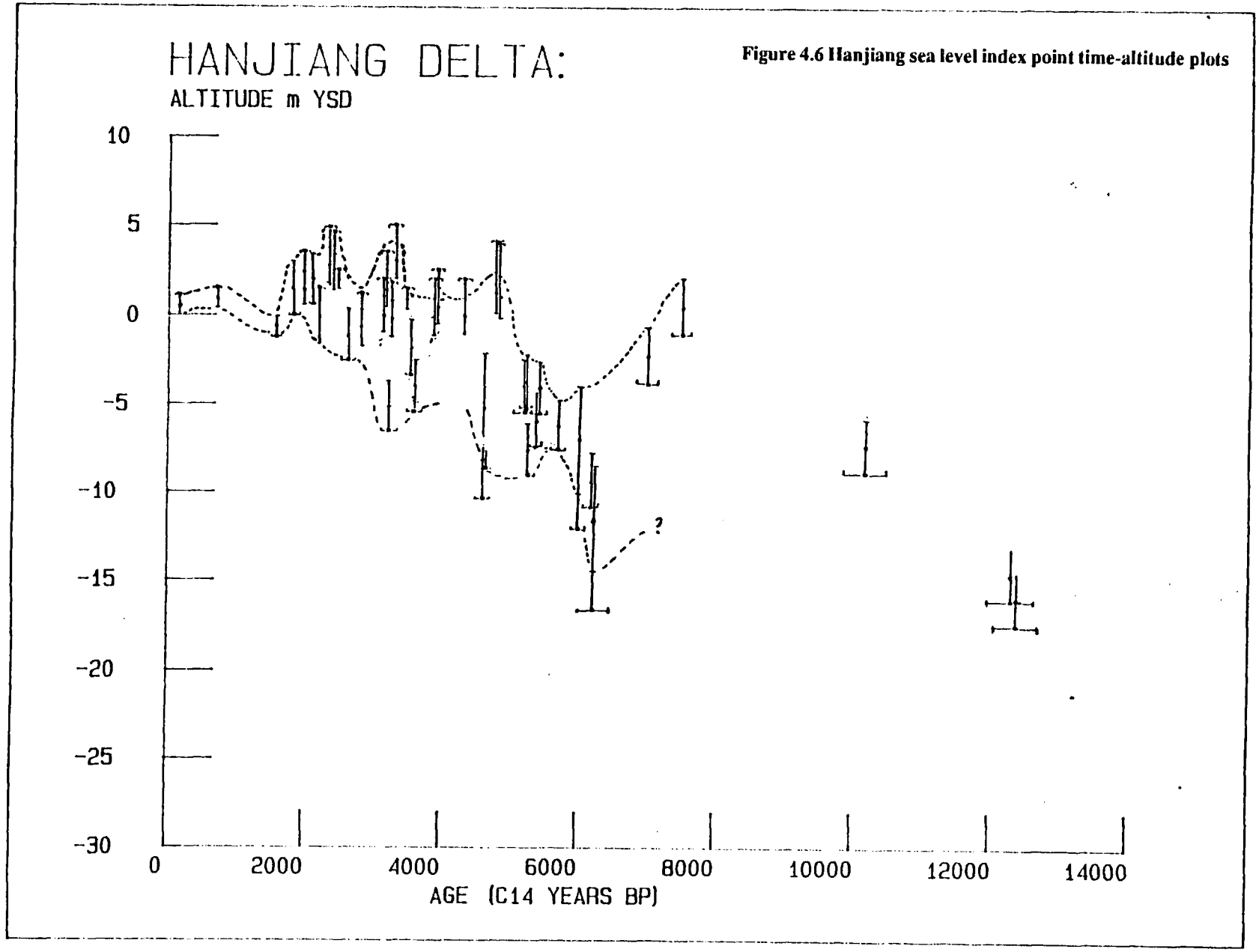

Figure 4.6 Hanjiang sea level index point time-altitude plots

Figure 4.7 Xisha Islands sea level index point time-altitude plots

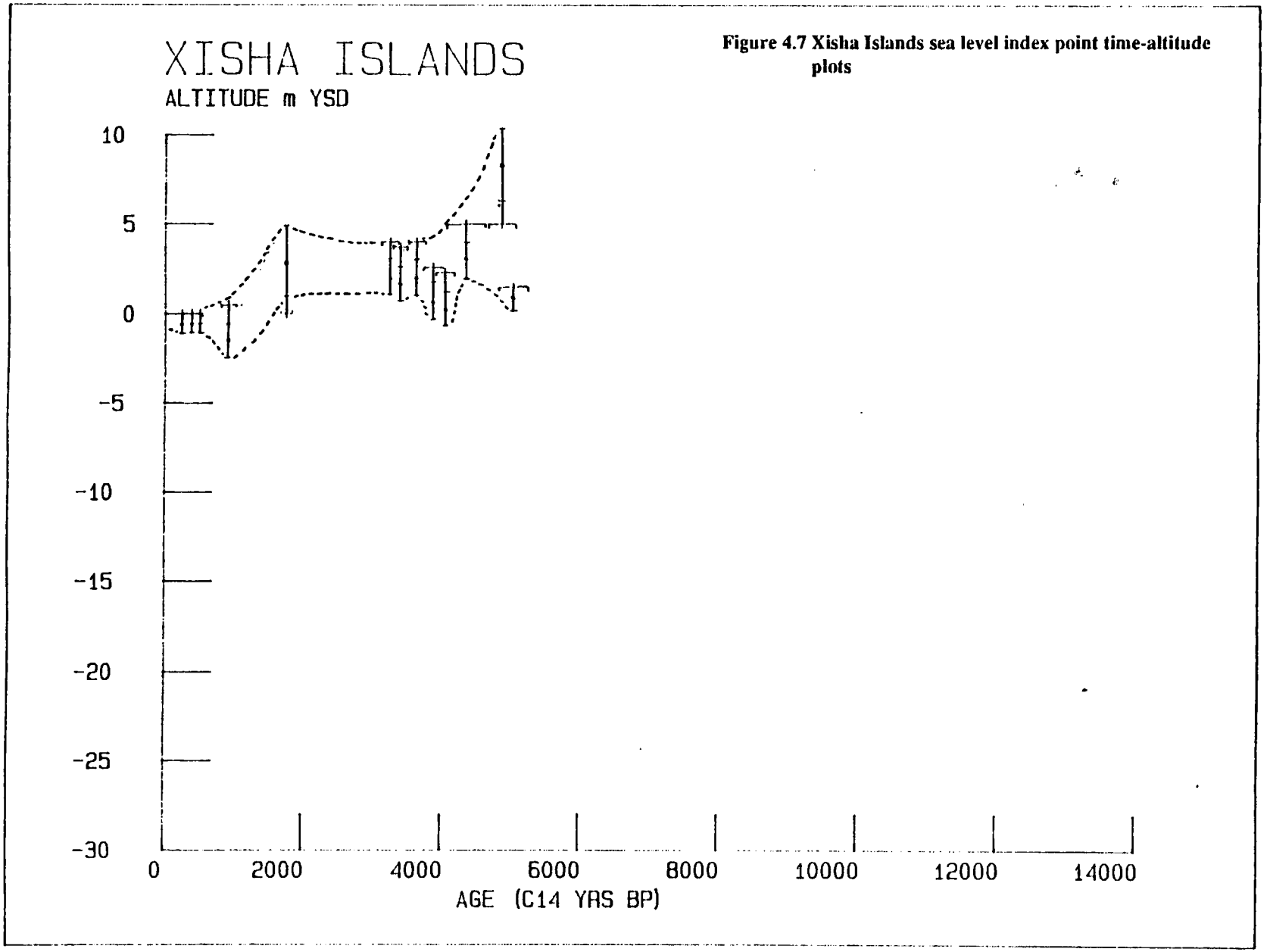

Figure 4.7 Xisha Islands sea level index point time-altitude plots

Figure 4.8 Hainan Islands sea level index point time-altitude plots

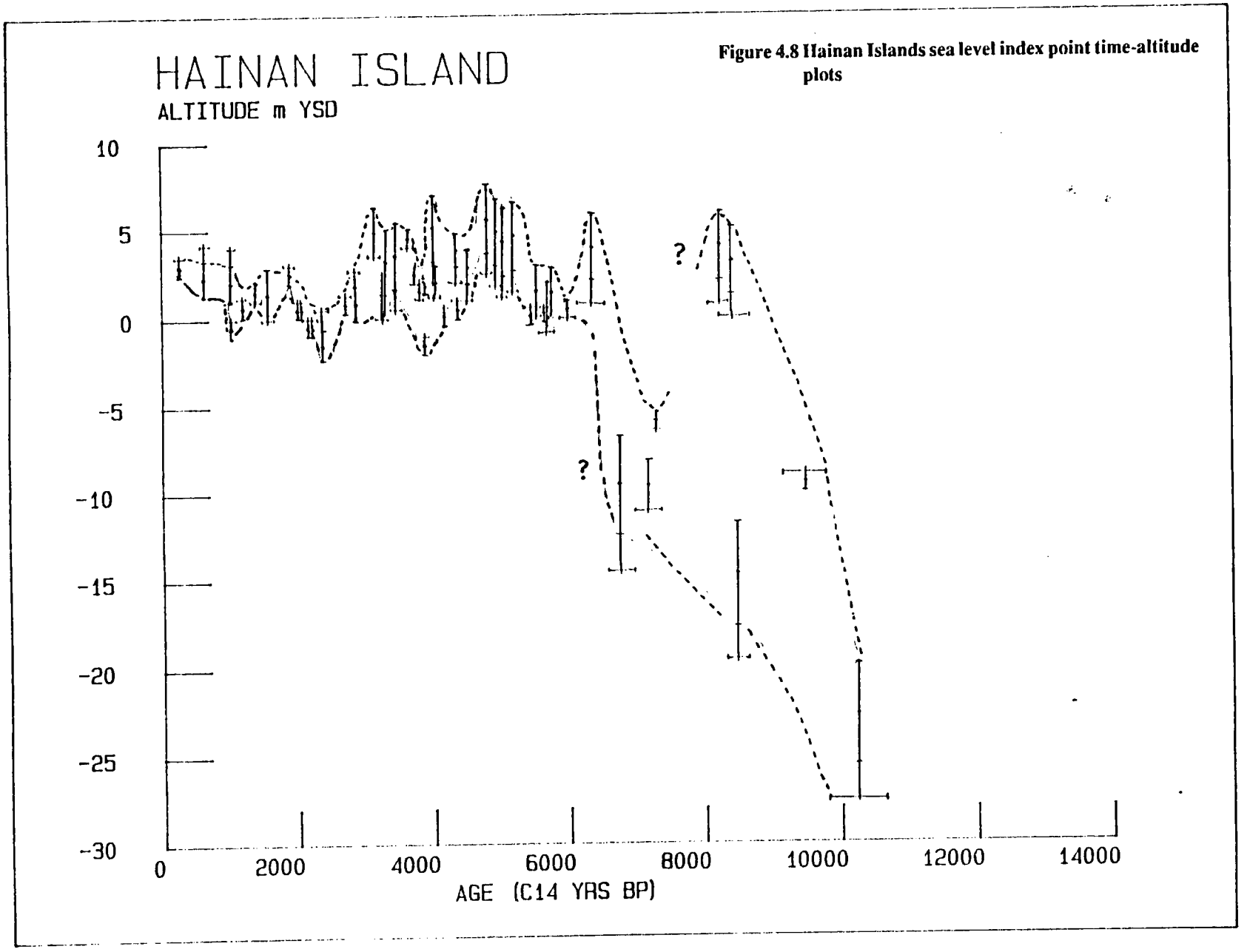

Figure 4.8 Hainan Islands sea level index point time-altitude plots

Figure 4.9 West Guangdong sea level index point time-altitude plots

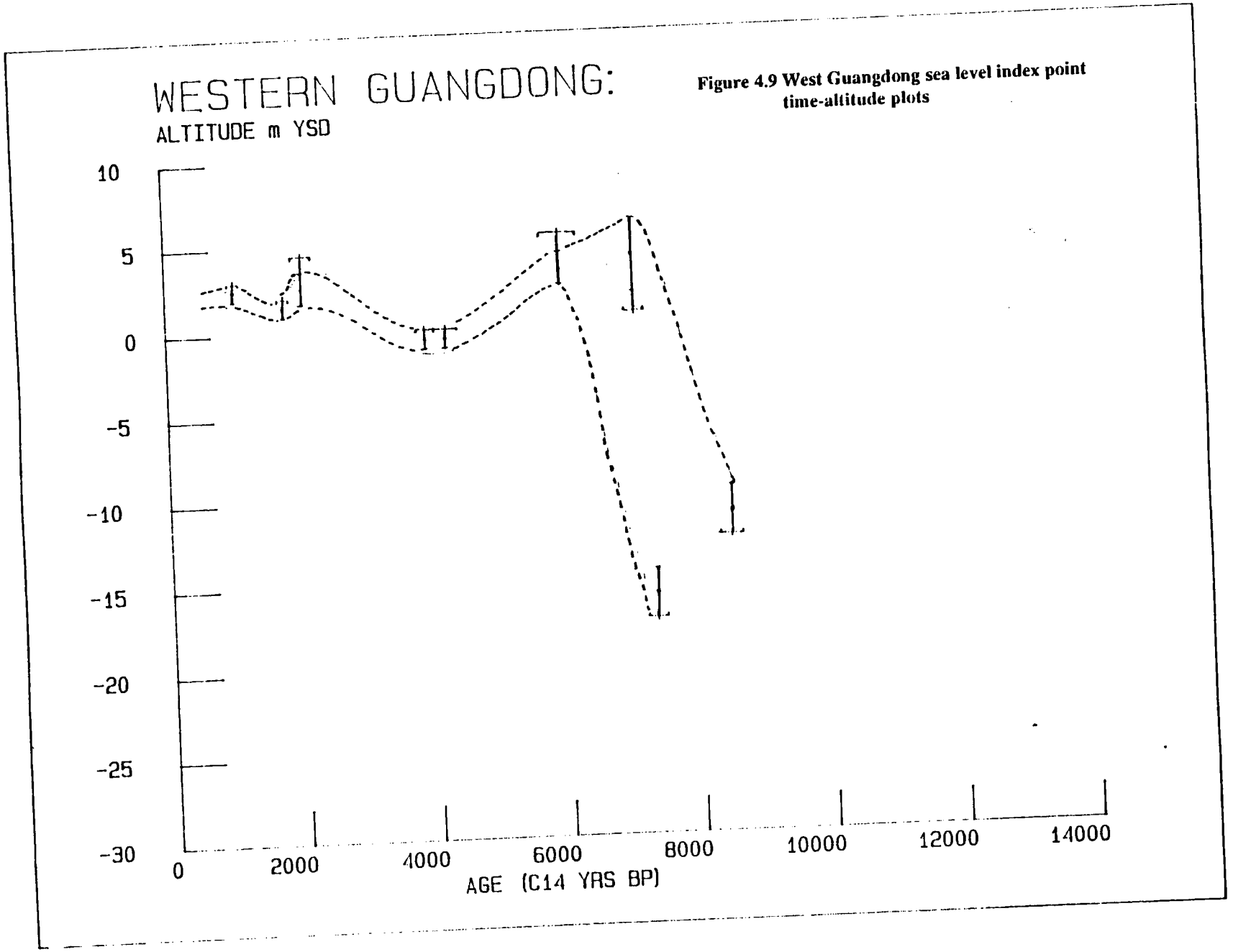

Figure 4.9 West Guangdong sea level index point time-altitude plots

Figure 4.10 Fujian coast sea level index point time-altitude plots

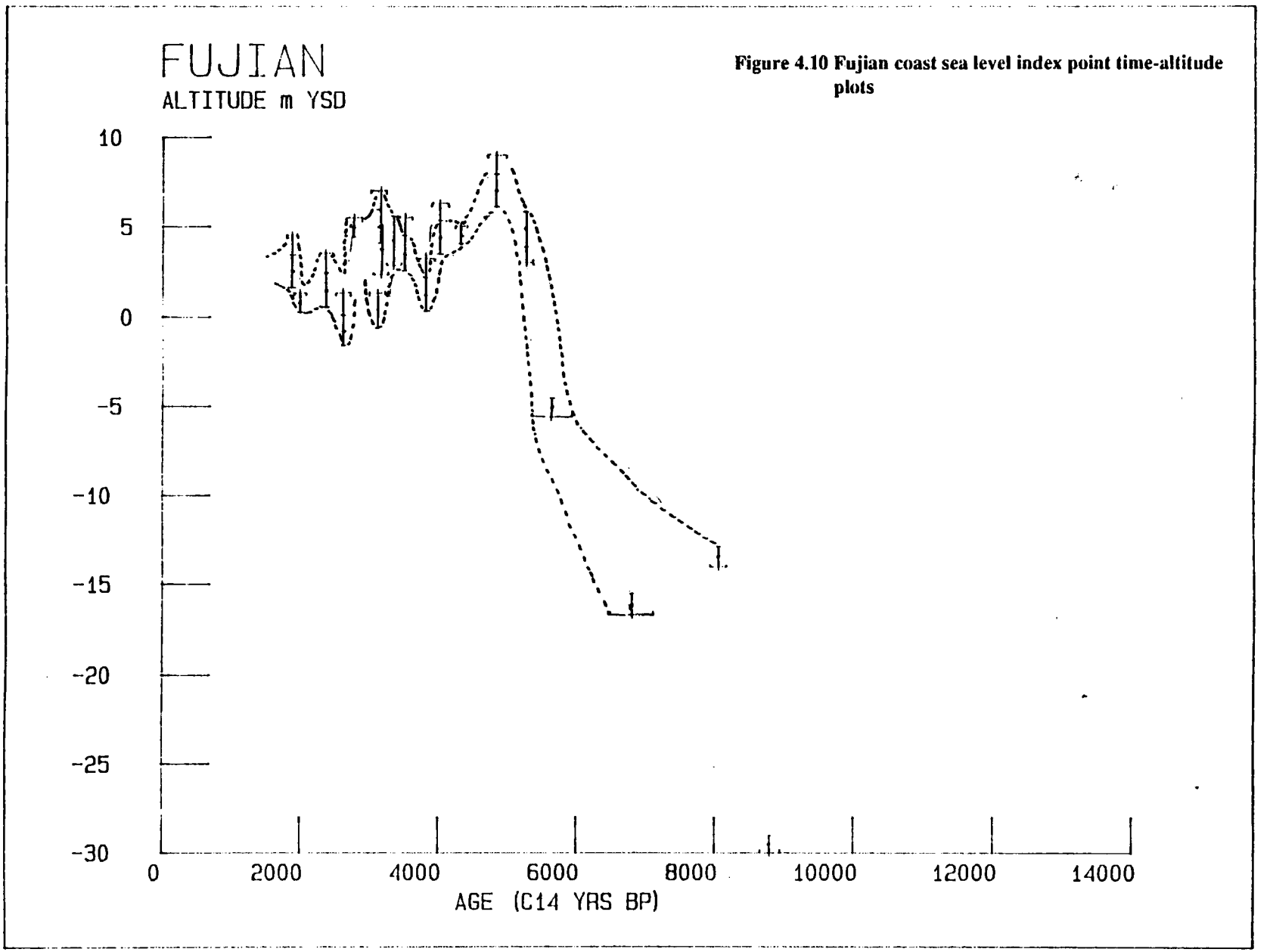

Figure 4.10 Fujian coast sea level index point time-altitude plots

Figure 4.11 Combined sea-level change envelopes from all parts of the south China coast

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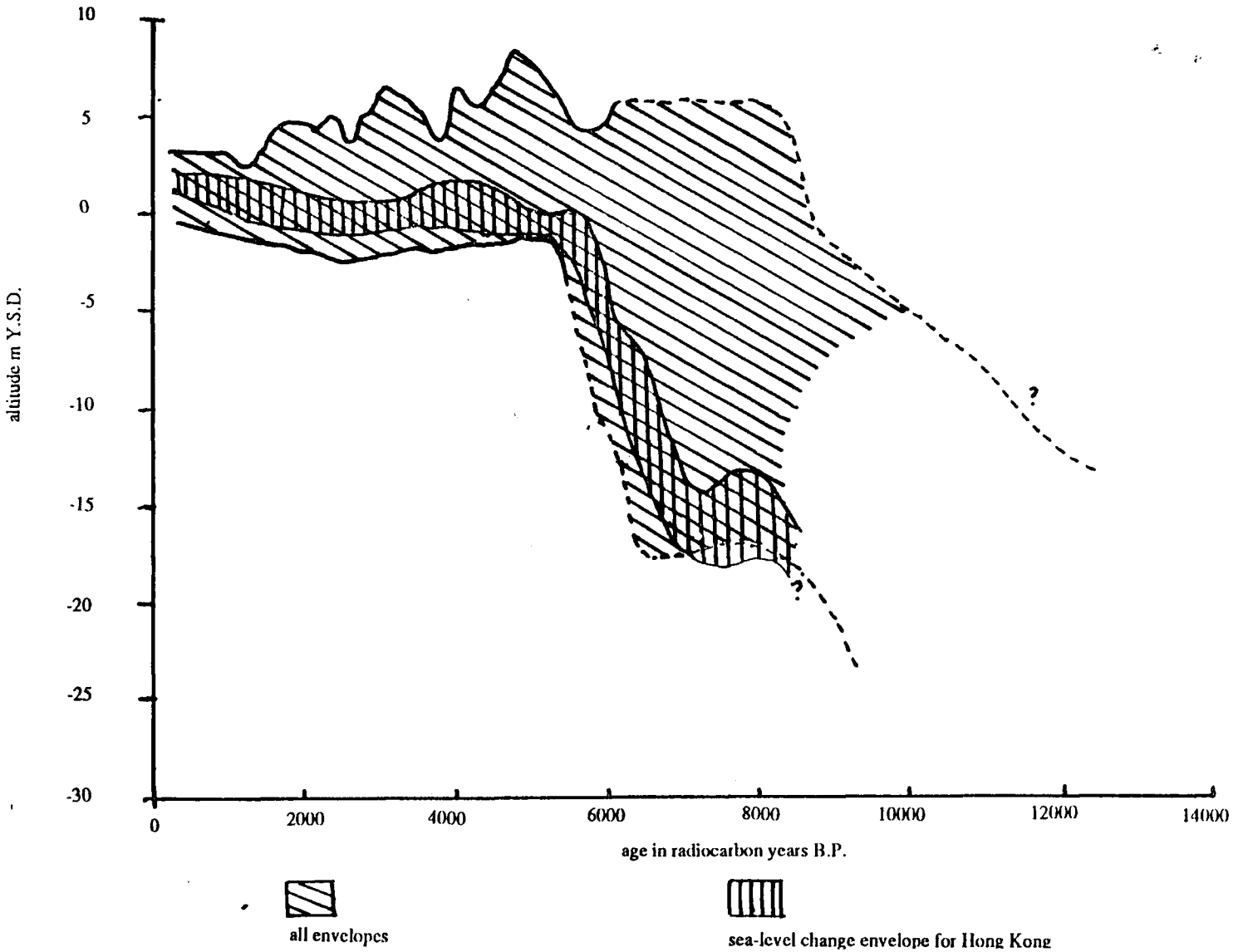

Figure 4.12 South China coast sea-level index points. Fixed and relational indicators. (Total of 98 data points).

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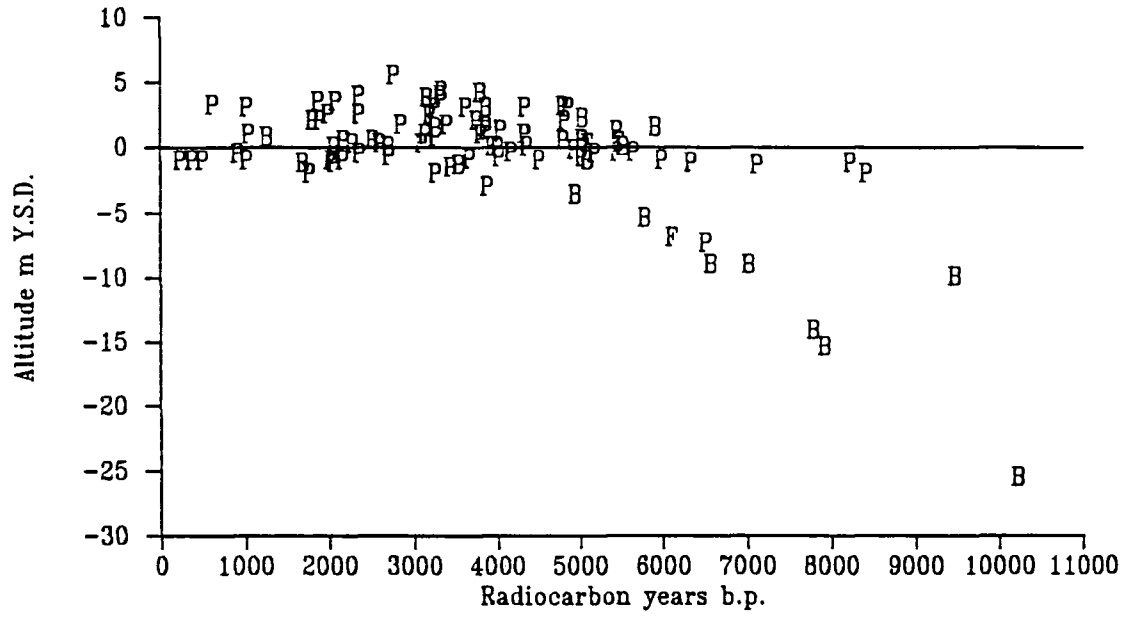


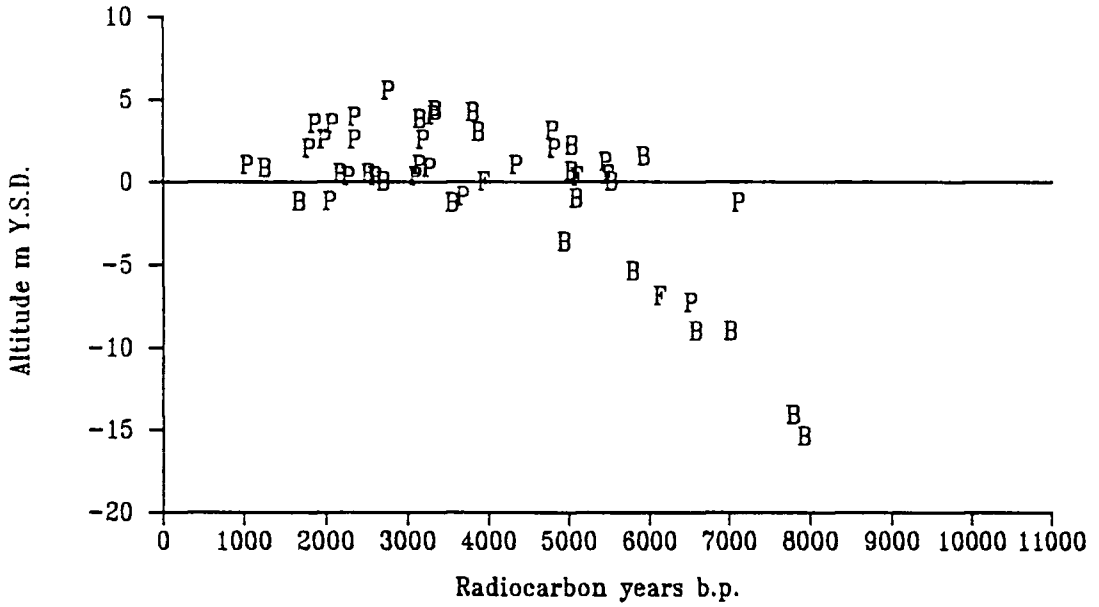
B subtidal indicator

P supratidal indicator

F fixed indicator (intertidal root sample - phrgmites?)

Figure 4.13 South China coast sea-level index points (not including Hainan Island and western Guangdong data). Fixed and relational indicators. (Total of 48 data points).

Figure 4.13 South China coast sea-level index points (not including Hainan Island and western Guangdong data). Fixed and relational indicators.



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P supratidal indicator

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Figure 4.14 Sea-level indicators from the Zhujiang delta including Shenzhen.

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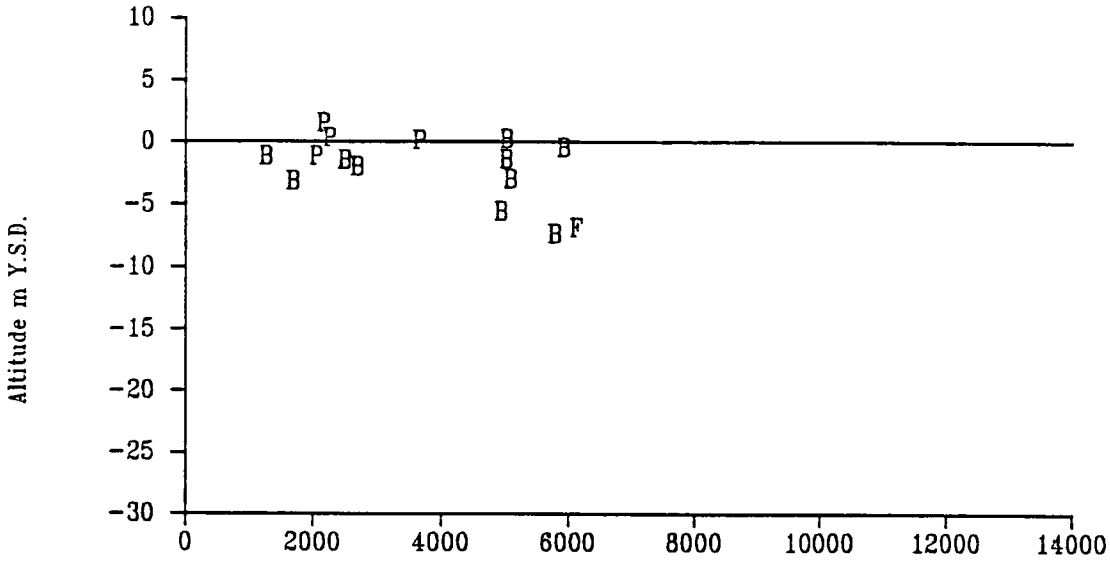

Figure 4.15 Sea-level indicators from Hong Kong.

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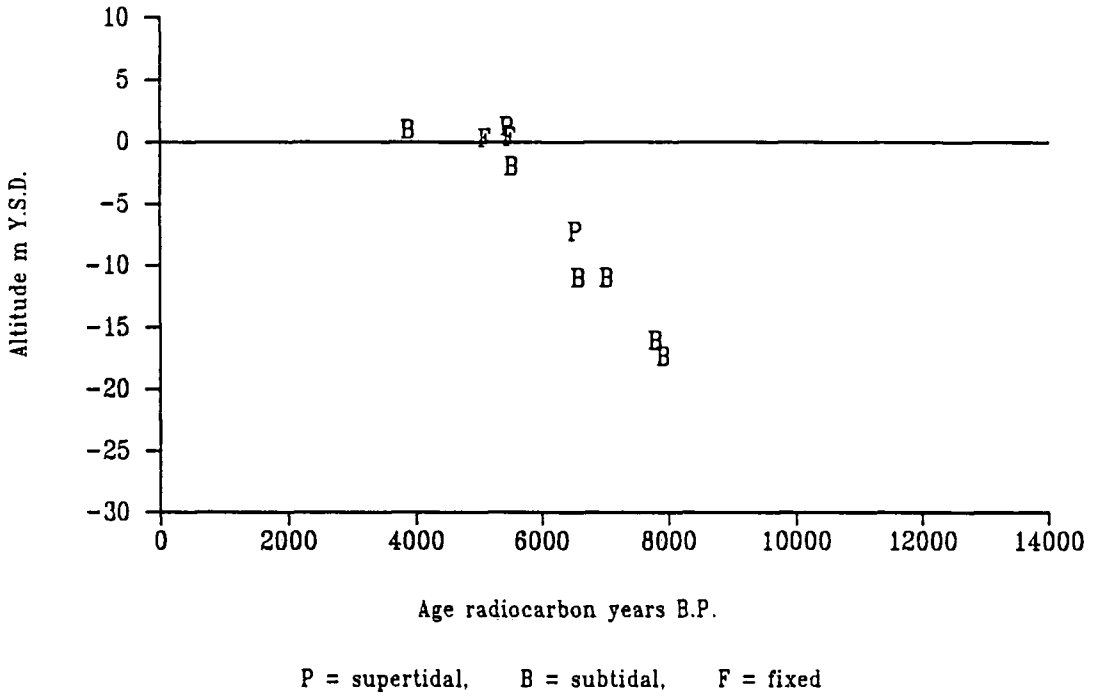

Figure 4.16 Sea-level indicators from Hainan Island.

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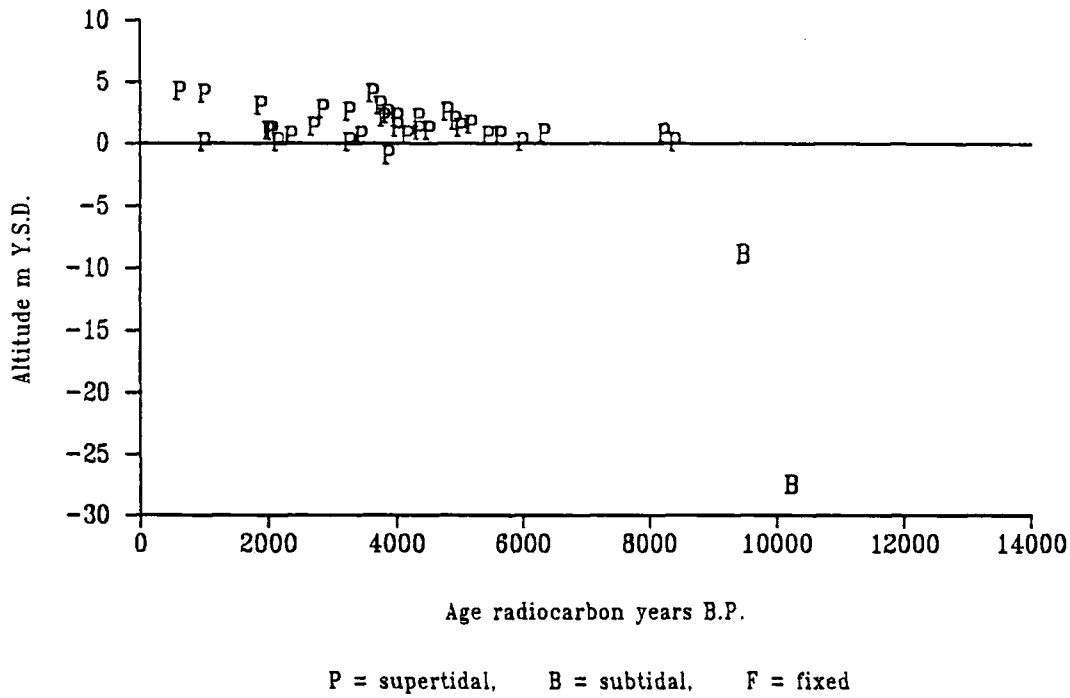
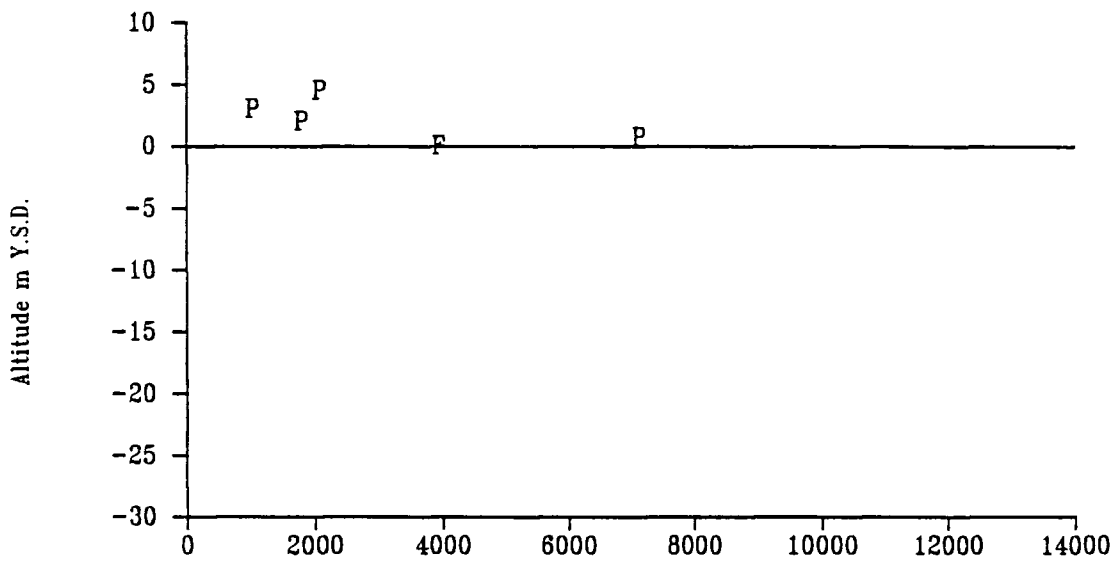


P = supertidal, B = subtidal, F = fixed

Figure 4.17 Sea-level indicators from the coast of western Guangdong.

Figure 4.17 Sea-level indicators from the coast of western Guangdong

Guangdong



P = supertidal, B = subtidal, F = fixed

Figure 4.18 Sea-level indicators found on the Xisha Islands.

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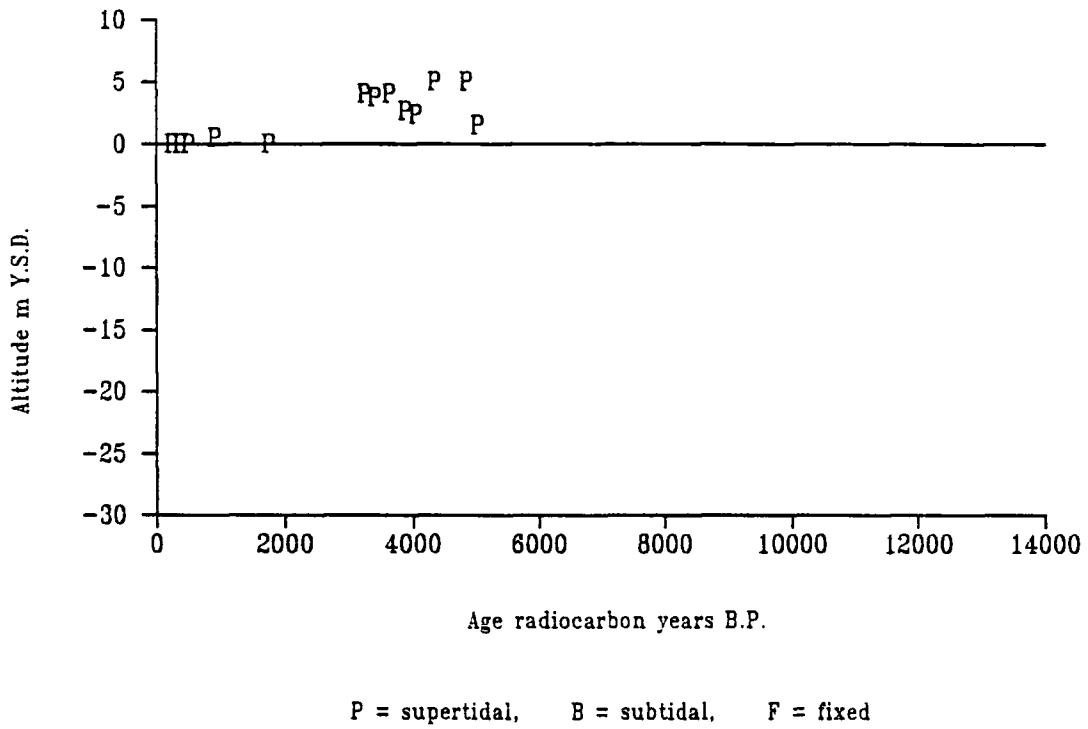

Figure 4.19 Sea-level indicators found in the Hanjiang delta.

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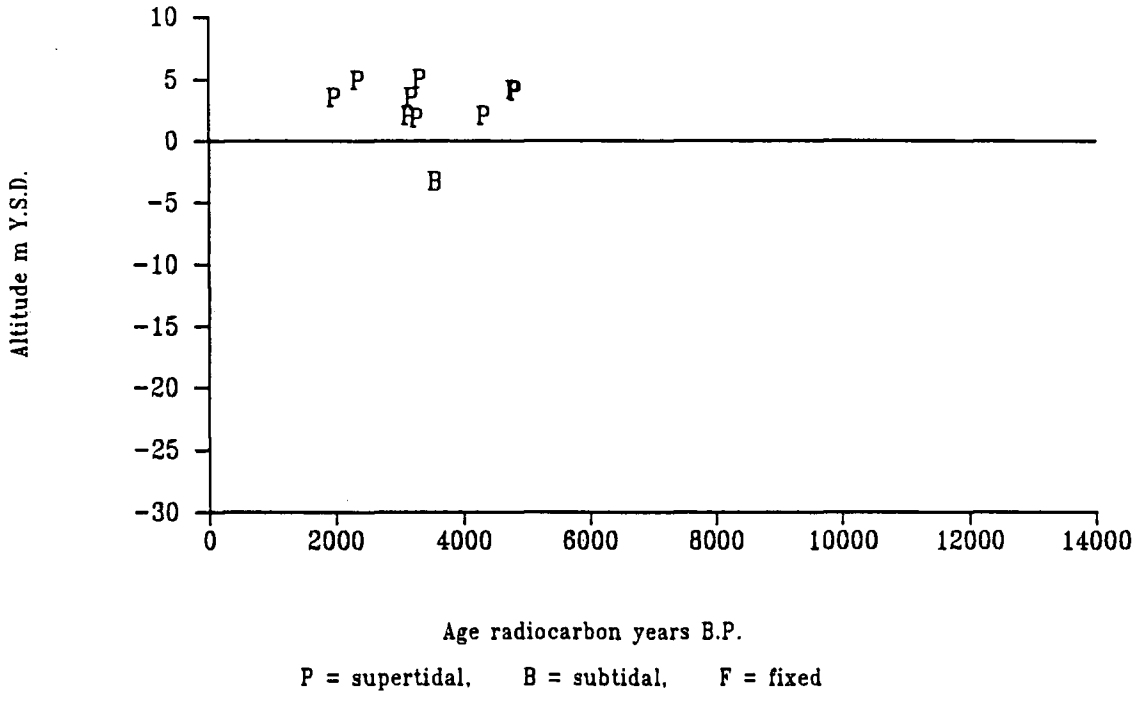

Figure 4.20 Sea-level indicators from the coast of Fujian province.

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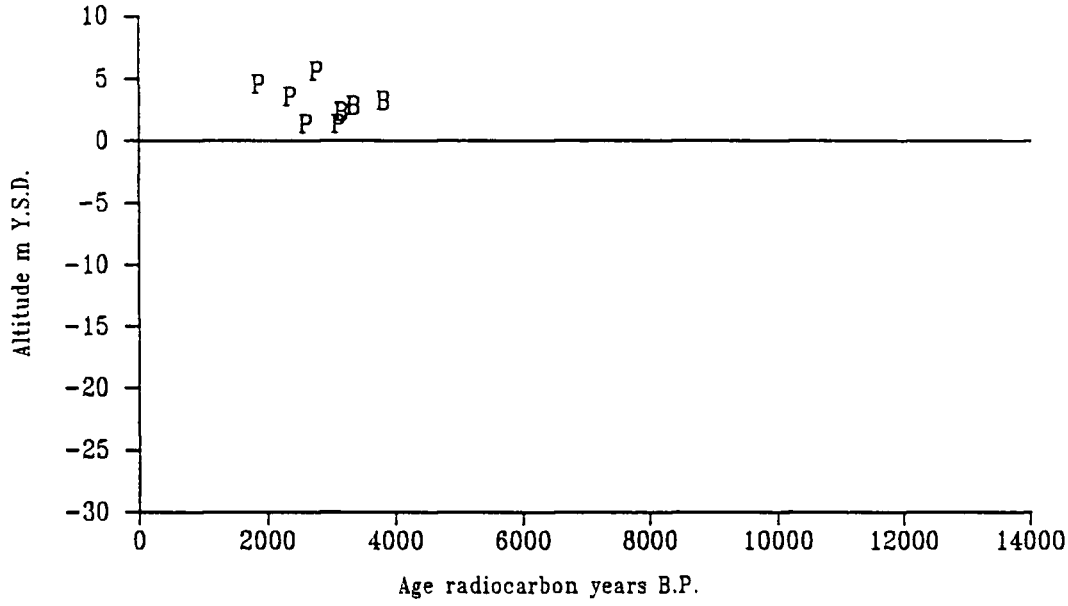


Figure 5.1 The structure of a G.I.S. to analyze the impacts of coastal change

FIGURE 5.1: The structure of a G.I.S. to analyse the impacts of coastal changes

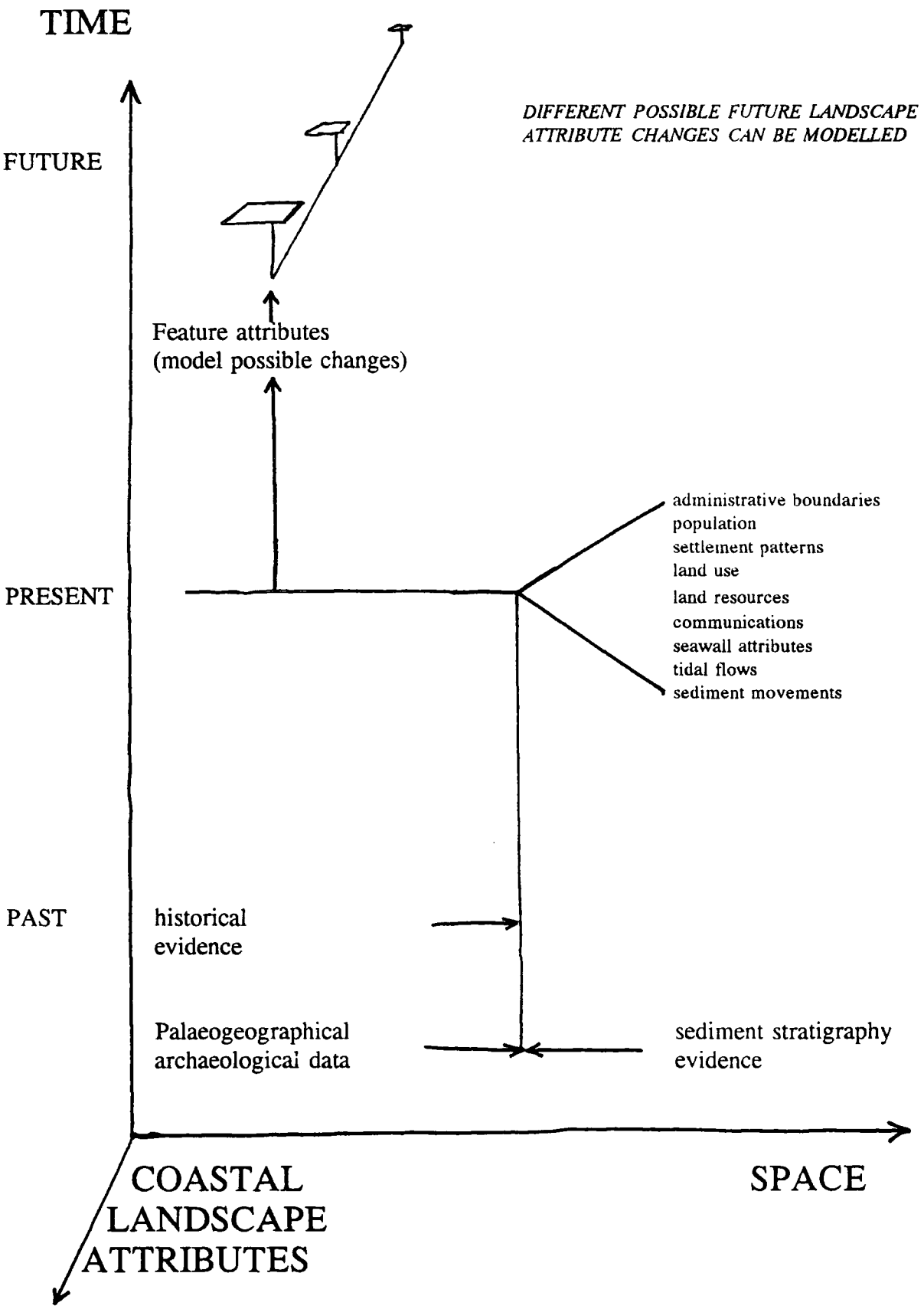


Figure 5.2 The Zhujiang Delta, and the location of tide gauge stations

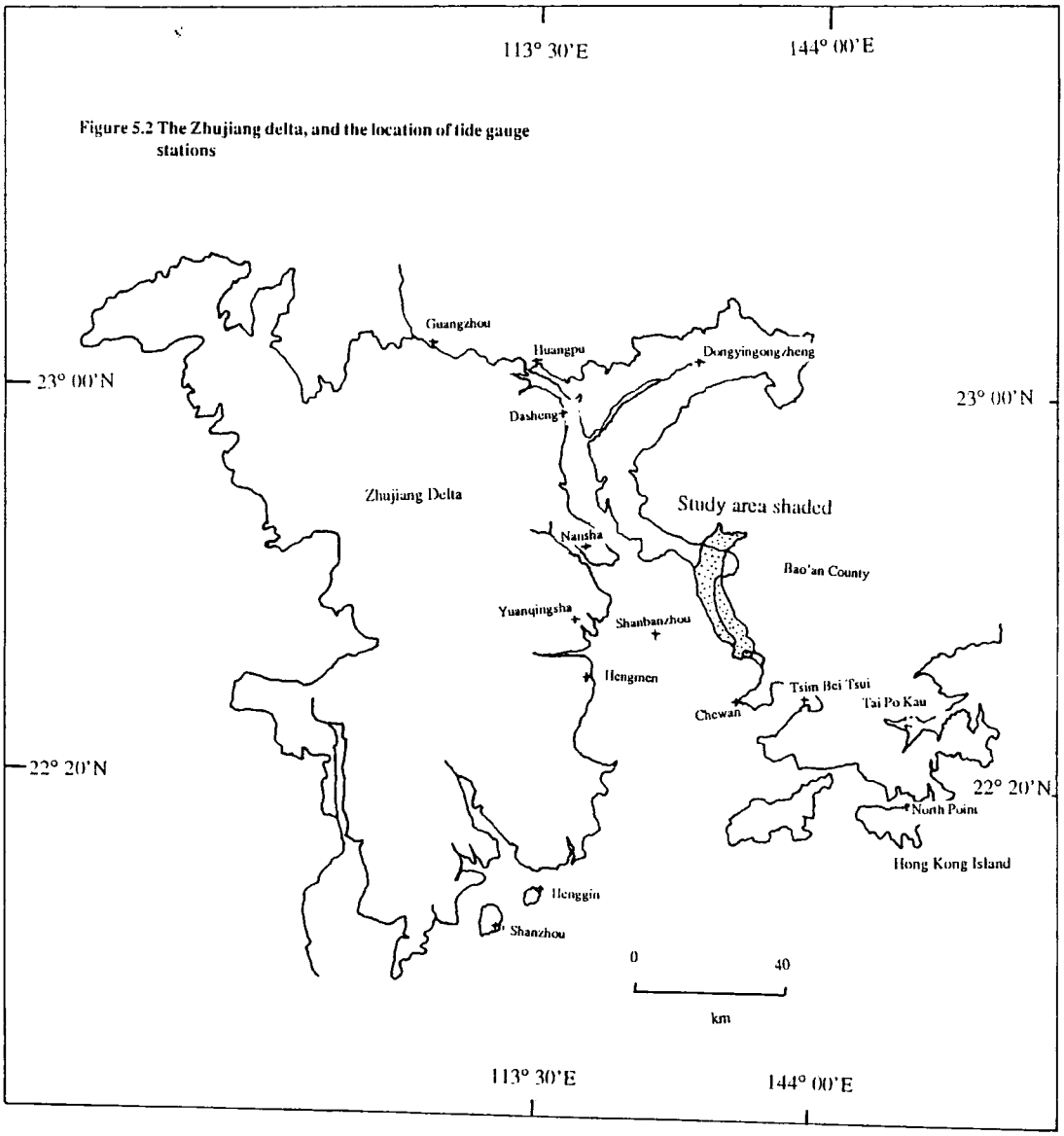
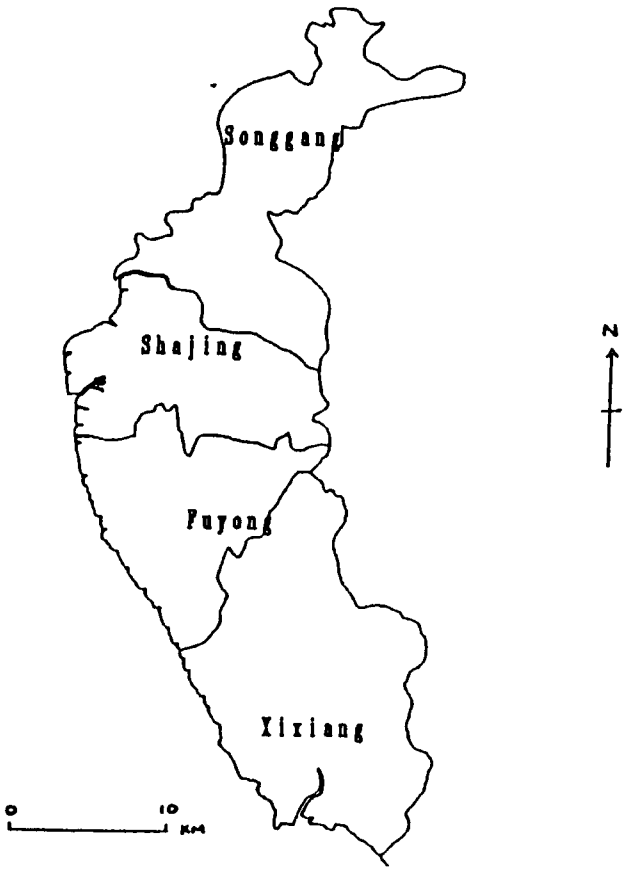


Figure 5.2 The Zhujiang delta, and the location of tide gauge stations

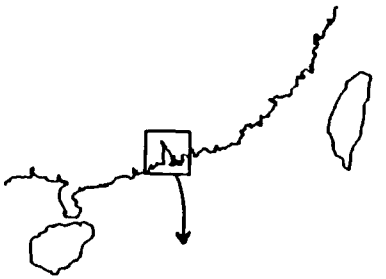
Figure 5.3 The location of the study area

Figure 5.3 The location of the study area



The study area covers four districts in the west of Bao'an County, Guangdong Province, southern China

Southern China and the South China Sea



Zhujiang Delta - study area shaded

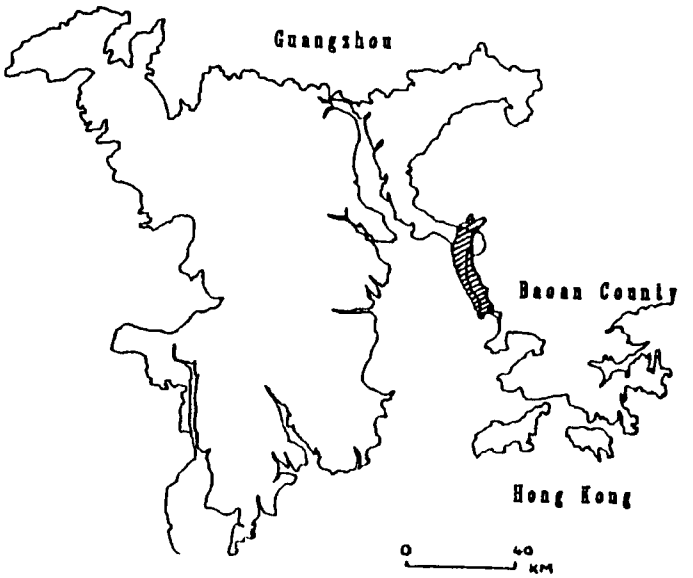


Figure 5.4 The structure of local government administration in the study area

Figure 5.4

The structure of Chinese local government related to the study area:

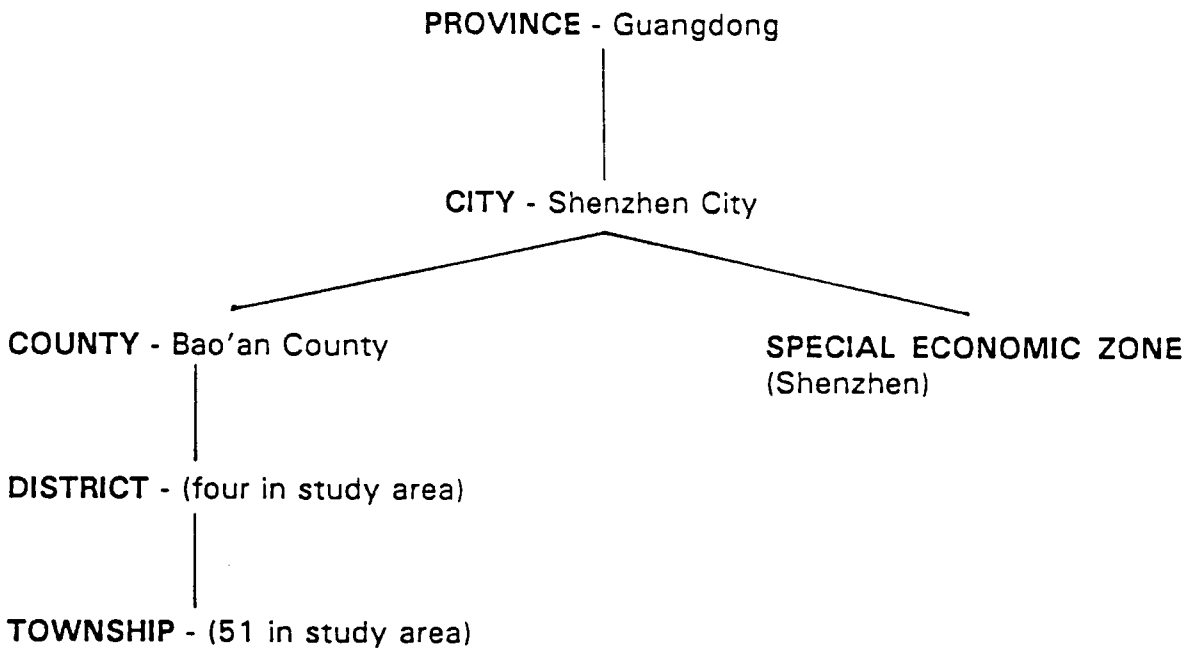


Figure 5.5 Levelled transect across the study area, 2 km south of Shajing (see Figures 5.3 and 5.10 for location)

Figure 5.5 **Levelled transect across the study area, 2 km south of Shajing (see Figures 5.3 and 5.10 for location)**

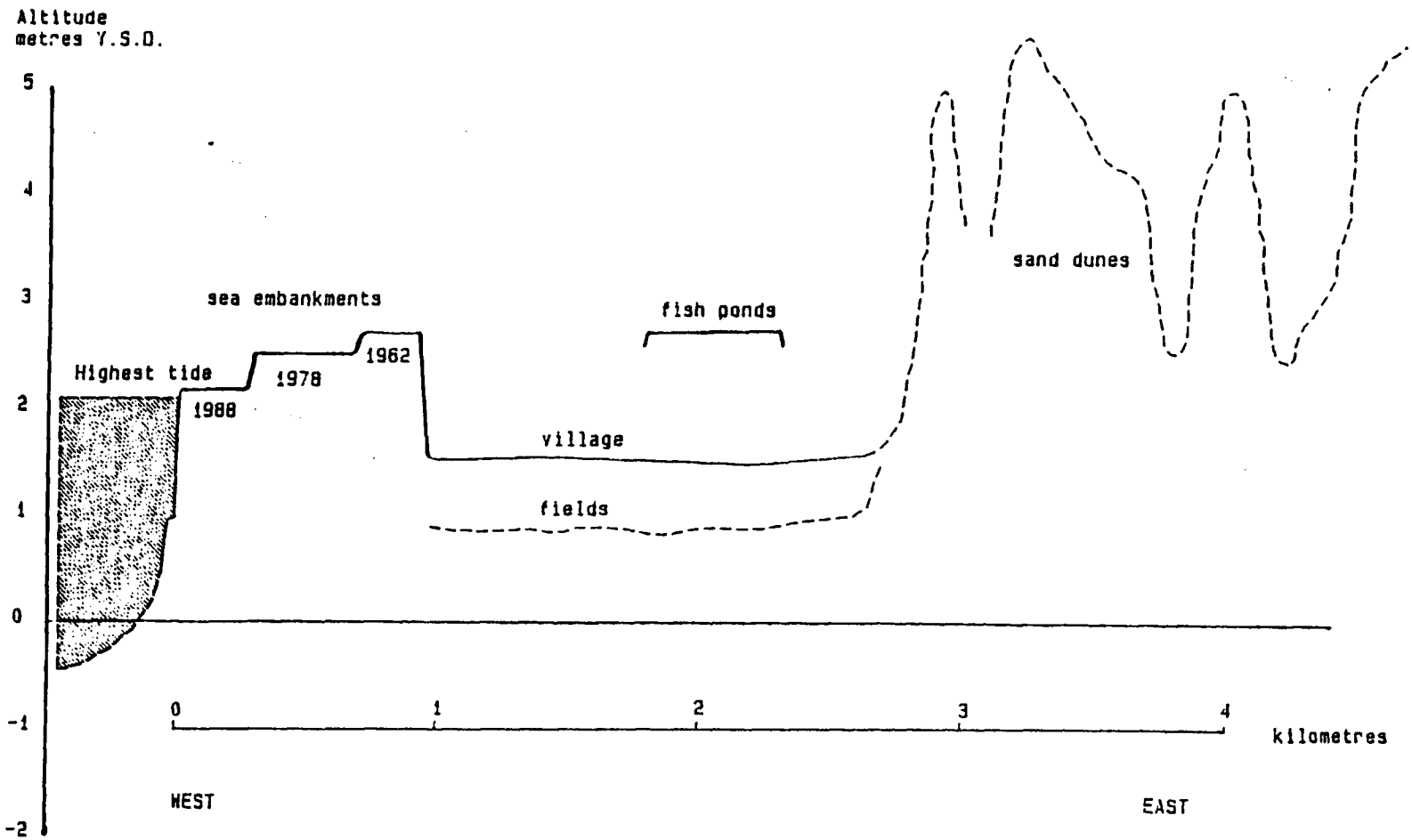


Figure 5.6 Recorded sea levels during three storms at the tide gauges in the Zhujiang Delta (all altitudes in metres Y.S.D.)

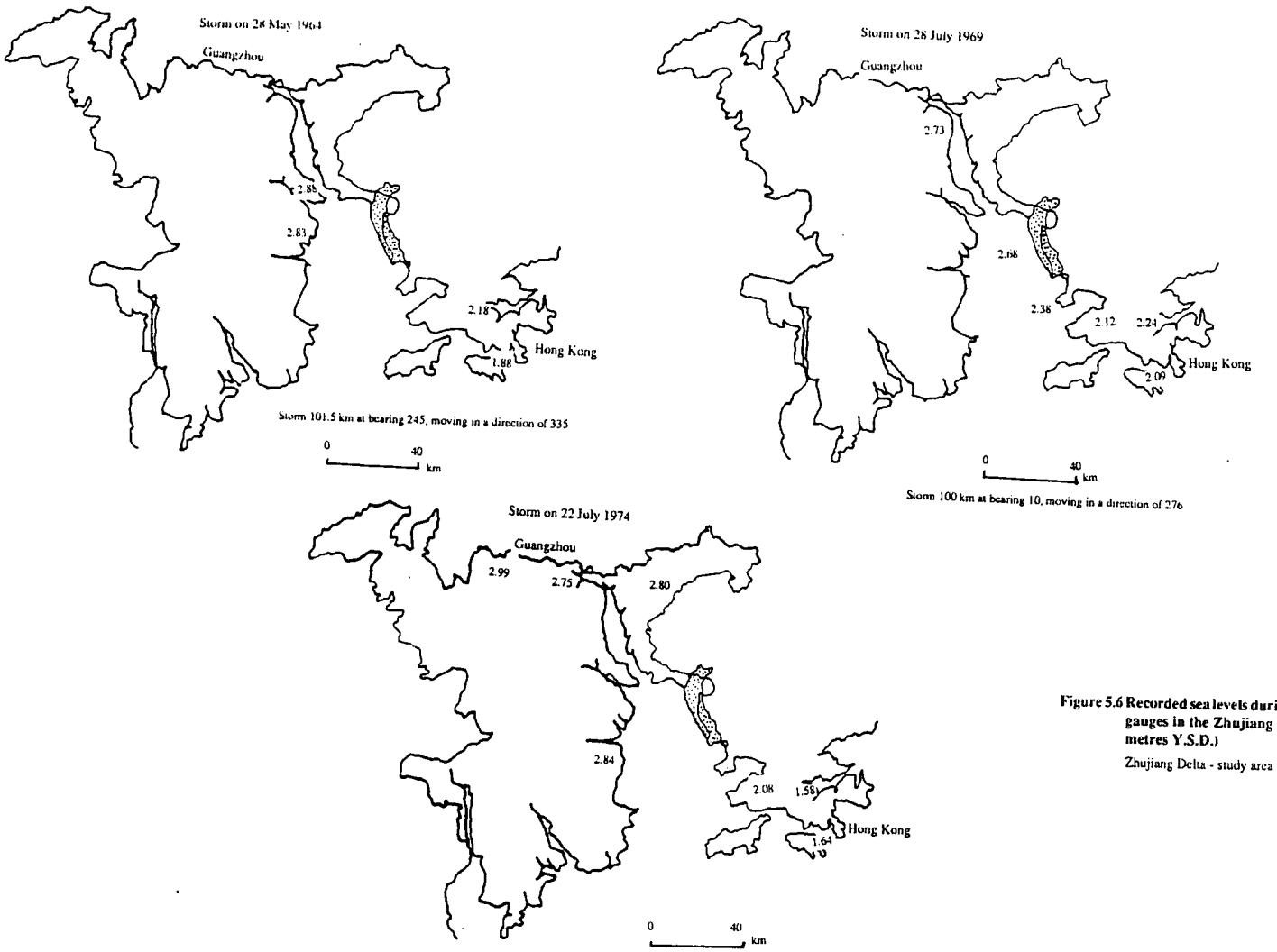


Figure 5.6 Recorded sea levels during three storms at the tide gauges in the Zhujiang Delta (all altitudes in metres Y.S.D.)

Zhujiang Delta - study area shaded

(See Figure 5.2 for details of tide gauges - study area shaded)

Figure 5.7 The tide gauge network in Hong Kong

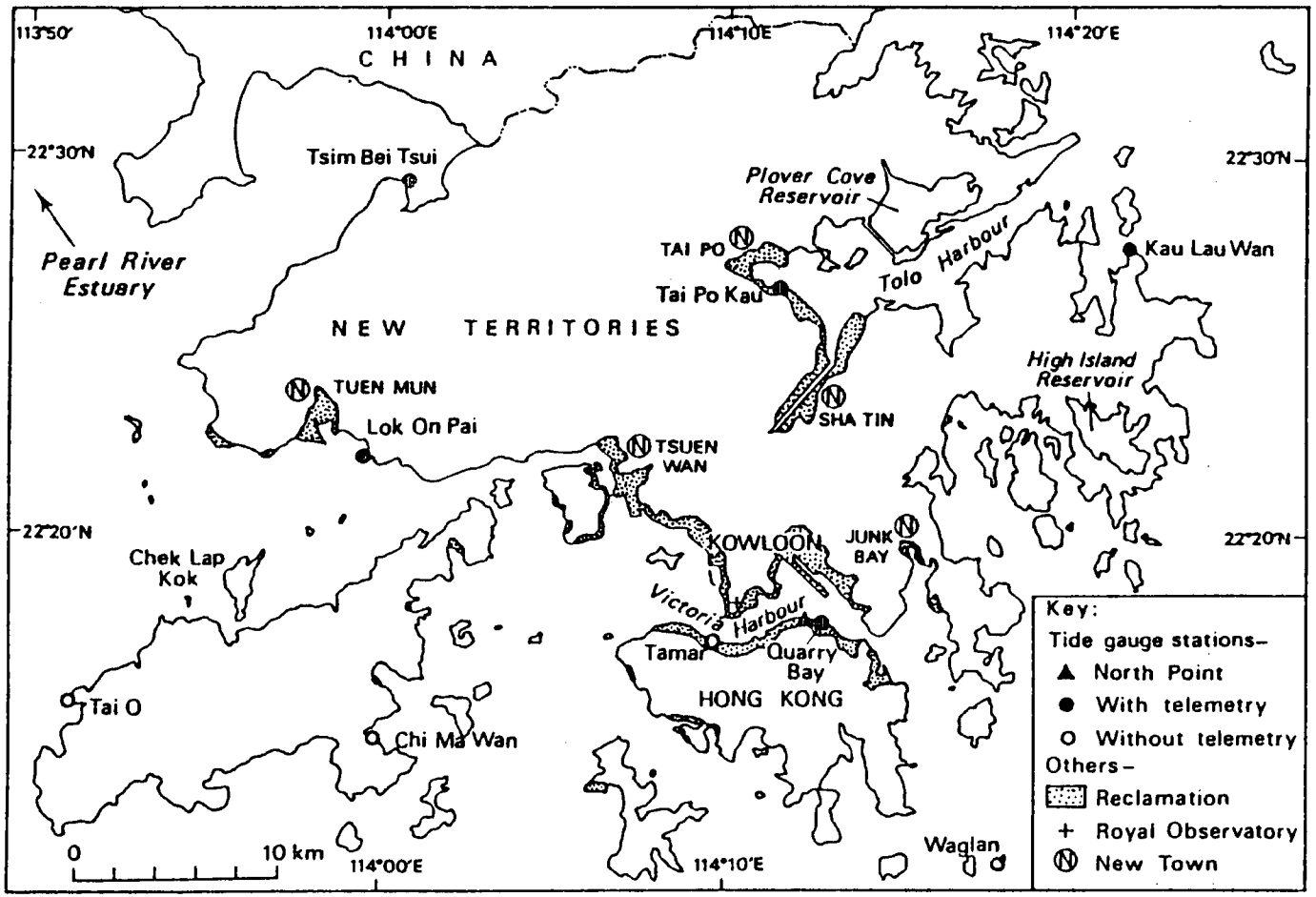


Figure 5.7 The tide gauge network in Hong Kong
(after Yim 1988a)

Figure 5.8 Ground settlement of the North Point tide gauge 1954-1976

Figure 5.8 Ground settlement of the North Point tide gauge 1954-1976

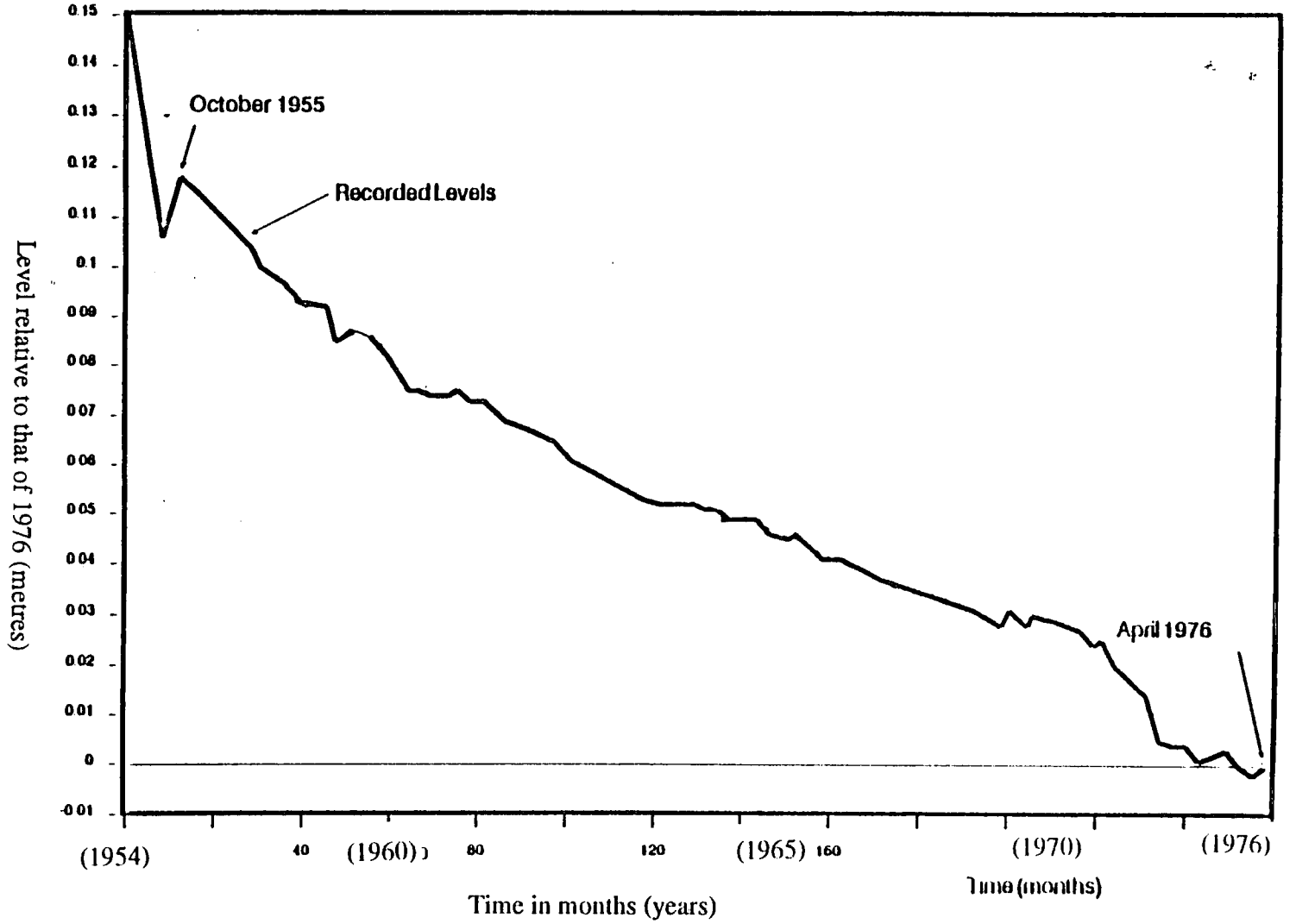
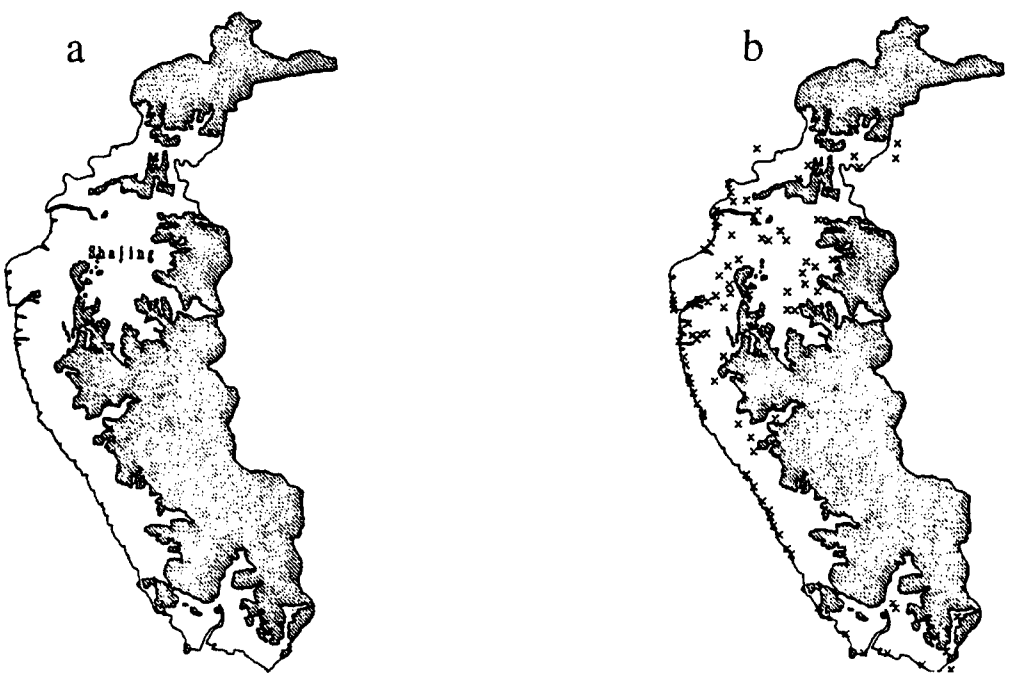


Figure 5.9 Altitudinal data for the study area

Figure 5.9 Altitudinal data for western Bao'an County



a) Land above +5m Y.S.D. (shaded)

b) Spot heights below +2.5m Y.S.D. marked "x" (land above +5m Y.S.D. shaded)

Figure 5.10 Reproduction of the 1:10,000 map of part of the study area

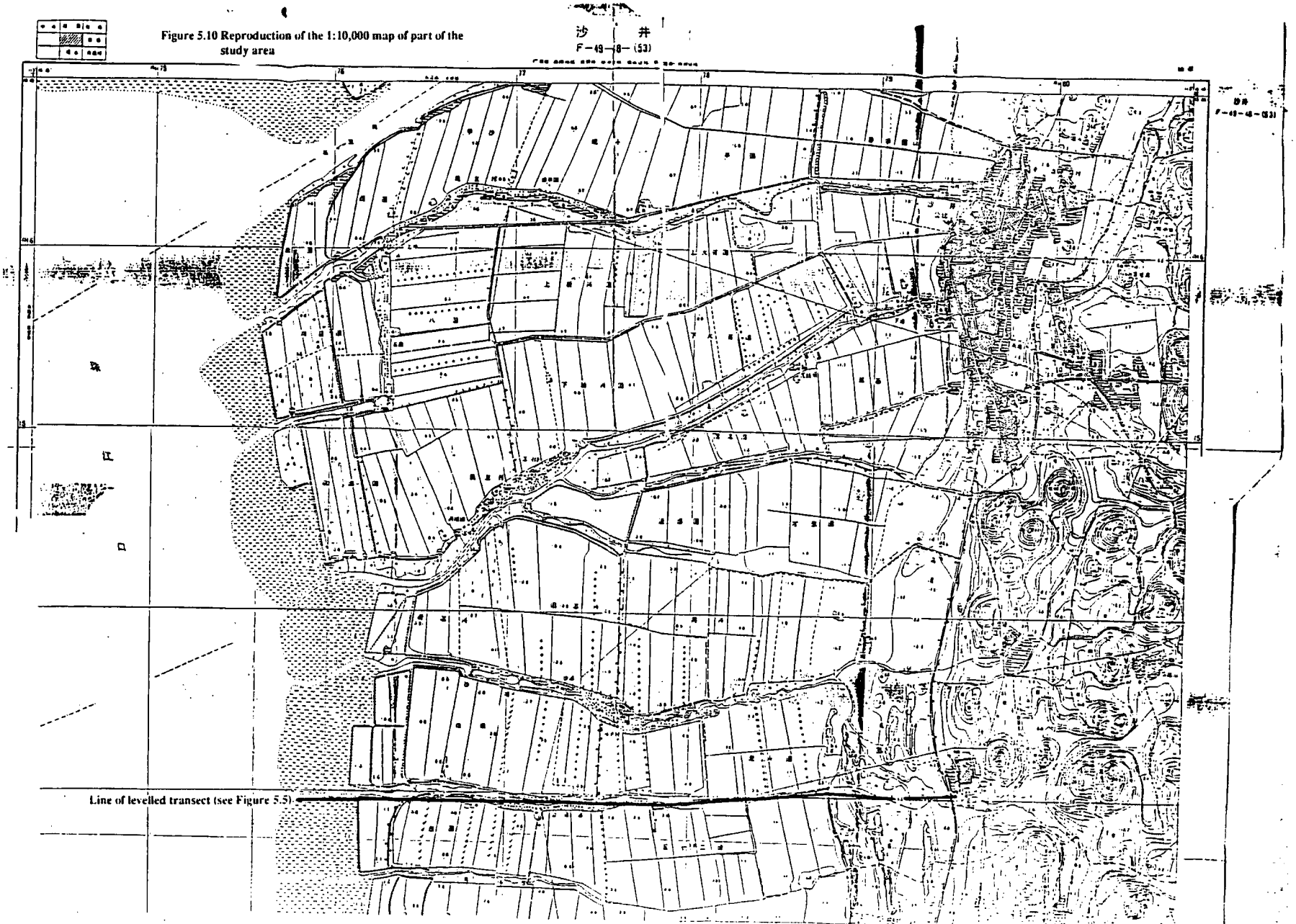


Figure 5.10 Reproduction of the 1:10,000 map of part of the study area

Figure 5.11 Relative altitudes of sea levels and land in the Zhujiang Delta

Figure 5.11 Relative altitudes of sea levels and land in the Zhujiang Delta

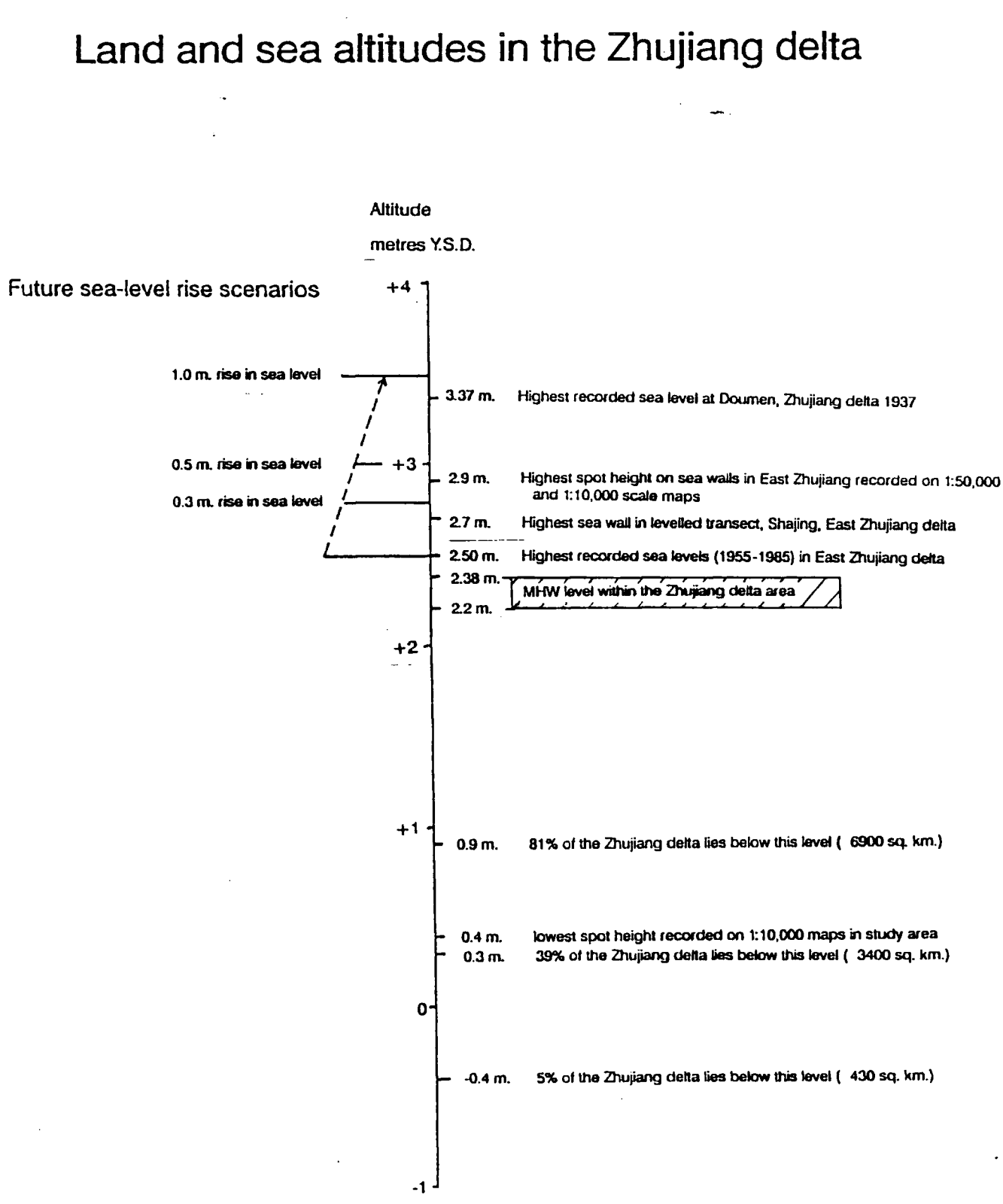


Figure 5.12 Population and altitude maps of the study area

ORIGINALS IN COLOUR

Figure 5.12 Population and altitude maps of the study area

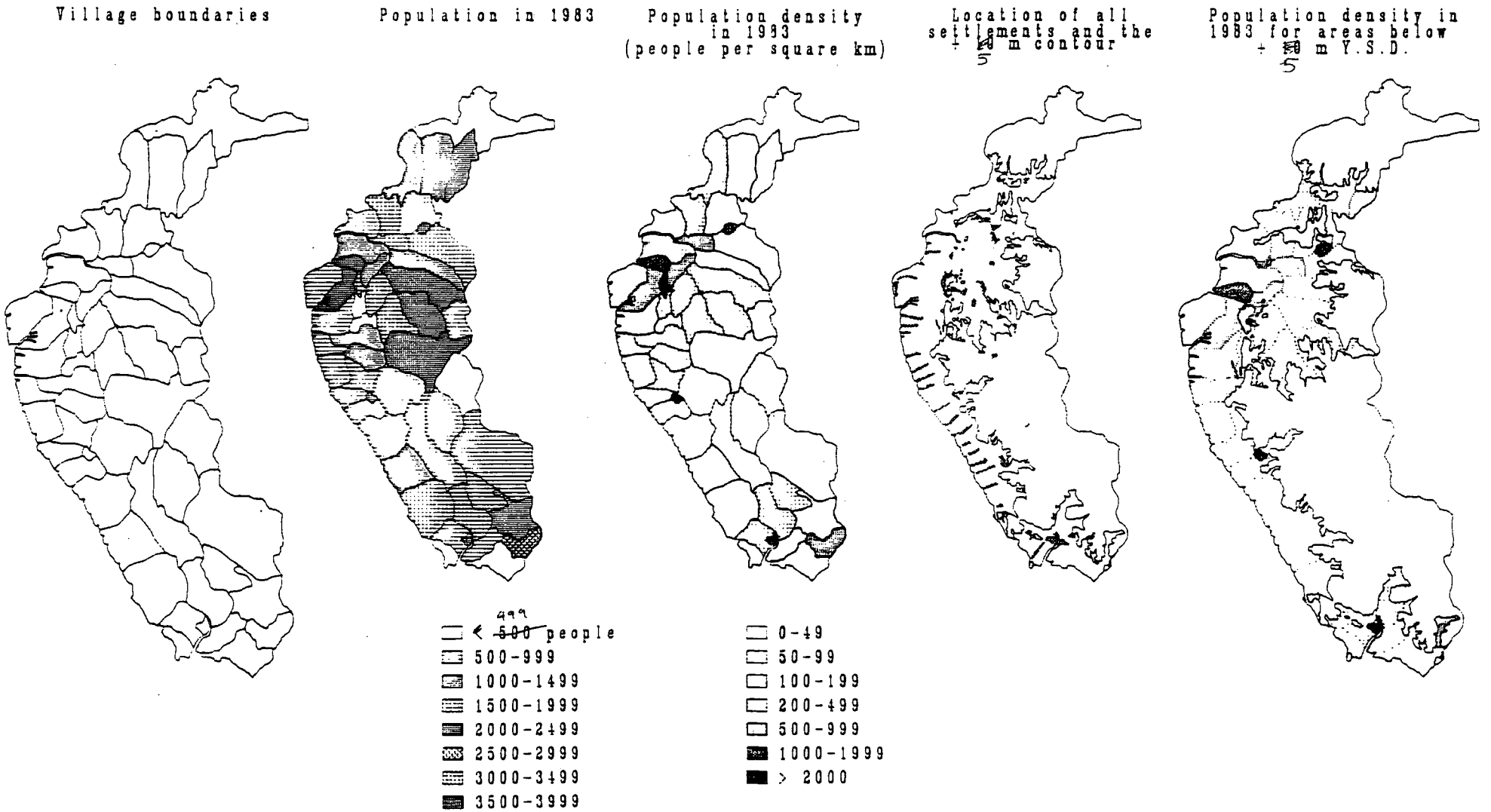
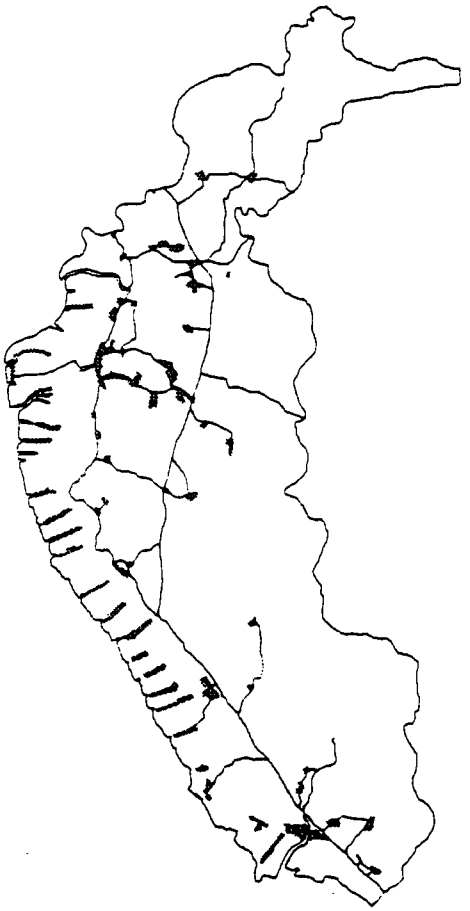


Figure 5.13 Communication routes in the study area

ORIGINALS IN COLOUR

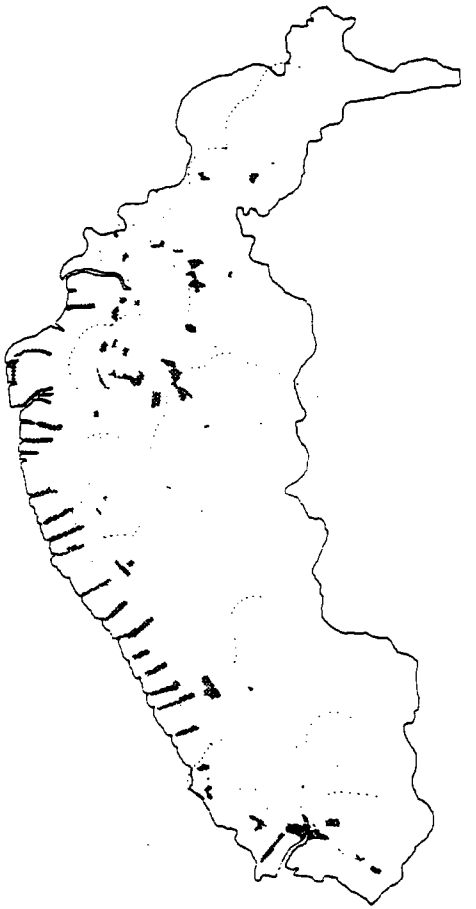
Figure 5.13 Communication routes in the study area

Roads and villages



Roads above + 10 m Y.S.D.

Settlements below +10 m Y.S.D.
and the area within 1 km of a
roads above + 10 m Y.S.D. (shaded green)



Greg Eaglefield 1988

Source: Institute of Geography, Guangzhou

Figure 5.14 Estimates of future sea level rise

Figure 5.14 Estimates of future sea-level rise

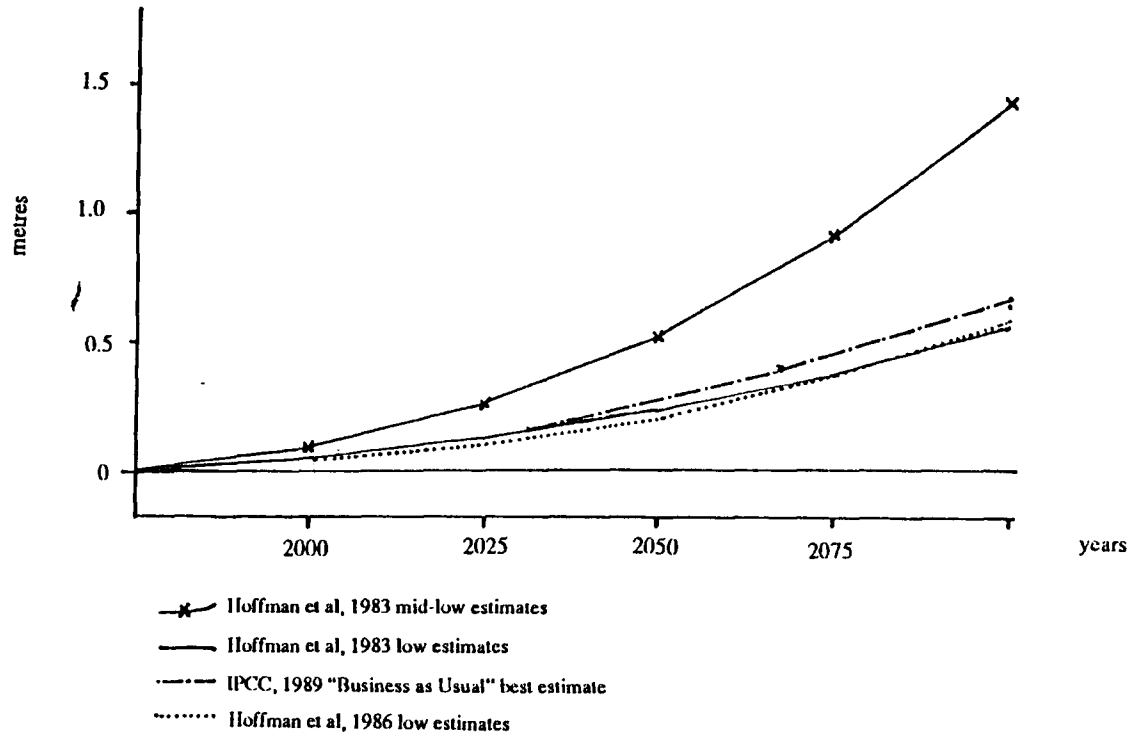


Figure 5.15 Estimates of future sea level rise added to the highest recorded sea level at Shanbanzhou

Figure 5.15 Estimates of future sea level rise added to the highest recorded sea-level at Shanbanzhou

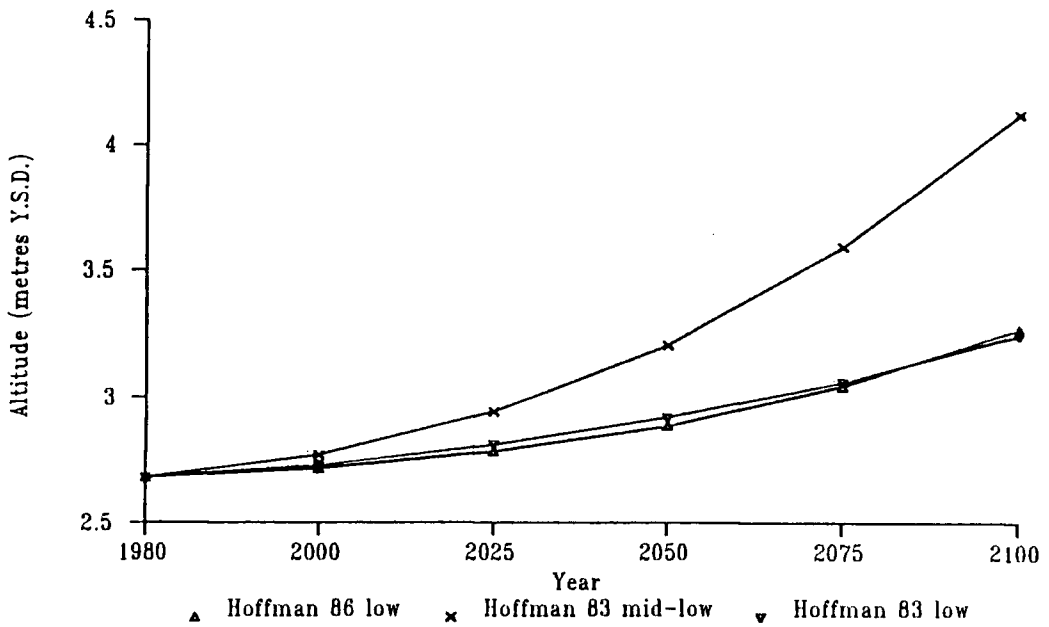


Figure 5.16 Sea level rise scenarios for the Zhujiang Delta, according to Hoffman et al (1986)

Figure 5.16 Sea-level rise scenarios for the Zhujiang delta

Hoffman et al 1986, LOW scenario added to the highest recorded sea-levels at tide gauges in the Zhujiang Delta

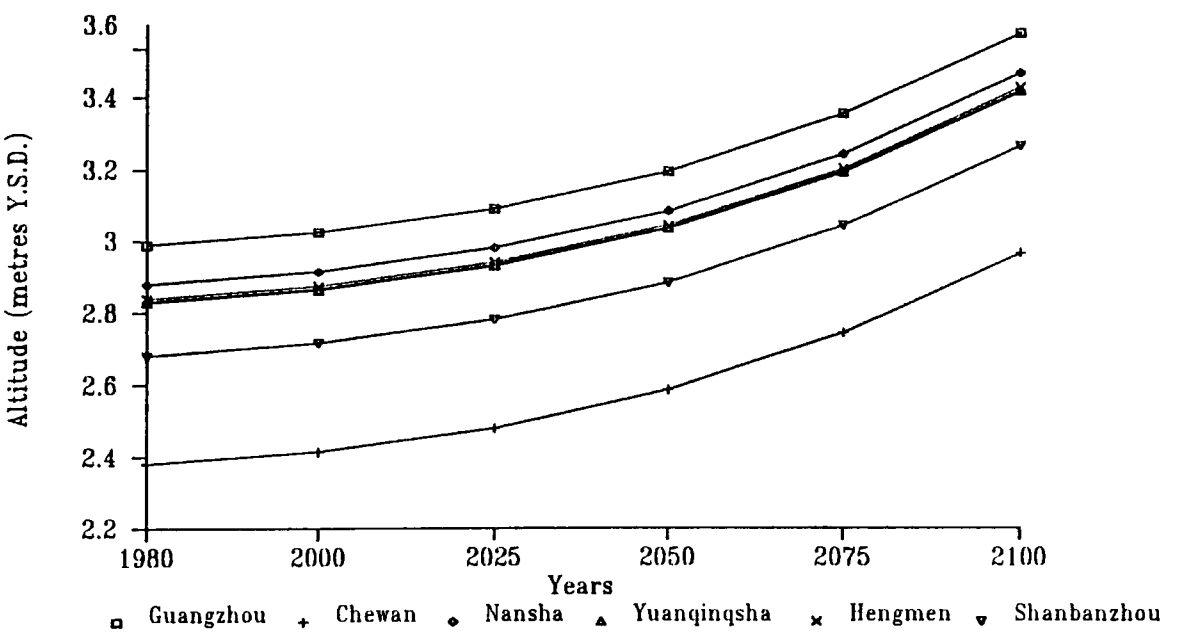


Figure 5.17 Sea level rise scenarios for Shanbanzhou, combined with an estimate of subsidence of 2 mm/year

Figure 5.17 Sea-level rise scenarios for Shanbanzhou, combined with an estimate of land subsidence of 2 mm/year

Sea-level rise scenarios used: Hoffman et al 1983, 1986.

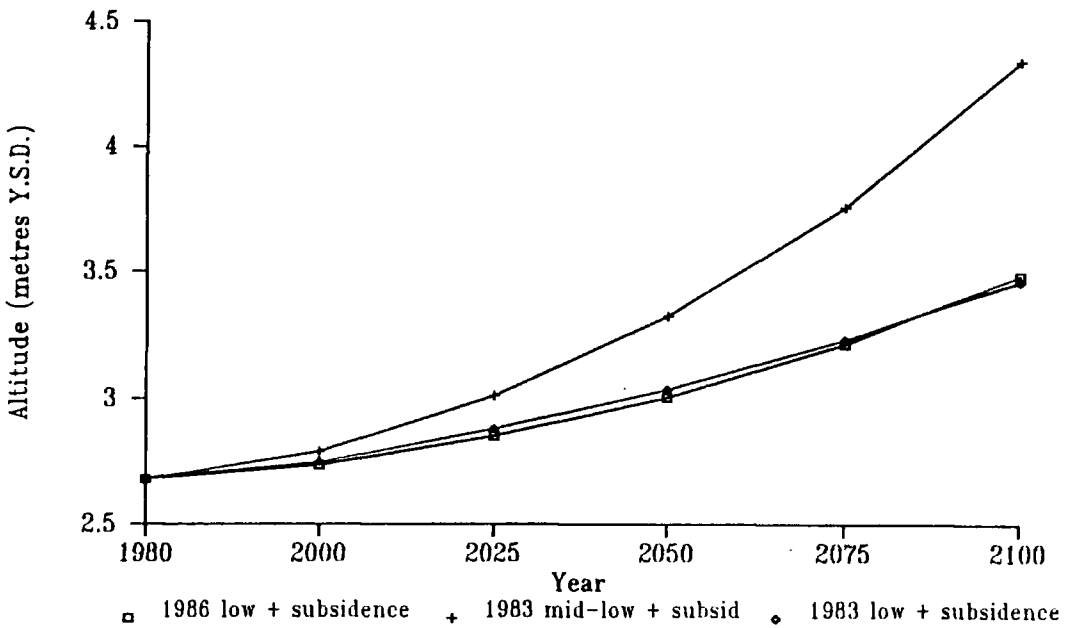
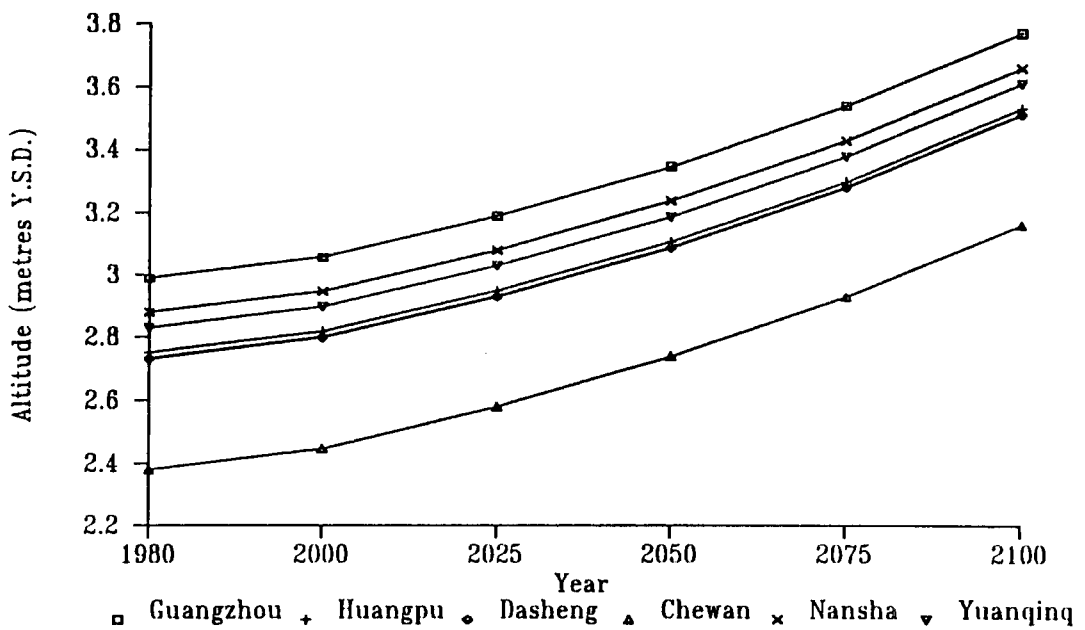


Figure 5.18 Sea-level rise scenarios for the Zhujiang Delta, combined with an estimate of land subsidence of 2mm/year

Figure 5.18 Sea-level rise scenarios for the Zhujiang delta (see figure 5.16) combined with an estimate of land subsidence of 2 mm/year.



The highest recorded sea-level at six tide gauge stations in the Zhujiang Delta have been used, and estimates of future sea-level rise and land subsidence have been modelled.

Figure 5.19 Possible increase in population for the Zhujiang Delta (10 counties) 1983-2100

Figure 5.19 Possible increase in population in the Zhujiang Delta 1983–2100
(10 counties)

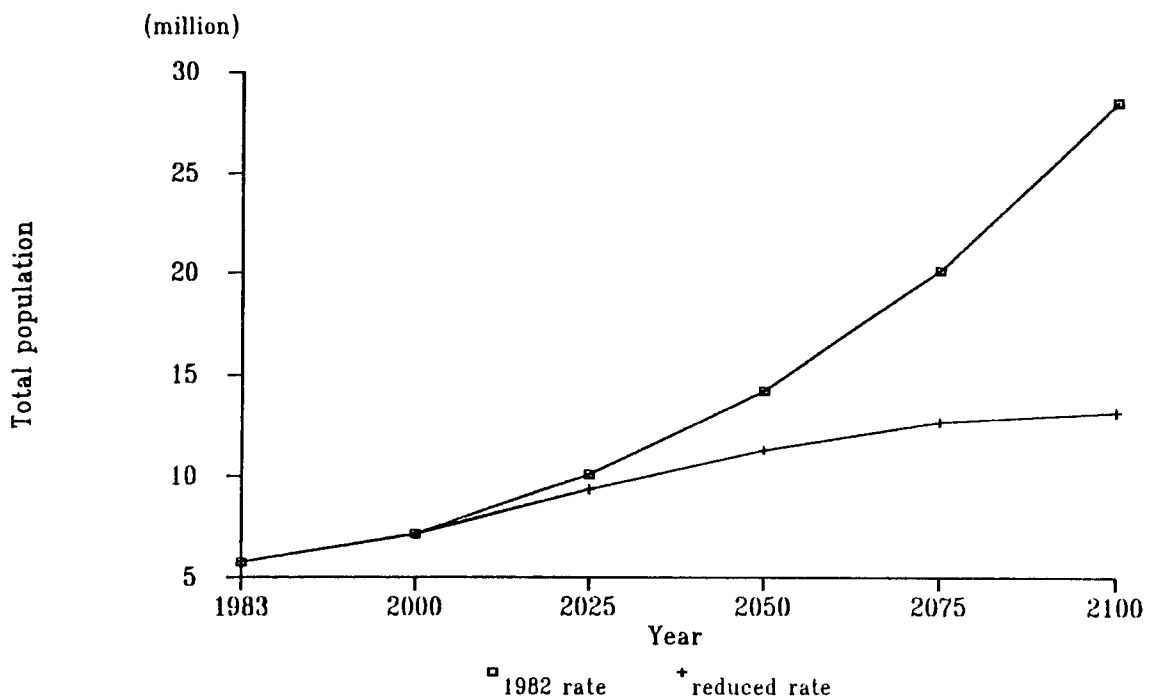


Figure 5.20 Possible increase in population for the Zhujiang Delta (19 counties) 1983-2100

Figure 5.20 Possible increase in population for the Zhujiang Delta 1983–2100
(19 counties)

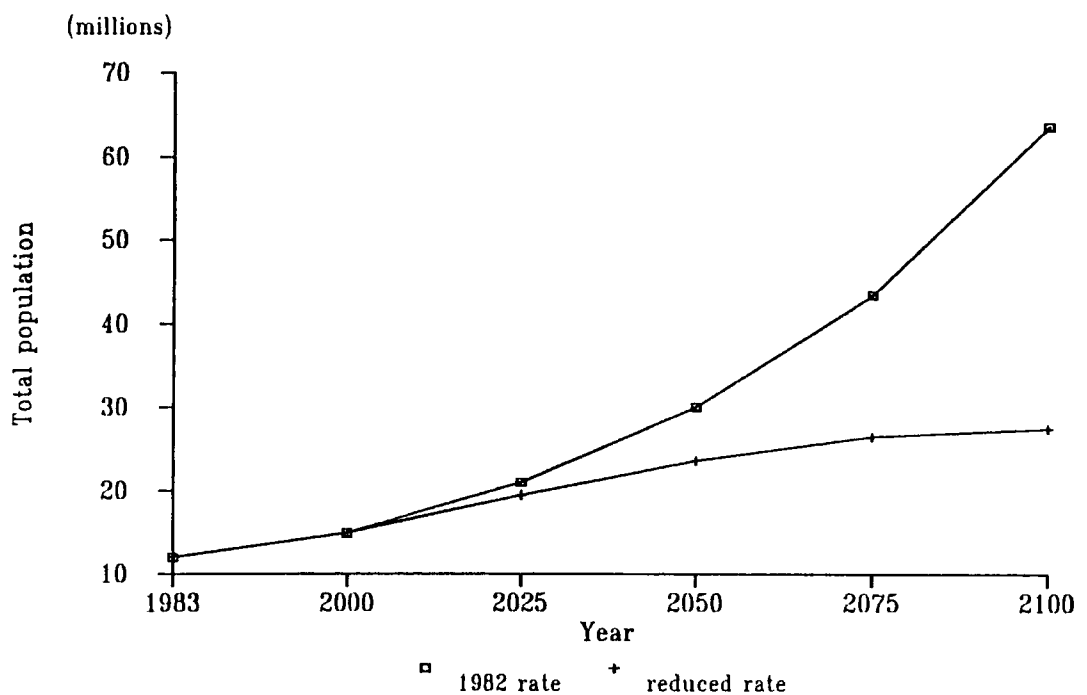
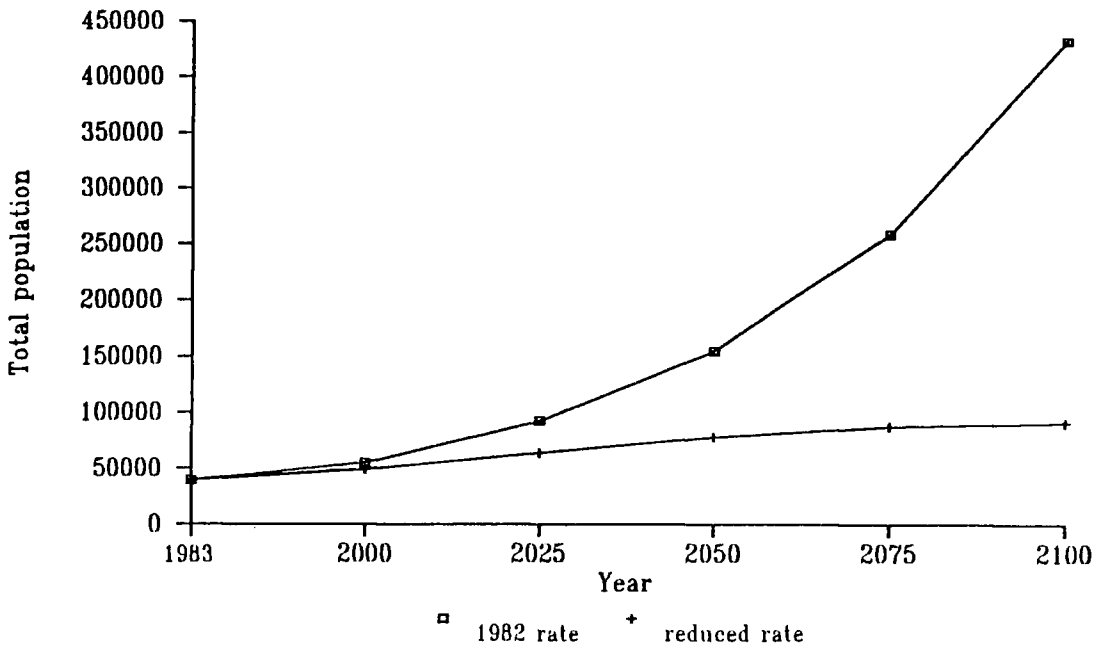


Figure 5.21 Possible increase in population of the Flood Risk Zone, Bao'an County, 1983-2100

Figure 5.21 Possible increase in population of the Flood Risk Zone, Bao'an county 1983–2100



The population of the FRZ has been assumed to be 39,000 in 1983 (see text for details)

Table 1.1 Sea level change methodology

Table 1.1
Sea-level changes methodology:

1	Selection of sites
2	Stratigraphic analysis description of sediments levelling plane table surveying
3	Analysis of sediment samples micropalaeontology particle size analysis loss on ignition
4	Interpretation of changes through the sediment sequence
5	Identification of sea-level index points and tendencies of sea-level change
6	Dating of sea-level index points Radiocarbon dating Thermoluminescence dating
7	Comparison of dated sea-level index points from a series of sites, and the development of sea-level change curves or envelopes.

Table 1.2 Offshore Quaternary stratigraphy of Hong Kong

Table 1.2: **Offshore Quaternary stratigraphy of Hong Kong** [after Berry and Ruxton (1960) and Holt (1962), summarised in Shaw et al (1986).]

Marine muds usually grey and shelly; sand may dominate in areas affected by strong currents.	Hang Hau Formation
Terrestrial alluvium sands,silts and clays with gravel bands, often mottled yellow-ochre and red; includes organic material.	Chep Lap Kok Formation
Weathered bedrock	

Table 1.3 Radiocarbon dated former sea level indicators

Table 1.3 **Radiocarbon dated former sea level indicators from Hong Kong** after Meacham (1979[1], 1980[2]).

Location	sample	age (C-14 years B.P.)	altitude (m P.D.)
Sham Wan[2]	shell	3870 ± 80	+0.6 to +1.4
Sham Wan[1]	shell	5520 ± 110	-2.6 to -1.0
Admiralty[1]	wood	6520 ± 130	-7.3
Prince Edward[1]	*ostrea*	6580 ± 130	-11.0
Argyle[2]	*ostrea*	7020 ± 160	-11.0

Table 1.4 Sedimentation rates in the Zhujiang Delta

Table 1.4: **Sedimentation rates in the Zhujiang Delta (mm year^{-1})** after Huang et al 1987a.

Time:	Late Pleistocene			Holocene		
	$Q3^{2-1}$	$Q3^{2-2}$	$Q3^{3}$-$Q4^{1}$	$Q4^{2-1}$	$Q4^{2-2}$	$Q4^{3}$
Rate:	0.787	0.936	0.299	2.665	2.180	2.710
Average:		0.67			2.52	

Table 3.1 Particle size analysis, Shajing Lagoon - SJA5, SJA6, SJA8, SJA19

Table 3.1 Particle Size Analysis, Shajing Lagoon, south China

Bore hole no.	*Depth * (cm.)*	*Altitude (m. Y.S.D.)*	*Gravel*	*Coarse sand*	*Medium sand*	*Fine sand*	*Coarse silt*	*Medium silt*	*Fine silt*	*Clay*
SJA5	510 - 513	-4·18 -4·21	0·2	3·6	6·2	29·4	7·9	12·2	11·3	29·2
SJA5	518 - 522	-4·26 -4·30	0·1	0·9	1·3	4·2	2·5	15·1	24·4	51·5
SJA6	148 - 150	1·12 1·10	nil	2·1	5·4	6·0	10·5	18·2	41·2	16·6
SJA6	155 - 158	1·05 1·02	nil	1·4	6·9	8·2	10·2	27·9	39·5	5·9
SJA6	165 - 167	0·95 0·93	nil	2·4	11·8	9·5	10·3	56·2	6·2	3·6
SJA8	70 - 74	1·82 1·78	0·1	22·3	28·5	3·8	4·6	4·2	5·9	30·6
SJA8	81 - 85	1·71 1·67	0·3	15·2	19·5	4·0	5·1	8·4	11·3	36·2
SJA8	91 - 94	1·61 1·58	nil	15·1	20·4	5·1	5·5	10·4	13·1	30·4
SJA8	96 - 98	1·56 1·54	0·6	20·7	25·7	4·8	4·8	8·0	9·9	25·5
SJA8	99 - 100	1·53 1·52	nil	12·9	18·5	5·3	7·2	13·2	14·5	28·4
SJA8	102 - 105	1·50 1·47	0·1	9·6	14·5	5·5	9·0	16·4	17·3	27·6
SJA8	108 - 110	1·44 1·42	nil	1·2	3·5	9·4	12·0	16·4	47·2	10·3
SJA8	208 - 210	0·44 0·42	0·2	6·3	19·0	26·4	10·4	11·3	14·9	11·5
SJA8	281 - 284	-0·29 -0·32	8·0	22·8	29·6	18·9	4·5	13·2	0·2	2·8
SJA8	290 - 294	-0·38 -0·42	1·3	31·8	53·6	5·8	2·1	1·1	1·3	3·0
SJA19	176 - 180	0·75 0·71	2·0	20·7	34·6	2·3	4·5	34·2	0·4	1·3
SJA19	186 - 190	0·65 0·61	0·7	4·4	26·5	8·7	8·3	47·7	0·1	3·6
SJA19	190 - 194	0·61 0·57	2·4	4·1	10·0	10·3	11·3	57·0	0·1	4·8
SJA19	198 - 201	0·53 0·50	0·5	9·9	25·2	18·3	1·3	41·3	1·1	2·4
SJA19	209 - 212	0·42 0·39	0·9	2·1	4·7	7·8	10·6	69·5	0·7	3·7

* centimetres from top of bore hole

Table 3.2 Particle size analysis, Sham Wan SW4

Table 3.2 Particle Size Analysis, Sham Wan, Lamma Island

Sample no.	*Depth * (cm.)*	*Altitude (m. P.D.)*	*Gravel*	*Coarse sand*	*Medium sand*	*Fine sand*	*Coarse silt*	*Medium silt*	*Fine silt*	*Clay*
1	67 - 70	3·83 3·80	4·2	44·8	7·8	3·7	7·6	7·9	5·1	18·9
2	84 - 87	3·66 3·63	3·4	13·6	4·1	4·6	13·6	18·1	11·1	31·5
3	96 - 99	3·51 3·54	1·0	4·4	1·4	2·9	16·3	21·9	13·9	38·2
4	106 - 109	3·44 3·41	0·3	4·3	0·8	2·7	16·1	23·3	14·5	38·0
5	122 - 124	3·28 3·26	0·1	4·8	1·0	3·5	17·7	19·2	11·1	42·6
6	280 - 283	1·70 1·67	0·5	7·6	1·6	9·2	15·3	16·7	13·1	34·2
7	301 - 304	1·49 1·46	0·9	6·8	3·4	3·5	13·8	19·4	15·6	38·4
8	322 - 325	1·28 1·25	0·2	6·4	1·7	4·3	14·3	17·1	15·6	40·4
9	333 - 336	1·17 1·14	2·2	7·8	2·6	4·4	15·6	18·1	14·7	34·6
10	341 - 343	1·09 1·07	35·1	30·2	5·1	2·2	4·7	3·3	3·4	16·0
11	369 - 372	0·81 0·78	25·4	36·6	4·8	2·0	3·9	2·6	1·8	22·9
12	384 - 387	0·66 0·63	36·0	20·6	3·1	3·1	4·8	3·9	2·7	25·8

* centimetres from top of bore hole SW4

Table 3.3 Particle size analysis, Tin Shui Wai - TSW/A

Table 3.3 Particle Size Analysis, Tin Shui Wai, Section A

*Depth **	*Altitude (m. P.D.)*	*Gravel*	*Coarse sand*	*Medium sand*	*Fine sand*	*Coarse silt*	*Medium silt*	*Fine silt*	*Clay*
2 - 3	-1·17 -1·18	0·1	1·8	5·9	45·2	16·5	6·7	5·4	18·4
8 - 9	-1·23 -1·24	0·1	1·2	6·7	42·4	19·9	6·2	5·1	18·4
15 - 16	-1·30 -1·31	nil	1·1	4·6	35·5	21·7	8·5	7·0	21·6
23 - 24	-1·38 -1·39	nil	0·3	2·5	33·0	26·6	8·6	6·0	23·0
28 - 29	-1·43 -1·44	0·5	2·2	7·3	34·3	18·0	8·9	5·8	23·0
36 - 37	-1·51 -1·52	0·1	3·3	23·7	50·6	9·6	2·4	1·7	8·6
42 - 43	-1·57 -1·58	nil	1·0	17·2	34·1	17·0	6·6	4·2	19·9
45 - 46	-1·60 -1·61	nil	1·7	9·6	34·5	21·2	8·1	5·1	19·8
48·5 - 50	-1·63 -1·65	0·2	2·1	37·8	47·0	7·3	1·8	1·0	2·8

* centimetres from top of monolith tin

Table 3.3 Particle Size Analysis, Tin Shui Wai, Section A

Table 3.4 Stratigraphy at Sham Wan as described by Frost (1978)

Table 3.4

Stratigraphy at Sham Wan as described by Frost (1978).

[The land surface across the site is approximately +3 m P.D., though Frost does not give accurately surveyed altitudes for each of the boreholes].

Point A	0 - 80 cm	top soil; firm brown sand.
	80 - 200	wet, coarse grey-white sand.
Point B	surface at +3.0 m P.D.	
	0 - 50 cm	roots, water, mud.
	50 - 90	brown clay with some sand, rootlets, wood fragments.
	90 - 160	grey-brown clay with thin sand layers, wood bits.
	160 - 240	grey clay with small shells, some wood and leaf fragments.
	240 - 280	grey clay with pockets of sand, few shells.
	280 - 360	grey-brown clay, smell of H_2S, leaf fragments.
	360 - 400	grey brown clay, smells.
	400 - 520	lighter grey clay with coarse sand, shells and large shell fragments.
Points C	0 - 140	grey-brown clay.
	140 - 250	grey clay with shells, softer than at point B; wall collapses at a depth of 250 cm.
Point D	0 - 100	coarse wet sand.
Point E	0 - 110	grey clay, very sandy.
	110 - 150	coarse wet sand.

See figure 3.9 (insert) for a location of the boreholes.

Table 4.1 Information collected for each dated sea level index point from southern China

Table 4.1 Information collected for each dated sea level index point from southern China

Location	The location of the site from which a sample was collected.
Sample	A description of the sample which has been dated.
Sample type	A classification of the sample (see table 4.2).
Altitude	The altitude in metres of the sample which was dated, relative to the Yellow Sea Datum (Y.S.D.).
Indicative meaning	The estimated altitudinal relationship of the dated sample to the altitude of sea level when the sample wes deposited (see table 4.2).
Indicative error	An estimate of the altitudinal error of the indicative meaning — summarised in table 4.2.
Age	The radiocarbon date of the sample in radiocarbon years before present (B.P.).
Date error	The error in radiocarbon years of two standard deviations from the calculated age of the sample.
Upper/Lower	Description of the sediments found above and below the sample.
Lab. code	The laboratory code of the radiocarbon dated sample where this has been made available. Many data from China have not had their laboratory codes included because these were not published. Although these dates have been included in this analysis, it must be stressed that the provenance of the information is unknown for these samples.

Table 4.2 Types of organic material dated using radiocarbon dating in the database of sea level index points

Table 4.2 Types of organic material dated using radiocarbon dating in the database of sea-level index points

Material		Estimated indicative meaning*
Wood	mangrove wood	+0.5m ± 0.5m +2.0m ± 0.5m
Rootlets	fragment of "intertidal" wood salt marsh	-1.5m ±1.5m +0.5m ±0.5m
Intertidal silt/clay Estuarine silt/clay	brackish diatoms marine diatoms	-1.5m ±1.5m -5.0m ±5.0m
Molluscs (associated with brackish water conditions)	intertidal clay beach deposit ridge deposit	-1.5m ±1.5m +0.5m ±0.5m +2.0m ±1.0m
Molluscs (associated with fresh water conditions)		+2.0m ±1.0m
Beachrock	"beach type" "shell ridge type"	+0.5m ±0.5m +2.0m ±1.0m
Ostrea	shells in their living position fragments	-1.5m ±1.5m -1.5m ±1.5m
Coral reef	in "living" position beach deposits ridge deposits	-2.0m ±2.0m +0.5m ±1.5m +2.0m ±3.0m
Lagoon Clay		0.0m ±1.5m

* altitude relative to mean sea-level at time of deposition (after Huang et al 1982).

Table 5.1 Mean tidal measurements from tide gauge stations in the Zhujiang Delta

Table 5.1 Mean tidal measurements from tide gauge stations in the Zhujiang delta *Source: Institute of Geography, Guangzhou*

Tide gauge station	Tropical cyclone recorded in Hong Kong when max. high tide recorded	Length of record (years before 1980)	Maximum recorded high tide (m. Y.S.D.)	Mean High Water (M.H.W.) (m. Y.S.D.)	Difference between max. recorded sea level and M.H.W. (m.)	Lowest recorded low tide (m. Y.S.D.)
Guangzhou	Ivy 1974	30	2·99	1·35	1·64	-1·07
Huangpu	Ivy 1974	30	2·75	1·32	1·43	-1·34
Dasheng	Viola 1969	24	2·73	1·31	1·42	-1·36
Dongyingongzhen	Ivy 1974	6	2·80	1·34	1·46	-1·31
Sishengwei	Ivy 1974	16	2·67	1·30	1·37	-1·44
Chewan	Viola 1969	20	2·38	0·99	1·39	-1·54
Shanshakou	Ivy 1974	27	2·74	1·26	1·48	-1·19
Nansha	Viola 1964	26	2·88	1·21	1·67	-1·01
Yuanquinqsha	Viola 1964	27	2·83	1·24	1·59	-0·82
Hengmen	Ivy 1974	27	2·84	1·20	1·64	-0·59
Shanbanzhow*	Viola 1969	23	2·68	1·16	1·52	-1·41

* record from 1956 to 1979

Table 5.1 Mean tidal measurements from tide gauge stations in the Zhujiang delta

Table 5.2 Recorded altitude of tide gauge at North Point

Table 5.2 Recorded altitude of tide gauge at North Point

Year	Month	Level (metres P.D.)
1954	October	4·109
1955	June	4·065
	October	4·077
1956	February	4·074
1957	February	4·063
	April	4·059
	September	4·056
1958	January	4·052
	July	4·051
	September	4·044
1959	January	4·064
	May	4·045
	September	4·041
1960	February	4·034
	April	4·034
	July	4·033
	November	4·033
1961	January	4·034
	April	4·032
	July	4·032
	December	4·032
1962	June	4·026
	November	4·024
1963	March	4·020
1964	July	4·012
	November	4·011
1965	April	4·011
	July	4·011
	September	4·010
	December	4·010
1966	March	4·008
	June	4·008
	September	4·008
	December	4·005
1967	March	4·004
	June	4·005
	December	4·000
1968	April	4·000
	September	3·998
1969	January	3·996
	December	3·993
1970	October	3·990
1971	April	3·987
	June	3·990
	October	3·987
	November	3·989
1972	April	3·988
	October	3·986
1973	January	3·983
	March	3·984
	June	3·979
1974	January	3·973
	April	3·964
	July	3·963
	October	3·963
1975	January	3·960
	April	3·961
	July	3·962
	October	3·959
1976	January	3·957
	April	3·959

Source: Royal Observatory, Hong Kong

Table 5.3 List of topologies generated by the Geographical Information System

Table 5.3 List of topologies generated by the Geographical Information System

Digitised coverage	Topology	Source of data	Residual mean square error
Study area boundary	Polygon	1:50,000 map	0·002
District boundaries	Polygon	1:50,000 map	0·003
Village boundaries	Polygon	1:200,000 map	0·004
Land use	Polygon	1:200,000 map	0·004
Land resources	Polygon	1:200,000 map	0·005
Spot heights	Point	1:50,000 map	0·001
Contour	Line	1:50,000 map	0·002
Transport network	Line	1:50,000 map	0·003
Settlements	Polygon	1:50,000 map	0·004

The residual mean square error is calculated when the digitised coverage was converted to the map co-ordinates using the TRANSFORM routine within pc ARC/INFO (see text for details).

Table 5.4 Annual recorded maximum sea levels, Hong Kong

Table 5.4 Annual recorded maximum sea levels *Source: Royal Observatory, Hong Kong*

Year	North Point		Chi Ma Wan		Tai Po Kau		Tsim Bei Tsui
	1	2	1	2	1	2	1
1954		3·20*					
1955		2·74*					
1956		2·83					
1957		3·08					
1958		2·44					
1959		2·22*					
1960		2·77*					
1961	2·62	2·59*					
1962		3·96				5·03	
1963	2·83	2·83*		2·93*		2·83*	
1964	3·12	3·14*		3·20*		3·63*	
1965	2·93	2·99*		3·08*		3·05*	
1966	2·90	2·38		2·65		2·44	
1967	2·82	2·80*		2·93*		2·99*	
1968	2·79	2·77*		2·90*		2·85*	
1969	3·11	3·11*		3·14		3·26*	
1970	2·90	2·62	3·00	2·74	3·15	2·89	
1971	3·23	3·23*	3·38	3·35*	3·35	3·35*	
1972	2·91	2·88	3·00		3·25	3·06	
1973	2·93	2·77		3·17*	3·12	2·93	
1974	3·32	3·32*	3·51	3·56*	3·42	3·43*	3·55
1975	2·92	2·92*	2·96	2·50	3·02	2·64	3·02
1976	2·79	2·66	2·93	2·93*	2·93	2·73	3·08
1977	2·98	2·98*	3·37	3·41*	2·99	3·00*	3·25
1978	2·85	2·85*	3·00	3·02*	2·90	2·91*	3·11
1979	2·78	2·78*	2·80	2·87*	2·65	4·35*	
1980	2·67	2·48	2·81	2·66	2·82	2·46	3·02
1981	2·77	2·66	2·75	2·83*	2·68	2·68*	3·16
1982	2·70	2·45			2·61	2·50	2·96
1983	2·81		3·05		3·04		3·62
1984	2·86		2·96		2·97		2·96
1985	2·72				2·79		3·08
1986	2·78		2·71		2·92		3·50
1987	3·06		2·63		3·09		3·07
1988	3·13		2·68		3·22		3·21

Notes (1) Maxima extracted from computer archive (2) Maxima during typhoon passage
* Maximum during typhoon coincident with annual maximum — all levels mCD

Table 5.5 Magnitude of storm surges and maximum sea levels in Hong Kong during three tropical cyclones

Table 5.5 Magnitude of storm surges and maximum sea levels in Hong Kong during three tropical cyclones

Tropical cyclone reported by Royal Observatory, Hong Kong		Storm surge in metres		Maximum recorded sea level in metres P.D. (metres Y.S.D. in brackets)	
		North Point	Tai Po Kau	North Point	Tai Po Kau
Ivy	22nd July 1974	0·56	0·70	2·51 (1·64)	2·45 (1·58)
Viola	29th July 1969	0·70	0·98	2·96 (2·07)	3·11 (2·24)
Viola	28th May 1964	0·94	1·40	2·75 (1·88)	3·05 (2·18)

Table 5.5 Magnitude of storm surges and maximum sea levels in Hong Kong during three tropical cyclones

Table 5.6 Sea altitudes recorded in Hong Kong during three tropical cyclones - mean monthly maxima

Table 5.6 Sea altitudes recorded in Hong Kong during three tropical cyclone storms — mean monthly maxima

Tropical cyclone reported by Royal Observatory, Hong Kong		Mean monthly maximum sea level at North Point 1962-1987 (metres P.D.) *Source: Yim, 1988*	Maximum sea level recorded during tropical storm (metres P.D.) *Source: Chen, 1983*	Difference between the mean monthly maximum at North Point and the maximum sea level recorded (metres)	Surge residual (metres) *Source: Chen, 1983*
Ivy	22nd July 1974	1·42	2·51	1·09	0·56
Viola	29th July 1969	1·42	2·96	1·54	0·70
Viola	28th May 1964	1·42	2·75	1·33	0·94

Table 5.6 Sea altitudes recorded in Hong Kong during three tropical cyclone storms — mean monthly maxima

Table 5.8 Percentage of work force employed in different economic activities in the study area in 1983

Table 5.8 Percentage of workforce employed in different economic activities in the study area, 1983

District	Agriculture	Forestry	Aquaculture husbandry	Animal	Industry	Other
Songgang	49	0	10	19	17	6
Shajing	21	0	45	11	21	2
Fuyong	54	0	13	11	14	6
Xixiang	37	0	12	12	22	9

Based on Zhong, 1985

Table 5.9 Income per capita in the study area in 1983

Table 5.9 Income per capita in the study area, 1983
(based on Deng, 1985)

District	Income in Yuan
Songgang	420
Shajing	570
Fuyong	460
Xixiang	550
Mean for Ba'oan County	**407**

Table 5.10 Percentage of gross income of each district in the study area derived from different economic activities

Table 5.10 Percentage of gross income of each district derived from different economic activities

District	Agriculture	Forestry	Aquaculture husbandry	Animal	Industry	Other
Songgang	49	0	10	19	17	6
Shajing	21	0	45	11	21	2
Fuyong	54	0	13	11	14	6
Xixiang	37	0	12	12	22	9

Based on Deng, 1985

Table 5.11 Land use data for the study area related to altitude

Table 5.11 Land use data for the study area related to altitude

Land use	Above	Below	Total	% by altitude		% by land use	
				Above	Below	Above	Below
Forest	77·7	3·6	81·3	95·5	4·5	50·3	3·1
Paddy	29·1	55·8	84·9	33·9	66·1	18·8	47·1
Non-irrigated arable	23·6	12·0	35·6	66·2	33·8	15·5	10·1
Vegetables	0·5	0·7	1·2	38·5	61·5	0·3	0·6
Orchard	3·0	1·4	4·4	69·1	30·9	2·0	1·1
Meadow	10·1	1·1	11·1	89·8	10·2	6·2	0·9
Freshwater fish ponds	0·9	30·9	31·8	0·8	99·2	0·2	26·1
Marine water fish ponds	0·0	7·8	7·8	0·2	99·8	0·0	6·6
Urban	1·0	3·8	4·8	20·3	79·7	0·6	3·2
Deserted	0·0	1·4	1·4	8·3	91·7	0·1	1·1
Lake	9·0	0·0	9·0	100·0	0·0	6·1	0·0
Total	**154·9**	**118·4**	**273·3**	**56·2**	**43·8**	**100·0**	**100·0**

Areas in square kilometres above and below the +10 metre Y.S.D. contour line

Table 5.12 Land resource data for the study area related to altitude

Table 5.12 Land resource data for the study area related to altitude

Land resource	Above	Below	Total	% by altitude		% by land resource	
				Above	Below	Above	Below
Forest (grade 1)	14·4	1·0	15·4	93·3	6·7	9·3	0·9
Forest (grade 2)	47·7	2·6	50·3	94·7	5·3	30·8	2·2
Forest (grade 3)	24·1	0·1	24·2	99·4	0·6	15·5	0·1
Paddy (grade 1)	6·3	26·2	32·5	19·4	80·6	4·1	22·1
Paddy (grade 2)	14·0	28·6	42·6	32·9	67·1	9·0	24·2
Paddy (grade 3)	8·5	10·0	18·5	45·8	54·2	5·5	8·4
Non-irrigated (grade 1)	3·7	0·3	4·0	93·7	6·3	2·4	0·2
Non-irrigated (grade 2)	22·6	9·9	32·4	69·5	30·5	14·6	8·3
Lake	9·0	0·0	9·0	100·0	0·0	5·8	0·0
Fish	2·2	35·4	37·6	6·0	94·0	1·4	29·9
Pasture	1·5	0·5	2·0	73·0	27·0	1·0	0·5
Urban	1·0	3·8	4·8	20·7	79·3	0·6	3·2
Total	**154·9**	**118.4**	**273·3**	**56·2**	**43·8**	**100·0**	**100·0**

Areas in square kilometres above and below the +10 metre Y.S.D. contour line

Table 5.13 Estimates of future mean sea level change

Table 5.13 Estimates of global sea level change, 1980-2100 (figures in metres)

Year		2000	2025	2050	2075	2100
Revelle (1983)*		—	—	—	0·700	—
Hoffman et al (1983)	High	0·171	0·549	1·067	2·127	3·453
	Mid-high	0·132	0·393	0·786	1·368	2·166
	Mid-low	0·088	0·262	0·523	0·912	1·444
	Low	0·048	0·130	0·238	0·380	0·562
Hoffman et al (1986)	High	0·055	0·207	0·547	1·919	3·672
	Low	0·035	0·101	0·205	0·364	0·587
Robin (1986)	High	—	—	—	—	1·540
	Low	—	—	—	—	0·240

* estimate of mean sea level rise to 2085

Table 5.14 Possible effects of future sea level change scenarios in the Zhujiang Delta

Table 5.14 The possible effects of future sea level change scenarios in the Zhujiang Delta

Tide gauge station	Maximum recorded high tide	Hoffman et al (1986) low estimates				
		2000 + 0·035	2025 + 0·101	2050 + 0·205	2075 + 0·364	2100 + 0·587
Guangzhou	2·99	3·025	3·091	3·195	3·354	3·577
Huangpu	2·75	2·785	2·851	2·955	3·114	3·337
Dasheng	2·73	2·765	2·831	2·935	3·094	3·317
Dongyingongzhen	2·80	2·835	2·901	3·005	3·164	3·387
Sishengwei	2·67	2·705	2·771	2·875	3·034	3·257
Chewan	2·38	2·415	2·481	2·585	2·744	2·967
Shanshakou	2·74	2·775	2·841	2·945	3·104	3·327
Nansha	2·88	2·915	2·981	3·085	3·244	3·467
Yuanqinqsha	2·83	2·865	2·931	3·035	3·194	3·417
Hengmen	2·84	2·875	2·941	3·045	3·204	3·427
Shanbanzhou	2·68	2·715	2·781	2·885	3·044	3·267

The data presented by *Hoffman et al, 1986* have been added to the levels of maximum sea level recorded in the past at the eleven tide gauge stations for which data is available. All figures in metres Y.S.D.

Table 5.15 Medium and high sea level rise estimates added to highest recorded sea levels

Table 5.15 Hoffman et al (1986) estimates of future sea level change

Tide gauge station	Maximum recorded high tide	Hoffman et al (1986) low estimates				
		2000	2025	2050	2075	2100
Guangzhou	2·99	3·065	3·231	3·435	3·694	3·977
Huangpu	2·75	3·825	2·991	3·195	3·454	3·737
Dasheng	2·73	2·805	2·971	3·175	3·434	3·717
Dongyingongzhen	2·80	2·875	3·041	3·245	3·504	3·787
Sishengwei	2·67	2·745	2·911	3·115	3·374	3·657
Chewan	2·38	2·455	2·621	2·825	3·084	3·367
Shanshakou	2·74	2·815	2·981	3·185	3·444	3·727
Nansha	2·88	2·955	3·121	3·325	3·584	3·867
Yuanqinqsha	2·83	2·905	3·071	3·275	3·534	3·817
Hengmen	2·84	2·915	3·081	3·285	3·544	3·827
Shanbanzhou	2·68	2·755	2·921	3·125	3·384	3·667

All figures in metres Y.S.D.

Table 5.16 The effects of scenarios of future sea level change combined with estimates of subsidence in the Zhujiang Delta of 2 mm per year

Table 5.16 The effects of sea level rise scenarios combined with subsidence in the Zhujiang Delta

Tide gauge station	Maximum recorded high tide	Hoffman et al (1986) low estimates				
		2000 + 0·035	2025 + 0·101	2050 + 0·205	2075 + 0·364	2100 + 0·587
Guangzhou	2·99	3·045	3·161	3·315	3·524	3·797
Huangpu	2·75	2·805	2·921	2·075	3·284	3·557
Dasheng	2·73	2·785	2·901	3·055	3·264	3·537
Dongyingongzhen	2·80	2·855	2·971	3·125	3·334	3·607
Sishengwei	2·67	2·725	2·841	2·995	3·204	3·477
Chewan	2·38	2·435	2·551	2·705	2·914	3·187
Shanshakou	2·74	2·795	2·911	3·065	3·274	3·547
Nansha	2·88	2·935	3·051	3·205	3·414	3·687
Yuanqinqsha	2·83	2·885	3·001	3·155	3·364	3·637
Hengmen	2·84	2·895	3·011	3·165	3·374	3·647
Shanbanzhou	2·68	2·735	2·851	3·005	3·214	3·487

Subsidence is assumed to be 2mm per year. The data presented by Hoffman et all (1986) have been added to the levels of maximum sea level recorded in the past at the eleven tide gauge stations for which data is available. All figures in metres Y.S.D.

Table 5.17 Projected population growth in 10 counties in the Zhujiang Delta 1983-2100

Table 5.17 Population growth in the Zhujiang Delta

	Population 1983	Birth rate %	Death rate %	Population 1984	Population 2000	Population 2025	Population 2050	Population 2075	Population 2100
Panyu County	670,333	1·90	0·58	679,181	837,739	1,162,755	1,613,867	2,239,996	3,109,043
Zhuhai City	133,208	1·84	0·52	134,966	166,475	231,062	320,706	445,130	617,827
Foshan County	285,540	1·37	0·56	287,853	327,513	400,700	490,241	599,790	733,821
Jiangmen County	216,097	1·43	0·56	217,977	250,382	310,924	386,104	479,463	595,395
Nanhai County	820,157	2·12	0·61	832,541	1,058,150	1,539,103	2,238,662	3,256,186	4,736,198
Shunde County	807,860	1·93	0·62	818,443	1,007,919	1,395,511	1,932,152	2,675,156	3,703,881
Zhongshan County	1,022,246	2·13	0·57	1,038,193	1,329,968	1,958,432	2,883,871	4,246,617	6,253,316
Doumen County	240,929	2·22	0·48	245,121	323,034	497,212	765,306	1,177,955	1,813,100
Xinhui County	803,831	1·82	0·56	813,959	994,511	1,360,058	1,859,969	2,543,628	3,478,578
Gaoyao County	696,903	2·00	0·61	706,590	881,230	1,244,421	1,757,299	2,481,554	3,504,304
Total	**5,697,104**			**5,774,831**	**7,176,920**	**10,100,178**	**14,248,175**	**20,145,474**	**28,545,463**

Source: Socio-economic data for countries in Zhujiang Delta (1982 census), China Atlas