CHAPTER 36

A PETROGRAPHIC STUDY ON LITTORAL DRIFT ALONG THE ISHIKAWA COAST, JAPAN

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ABSTRACT

Based on the longitudinal variation series in various properties of beach sediments and topographic profiles along the southern coast of Ishikawa Prefecture, Japan, the prevailing direction and mechanism of littoral drift are discussed.

INTRODUCTION

The coasts facing Japan Sea have been suffering a serious beach erosion due to the destructive storm waves generated by winter monsoon. The coastal erosion is particularly severe along the southern coast of Ishikawa Prefecture, where shoreline is estimated to have been retiring steadily as far as 2000 meters in the past 1800 years. The movement of beach material normal to the coast is mainly responsible for such considerable changes which occur on the shore and result in inundation of water in lowland due to the blocking-up of the river mouth. The objectives of our study are to determine the sources of sediments on the coast and to ascertain whether any areal differences in sediment properties can be used to define the prevailing direction and the pattern of local beach drift. The results obtained from our previous study on beach drift along the Niigata coast[1] and the Sagami Bay coast[2] are comprised in the discussion.

GENERAL DESCRIPTION OF THE AREA

Field investigations were carried out along the shoreline of the southern Ishikawa coast as in Fig. 1. The shoreline studied by authors is marked by some 40 kilometers of continuous beach which is aligned to face approximately the direction of approach of the dominant waves striking the beach more or less at right angles. The larger part of the shoreline is composed of sandy beach except at the rocky coast in its southwestern end. Although several rivers drain into the Japan Sea in the beach, no rivers seem to contribute so much appreciable amounts of sediments to the adjacent beach as the river Tedori does. The Tedori build up the largest alluvial fan (Fig.2), the margin of which is bordered by the shoreline and is cut across by wave attack. Centering around this fan one or two

rows of coastal dunes of low relief run in parallel with the strike of the coast, that is from NE to SW. In some places the wave directly attack these dunes and the shore is undercut to produce low cliffs. Behind these dunes there are lagoons some of which are now under reclamation to acquire farm land.

FIELD AND LABORATORY PROCEDURES

Field operations were carried out at three different times, that is, Aug. and Dec. 1962 and Feb. 1963. 34 sampling localities were spaced at 0.5-1.0 kilometers intervals along the shoreline (Fig.1). The methods of analysis on the samples taken from these sampling localities are as follows;

A) Amounts of gravel cover: This is a new parameter proposed by the authors to characterize the degree of gravel cover on the beach surface. The amount of gravel cover is expressed in terms of proportion of the beach surface covered by gravels.

B) Lithological composition of beach gravels: In order to estimate the source and the drifting direction of beach gravel, the lithological composition of the pebbles among the beach gravels was examined. The pebble samples were classified into some rock types and the lithological composition of pebbles was expressed as a percentage of each rock type by the number of pebbles.

C) Mean volume of the largest five gravels: The drifting directions of the beach gravels may be controlled by the littoral drift current there. In this process, the beach gravel may decrease in volume with increasing distance away from the source. From this point of view, the variation series of the mean volume of largest five gravels of various rock types were measured.

D) Shape and roundness of beach gravels: Concerning the shape, flatness was used and some 100 pebbles for various rock types were measured. Flatness F is defined as the ratio of ab/c^2 in which a, b, and c are the largest, the intermediate and the shortest diameter of the pebble respectively. The roundness was also measured by using the Krumbein's figure.

E) Size distribution of beach sand: The sand size samples taken from the back shore were sieved by the Tyler's Standard Screens. The cumulative curves were made on graphs showing the relation between the percentage of weight and the diameter in ϕ scale. Then, using this graph, three characteristics were calculated by the following formulas:

as the median diameter $\quad Md\ \phi = \phi_{50}$

as the sorting coefficient $\quad PD\ \phi = (\phi_{90} - \phi_{10})/2$

$\quad QD\ \phi = (\phi_{75} - \phi_{25})/2$

F) Mineralogic composition of beach sand: Magnetic minerals have strong specific gravity than non-magnetic ones in general. It is assumed, therefore, that the minerals having

various specific gravity are selectively transported by the wave and current. So that, the mineralogical compositions of sand samples were examined by using the Magnetic Minerel Separator. It was expressed in the weight percentage of the five groups with different magnetism.

On the other hand, beside these sample analyses, the beach profiles at right angles to the coast were surveyed repeatedly at the sampling localities. Observation on condition of the beach was also made.

DISCUSSION OF RESULTS

A) Amounts of gravel cover: Fig.3 shows the areal distribution of the amounts of gravel cover along the shoreline. This figure may indicate that the beach gravels were predominantly transported southwestwards away from the river mouth of the Tedori. On the other hand, the reduction in beach gravel is most significant during the period of storm waves in winter, whereas the accretion takes place during the period of quiet water in summer. This tendency is also ascertained by the results of our beach surveys conducted at three hours intervals. Waves generated by winter monsoon are especially destructive of beach and may result in the pronounced movement of beach materials towards near-shore.

B) Lithological composition of beach gravel: As concerns the lithological composition of pebbles, the highest percentage is found in the andesitic pebbles, next comes tuffaceous gravel of Tertiary age. It demonstrates that this stretch of beach can be separated into two segments bordered by the river mouth of the Tedori. Starting from the mouth, the lithological composition of pebbles shows a series of variation in either directions as in Fig.4, and along the southwestern half of the beach it is more similar to that of the deposits of the river Tedori as in Tab.1 than that of the northeastern half of the beach. These facts indicate that the beach pebbles were primarily derived from the river Tedori and that most of them has been moving predominantly southwestwards. Toward both ends of the shoreline it shows a increase in the percentage of andesitic gravels and corresponding decrease in other rocks. Such variation in the lithological composition can be explained by the selective removal and more quick attrition of other rocks.

C) Mean volume of the largest five gravels: Its areal distribution along the shoreline shows that the peak value is found in the vicinity of the mouth of the river Tedori and that from there the values decrease in either directions with increasing distance (Fig.5). The decreasing rate is greater towards northeast. These facts suggest that beach material probably come from the river Tedori and that southwesterly movement of beach material may predominate.

D) Shape (Flatness) and roundness of beach gravel: It

can be said from Fig.6 that rhyolite is more flat than andesite On the whole, pebbles of any rock type become more and more flat with distance from the river mouth of the Tedori. Pebbles along the southwestern side of the mouth are slightly less flat than those along the northeastern side.

Although comparisons of roundness for each rock type show no significant difference, roundness of granite is slightl higher that that of other rocks. The areal distribution of roun ness shows a similar trend as that of other parameters. Thus the trend points again to the river Tedori as the principal source and also the southwestward drift away from the source area.

E) Size distribution of beach sands: The median diameter is approximately 0.3 mm as in Fig.7 and the size distribution of beach sands is similar to that of the deposits of the river Tedori. The median diameters and sorting coefficients of beach sands tend to increase with distance from the river mouth. No definite rule was found to apply the pattern of size distribution of beach sands for the whole stretch of the shoreline, because finer materials such as sands are more movable with feeble waves and currents which exerted locally.

F) Mineralogic composition of beach sand: Results of mir eralogic analysis demonstrate that the principal components of sand samples are such non-magnetic minerals as quartzs and feldspar. In places a bulk of heavy minerals such as magnetite appear where longshore current prevent the establishment of beach an thus strip the coast against incoming waves (Fig. 8). The possible explanation of such heavy mineral assemblage is the selective removal of lighter minerals by the sorting action of waves on attacking coastal dunes. Variations in mineralogic compositio of sand samples along the shoreline are not systematic.

CONCLUSIONS

From the results obtained it can be said that the principal source of the beach material along the southern Ishikawa coast is the river Tedori and that the beach material moves towards southwest predominantly.

On the other hand, the results of our survey of beach profiles at three hours intervals revealed the pronounced erosion of beach, i.e. waves cut away a vertical thickness of 1.5 meters of the beach material and overall landward retreat of waterline amounted to 16 meters during the passage of a depression as is typically exemplified by Fig.9A and 9B. The beach ohanges associated with the passage of periodic local storms cause such a drastic cut and fill of the beach in a short period of time. The largest wave appeared during the measurement on the beach profile was some 2 meters in wave height and 8.5 seconds in wave period. Also, the erosion and deposition on the beach might be decided by the scale of wave, e.g. the wave steepness.

According to our observation[3], the erosion of beach took place when the wave steepness became larger than some 0.020. So that, this value may be taken as the boundary one of wave steepness which decide whether the erosion of beach happens or the deposition does.

In attempt to evalute the transport velocity of beach gravel, we tried to compare the size-distance relationship of gravels of the same lithology in three different coasts, that is, Ishikawa, Niigata and Sagami Bay coasts.[4] For instance, in case of granite as in Fig.10, the relation is expressed as a negative exponential of the form $v/v_0 = e^{-\lambda x}$, where, v is the volume, λ is the coefficient of volume reduction, x is the travelling distance and v_0 is v at $x=0$. The gentlest slope of the trend line for Ishikawa coast suggests that along this coast the transport velocity of beach gravels per unit distance is higher than the other two.

ACKNOWLEDGEMENT

The authors wish to express their gratitude to Prof. Dr. C.J.Sonu of Louisiana State University, Dr. N.Shiraishi of Nippon Tetrapod Company and Dr. T.Suzuki of Chuo University who afford us facilities for these investigations. Thanks are also due to Prof. Dr. M.Honma of Tokyo University and Prof. Dr. Y.Ishikawa of Risshô University for their useful suggestions and encouragement throughout our study.

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GRAVEL

	Granite	Rhyolite	Tuff	Andesite	Others
Lithological composition	10.8%	3.8%	27.4%	35.0%	22.9%
Mean vol. of the largest five gravels	9,098cm^3	4,102cm^3	9,465cm^3	5,091cm^3	----
Shape(flatness)	0.37	0.40	0.35	0.34	----
Roundness	6.7	5.7	6.2	6.1	----

SAND

Size distribution	Md.	QDØ	PDØ
	0.20mm	0.27	0.58

Mineral composition	Magnetite	Hematite Limonite etc.	Augite Hornblende etc.	Olivine Biotite etc.	Quartz Feldspar
	0.5%	7.7%	1.9%	8.0%	81.8%

Table 1. Various value of sediments in the river-bed of the Tedori.

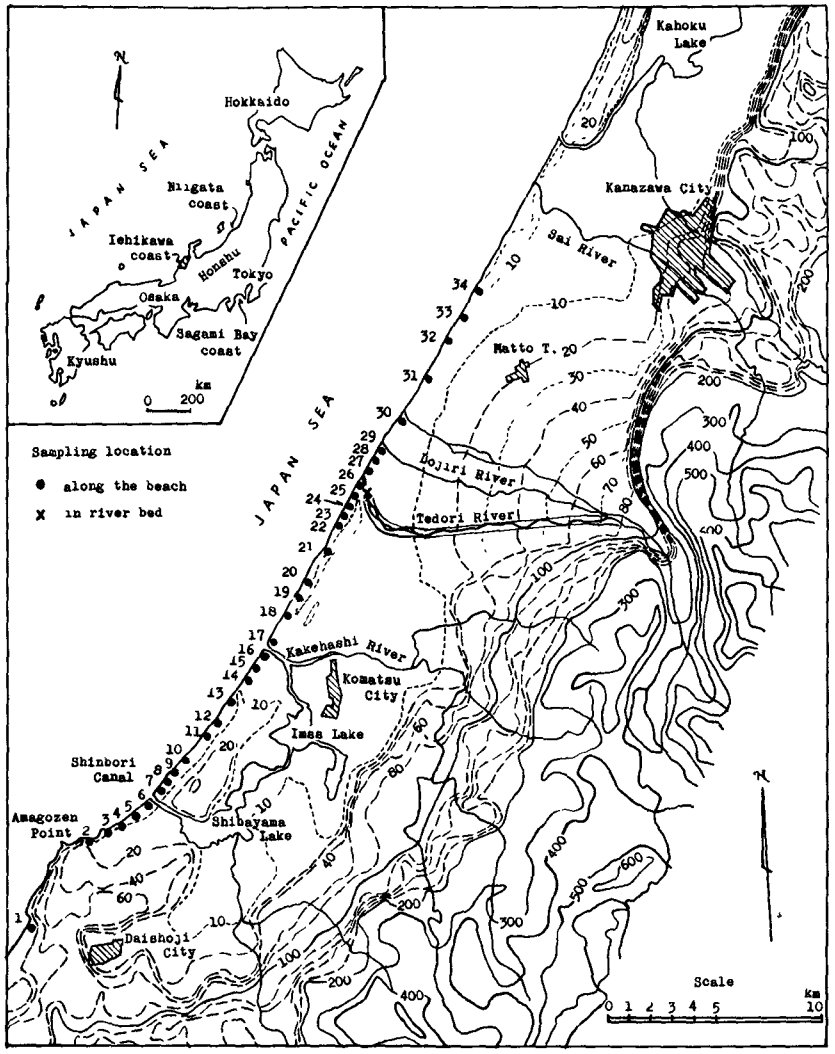

Fig. 1. General sketch map of the studied area.

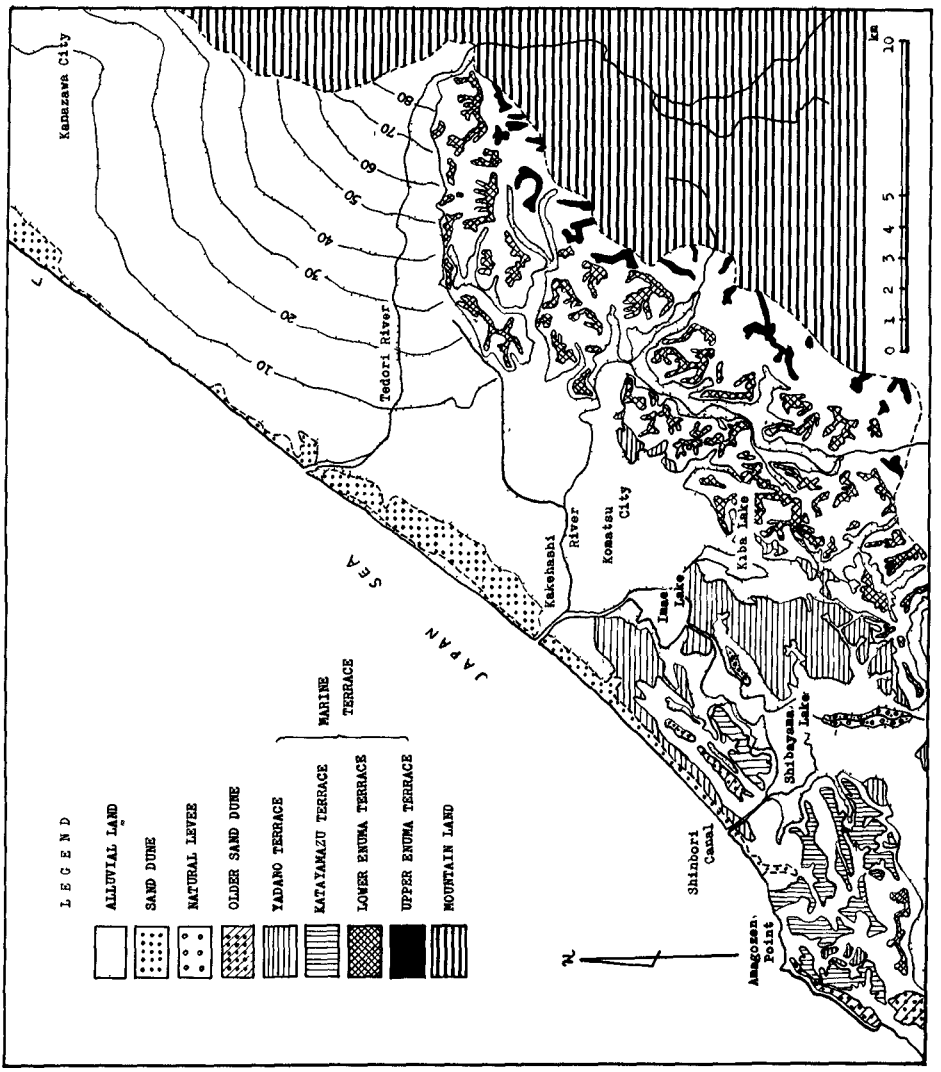

Fig. 2. Geomorphological map of the studied area.

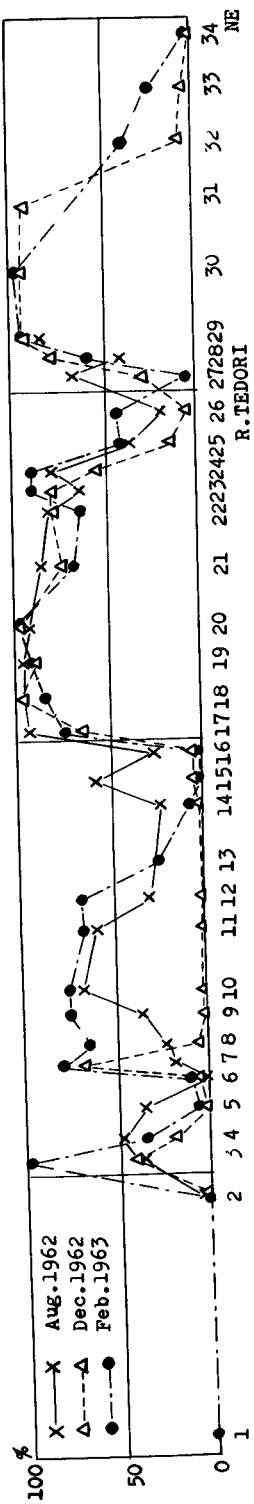

Fig. 3. Distribution of amounts of gravel cover along the shoreline.

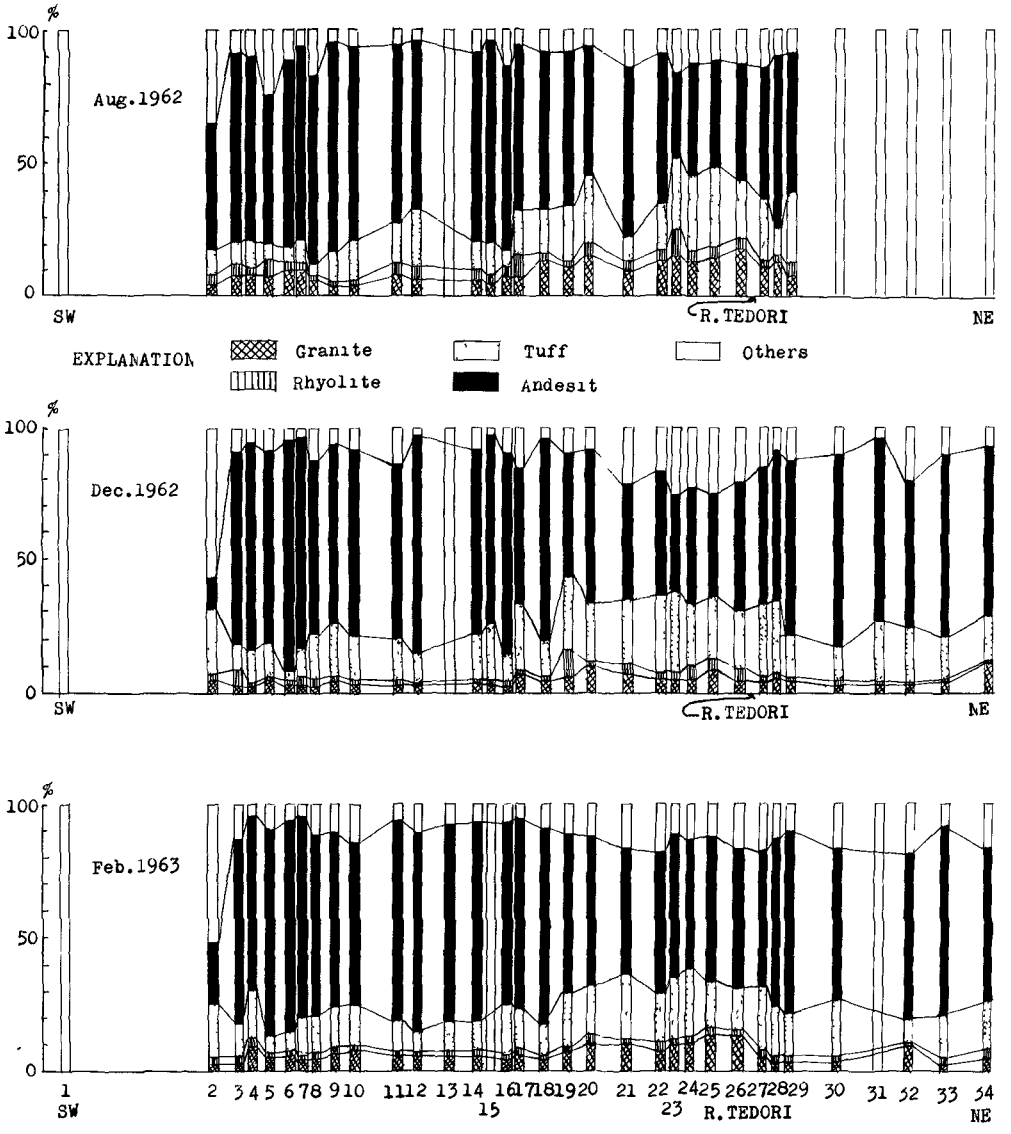

Fig. 4. Distribution of lithological composition of beach gravel along the shoreline.

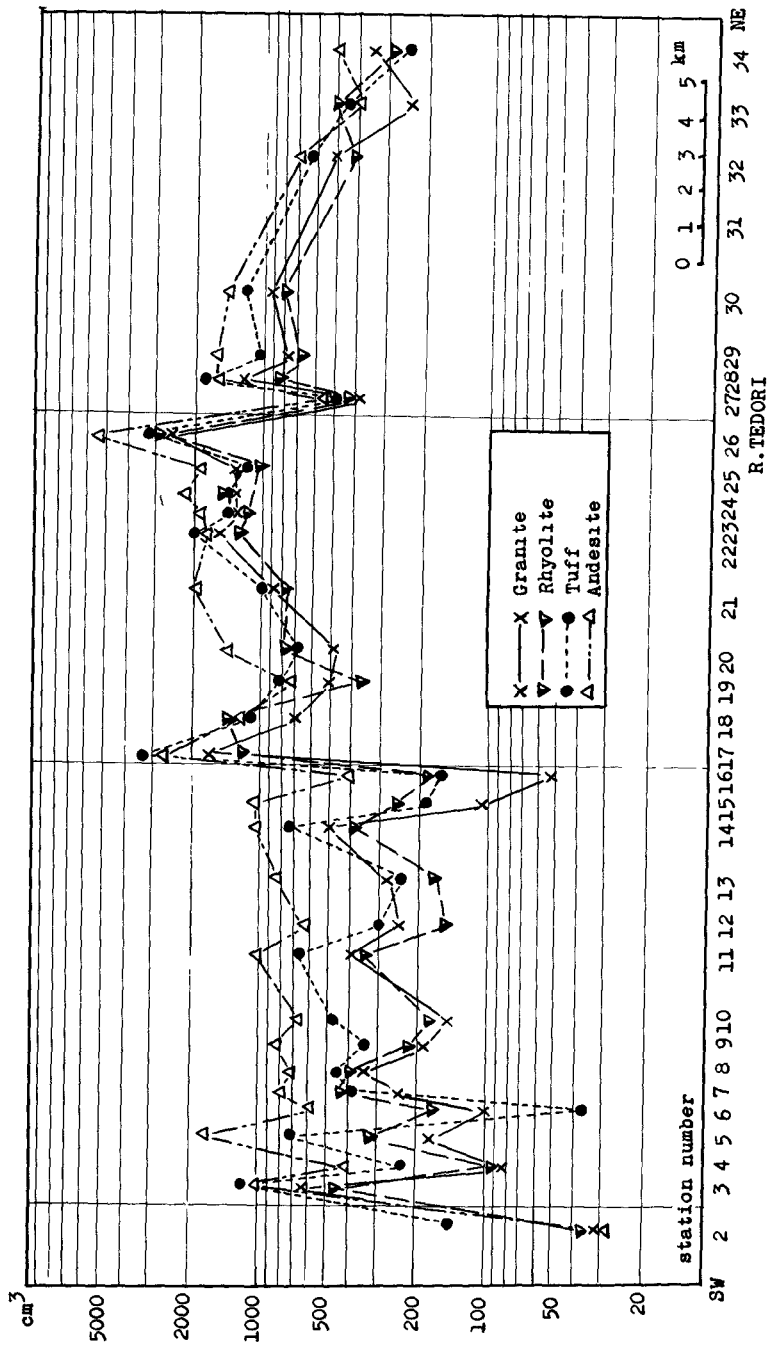

Fig. 5. Distribution of mean volume of the largest five gravels along the shoreline.

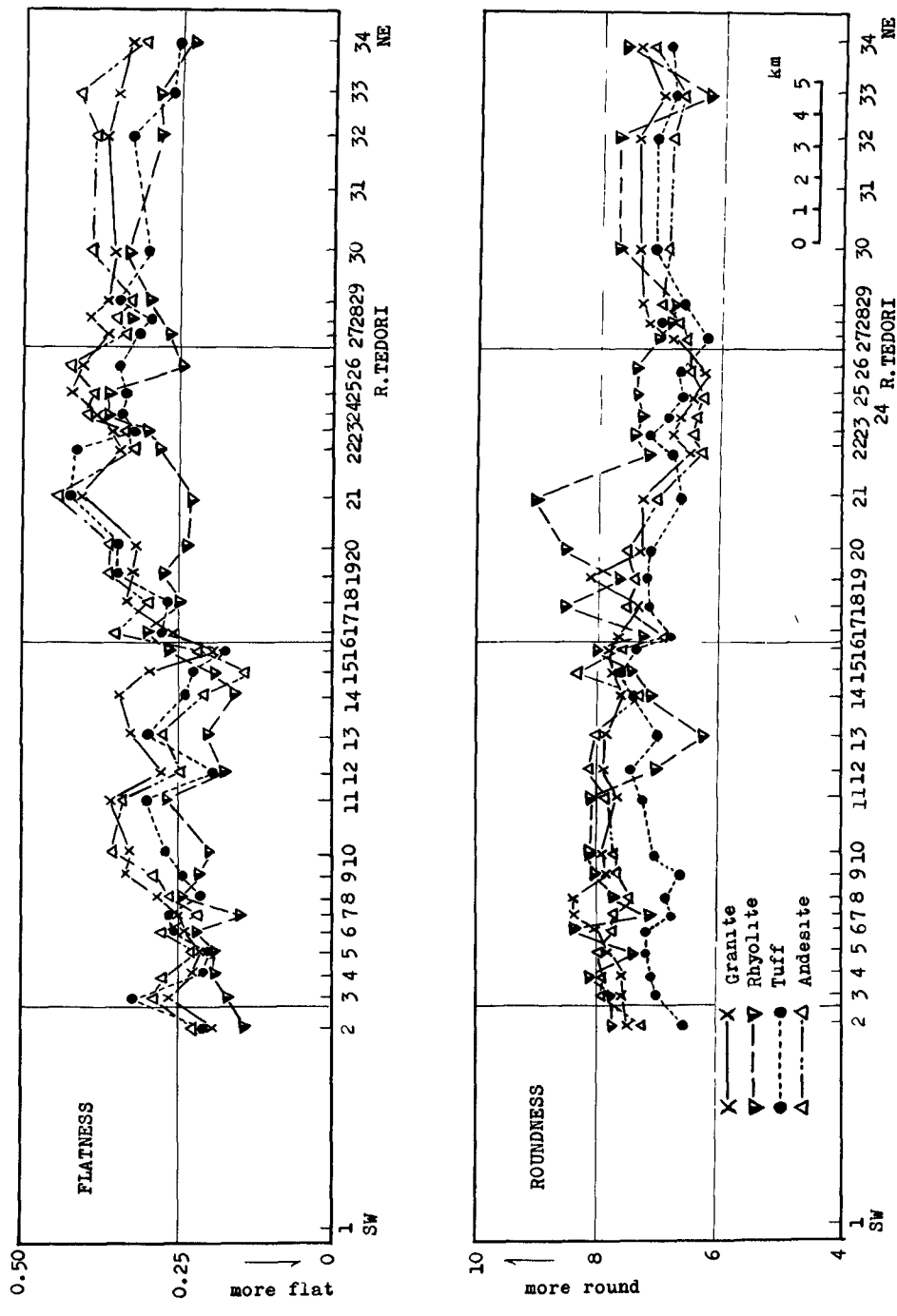

Fig. 6. Distribution of flatness and roundness of each pebble along the shoreline (Feb. 1963).

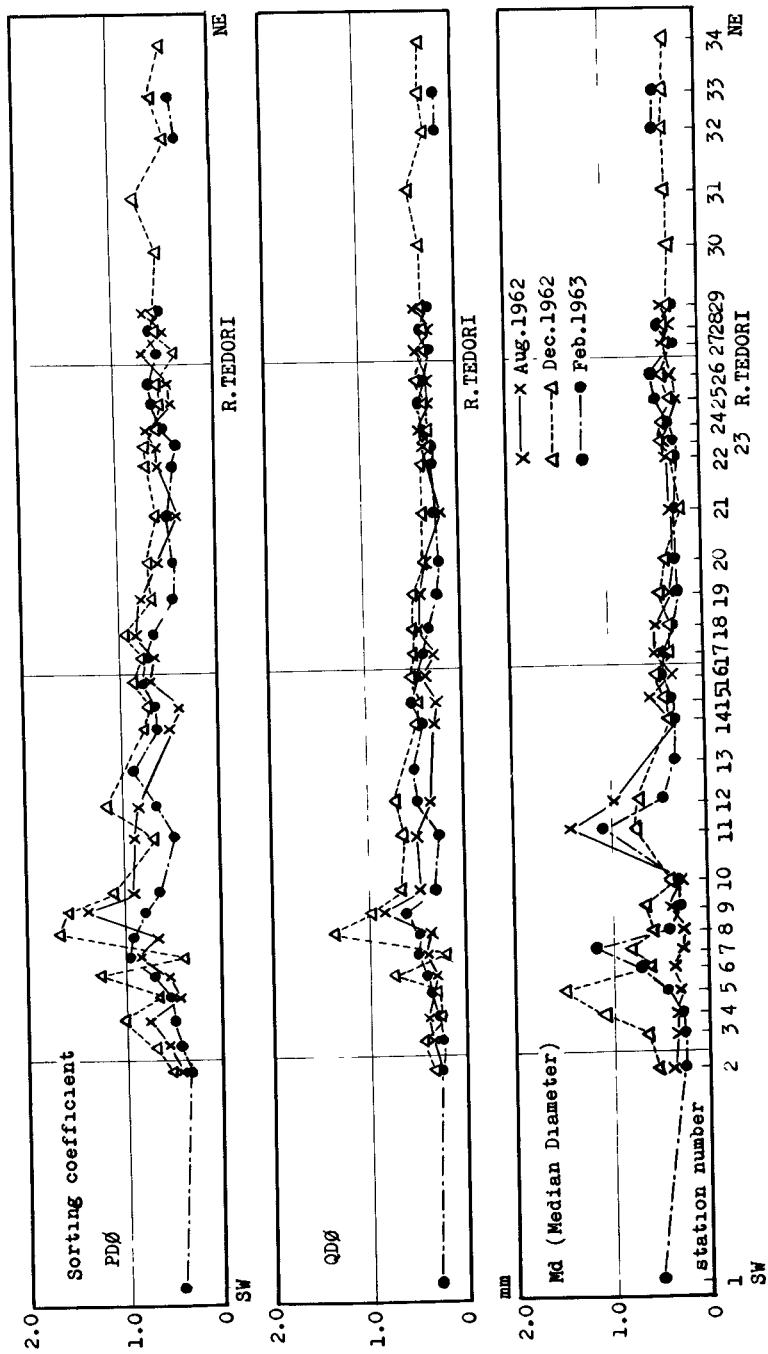

Fig. 7. Size distribution of beach sand along the shoreline.

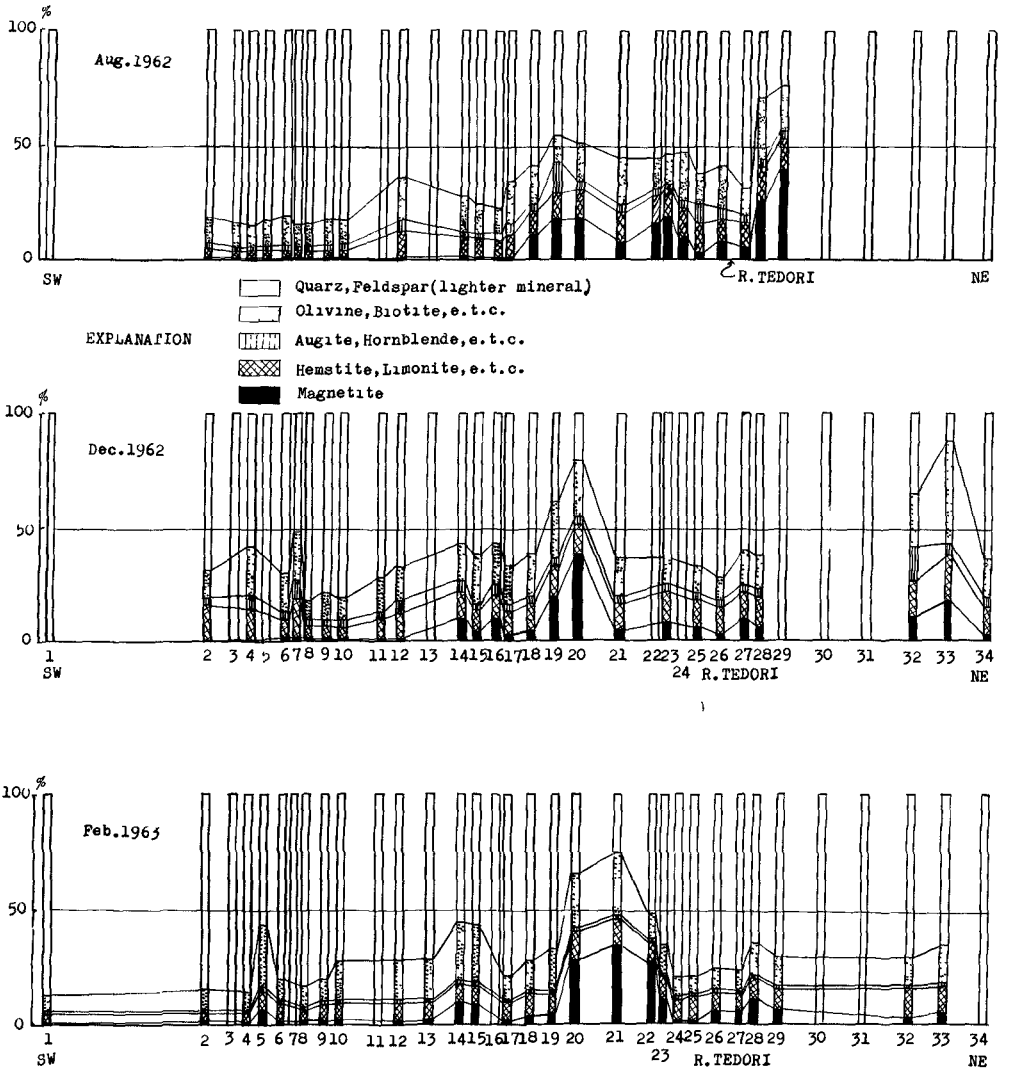

Fig. 8. Distribution of mineralogic composition of beach sand along the shoreline.

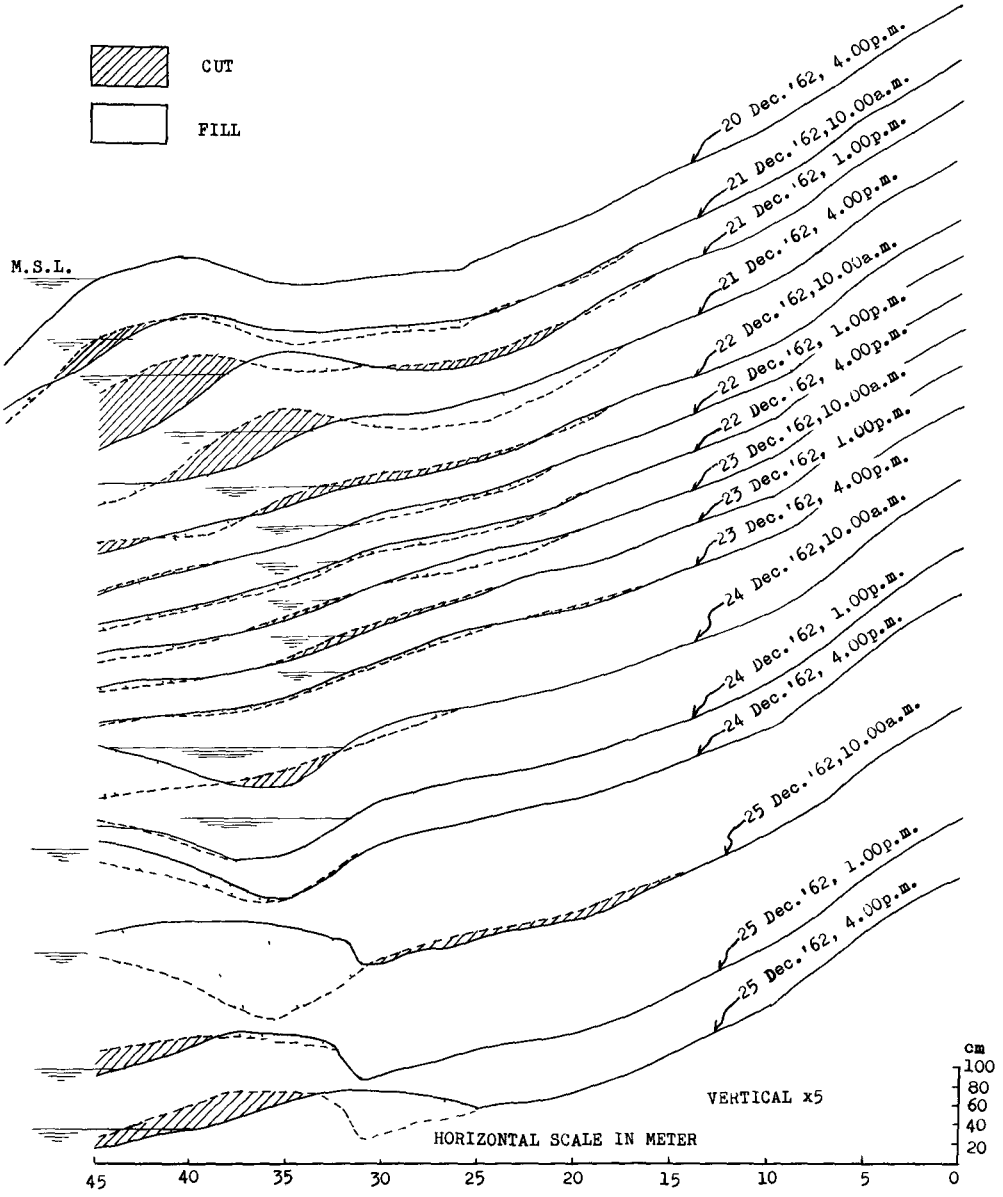

Fig. 9A. Cut and fill diagram of each profile (St. 5).

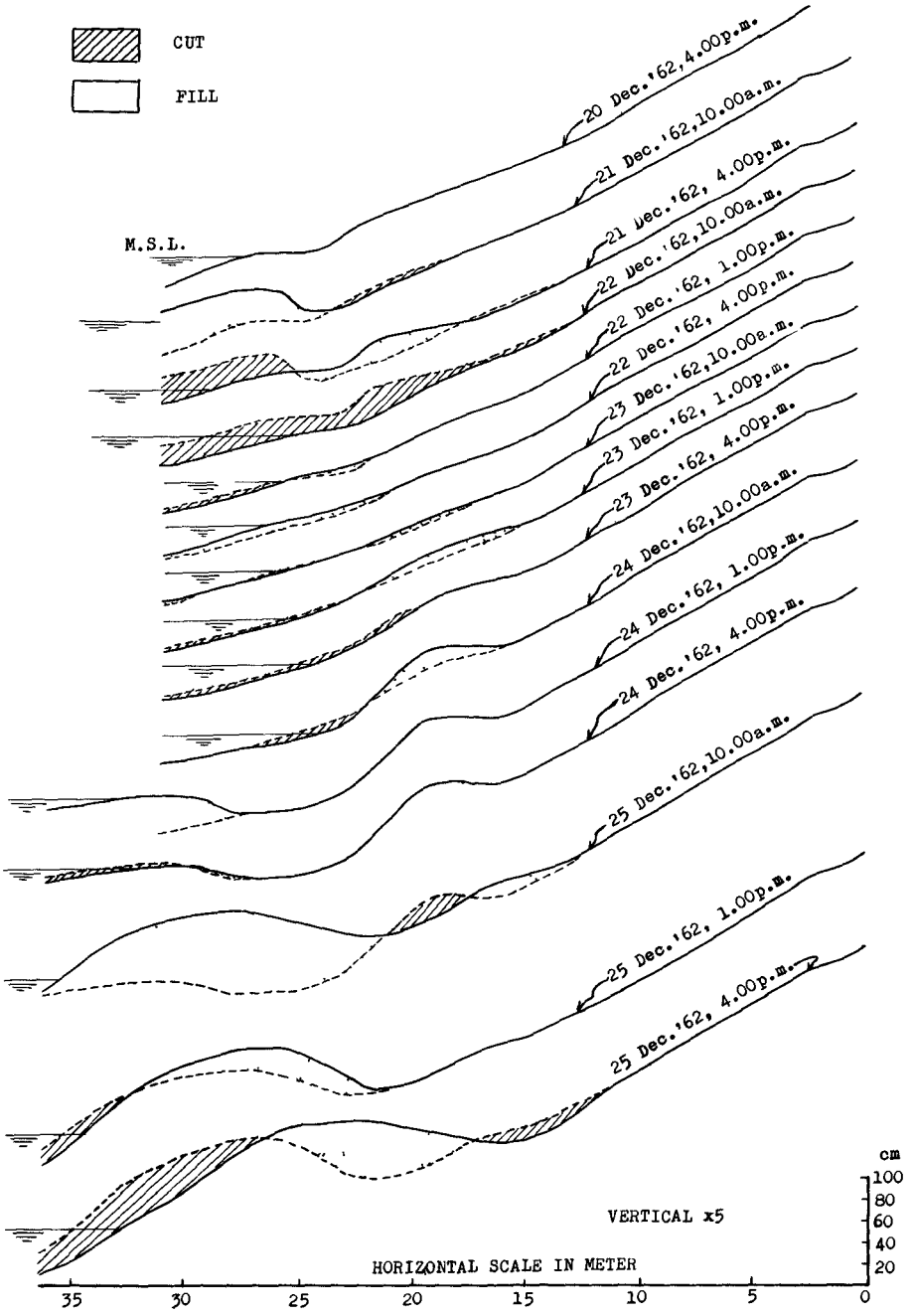

Fig. 9B. Cut and fill diagram of beach profile (St. 8).

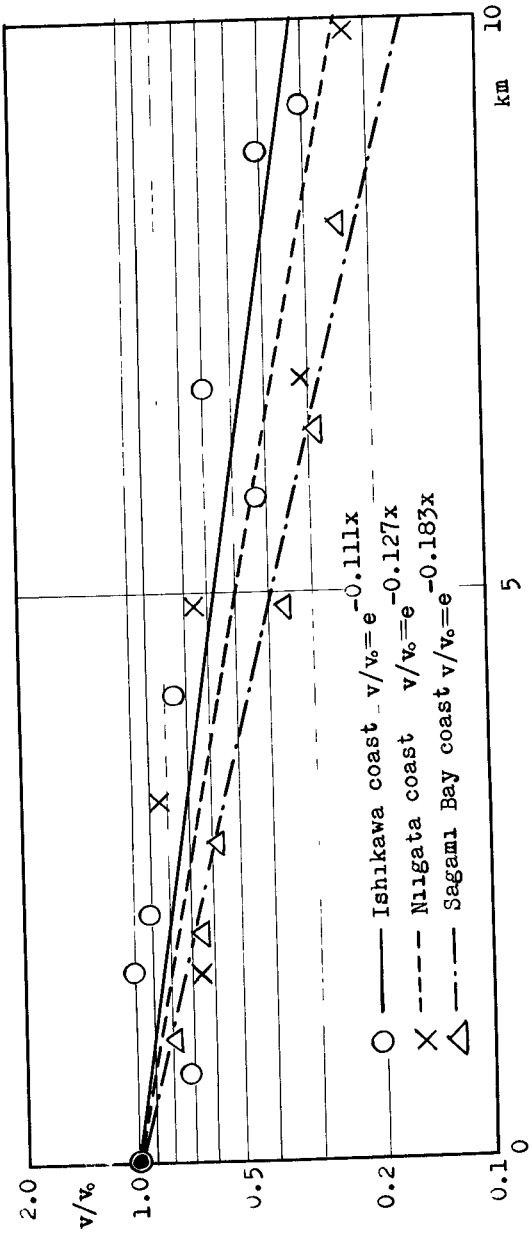

Fig. 10. Variation of (v/v_0) with the travelling distance (x) at Ishikawa, Niigata and Sagami Bay coasts.