Buried Terraces in the Lower Sagami Plain, Central Japan : Indicators of Sea Levels and Landforms during the Marine Isotope Stages 4 to 2 (Part III)

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CONTENTS

5. Recognition and Distribution of Buried Terraces in the Lower Sagami Plain

This chapter deals with the recognition and distribution of buried terraces in the lower Sagami Plain. The W-E cross sections and longitudinal profile section demonstrate buried terraces in the area on the basis of interpreting borehole logs. The correlation between these buried terraces and subaerial terraces is discussed.

5.1 Recognition of buried terraces

1) Previous works

Kaizuka and Moriyama (1969) first reported buried landforms in the lower Sagami Plain, and correlated them with subaerial terraces. They described several levels of buried terraces in this area, such as buried fluvial terraces and wave-cut platforms.

Three steps of buried terraces (the Upper, Middle and Lower), were shown near Atsugi City. In the Tomei Expressway section, buried upper terrace gravel occurs at the altitude of -1 m a.s.l. Tephras about 7-10 m thick were seen on the section. It was correlated with the Nakatsuhara Terrace. The middle terrace, mantled with 5-m thick tephras, was seen at -5 m a.s.l., and was correlated with one of the Tanahara Terrace. The lower terrace with 3-m thick tephras was seen at -12 m a.s.l., and was correlated with one of the Minahara Terrace. The buried upper terrace (Nakatsuhara Terrace) was also seen in the western rim of the plain.

On the other hand, Oka *et al.* (1979) described buried terraces in the lower reaches of Sagami Plain, with quite different correlations from Kaizuka and Moriyama (1969) (Table 5.1). Near Atsugi City, they correlated the up-

per, middle and lower terraces with the Tsuchiya (middle Pleistocene, the MIS 7), Shimosueyoshi and Tanahara terraces respectively. The thickness of the mantling tephras on each surface was 15 m for the upper, 10 m for the middle, and 7 m for the lower terrace.

If there is a buried Shimosueyoshi terrace near Atsugi, as suggested by Oka *et al.* (1979), the region would be subsiding. However, the eastern side of the Sagami River is uplifting, as the Shimosueyoshi Terrace (Koza Upland) shows.

Kaizuka and Moriyama (1969) showed two buried terraces, named 'Samukawa Buried Terrace' and 'Chigasaki Buried Terrace' in the left bank (east) of the Sagami River. The former consists of 20-m thick terrace gravel occuring at -40 m a.s.l. It was not clear whether tephras covered the terrace or not. The Chigasaki Buried terrace with 15-20-m thick gravel occurs at -25 m to -30 m a.s.l. The former was correlated with the buried Minahara terraces, and the latter, with the buried Tanahara terraces. They also found the 'Tsujido buried wave-cut platform' from Chigasaki to Tsujido, and the 'Asahi buried wave-cut platform' in Hiratsuka. They were correlated with Holocene transgression.

Oka *et al.* (1979) found 5-16 m thick tephras including a pumice bed covering the buried terrace near Samukawa Station. It was correlated with the subaerial 'M2' terrace (S3 in this study). They subdivided the buried terrace in the Chigasaki area into two terraces and correlated them with 'M2' (upper) and 'M3' (lower). The upper was covered with 13-m thick tephras, while the lower was covered with 7 m. The TPfl deposits were found directly above the lower terrace gravel.

Kaizuka and Moriyama (1969) did not determine whether or not the pumice mantled gravel of the Buried Chigasaki terrace. This buried terrace is probably one of the Sagamihara terraces as Oka *et al.* (1979) suggested.

Table 5.1 Correlation of buried terraces by previous works

Area	Kaizuka and Moriyama, 1969	Oka et al., 1979
Atsugi	upper:-1 to -2 m gravel (Nakatsuhara)	15 m 'loam' (Tsuchiya)
	middle: -5 m (Tanahara; Ts or Minahara)	10 m 'loam' (Shimosueyoshi)
	lower: -12 m (Minahara)	7 m 'loam' (Tanahara)
Samukawa		5 to 16 m 'loam'
	-40 m gravel (Minahara)	('M2' ; S3)
Chigasaki	-5 m gravel ('Tsujido wave-cut platform'; H)	upper: 13 m 'loam' ('M2' ; S3)
		lower: 7 m 'loam'/ TPfl
	-25 to -30 m gravel (Tanahara)	('M3')

*Terraces in the same line do not mean they are equivalent each other.

However, a problem remains on the 'Tsujido Wave Cut Platform'. The present study must start with correlations of buried terraces with subaerial ones for these problems to be solved.

2) Recognition of buried terraces

The identification of these buried terraces is based on two important points : the sequence of tephra layers covering terrace deposits, and the longitudinal and cross-sectional continuity of deposits. Both were deduced by many borehole logs (shown in the Appendix).

Buried tephras : Air-laid tephras are referred to in borehole logs as 'Kanto Loam', 'tuffaceous silt/clay', or clayey material containing pumice/scoria. They generally show brown, gray-brown and gray in color, but sometimes are described as green-gray, or black. In contrast, clay in the Recent deposit show gray or blue gray in color, and contains shells or organic materials. The Standard Penetration Test Value (N-value) of buried tephras vary between 5 and 20, slightly harder than clay of the Recent deposits, depending upon compaction and differences of parent materials.

The observations of 'scoria' or 'pumice' in borehole logs were used to identify the tephras. Some of borehole logs mentioned a remarkable pumice bed, which probably is Hk-TP. The description of 'pumice' is often seen in borehole logs, when the thickness of tephras exceed 15 m.

Thicknesses of tephras can be reduced from the original ones due to river erosion represented by topped sand and gravel. The author investigated some core samples, which were offered with borehole logs. Some of them were processed for microscopic examination of volcanic glass.

Longitudinal and cross-sectional continuity of deposits : To confirm the continuity of buried terraces, geological cross sections were prepared. Longitudinal profiles for the right bank and left bank, and east-west geological cross sec-

tions at intervals of one kilometer along the Sagami River, were drawn.

5.2 Distribution of buried terraces

1) Outline

Figure 5.1 shows the distribution of buried terraces in the lower Sagami Plain.

Each of the Minahara Terraces ('Mi' and 'My') submerges into the alluvial plain, at 21.5 km and 19 km upstream from the river mouth in the left bank, respectively. Buried terraces following these terraces are seen in the left bank in Zama and Ebina.

One of the Tanahara terraces, fringing the southern Nakatsuhara Upland, is submerging into the alluvial plain near Atsugi City (15.5 km from the river mouth). This Tanahara terrace continues to the south as a buried terrace (to 11 km from the river mouth).

The well-developed buried Nakatsuhara Terrace occurs in the western part. The submerging part of Nakatsuhara was eroded away by the present Nakatsu River. The buried Nakatsuhara Terrace is found in Hiratsuka city (6.5 and 2.3 km from the present river mouth), and near the present river mouth (0.5 km from the present river mouth).

The buried Sagamihara Terraces are seen in the Samukawa and Chigasaki areas. They are correlated with S3, S4 and S5 terraces.

The buried valley bottom of the Paleo Sagami River is estimated to exist along the present river.

2) The interpretation of cross sections

The distribution and characteristics of deposits of buried terraces are shown below by using the W-E cross sections from the upper reaches (Fig. 5.2).

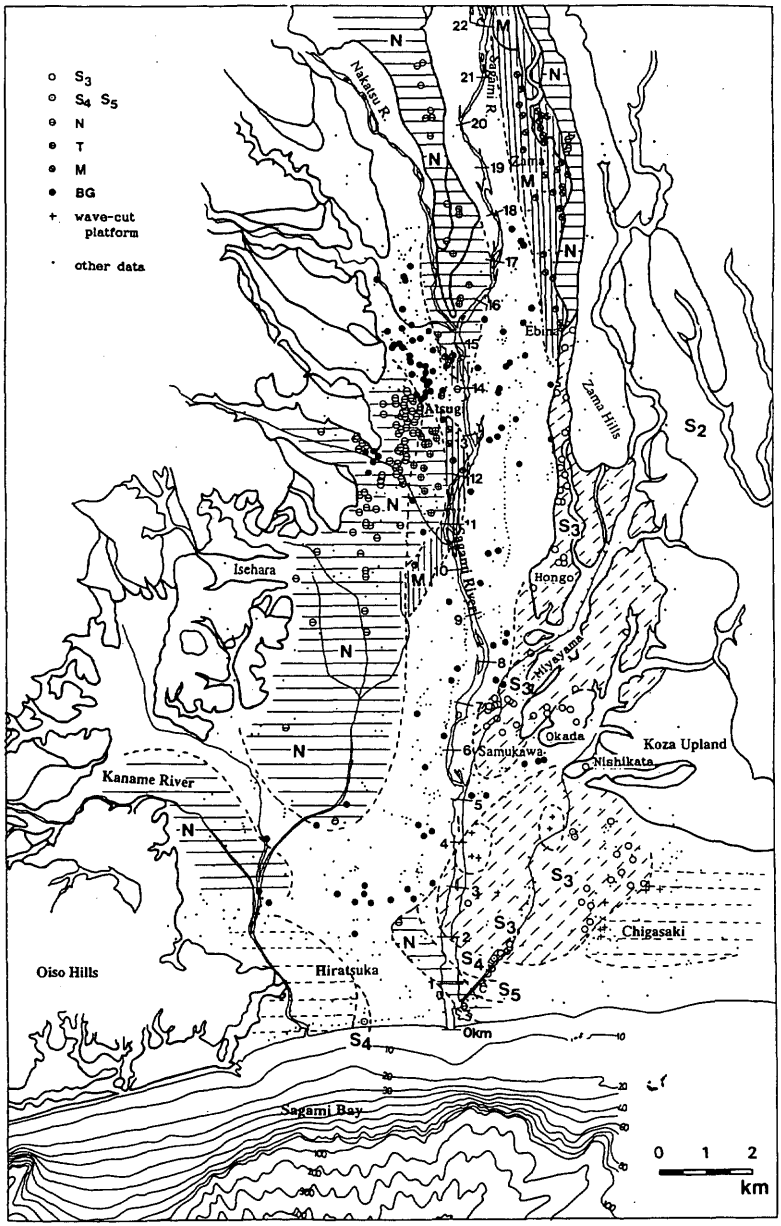


Fig. 5.1 Distribution of buried terraces in the lower Sagami Plain

22-16 km from the river mouth (Zama to Atsugi): This area is a valley plain located between Nakatsuhara and Sagamino uplands. The Nakatsuhara Terrace on the east side of the Sagami River was formed by the trunk Sagami River, and the western one was formed by the tributary Nakatsu River. Each surface is covered by the same sequence of tephras about 10 m thick, in which S2S is seen at the bottom part. These terraces seem to converge at Atsugi.

Two of the terraces of the Minahara group ('My' and 'Mi') submerge into the alluvial plain in the left bank of the Sagami River. They can be traced downstream as buried terraces.

The total thickness of the Recent deposits is 20-30 m, mainly of gravel in the upper reaches (20-18 km). While in the lower reaches (17-16 km), the thickness increases and sand and silt layers occupy the greater part of the Recent deposits, except for the gravel layers at the top and bottom.

The bottom gravel of the Recent deposits lie at a deeper section than the buried Minahara terrace gravel. Consequently the bottom gravel layer in this area seems to have been formed in the Holocene. The author tentatively calls this gravel 'BGH'.

15-10 km from river mouth (Ebina and Atsugi): Extensive buried terraces (upper, middle and lower) are seen in the right bank. Kaizuka and Moriyama (1969), and Oka *et al.* (1979) gave different explanations for these terraces, as mentioned earlier. The author obtained more data to solve the discrepancy.

The buried upper terrace exists broadly in the right bank, from Atsugi to Isehara. The surface gradually reduced in height towards the south along the Sagami River, and uniform thick tephras with no pumice bed (thickness about 10 m) cover this terrace. The thickness of the gravel bed underlying the tephras is about 5-10 m. It is correlated with the Nakatsuhara Terrace.

In this area, the buried gravel of the middle terrace is seen near the Atsugi Interchange of the Tomei Expressway, between the upper terrace and the present Sagami River. It is covered with about 5-m thick tephras. Acording to the thickness of the tephras and the distribution of subaerial terraces in the upper reaches, it should be correlated with one of the Tanahara Terraces. The same combination of both terraces is seen in the subaerial terraces near Kaneda (19-17 km).

The buried lower terrace exists in a small area, NE of Hon-Atsugi Station of the Odakyu Line. The thickness of the mantling tephras is about 2-3 m. It can be correlated with the Minahara Terrace.

The buried paleo Nakatsu River valley is traced from Tsumada to Hon-Atsugi Station. The buried paleo Sagami River valley is seen in the left bank. The BGH occurs at the depth of around -10 to -30 m.

The Recent deposits consist of thick peat and clay in Atsugi City. It is a typical 'weak ground' formed at a drowned valley or a back marsh area.

9-5 km (North Hiratsuka and Samukawa): The buried Nakatsuhara terrace is seen in the right bank (9-6 km).

An apparent buried terrace is seen in the left bank, from Miyayama (7 km from the mouth; where Samukawa Shrine is located), to Samukawa Station. It corresponds to the S3 terrace. However, the '7 km' section shows two levels of terraces in the Samukawa area. The present study gives a view of landforms which is different from Oka *et al.* (1979) as follows.

The subaerial terraces are distributed into four parts, namely, Hongo, Miyayama-East, Okada and Nishikata (Fig. 5.1). Though Hongo and Miyayama-East terraces submerge into the alluvial plain, Okada terrace does not submerge. The altitude of Okada terrace is 26 m a.s.l. at its south end, while those of Miyayama-East and Nishikata are 14 m a.s.l. Oka *et al.* (1979) in interpreting their findings, stated that a flexure dome (Samukawa

Dome) exists and deformed the 'M2' (S3 in this study) terrace in this area.

The author does not support the existence of an abrupt flexure dome in a small area, located in a syncline (Hadano-Yokohama Line ; Machida, 1973). The Okada terrace may be an isolated older terrace (possibly S2).

The buried valley bottom is seen at the depth of around 60-70 m. The wave-cut platform is seen at the rim of Koza upland ('5 km' section).

4-0 km (coastal area): The buried S3 terrace is seen in Chigasaki. Oka *et al.* (1979) found Hk-TP in borehole logs, near the base of the tephras on this buried terrace.

The buried terrace, whose gravel surface has a depth of -50 m a.s.l. (in the '1 km' section) is correlated with the S4 terrace. It is also suggested that the S5 terrace exists at the river mouth in spite of its patchy occurrence.

The wave-cut platform exists in the eastern part of Chigasaki City. A gravel bed and 'tuffaceous silt' are seen in the '2 km' and '3 km' sections at -15 to -20 m. The gravel bed is found to be shallower than the S3 terrace gravel. The 'tuffaceous silt' sometimes contains pumice in borehole logs. However, the thickness of the 'tuffaceous silt' varies, and the N-values are extremely large (>40). The upper parts of this silt have been eroded by the overbedded Recent deposits of sand and gravel. Moreover, there is no fluvial terrace to be correlated with these deposits. Therefore it may be correlated with "Tsujido buried wave-cut platform" (Kaizuka and Moriyama, 1969). They suggested that this wave-cut platform was formed during the Holocene transgression.

The author found the buried Nakatsuhara Terrace in the coastal area. A 10.4-m thick 'volcanic ash' covering a gravel bed was found in borehole log 'H-30' (Fig. 5.3). The depth of the gravel bed surface is -65 m a.s.l. Another was found near the present river mouth, at Shonan Ohashi Bridge ('MC-II-

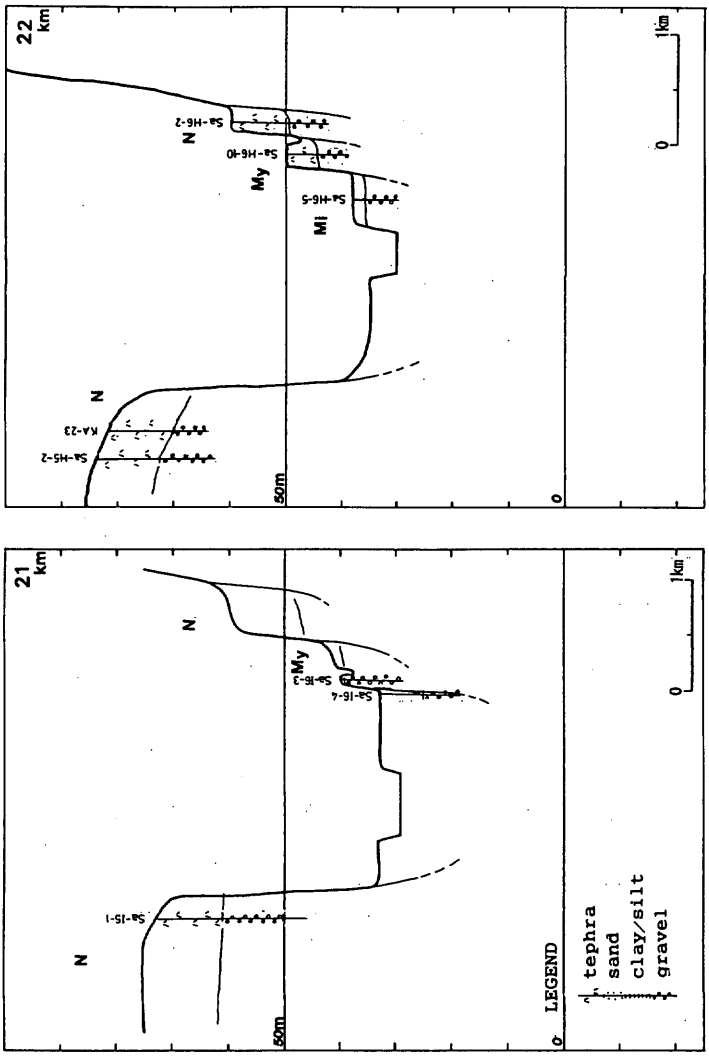


Fig. 5.2 W-E cross sections of the lower Sagami Plain

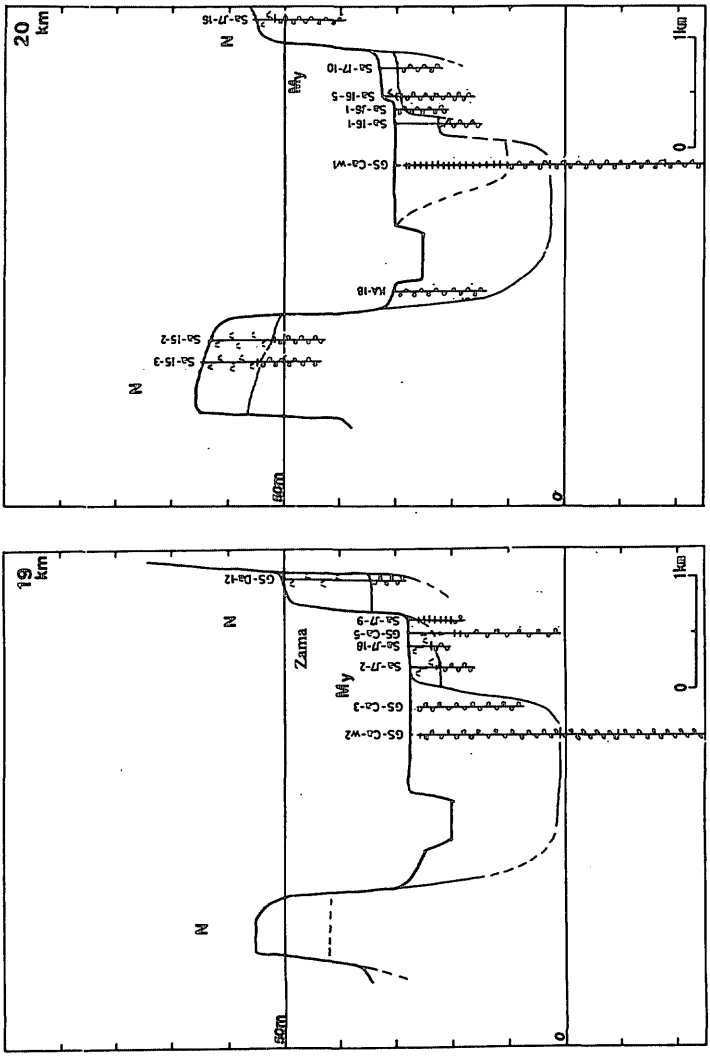
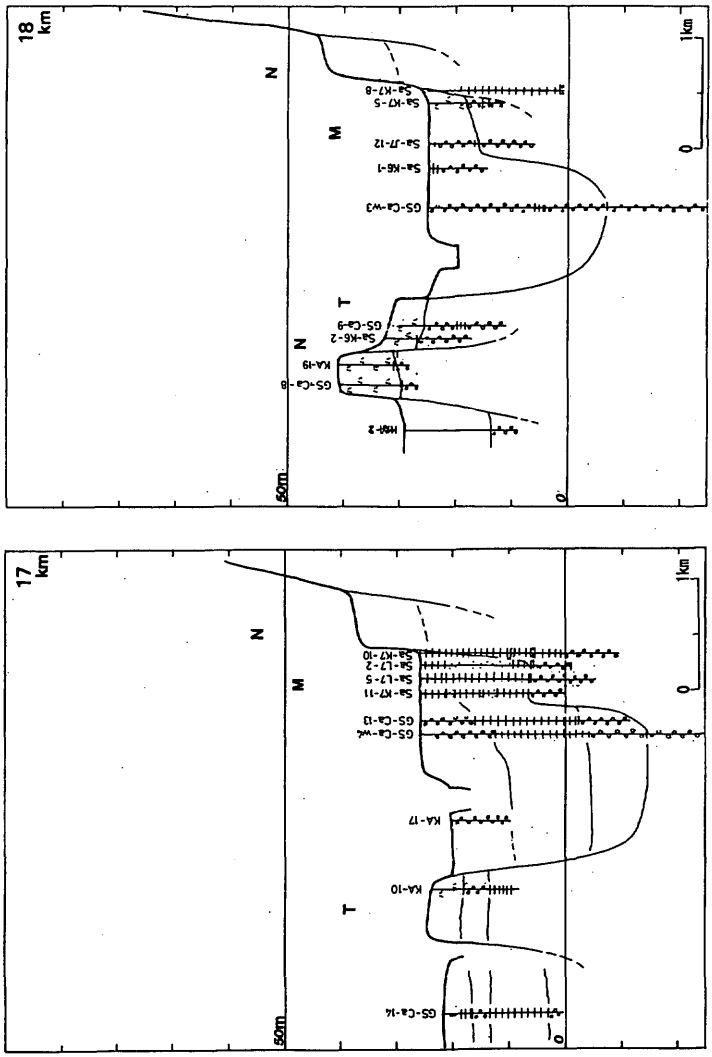

20 km
N
Sa-J7-16
Sa-17-10
Sa-16-5
Sa-16-1
Sa-J8-1
GS-Ca-W1
FA-18
Sa-15-2
Sa-15-3
N
1km
0
80m
0
19 km
GS-Da-12
N
Zama
Sa-J7-9
GS-Ca-5
Sa-J7-18
Sa-J7-2
GS-Ca-3
GS-Ca-W2
N
1km
0
80m
0

Fig. 5.2 (cont.)



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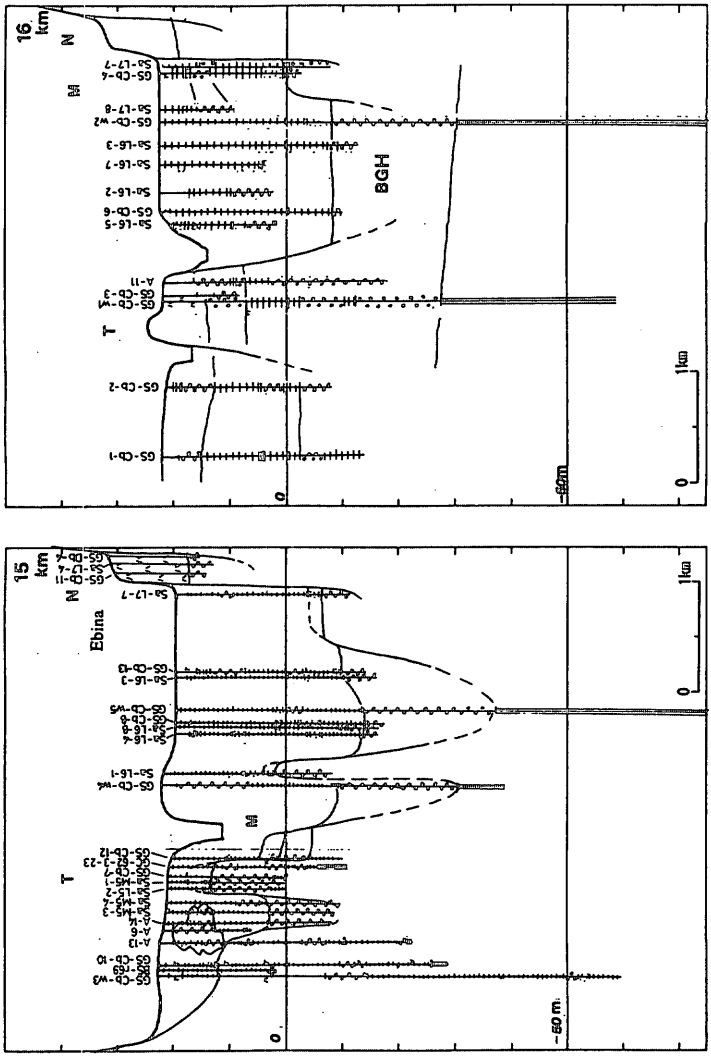

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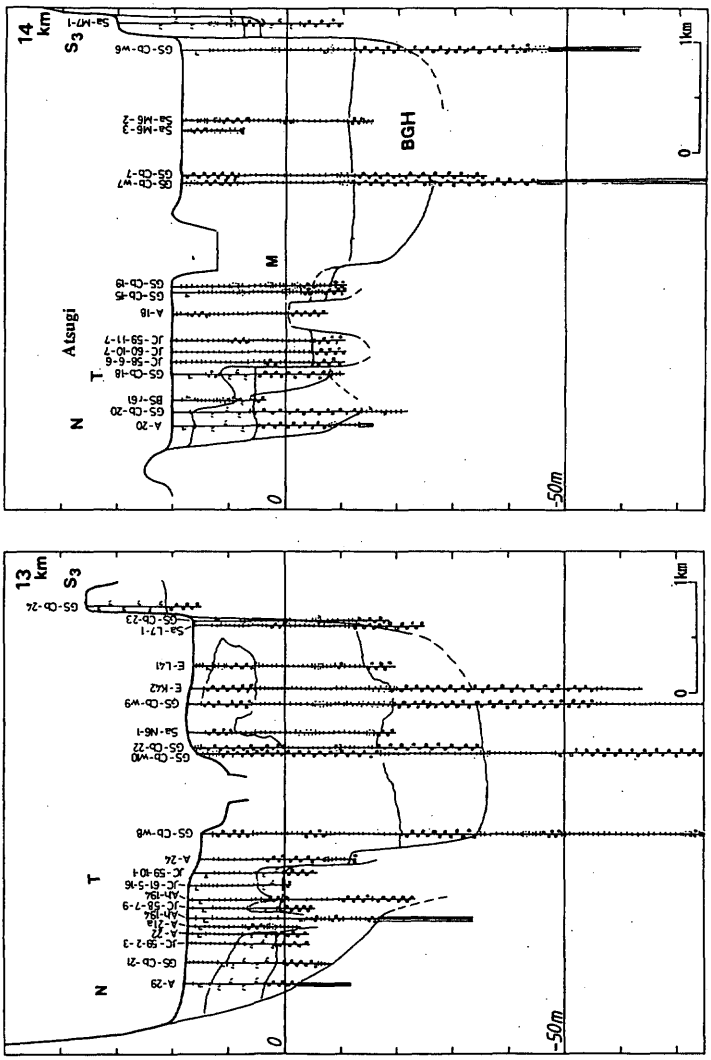

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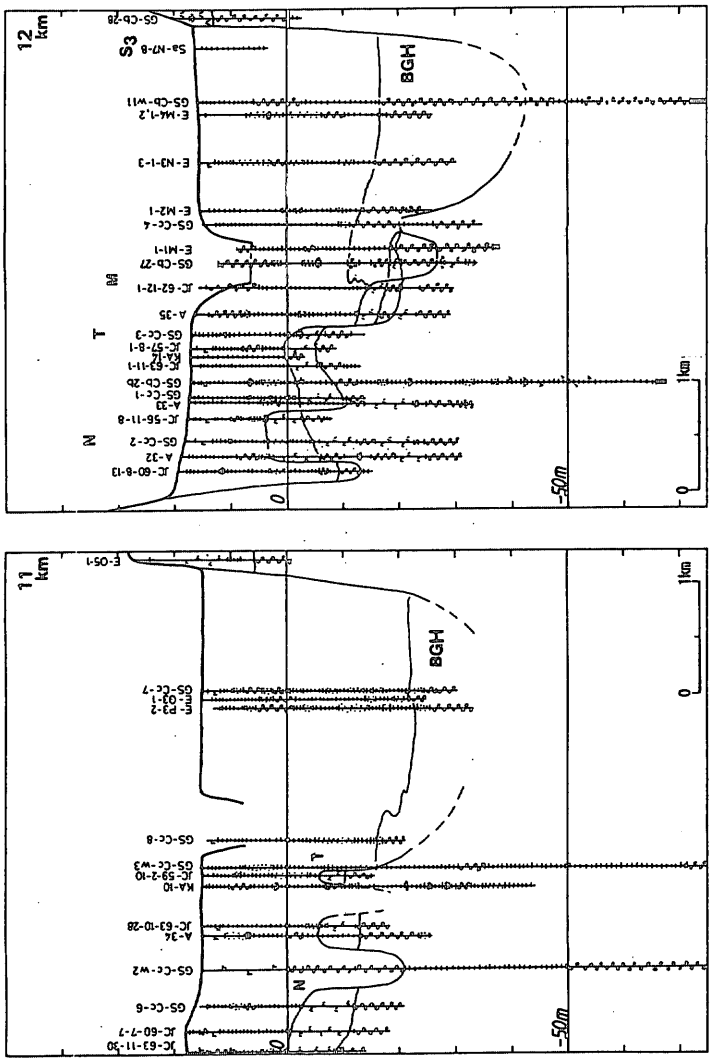
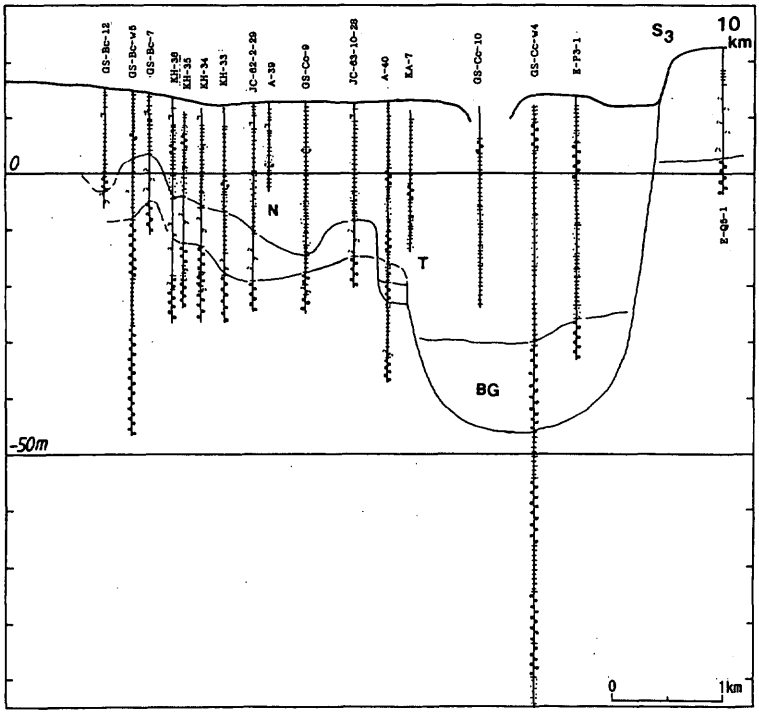

12 km
S3
BGH
GS-CB-28
Sa-N7-8
GS-CB-W11
E-MA-1.2
E-N3-1-3
E-M2-1
GS-CC-4
E-M1-1
GS-CB-27
JC-62-12-1
A-35
GS-CC-3
JC-57-8-1
MA-16
JC-63-11-1
GS-CB-26
GS-CC-1
A-33
JC-56-11-8
GS-CC-2
A-32
JC-60-8-13
N
M
T
S
0
-50m
1km
0
11 km
E-05-1
BGH
E-P3-2
E-03-1
GS-CC-7
GS-CC-8
GS-CC-W3
JC-59-2-10
MA-10
A-34
JC-63-10-28
GS-CC-W2
GS-CC-6
JC-60-7-7
JC-63-11-30
T
N
S
-50m
1km
0

Fig. 5.2 (cont.)



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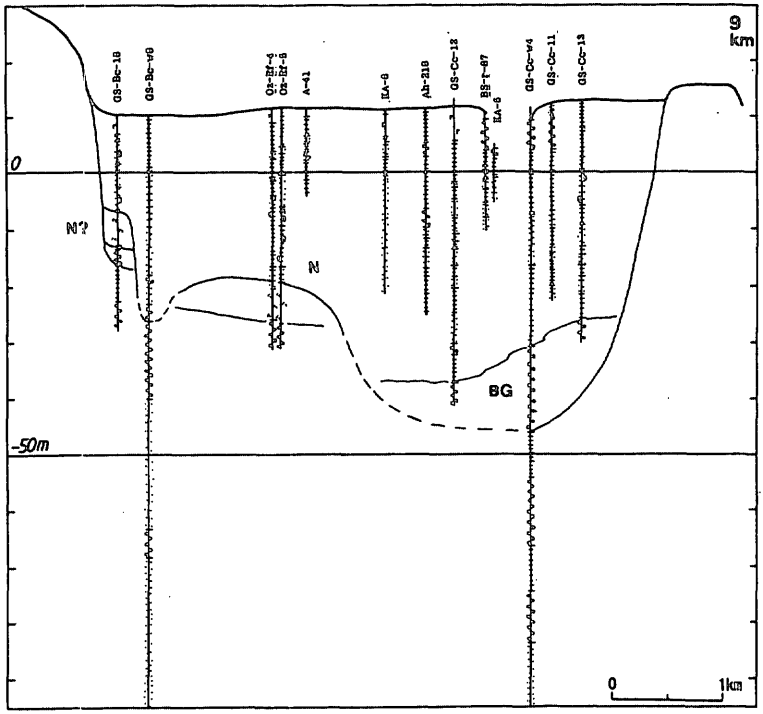

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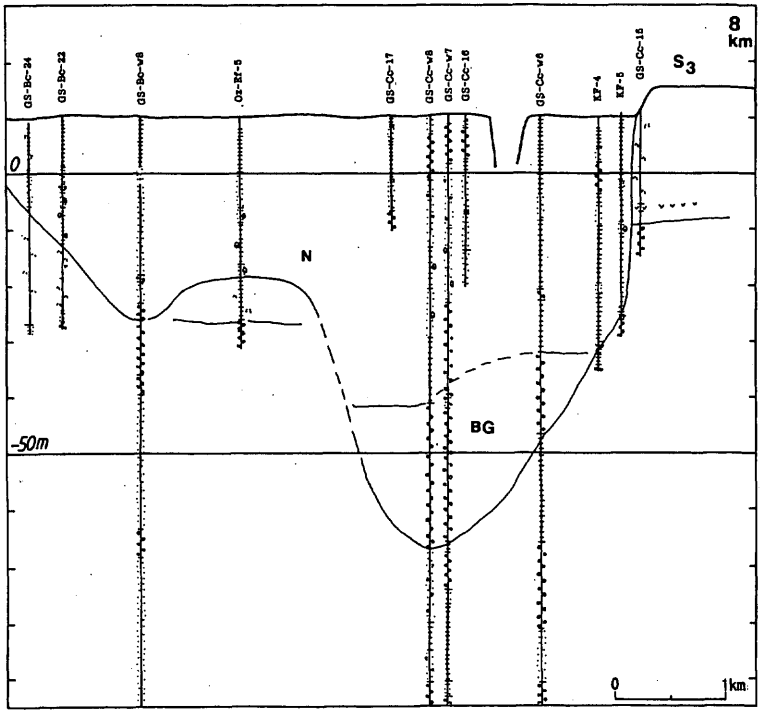

8
km
GS-Bc-24
GS-Bc-23
GS-Bc-v6
Oz-Bf-5
GS-Cc-17
GS-Cc-v8
GS-Cc-v7
GS-Cc-16
GS-Cc-v6
KF-4
KF-5
GS-Cc-15
S3
0
N
BG
-50m
0
1km

Fig. 5.2 (cont.)

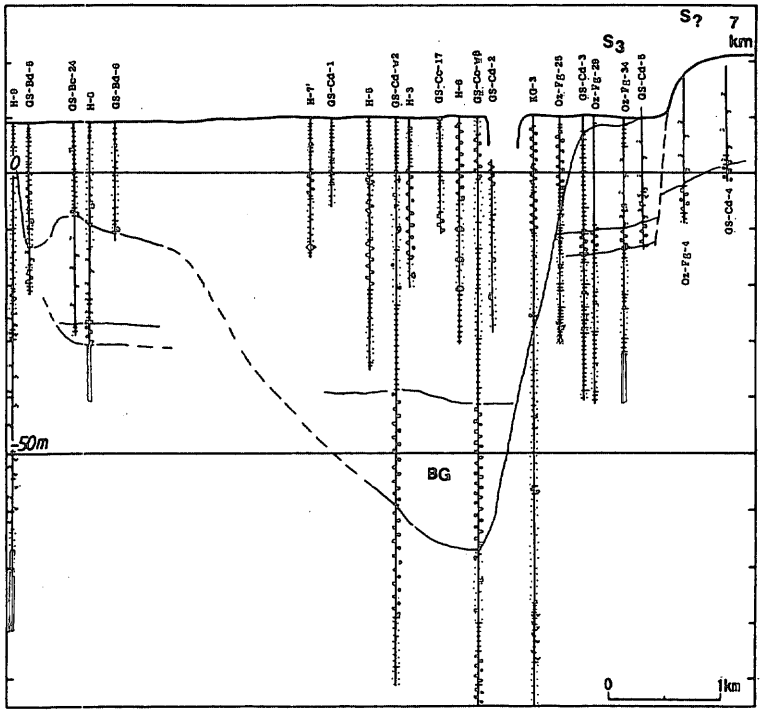

S?
7
km
S3
H-8
GS-Bd-5
GS-Bc-24
H-8
GS-Bd-6
H-7'
GS-Cd-1
H-8
GS-Cd-v2
H-3
GS-Cc-17
H-8
GS-Cc-18
GS-Cd-2
KG-3
Oz-Fg-25
GS-Cd-3
Oz-Fg-29
Oz-Fg-34
GS-Cd-5
Oz-Fg-4
GS-Cd-4
0
-50m
BG
0
1km

Fig. 5.2 (cont.)

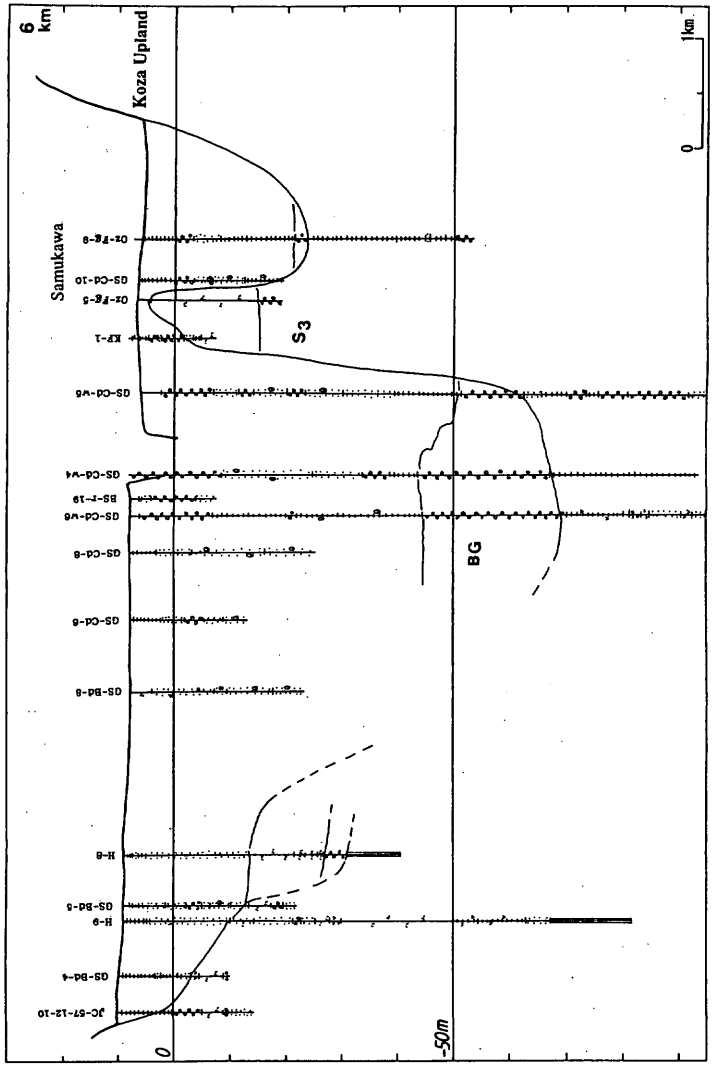
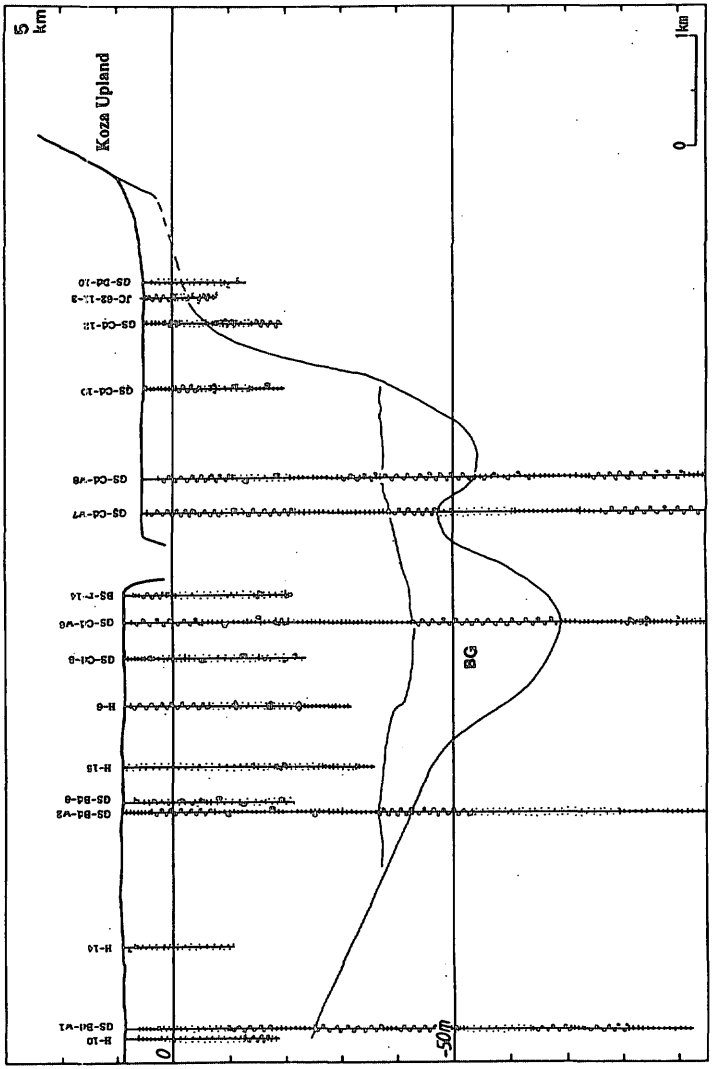

6 km
Koza Upland
Samukawa
1km
0
S3
BG
0
-50m
Oz-FG-8
QS-Cd-10
Oz-FG-5
KF-1
QS-Cd-W5
QS-Cd-W4
BS-F-19
QS-Cd-W6
QS-Cd-8
QS-Cd-6
QS-Bd-8
H-8
QS-Bd-5
H-9
QS-Bd-4
JC-87-12-10

Fig. 5.2 (cont.)



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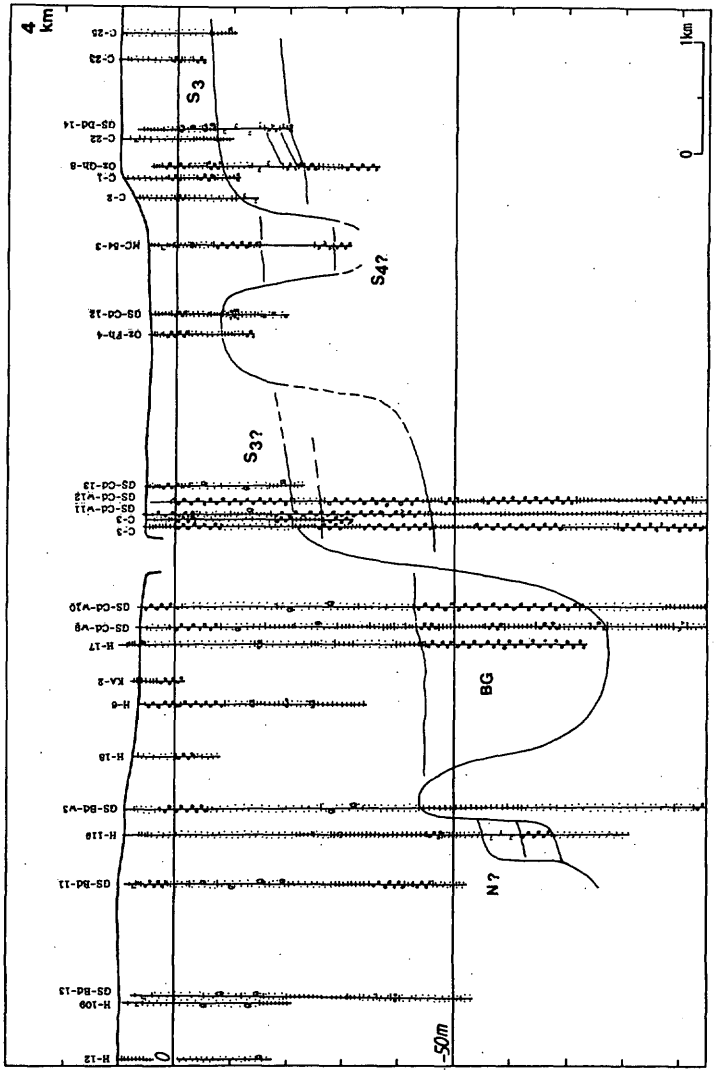
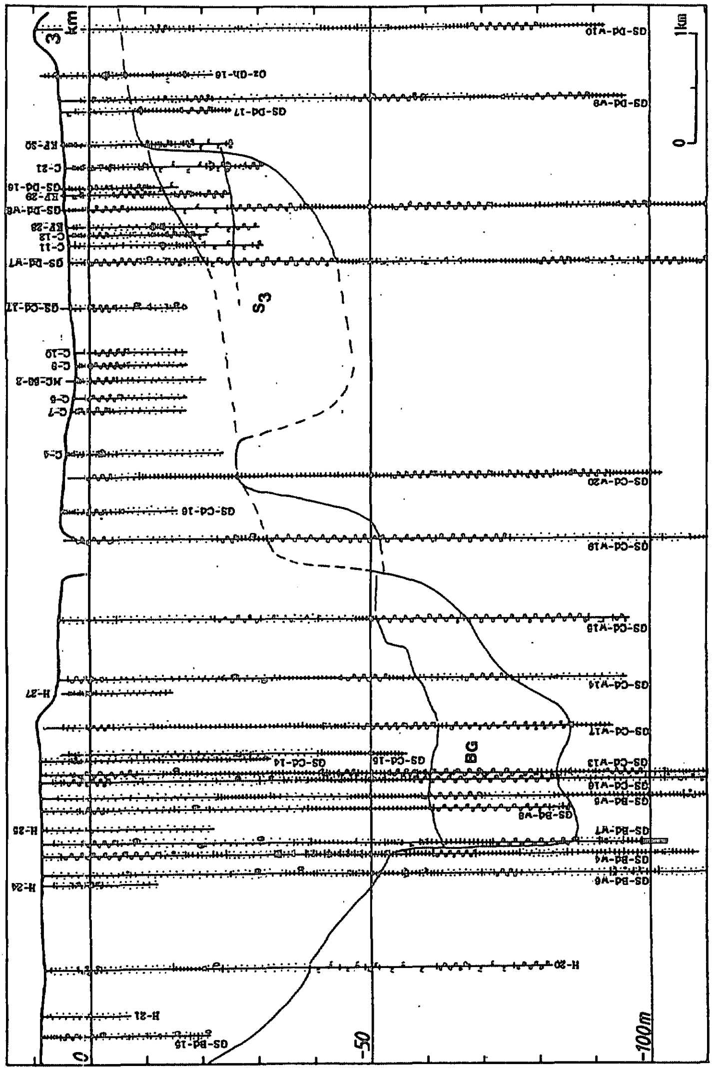

4 km
1km
0
S3
S4?
S3?
BG
N?
-50m
C-25
C-23
C-22
C-1
C-2
MC-84-3
OS-CD-12
OS-FD-4
OS-CD-13
OS-CD-W13
OS-CD-W11
C-3
OS-CD-W10
OS-CD-W9
H-17
KA-2
H-6
H-18
OS-BD-W3
H-118
OS-BD-11
OS-BD-13
H-109
H-12

Fig. 5.2 (cont.)



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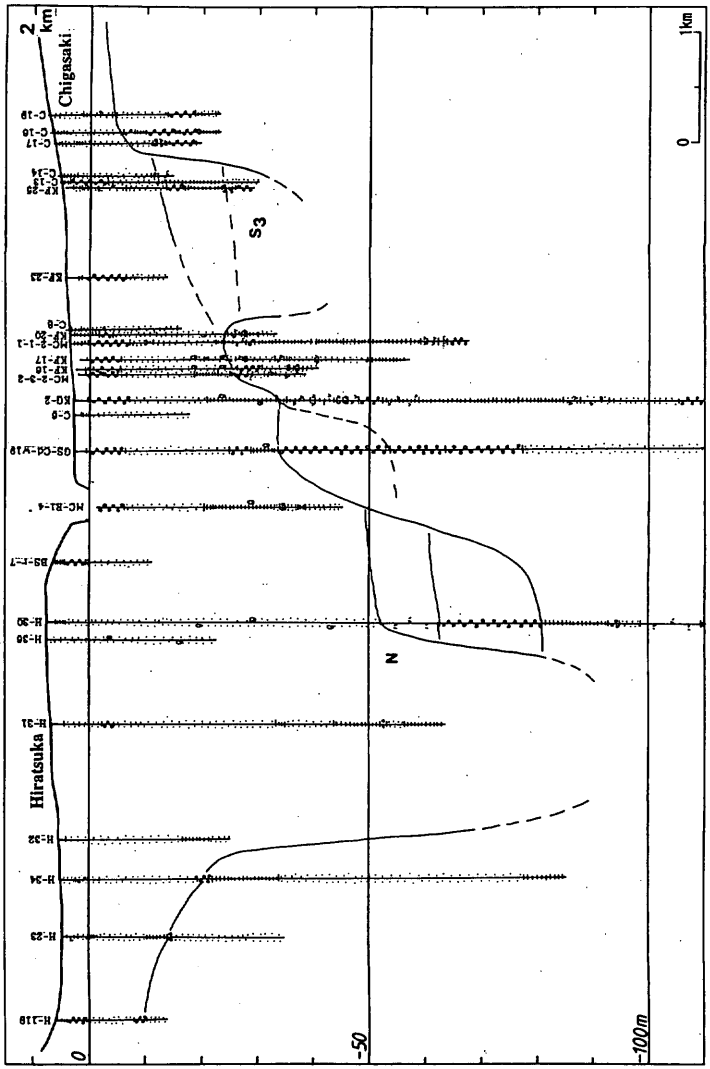

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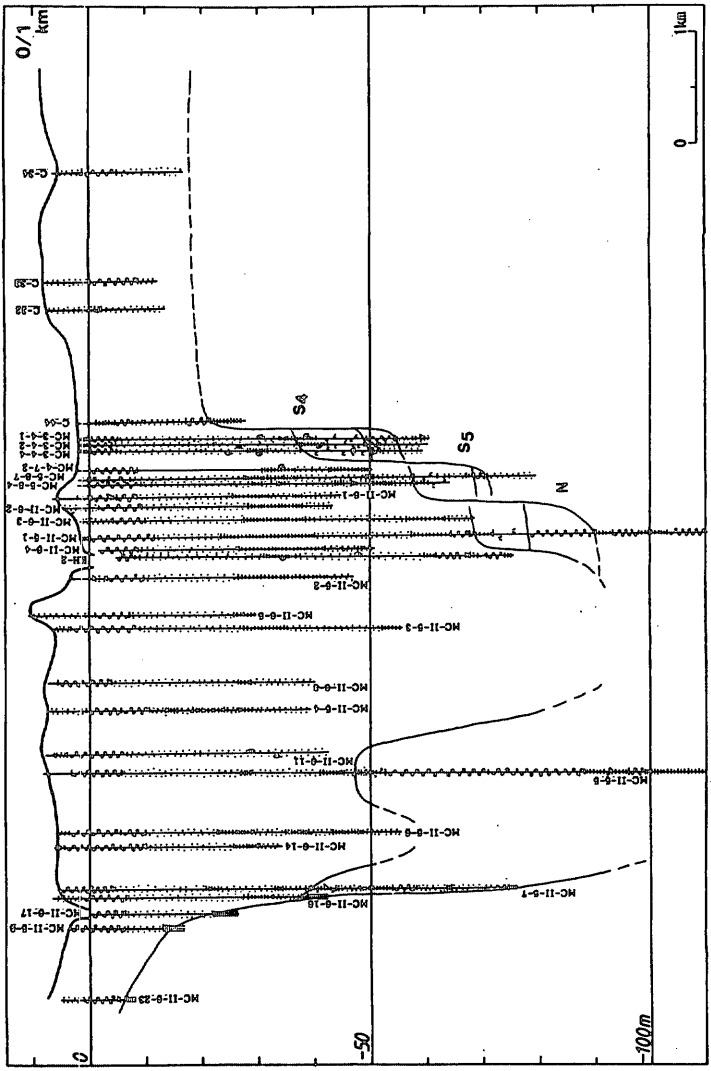

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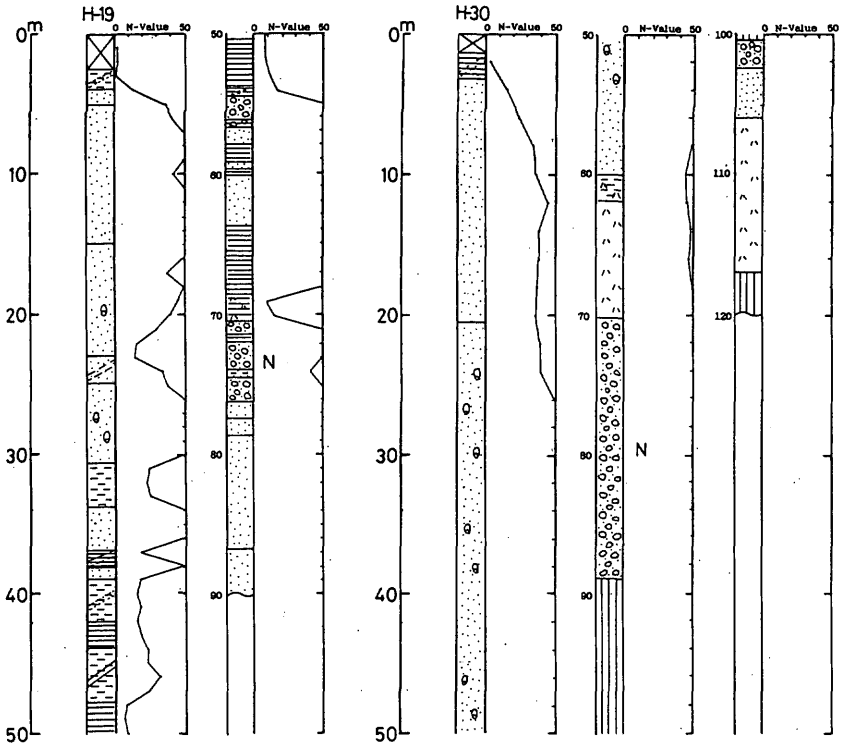

Fig. 5.3 Bore hole logs of buried Nakatsuhara Terrace in Hiratsuka
Localities are shown in Fig. A-1.

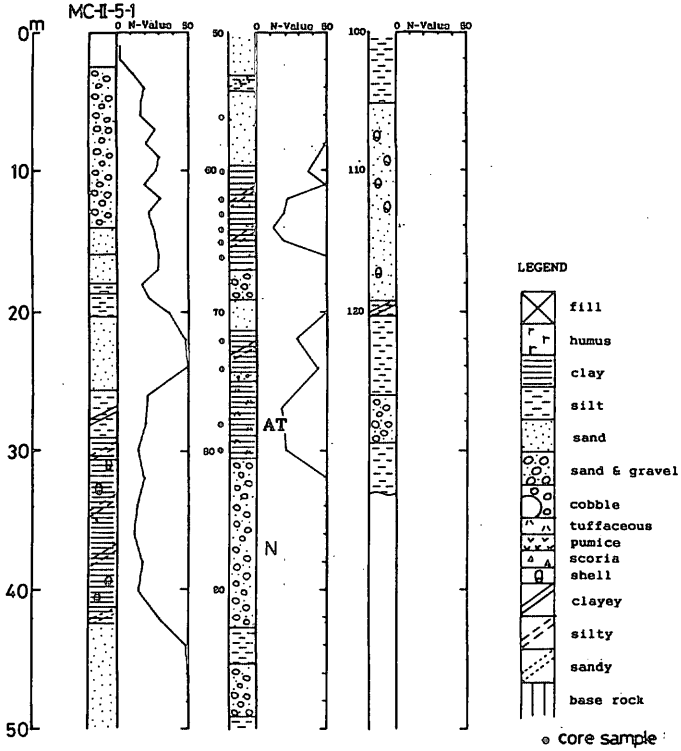
MC-II-5-1
0 N-Value 50
0 N-Value 50
0 N-Value 50
m
0
10
20
30
40
50
50
60
70
80
90
100
110
120
AT
N
LEGEND
fill
humus
clay
silt
sand
sand & gravel
cobble
tuffaceous
pumice
scoria
shell
clayey
silty
sandy
base rock
core sample

Fig. 5.3 (cont.)

5-1'). A 5.6-m thick 'tuffaceous clay' covers this gravel bed, whose depth is -78 m a.s.l. The author found volcanic glass of AT (mean refractive index : 1.5008, see appendix) in the core sample of this 'tuffaceous clay', 2 m above the gravel bed.

The center of the buried valley bottom can be estimated to run 1-2 km west of the present river mouth. The boreholes penetrating BG have not been obtained around the present river mouth. However, the BG at the present river mouth can be estimated at around -90 to -100 m a.s.l., by extrapolation from the longitudinal profile.

3) Longitudinal profiles of buried terraces

Figure 5.4 shows longitudinal profiles of terraces and deposits projected along the present Sagami River. Characteristics of each terrace are as follows.

Sagamihara Terraces : S3 terrace gravel submerges into the alluvial plain at 11-12 km from the present river mouth (Ebina City). It can be traced to c.2.5 km (Chigasaki City), at -25 m a.s.l. The thickness of gravel exceeds 20 m in Chigasaki. The average gradient is $3.7 * 10^{-3}$ (15.6-2.5 km). It is not clear whether the buried terrace at 1.6-2 km is equivalent to the S3 or not because the gravel and tephras are thin.

The S4 terrace is seen at 1 km from the present river mouth (at -50 m a.s.l.). A pumice bed is seen in a borehole log, that is possibly Hk-TP, 2.7 m above the gravel bed ('MC-3-4-4'). This terrace can befound at 6.5 km, 4.1 km and 0.1 km from the river mouth. The average gradient is $5.8 * 10^{-3}$ (6.5-0.1 km).

The S5 terrace possibly occurs at 0.7-0.8 km from the river mouth. The gravel depth is around -70 m a.s.l.

Nakatsuhara Terrace : Nakatsuhara terrace gravel in the left bank seems to

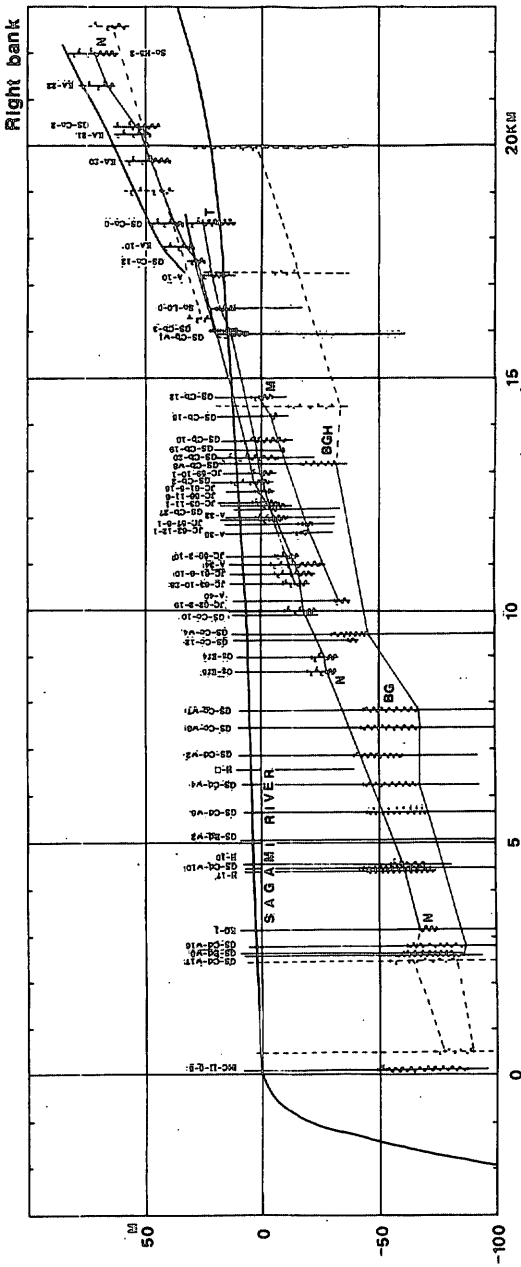

Fig. 5.4a Longitudinal profiles of buried terraces (right bank)

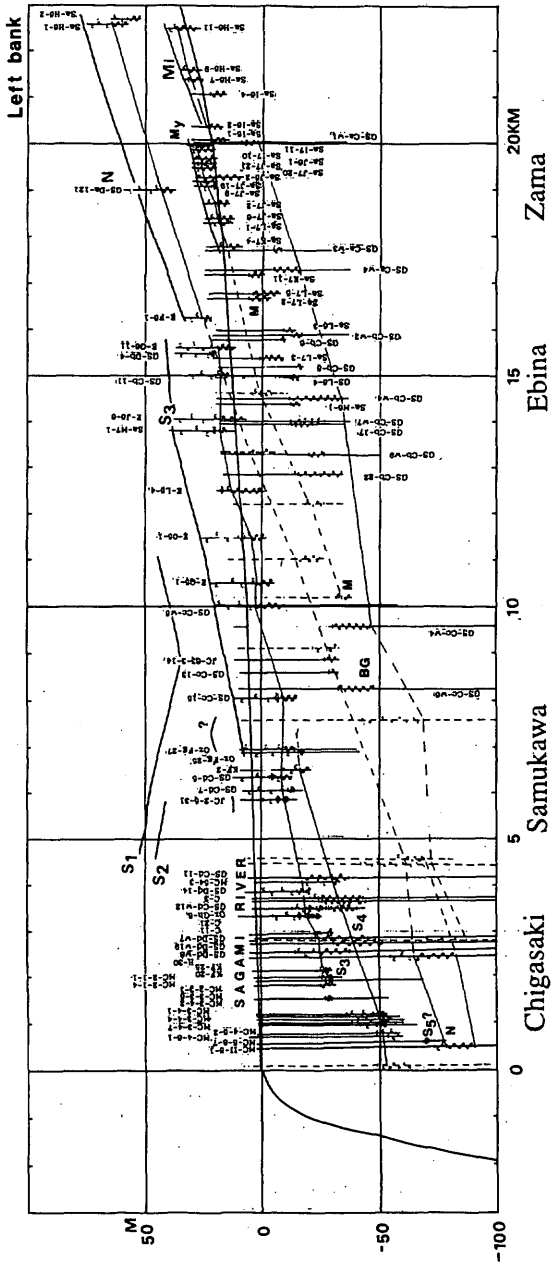

Fig. 5.4b Longitudinal profiles of buried terraces (left bank)

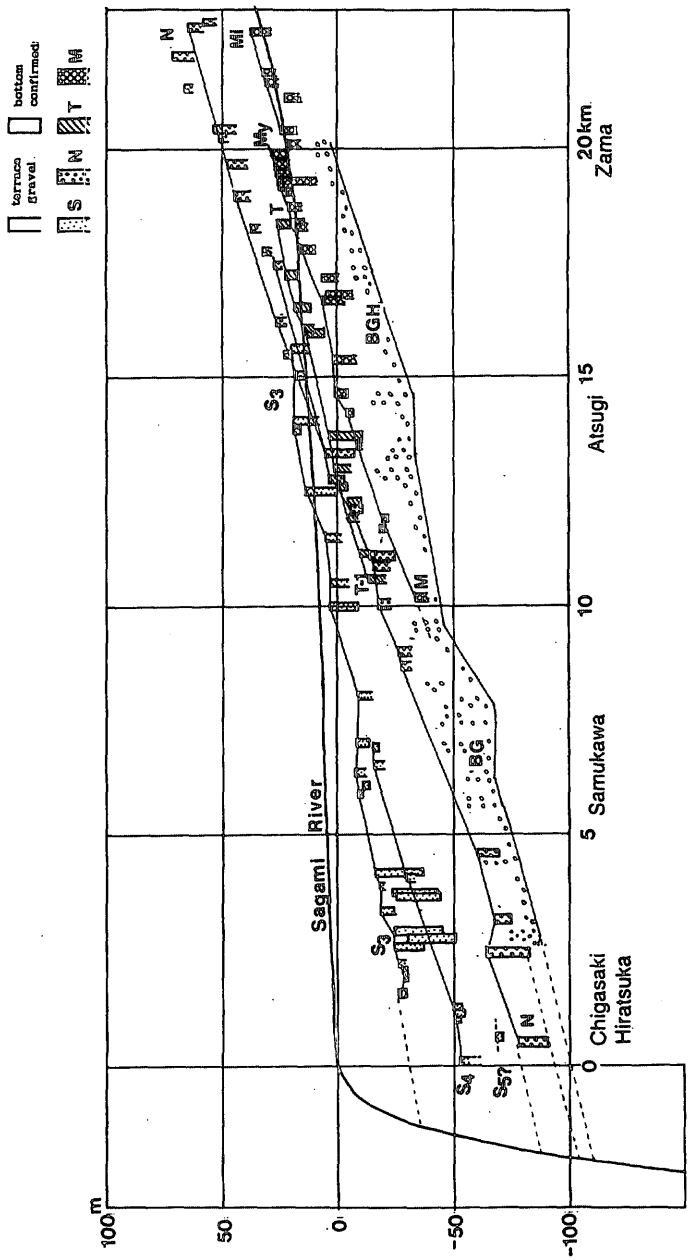

Fig. 5.4c Longitudinal profiles of buried terraces (compiled)

submerge into the alluvial plain at 15.5 km.

In the right bank, this terrace has a steeper profile than in the left bank because the origin of the terrace is the Nakatsu River. It seems to submerge into the alluvial plain at 14-15 km from the present river mouth.

The Buried Nakatsuhara terrace deposits can be traced to the lowermost reach of this plain (seen at 4.5, 3.1, 2.5 and 0.5 km from the present river mouth). The thickness of the gravel bed is 10-20 m in the lower reaches, and the depth is similar to that of BG (-78 m a.s.l. at 0.5 km). However, the thick tephras covering the gravel bed distinguish it from BG. The average gradient of the Nakatsuhara Terrace is $6.3 * 10^{-3}$.

Tanahara Terraces : Tanahara-1 terrace submerges into the alluvial plain at 16-17 km from the present river mouth. The buried Tanahara terrace is seen in Atsugi City. As the profiles of this terrace and the Nakatsuhara terrace are very similar, they may converge in the lower reaches.

Minahara Terraces and BG : The gravel bed of the Minahara-Isobe terrace (Mi) submerges into the alluvial plain at Isobe, Sagamihara City, 20-21 km from the present river mouth. The Minahara-Yotsuji terrace (My) submerges at Zama City, 18-19 km from the present river mouth. Gravel beds of the buried Minahara terraces can be traced to 10.2 km from the river mouth. They seem to converge with Basal Gravel (BG) of the Recent deposits there. The thickness of the Minahara gravel is not clear, while that of BG sometimes exceeds 20 m. At 2.8 km from the present river mouth, BG is seen in -65 to -83 m a.s.l.

The average gradient of this terrace surface is $6.5 * 10^{-3}$ (20.0-10.2 km), or $6.8 * 10^{-3}$ (20.0-2.8 km, to the bottom of BG). The gradient of the BGH (bottom gravel of the Recent deposits in the upper reaches) is $4.6 * 10^{-3}$ (20.0-9.6 km).

(to be continued)

付記：

本論文は 1995 年に東京都立大学へ提出した学位請求論文の全文であるが，「人間・自然論叢」ページ数制約のため 4 分割して投稿することにしたものである．このため，引用文献は Part IV の最後にまとめて提示する．