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IV. SUBSTRATE STRUCTURE BY 3.5 KHZ SBP IN THE GH80–5 AREA

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Introduction

A subbottom profiling survey was carried out by a 3.5 kHz SBP all over the area in this cruise in order to clarify the structure of surface sediments and its implication in the occurrence of manganese nodules. The profiles in the detailed survey areas I and II were analyzed for the sharpness of water-sediment boundary, the type of sequence and the thickness of the uppermost transparent layer.

The sharpness of water-sediment boundary is divided into three grades, i.e. sharp, medium and obscure. These features correspond with those on the 12 kHz PDR records.

The acoustic sequence is divided into five types, i.e. A : upper transparent layer and lower opaque layer, B : upper transparent layer containing weak continuous reflectors and lower opaque layer, B′ : upper transparent layer containing disseminated uncontinuous reflectors and lower opaque layer, C : upper transparent layer of which lower part shows finely stratified structure and lower opaque layer, C′ : upper transparent layer of which lower part shows semi-opaque pattern and lower opaque layer, and D : wholly opaque layer (Fig. IV–1). Correspondence of the acoustic sequence by 3.5 kHz SBP and that by the seismic reflection survey system (Tamaki, Chap. V in this report) is not clear, especially for the types B, B′ and C′ mentioned above. The finely stratified structure in the type C is, however, definitely correlated to the "turbidite" sequence in the seismic reflection record. Besides, sedimentary structure which makes the weak continuous reflectors in the type B or the disseminated uncontinuous reflectors in the type B′ is still unknown.

The thickness of the uppermost transparent layer, which is calculated assuming the sound velocity of 1.5 km/sec., is less than 100 m in the detailed survey areas. In the areas of the acoustic sequence C or C′, the thickness estimated is for the upper layer containing stratified or semi-opaque lower part.

Outlined substrate structure in the detailed survey areas I and II, and its implication in the occurrence of manganese nodules are mentioned below.

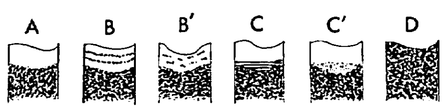

Fig. IV–1 Five types of acoustic sequence by 3.5 kHz SBP.

Substrate structure in the detailed survey area I

The water-sediment boundary is sharp or medium in the northern half of this area and mainly obscure in the southern half (Fig. IV–2). The acoustic sequence mainly of the types A, B or B′ are observed in the northern half, while the type B′ dominantly covers the southern half (Fig. IV–3). The thickness of the uppermost layer in this area does not exceed 50 m except a small portion in the midst of the area (Fig. IV–4). In the southern half, sea bottom topography rolls gently having relative height of about 30 m. The thickness of the uppermost layer changes rapidly in parallel with the rolling topography. Interrelation between the sharpness of water-sediment boundary and the types of acoustic sequence is not rigid. Vast distribution of the obscure water-sediment boundary in the southern half, however, matches with

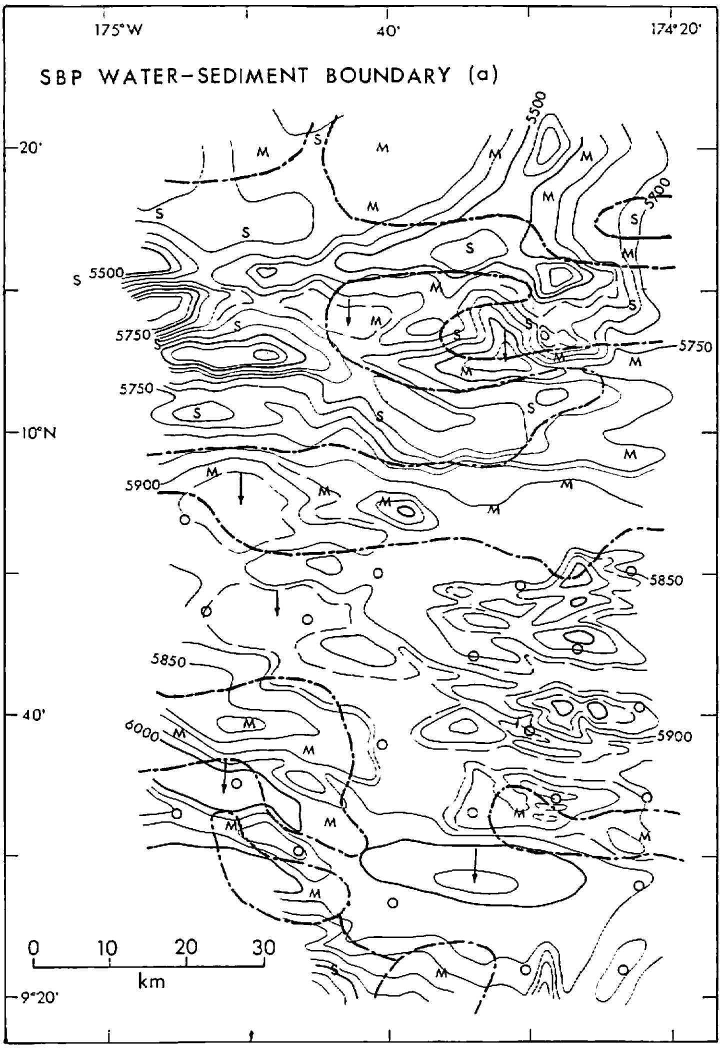

Fig. IV–2 Water-sediment boundary in the detailed survey area I.

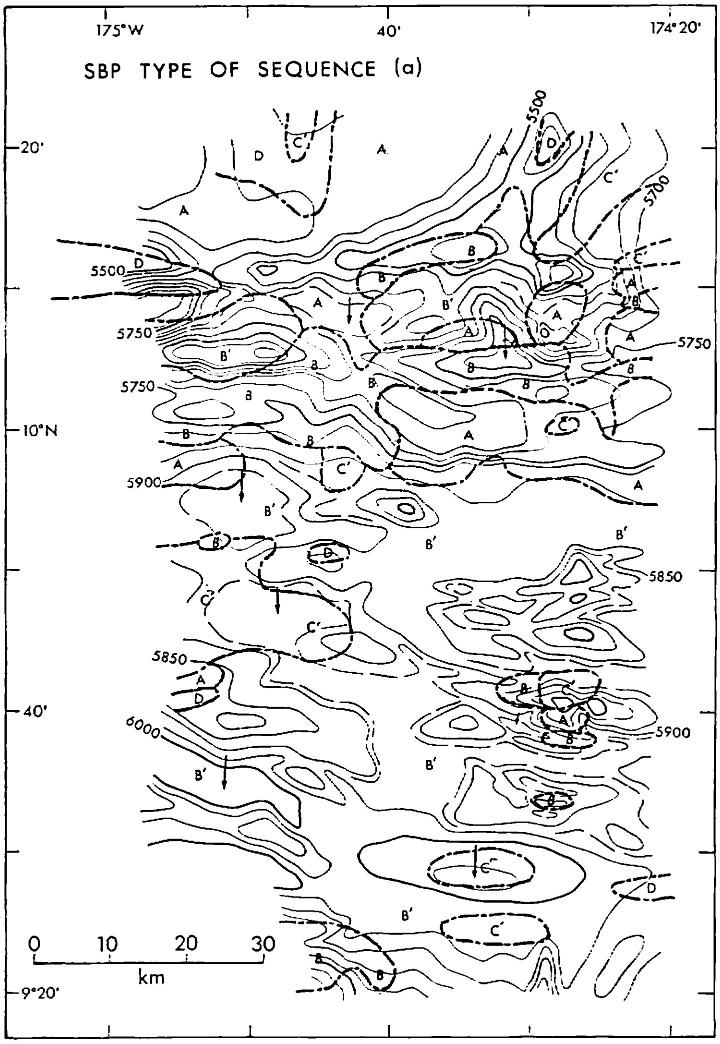

Fig. IV–3 Acoustic sequence by 3.5 kHz SBP in the detailed survey area I.

the distribution of B′ type of acoustic sequence. Besides the sharp water-sediment boundary appears often with A type of acoustic sequence, of which typical examples along two survey lines are shown in Usui and Nakao (this cruise report, Fig. IV–6).

Manganese nodules with rather smooth surface feature (s-type nodules) occur on the sea floor where the acoustic water-sediment boundary is sharp and the type of sequence is A, while the nodules with rough surface feature (r-type nodules) do being thinly covered by soft sediment in the area where the boundary is obscure and the type of sequence is largely B′. Sharpness of the water-sediment boundary must reflect the abundance of manganese nodules exposed on the sea floor.

Substrate structure in the detailed survey area II

Distribution pattern of the water-sediment boundary is divided into four zones in

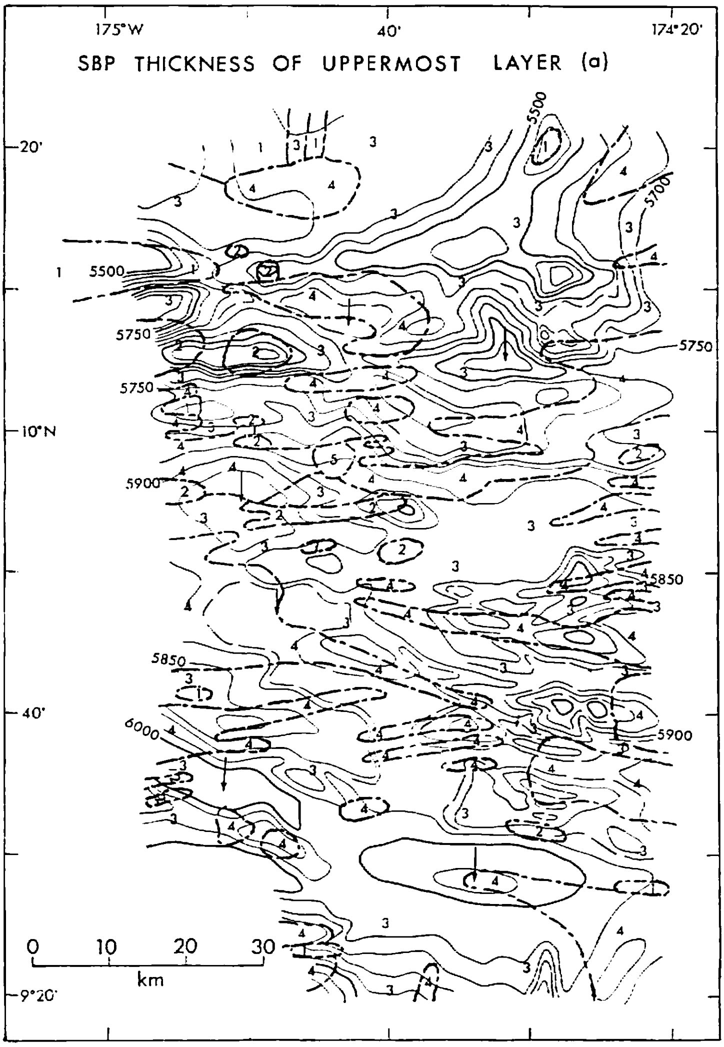

Fig. IV–4 Thickness of the uppermost layer by 3.5 kHz SBP in the detailed survey area I. The thickness is 1 : 0 m, 2 : traceable, 3 : less than 20 m, 4 : 20–50 m or 5 : 50–100 m.

this area (Fig. IV–5). They are (1) obscure zone, (2) sharp or medium zone, (3) obscure zone and (4) medium zone from northeast to southwest. The first zone covers Magellan Trough and its borderland, while the last zone is corresponding to the so-called turbidite area (TAMAKI, Chap. V of this cruise report). Zonal distribution is also outstanding for the acoustic sequence in this area (Fig. IV–6). Two zones covered by the obscure water-sediment boundary are almost corresponding to those covered by B′ type of acoustic sequence. In and around Magellan Trough, A or D type of the acoustic sequence dominates. Distribution of A type sequence is well corresponding to the distribution of medium sharpness of water-sediment boundary there.

As for the thickness of the uppermost layer (Fig. IV–7), it is usually less than

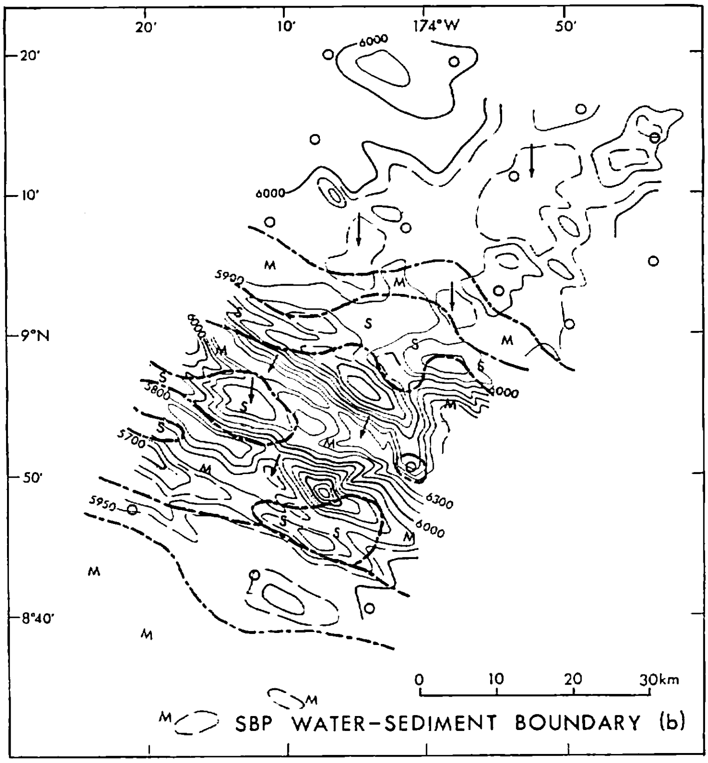

Fig. IV-5 Water-sediment boundary in the detailed survey area II.

50 m and rather uniform in spite of rolling topography and basement in the northern part of the area. Very thin (less than 20 m) transparent layer develops in and around Magellan Trough except on the ridges bordering the trough, where apparently no transparent layer is observed.

Rather thick uppermost layer (up to 100 m) in the southernmost part of the area shows the distribution of so-called turbidite sequence.

Interrelations among the surface feature of manganese nodules, sharpness of acoustic water-sediment boundary and the type of acoustic sequence described for the detailed survey area I are almost the same for this area. In the area covered by so-called turbidite sequence, however, the nodules are scarse in spite of medium sharpness of the water-sediment boundary. It is easy to understand that redistribution of sediment by turbidity current is unfavorable for the growing of nodules.

Discussion

It is obvious that the sharp water-sediment boundary on the 3.5 kHz SBP record implies intense reflection of the sound, which must be caused by exposed s-type manganese nodules of higher coverage.

As for the interelation between the thickness of the uppermost part on the 3.5 kHz SBP record and the nodule occurrence, MIZUNO (1981) described two

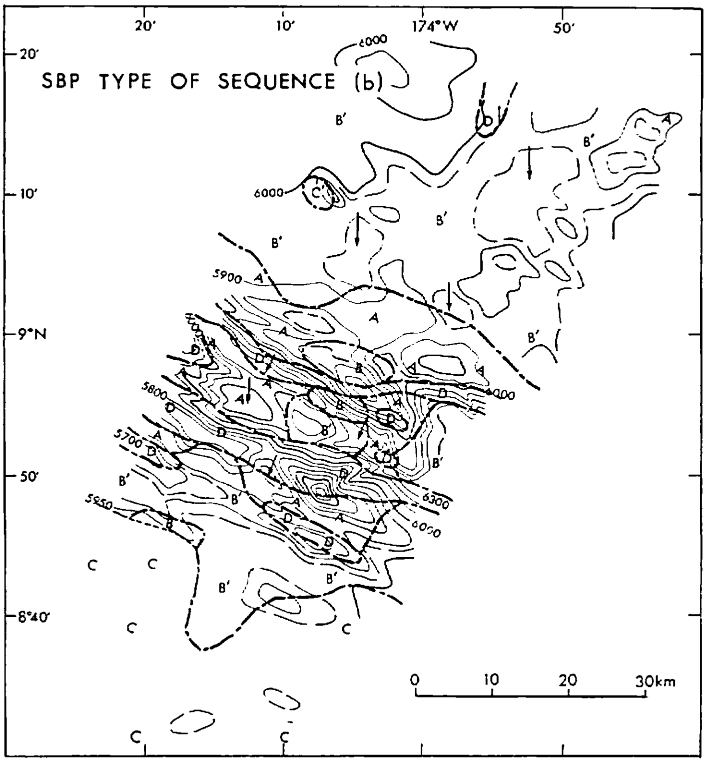

Fig. IV–6 Acoustic sequence by 3.5 kHz SBP in the detailed survey area II.

examples as follows.

Example 1. (in a deep-sea basin, around 10°N, 167°40'W):

The variability of manganese nodules in the area is well correlated to the distribution of the latest Pliocene to Quaternary sequence. The slower deposition of the sediment sequence is correlated with a lot of s-type nodule, whereas the faster deposition with a small amount of r-type nodule. Assuming that the nodule growth has been controlled by the sedimentation rate during the latest Pliocene and the Quaternary, the slower sedimentation less than 2 mm/1,000 y favored the growth of s-type nodules more than 8 kg/m^2, the sedimentation of 2 to 5 millimeters per 1,000 y favored the growth of r-type nodules, and the sedimentation more than 5 mm/1,000 y prevented the growth of nodule.

Example 2. (in a knoll area, around 5°N, 173°W):

The transparent layer of Unit I in the main part of the knoll is very poor, lack to less than 20 m thick, but it changes to very thick, up to 250 m in thickness toward the foot of the knoll.

The variability of the nodules is quite consistent with the thickness change of the transparent layer, and the r-type nodules occur in the sediments accompanied by thick transparent layer, whereas the s-type nodules occur in the area without or with very thin transparent layer. We have very scarce data about the age of the

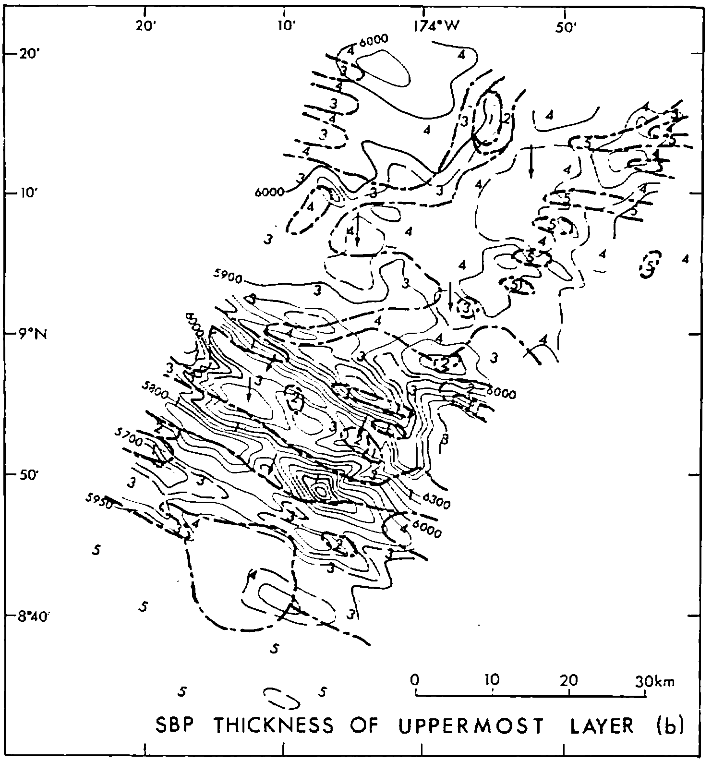

Fig. IV–7 Thickness of the uppermost layer by 3.5 kHz SBP in the detailed survey area II. The thickness is shown by the same numbers as those in Fig. IV–4.

transparent layer at the present time. However, the piston-core data obtained the GH79–1 main survey area suggest that the very thin transparent layer on the abyssal knoll is likely of the younger age, probably the latest Pliocene to the Quaternary, overlying the middle Eocene to Cretaceous sequence with a great hiatus.

In the case of the example 1, sedimentation rates of 2 mm/1,000 y and 5 mm/1,000 y can be converted into thickness of the layer, which deposited during the latest Pliocene and Quaternary (for two million years), of 4 m and 10 m respectively. Therefore, the critical thickness of transparent layer, which borders the area of the s-type nodules and the r-type nodules, is 4 m in a basin area or 20 m in a knoll area.

On the other hand, the pattern of variation of manganese nodule abundance and type varies being controlled by the topography without consistent relation with the thickness of uppermost transparent layer in the detailed survey area of this cruise (Usui and Nakao, Figs. IX–3 and –4, in this cruise report). Besides, Nishimura (Chap. VII of this cruise report) pointed out an example that the area with larger sedimentation rate of the upper lithologic unit (2–4 m/Ma) coincides the area with distribution of s-type nodules and the area with smaller sedimentation rate of the upper lithologic unit (smaller than 1 m/Ma) does the area with r-type nodules. Furthermore, according to Joshima (Chap. X of this cruise report) and Nishimura (Chap. VII of this cruise report), thickness of the sediment deposited during last 2 million years is fairly thinner than that of acoustic transparent layer on 3.5 kHz SBP record.

These facts suggest it is necessary to re-examine the interrelations among stratigraphy, acoustic sequence and nodule occurrence.

Reference

MIZUNO, A. (1981) Regional and local variabilities of manganese nodules in the Central Pacific Basin. Geol. Surv. Japan Cruise Rept., no. 15, p. 281–296.