Fourth International Conference on Scour and Erosion 2008

COASTAL EROSION SURFACES DETECTED BY GROUND PENETRATING RADAR AND CORING SURVEY: A CASE STUDY IN COASTAL AREA AROUND THE TENRYU RIVER MOUTH

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A stratigraphic survey was conducted in the coastal section about 4 km west of the Tenryu River mouth by using a Ground Penetrating Radar (GPR) and cores. The coastal stratum in this region had been developed by coastal progradation. GPR analysis reveals that there are two types of reflecting surfaces. One is erosional surface which truncates underlying reflecting surfaces. The other is depositional surface which usually downlaps or overlaps on underlying erosion surfaces. Erosional surfaces usually show stronger reflectance than depositional surfaces especially around the low-tide level. Erosional surfaces with sharp contact were also found in cores sampled within the same section of GPR survey. The cores consist mainly of fine to very coarse sands, but most of erosion surfaces are directly covered by gravels. These erosion surfaces in cores correspond with the erosion surfaces in GPR profile. The GPR survey and core analysis show the existence of erosional events within the coastal progradation.

Key Words : *Ground Penetrating Radar, core, erosion surface, gravel layer, coastal erosion*

1. INTRODUCTION

cause its drainage is the most active tectonic region along the Median Tectonic Line. The region around the Tenryu River mouth suffers from coastal erosion because of the reduction of sediment discharge of the river. The reduction is due to dam construction in drainage basins since 1930s (Fujiwara et al. 2007). However, the shoreline had moved seaward until that time due to sufficient sediment discharge from the river (Hiramatsu et al., 2008). Such rapid progradation of coastal system provides high-resolution geological record. This coast is thought to be a good recorder of coastal sedimentation and erosion event. Ground Penetrating Radar (GPR) survey and core analysis are conducted in this area in order to reveal the process of coastal development and to verify the applicability of GPR survey on coastal stratum.

The cross-shore survey line is situated in the Nakatajima aeolian dune and Hamamatsu Shinohara coast of Shizuoka prefecture in Japan (Fig. 1). It is about 4km west of the Tenryu River mouth. In this region, the shoreline had moved about 5m seaward every year in 19th century (Takagawa et al., 2008). The stratum formed by the coastal progradation was surveyed by using GPR and core samples.

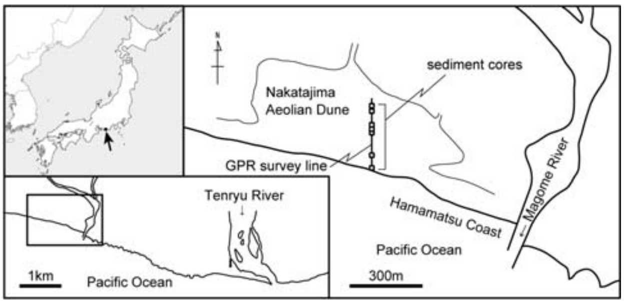

Fig.1 Locality map of the GPR survey line and core sampling positions.

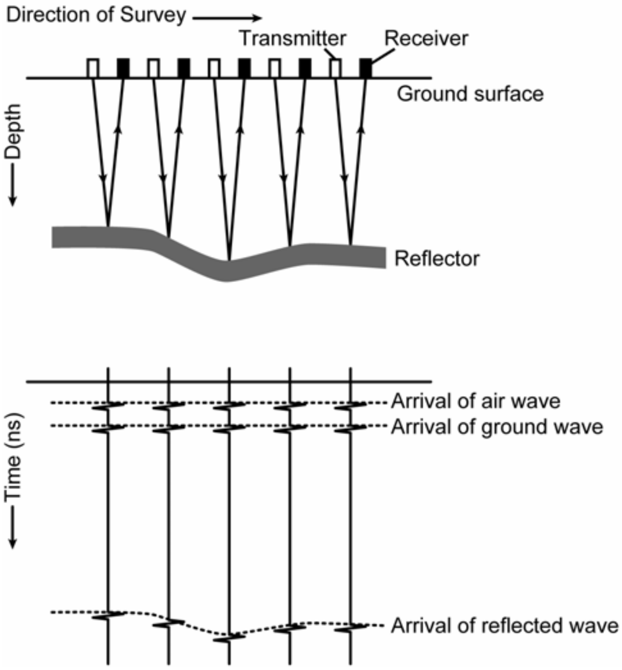

Fig.2 A schematic diagram of GPR survey modified after Jol and Bristow (2003).

2. GROUND PENETRATING RADAR

GPR profiles are similar in appearance to seismic profiles, except that GPR data are acquired by using transient electromagnetic energy reflection. A short pulse of high frequency electromagnetic energy, usually in the 10 to 1,000 MHz range, is transmitted into the ground. Some of the energy is reflected back to the surface from the boundary between different subsurface lithologies, including such changes as sediment grain size, mineralogy, density, and water content (Fig. 2). This effect enables the subsurface stratigraphy and ground moisture conditions to be inferred from the character of the radar return signals.

A Noggin plus 250 radar system was used in this study. The frequency of transmitting pulse is 250MHz. Traces at each surface location (0.05m intervals) were digitized at a sampling time interval of 0.4 nanoseconds and vertically stacked 442 times. Profiles were processed and plotted using Reflex2D-Quick (version 1.0) software. A radar profile of a cross shore section was collected (Fig. 1). A topographic survey was performed with a GNSS GPS survey system along the section after the GPR survey. The topographic data were referenced to the elevation datum of Tokyo Peil (T.P.) and used for static correction of the radar profiles. Processing of the GPR data included Dewow filtering, zero-time corrections, gain control, time-depth conversion and static corrections. The radar wave velocities were calculated from reflection hyperbola, and the velocity data were used for time-depth conversion of the radar profile. The calculated velocities were different between saturated sediments under groundwater level (+0.4m T.P.) and unsaturated ones above the level. These were 0.05 and 0.10 m/ns, in respectively. These are concordant with velocity data of saturated sand and unsaturated sand summarized by van Heteren (1998).

Processed radar profile shows that there are two horizontal subsurfaces of strong reflectance at the elevation of +1.6 and +0.4m. The former is thought to be a boundary between aeolian dune sediments and coastal sediments (cf Knight et al., 1998; van Heteren et al., 2000), because of the difference of stratigraphic pattern. Subsurfaces in the coastal

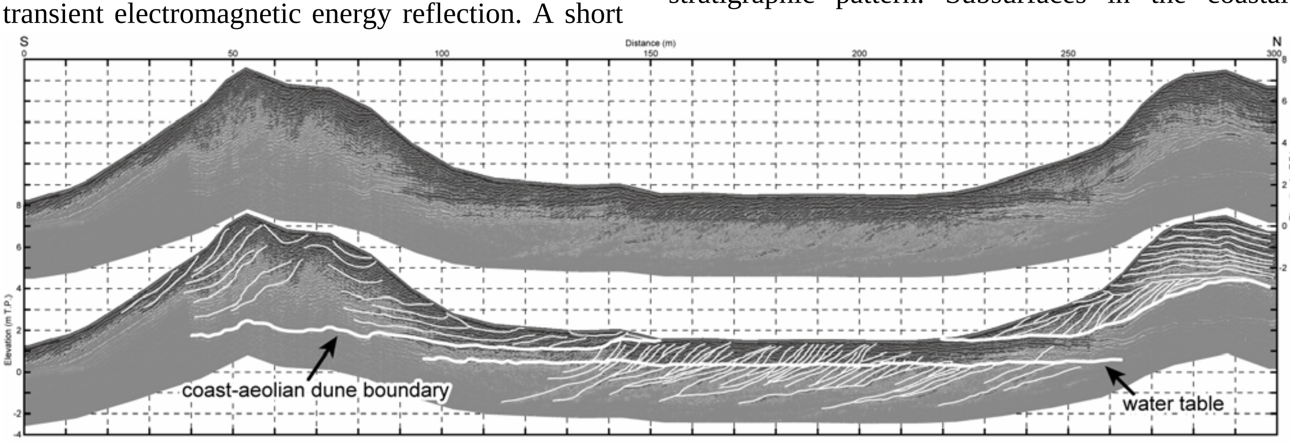

Fig.3 GPR profile along the survey line.

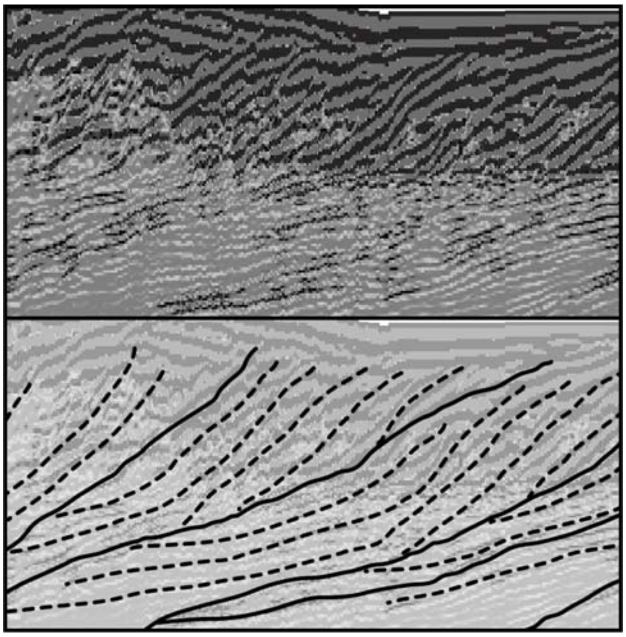

Fig.4 Two types of subsurfaces recognized in GPR Profile. The solid line shows an erosional surface and dotted lines show sedimentation surfaces.

sediments incline seaward, but subsurfaces in aeolian dune sediments inclines to various direction in the cross section. This is because coastal profile moves parallel to the cross section and aeolian dune moves perpendicular to the section. Aeolian dune usually moves eastward, parallel to the shoreline because of the significant direction of winter strong wind (Sato, 2008). The latter is a water table (Fig. 3). Most of subsurfaces inclined to seaward are recognized in the coastal sediments (Fig. 4). These subsurfaces are classified into two types. One is an erosional surface which truncates underlying subsurfaces. It is found as a continuous liner line from the high-tide level (+0.9m T.P.) to the low-tide (-1.1m T.P.) and its slope is between 1/25-1/10. It is recognized as a strong reflectance surface around the low-tide level in the GPR profile (Fig. 5). The other is sedimentary surface which downlaps or concordantly overlaps underlying surfaces. It is concave up at the mean water level. the upper part of it has steeper slope of 1/6-1/5 around the high-tide level and the lower part has milder slope of 1/22-1/12 around the low-tide level.

3. SEDIMENT CORES

Sediment cores were sampled at seven points on the survey line by using percussive cores (Fig. 5). The cores show facies characteristics of beach deposits. Percussive cores recovered sediments from elevations between +2.0 and -2.5 m, where the backshore and foreshore facies occur (Fig. 5). Sediments in these cores generally consist of fine to coarse sand and show well-defined horizontal parallel lamination with concentrations of heavy minerals (Fig. 6A). Several gravel layers overlapping

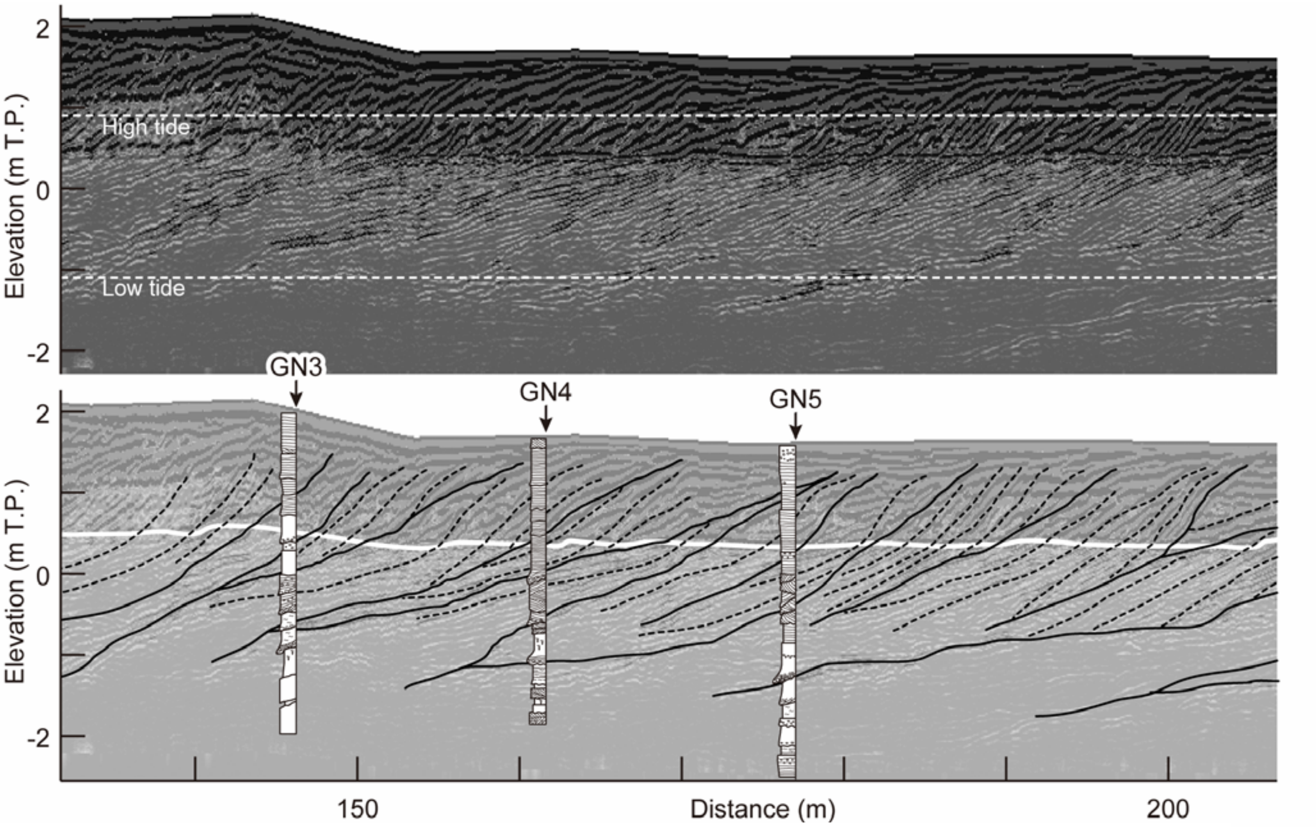

Fig.5 GPR Profiles and columner sections of sediment cores.

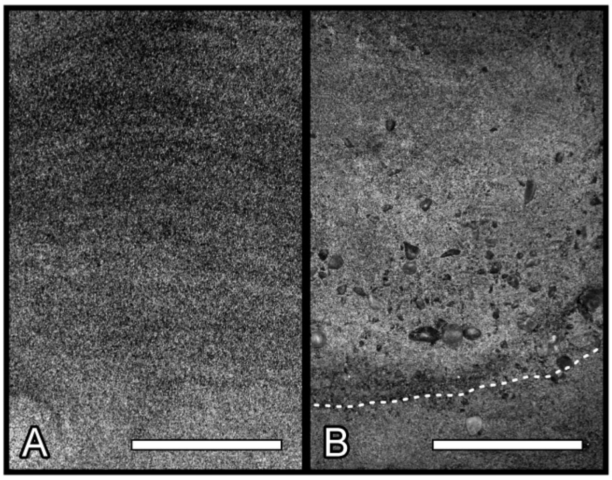

Fig.6 Photos of sediment cores. (A) Characteristic feature of foreshore facies. Well-defined horizontal parallel lamination with concentrations of heavy minerals is shown. (B) An erosion surface and overlapping gravels. The dotted line shows a erosion surface. Scale bars are 10cm.

erosional surfaces were also found in these cores. These are usually distributed around the low-tide level (Fig. 6B). These layers contain granule- to pebble-sized gravels. These gravels are thought to be relict sediments which were left behind on the foreshore surface at the event of foreshore erosion. In the modern beach, a beach step is usually developed near the low-tide level and gravels tend to be around the step. Therefore, the erosion surface overlapped by gravels is thought to be formed by cross-shore movement of a beach step.

Erosion surfaces detected by GPR profile correspond with erosion surfaces recognized in sediment cores (Fig. 5). This shows the availability of GPR to study the coastal erosion event on the geologic record. Gravel layers overlapping erosion surfaces correspond with strong reflectance subsurfaces in the GPR profile. This indicates that the boundary between sand layer and gravel layer that have different electromagnetic properties behaves as a strong reflector. Therefore, it is thought to be possible to estimate the spatial distribution of gravel layers on the basis of the analysis of reflection intensity of GPR profile.

4. CONCLUSIONS

1) GPR survey and sediment core analysis were conducted in the cross-shore section of Nakatajima aeolian dune and Hamamatsu Shinohara coast.
2) The stratum of the survey section is divided at the elevation of +1.6m T.P. into two types of sediments. The upper part consists with aeolian dune sediments and the lower part consists with coastal sediments.
3) Subsurfaces in coastal sediments were classified into erosion surfaces and sedimentation surfaces according to the existence of truncation of underlying surfaces.
4) Spatial distribution of coarse sediments was recognized in sediment cores, being correspond to erosion surfaces recognized in GPR profiles.
5) Erosion surfaces around the low-tide level were usually covered by gravels, showing a strong reflectance. These were thought to be formed by the cross-shore movement of beach steps.
6) GPR is a useful tool to study historic events of coastal sedimentation and erosion.

ACKNOWLEDGMENT: This study was conducted under the Tenryu-Enshunada Project funded by the Japan Science and Technology Agency (JST).

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