XVII. RELATION BETWEEN MANGANESE NODULE DISTRIBUTION AND ACOUSTIC STRATIGRAPHY IN THE EASTERN HALF OF THE CENTRAL PACIFIC BASIN

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The relation between manganese nodule distribution and acoustic stratigraphy of substrates by seismic reflection and 3.5 kHz records is described here for both the GH76-1 and easterly adjoining GH74-5 areas. In the GH74-5 area, this relation has already been discussed, but this was only related to the 3.5 kHz records (MIZUNO *et al.*, 1975). In this area, the abundance of nodules at each sampling point depends on the thickness of the 3.5 kHz transparent layer. Where the transparent layer is more than 30 m thick nodules are poorly distributed with an abundance less than about 2 kg/m^2. A nodule abundance of more than 5 kg/m^2 occurs where the transparent layer is thinner, and an abundance of more than 20 kg/m^2 is restricted to those area where the transparent layer is between 10–20 m in thickness.

An examination of seismic reflection records, in addition to the 3.5 kHz records, provides a more precise picture of the relation between manganese nodule distribution and acoustic stratigraphy. The distribution is likely to be related to facies type of the seismic reflection Unit I throughout both areas.

The acoustic sequence, as deduced from the seismic reflection records, in the GH76-1 area is divided into three units, Unit I, Unit II, and acoustic basement, in descending order (TAMAKI, this report). Unit II consists of semi-opaque layers, associated with a strong reflector, probably a Middle Eocene to Oligocene chert bed at its uppermost part. The acoustic basement is probably Cretaceous basalt in most places.

Unit I is largely represented by a transparent layer, but it has three acoustic facies types. Type A is characterized by complete transparency of the whole of Unit I and is most widely distributed in the GH76-1 area and likely consists of oozy and clayey sediments in the southern and northwestern areas, respectively. Type B is interbeded with some reflective layers and is localized in the northeastern area. Type C is characterized by the development of coherent reflectors which are correlated with turbidite beds and an overlying thinner transparent layer. This type is distributed in the western abyssal plain district.

Three facies types of Unit I are also present in the eastern area adjoining the GH74-5 area. There, Type A extends to the south-central part (around the 168°W line) from the GH76-1 area; Type B is widely distributed in the northern part; and Type C is also widely distributed in the eastern part which, to the west, adjoins the Christmas Ridge. The distribution of the types throughout both areas is shown in Fig. XVII-1, together with the thickness distribution of Unit I which decreases towards the north and northwest from more than 200 m to less than 50 m.

The 3.5 kHz substrate sequence in the GH76-1 area, which consists of transparent and underlying opaque layers, is divided into four Types, *a*, *b*, *c*, and *d* (MIZUNO and

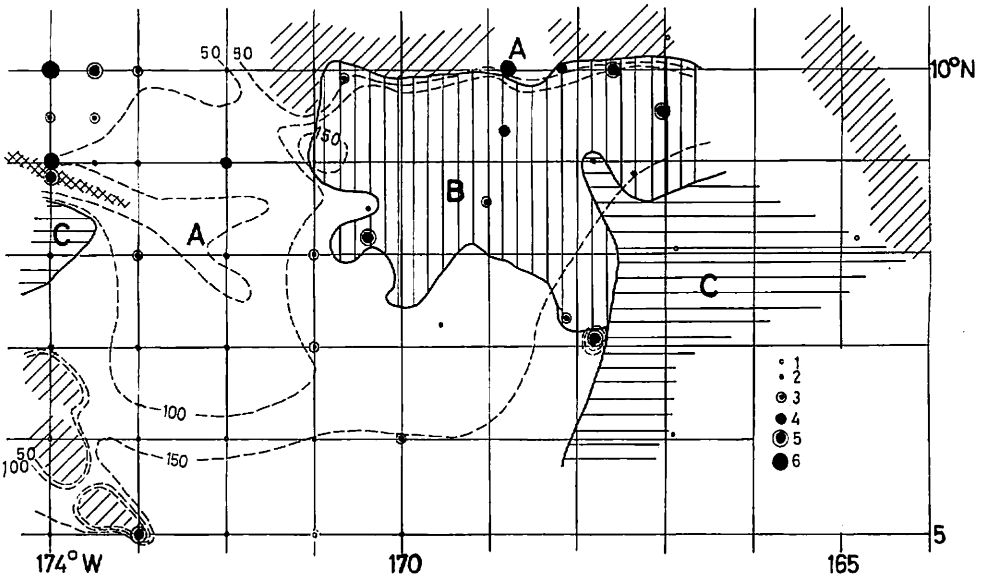

Fig. XVII-1 Distribution of three types of Unit I and manganese nodule abundance in the GH76-1 and GH74-5 areas.

Distribution of types: vertical hatch, Type B. horizontal hatch, Type C. unhatched, Type A.

Nodule abundance (in kg/m^2): 1, not present. 2, less than 1. 3, 1-5. 4, 5-10. 5, 10-20. 6, 20-30.

Others: Oblique hatch and crossed hatch show the areas of seamounts and the GH76-1 Trough, respectively. The broken line gives the isopach map of Unit I in meters.

Tamaki, in this report). Types *a*, *b*, and *c* are roughly correlated with the seismic reflection Types A, B, and C of Unit I, respectively, although the acoustic nature is different in most cases. The transparent layer of Type *a* is thinner than that of Type A and may represent ooze and/or clay above a chert bed in the lower part of A (Tamaki, in this report). The transparent layer of Types *b* and *c* also does not represent the whole sequence of Types B and C, but only that of the uppermost transparent layer of the types: the reflective part and turbidite layer of the types are recorded as the opaque layer in the 3.5 kHz types in most cases.

Fig. XVII-2 shows the correlation between manganese nodule abundance and thickness of the transparent layer in the 3.5 kHz and seismic reflection records. The occurrence of nodules in relation to the seismic reflection types of Unit I is superposed on Fig. XVII-1. Both the figures have the same characteristic features.

With respect to the areal distribution of Type A of Unit I, a definite relation is present between nodule abundance and the thickness of Unit I and the 3.5 kHz transparent layer. Manganese nodules are very few where Unit I is over 120 m thick and where the 3.5 kHz transparent layer is more than 100 m thick. Also, the nodules are less than 2 kg/m^2 in the 3.5 kHz transparent layer with a thickness of over 45 m and less than 100 m thick. Manganese nodules more than 10 kg/m^2 are restricted to areas where Unit

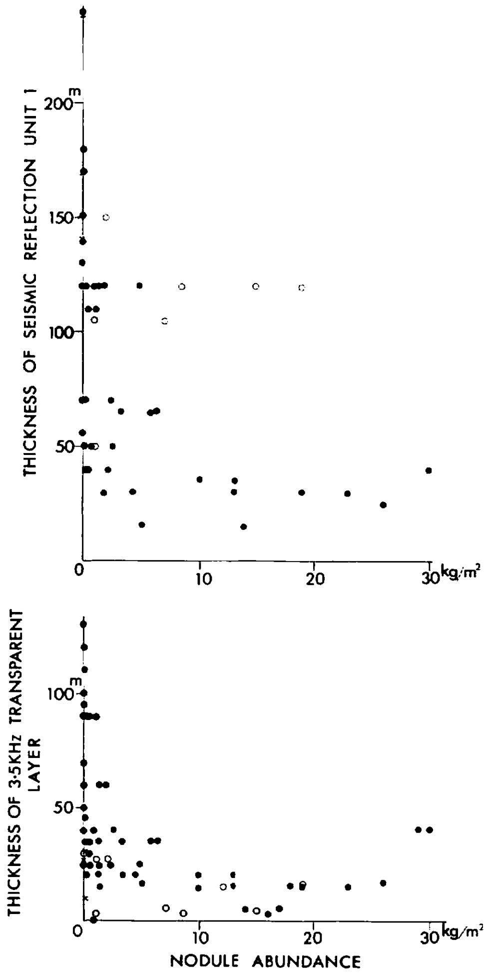

Fig. XVII-2 Correlation between manganese nodule abundance and thickness of acoustic layer at each sampling station. Upper and lower figures indicate the thickness of Unit I in the continuous seismic reflection record and that of the transparent layer in the 3.5 kHz record, respectively. Solid and open circles indicate seismic reflection, Type A and Type B, respectively, and the cross indicates Type C.

I and 3.5 kHz transparent layer are less than 50 m thick, although a few nodules occur in some places.

It is apparent from the figures that manganese nodules with an abundance more than 20 kg/m^2 are restricted to the substrate of Type A.

A typical example on a single survey line is demonstrated by the relation on the line of Sts. 414–415. As shown in Fig. VII-8b, both transparent layers of 3.5 kHz and seismic reflection records are poorly developed at St. 414 where the maximum manganese nodules concentration is 17 kg/m^2. The transparent layers abruptly increase in thickness to about 0.5 sec (in 3.5 kHz and seismic records; in two-way reflection time) or more.

The thick transparent layer continues eastwards toward St. 415 where no manganese nodules were collected.

Despite the general tendency of increasing nodule abundance and decreasing thickness of the transparent layer, some anomalous relations are also found in some places.

Along the line Sts. 407–433–408, the seismic reflection transparent layer is almost uniformly developed with a thickness of between 30 to 40 m (Fig. VII-9) and the 3.5 kHz layer has a thickness of 40–20–15 m at the respective stations. The nodule distribution varies irregularly in abundance of 29–30, 2–4, and 20–23 kg/m^2, at these stations (Table I-5).

An interesting example is given by the relation between nodule abundance and thickness of the 3.5 kHz transparent layer from just east of St. 407 towards east-northeast.

Over a limited area including St. 407 with the extent of 17 km (west-east) and 4 km (north-south), the nodule abundance and the transparent layer thickness have a somewhat irregular relation (Fig. XVII-3). As indicated in Table XVII-1, three groups of relationship are found. One is a large nodule abundance of 29–30 kg/m^2 related to the 40 m thick layer at St. 407. This disappears within a short distance towards the east and northeast. The second is the abundance of 0.8 kg/m^2 related to an 0 m layer related to the flank of an abyssal hill (FG32-1). The third is the abundance of 0.3–1.3 kg/m^2 and 18 kg/m^2 associated with a 15–35 m thick layer on the deep sea flat bottom (FG32-2—8). This group suggests a rough relationship of increasing abundance and decreasing transparent layer thickness, although different from the general relationship described before.

The base of seismic transparent layer of the Type A sequence is assigned to Middle Eocene-Oligocene age, and the change of thickness of the transparent layer might be related to the rate of sedimentation since that time. The difference of sedimentary rate might explain the general relationship that the transparent layer of Type A over 45–50 m yields no significant amounts of nodules and that large amounts of nodules occur in the thinner transparent layer. However, the anomalous relations cited above,

Table XVII-1 Nodule abundance and thickness of transparent layer on the 3.5 kHz records in the environs of Sts. 407 and 407A2.

I. depth (m). II. abundance of nodules (kg/m^2). III. transparent layer thickness (m).

Station		I	II	III
St. 407	G171	5,910	30	40
	FG5–1	5,910	29	40
	FG5–2	5,920	29	40
St. 407A	FG32–1	5,800	0.8	0
	FG32–2	5,930	18	15
	FG32–3	5,930	1.2	20
	FG32–4	5,940	0.3	30
	FG32–5	5,920	0.5	35
	FG32–6	5,900	0.3	35
	FG32–7	5,910	1.3	35
	FG32–8	5,980	1.3	25

and more generally speaking, the fact that the thinner transparent layer also yields little nodules in some places, indicates that this cannot be used as a general explanation. Other controlling factors may also effected the quantitative distribution of nodules and have to be elucidated in the future.

In areas where the Type B sequence occurs the situation is very different from that of Type A. Manganese nodules occur either abundantly or less abundantly at each sampling point, with a maximum abundance of about 19 kg/m^2. Unit I attains a thickness of 100–150 m and this is not related to nodule abundance. However, the uppermost transparent layer of the 3.5 kHz records shows some relationships to nodule abundance. As indicated in Fig. XVII-2 (lower figure), the layer more than about 30 m thick yields very little nodules, while the layer of less thickness contains abundant nodules, although in places nodules are sparse. A general explanation of this is not yet clear, but the rate of sedimentation of the 3.5 kHz uppermost transparent layer may be important although its age is still problematic.

Manganese nodules are absent or sparse in the area of the Type C sequence which is developed on the abyssal plains in the western and eastern parts of the GH76-1–GH74-5 areas, and have no apparent relationship with the thickness of Unit I and the 3.5 kHz transparent layer. This may be related to turbidite deposition during Middle Eocene-Late Oligocene which could have prevented nodule growth. Also nodules may not have grown during Neogene-Quaternary when the uppermost transparent layer was accumulating. Lack of nodule growth during Neogene-Quaternary times, might have been related to the sedimentary environment of abyssal plain formation succeeding the turbidite deposition. At present no conclusion can be drawn about this problem.

In summary, the abundance of manganese nodules at each sampling point is related to the three facies types of seismic reflection Unit A in different ways. The sedimentary rate and/or type of sedimentation during Middle Eocene-Quaternary might have contributed in part to these relations, although other factors may have influenced nodule growth. Thus, the genetic relation between nodule formation, sedimentary process, and environment remains unsolved in the present phase of study. However, the relationship empirically deduced from the GH76-1 and GH74-5 cruises will serve to give a preliminary estimation in the survey area without sampling or optical data on manganese nodules and only with acoustic observations in the Central Pacific Basin. It is suggested that both seismic reflection and 3.5 kHz records is both useful and desirable for the estimation.

Reference

MIZUNO, A., ARITA, M., HONZA, E., KINOSHITA, Y., MARUYAMA, S., NOHARA, M., SAWADA, K., and TAMAKI, K. (1975) Preliminary conclusion on sedimentology and manganese deposits. *in* MIZUNO, A. and CHUJO, J. (*eds.*), *Geol. Surv. Japan Cruise Rept.*, no. 4, p. 89–94.