

## Effect of Sediment-Water Interface 'Boundary layer' on Exposure of Nodules and their Abundance : A study from seabed photos

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### Abstract

The results obtained from seabed photos and boomerang grab samples reveal a striking similarity in distribution patterns of size classes of polymetallic nodules. Due to partial sediment cover, there is a 'fractionation' effect on nodules, which affects nodule abundance estimates based on photos. A model showing variable burial (or exposure) depending upon the thickness of the Sediment-Water Interface Boundary (SWIB) layer is presented. Standard relationships can be established between nodule burial and SWIB thickness.

### INTRODUCTION

With the continuing development of seabed photography as a tool for exploration of nodules, higher efficiency of this technique over most other sampling devices has been established (Anonymous, 1979; 1982). This technique is preferred due to the large area it covers than other samplers (Fig. 1) and lesser chances of mechanical failure or missing a nodule. Moreover, it is much faster and more economical.

Various studies have been carried out on nodule distribution, coverage and abundance estimation from seabed photos and comparison with grab samples (Ewing *et al.* 1971; Frazer *et al.* 1978; Fewkes *et al.* 1979; Felix, 1980). They have emphasised the need for a correction factor for photo estimates to account for burial of nodules under the upper soft, fluffy sediment layer or the sediment-water interface boundary (SWIB) layer (Menard, 1964; Cronan and Tooms, 1967; Sorem and Fewkes, 1979).

The present study deals with exploration of nodules in the Indian Ocean, using photo-boomerang grabs and comparison of the abundance data with that of the grab samples in order to work out certain relationship between nodule burial and SWIB layer, which can be used for calculation of nodule abundance from seabed photos without actually collecting the nodules.

### METHODS AND APPROACH

The data used in this study was collected during the fourth cruise of *MV Farnella* from 12 operations of photo-boomerang grabs (Table I). Nodules in grab and photos at each location were classified in different sizes: 0-2 and 2-4 cm as small; 4-6 cm as medium, and 6-8 and 8-10 cm as large.

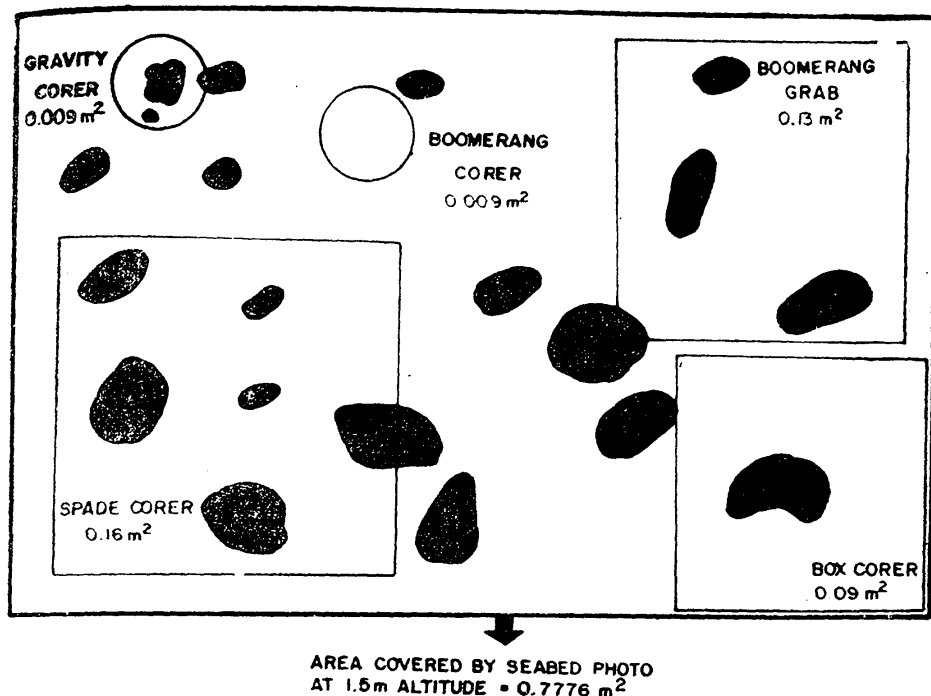


Figure 1. Area covered by samplers and seabed photographs, with patchy distribution of nodules on seafloor.

The coverage ( $C$ ) of nodules was calculated as

$$C = \frac{a_n}{a_p} \times 100 \quad \dots \quad (1)$$

where  $a_n$  = area of the nodules in the photograph

and  $a_p$  = total area of the photograph.

Nodule abundance from photos ( $A_p$ ) was calculated as (Handa and Tsurusaki, 1981).

$$A_p = 7.7 \times D \times C / 100 \quad \dots \quad (2)$$

where  $D$  = average nodule diameter (cm).

Nodule abundance from grab ( $A_g$ ) is

$$A_g = S / 0.13$$

where  $S$  = sample recovered

0.13 = area of the grab, ( $m^2$ ).

$$\text{Relative abundance (RA)} = A_p / A_g \times 100 \quad \dots \quad (3)$$

## RESULTS

### Comparison of size classes

There appears to be a striking similarity in the distribution patterns of various nodule sizes (Table II) except for a marginal difference in the frequency (%) distribution of the smallest size class (0-2 cm) when compared in photos (32.3%) and

TABLE I. Results of seabed photography and grab operations for Nodules in the Central Indian Ocean Basin.

Sl. No.	Station No.	Sampler Used	Water Depth (m)	Camera Adjustments			Area Covered		Abundance Recorded		Relative percentage of abundance in photo wrt. grab (%)
				Film used Col/B & W	Lens Aper.	Cnt. lengths (m)	By Photo-graph (cm × cm)	By Nodules (%)	Photo (kg/m <sup>2</sup> )	Grab (kg/m <sup>2</sup> )	
1.	3250	PBG *	5220	Colour	5.6	1.0	47 × 71	<1	0.10	2.30	4.0
2.	3252	"	5160	"	2.8	2.0	95 × 142	16.22	5.24	15.40	34.0
3.	3256	"	5105	"	5.6	1.0	47 × 71	—	—	1.92	—
4.	3257	"	5100	"	5.6	1.0	47 × 71	<1	0.10	1.92	5.0
5.	3269	"	5100	"	4.0	1.5	72 × 108	1.77	0.37	0.60	61.6
6.	3279	"	5250	"	4.0	1.5	72 × 108	1.77	0.45	5.00	9.0
7.	3282	"	5230	B & W	5.6	1.5	72 × 108	1.42	0.34	8.46	4.0
8.	3289	"	5030	"	5.6	1.5	72 × 108	1.93	0.80	1.15	69.5
9.	3293	"	5200	"	5.6	1.5	72 × 103	18.26	5.06	14.62	34.6
10.	3294	"	5020	Colour	5.6	1.0	47 × 71	17.70	5.00	11.54	42.6
11.	3302	"	5220	B & W	5.6	1.5	72 × 108	17.16	5.97	6.92	86.2
12.	3304	"	5290	"	5.6	1.5	72 × 108	38.80	10.77	9.62	112.0

\* PBG - Photo-boomerang Grab

TABLE II Comparison of size classes of Nodules in photographs and grabs

Sr. No.	Station No.	Size classification of Nodules										Total	
		0-2 Cm		2-4 Cm		4-6 Cm		6-8 Cm		8-10 Cm		P	G
		P	G	P	G	P	G	P	G	P	G		
1.	3250	—	—	—	2	1	4	—	—	—	—	1	6
2.	3252	78	57	80	81	28	28	2	2	—	—	188	168
3.	3256	—	5	—	16	—	—	—	—	—	—	—	21
4.	3257	—	14	—	12	1	1	—	—	—	—	1	27
5.	3269	7	2	17	22	6	6	—	—	—	—	30	30
6.	3279	5	30	27	27	5	5	1	1	—	—	38	63
7.	3282	—	3	—	16	10	10	1	1	—	—	11	30
8.	3289	—	44	10	17	—	—	—	—	—	—	10	61
9.	3293	34	22	48	45	16	10	3	3	1	1	102	87
10.	3294	10	10	28	31	12	16	3	2	—	—	53	53
11.	3302	20	12	32	11	8	8	—	—	—	—	60	31
12.	3304	34	19	42	36	8	8	2	2	1	1	87	66
Total		188	218	284	316	95	96	12	11	2	2	581	643
Freq. (%)		32.35	34.30	49	49	16.3	15	2	1.7	0.35	0.31	100.05	100.01

Abbreviations :- P-Photo, G-Grab.

grabs (34%). This can be due to burial (or non-exposure) of small nodules under SWIB layer (Felix, 1980).

#### Sediment cover and nodule exposure

Varying thickness of SWIB layer can be observed from the total or partial burial of the camera counterweight in the photographs. Stations having smaller nodules, show none exposed in photos, in case of thick SWIB layer (station nos. 3250, 3256, 3257, 3282) as against those photos with comparatively thin SWIB layer (station nos. 3279, 3289).

In some cases, the number of nodules of smallest size class as seen in photos is larger than those from grab, due to the 'fractionation' effect of thin cover of sediment on the nodules which 'divides' the nodules in more than one part when seen in the photograph, hence giving a 'feeling' of larger number of nodules of the smaller size class (Fig. 2).

#### Nodule abundance and coverage

Distribution of nodule abundance (Table III) shows that the estimates from photos are lower than that of grabs. Due to sediment cover, average diameter of

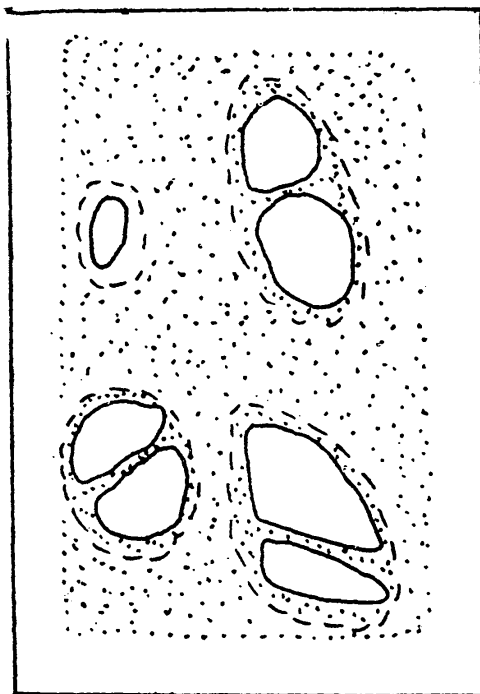


Figure 2. 'Fractionation' effect on nodules due to thin sediment cover. Dotted lines show actual nodule boundary, continuous lines show exposed parts of nodule.

TABLE III.  
Distribution of abundance values of Nodules in photos and grabs.

Abundance (kg/m) <sup>2</sup>	Photo			Grab		
	Freq.	Freq. (%)	Cumm. Freq.	Freq.	Freq. (%)	Cumm. Freq.
0.00	1	8.33	8.33	0	0.00	0.00
>5.00	7	58.33	66.66	6	50.00	50.00
5.00-10.00	3	25.00	91.66	3	25.00	75.00
10.00-15.00	1	8.33	99.99	2	16.66	91.66
15.00-20.00	0	0.00	0.00	1	8.33	99.99
	12			12		

nodule quite small as a result of fractionation effect or burial of nodules, whereas grab penetrates into these sediments, collecting the buried nodules.

Nodule coverage has no direct bearing on abundance, because abundance also depends on the size (and shape) of nodules (Felix, 1980) and thickness of the SWIB layer (Sorem and Fewkes, 1979).

### SWIB layer and abundance estimates

Wherever the SWIB layer is thin, there is a high relative percentage of agreement (RA > 60%) because more number of nodules are exposed, and in case of thick SWIB layer, there is a low percentage of agreement (RA < 10%) and the intermediate thickness shows RA = 30-50% (Table IV).

TABLE IV.  
Relationships of various parameters studied on Nodules in Central Indian Ocean Basin.

Sl. No.	Stn. No.	Cnt. Wt. Penetration	SWIB layer thickness	Comparison of size classes	Relat. %age of abund. in photo wrt. grab.
1.	2250	Complete	Thick	Only 1 of medium size is exposed, others buried	4.0%
2.	3252	Intermediate	Intermediate	Almost all nodules are exposed	34.0%
3.	3256	Complete	Thick	All nodules totally buried	—
4.	3257	Complete	Thick	Only 1 of medium size is exposed, smaller buried	5.0%
5.	3269	Partial	Thin	All nodules seem to be exposed	61.6%
6.	3279	Complete	Thick	Small size nodules are buried	9.0%
7.	3282	Complete	Thick	Only medium and large nodules exposed, smaller ones buried	4.0%
8.	3289	Thin	Intermediate	Many of 2-4 cm class exposed, only smallest size buried	69.5%
9.	3293	Intermediate	Intermediate	Almost all nodules seem to be exposed	34.6%
10.	3294	Intermediate	Intermediate	Almost all nodules exposed	42.6%
11.	3302	Partial	Thin	Many nodules exposed	86.3%
12.	3304	Partial	Thin	Many nodules exposed	112.0%

## DISCUSSION

### Effect of SWIB on nodule exposure

A hypothetical model (Table V) can be prepared to show variable burial of nodules depending upon their size and thickness of the SWIB, taking into consideration that (i) the Sediment-Water Interface Boundary thickness extends up to about 10 cm (Sorem and Fewkes, 1979; Felix, 1980), and (ii) the nodule sizes generally range from < 1 to about 10 cm along their longer axis. Since, nodules are assumed to be spherical, whereas in practice they are shorter along the vertical axis, more so

TABLE V. A model showing variable burial of nodules under varying thickness of SWIB layer.

Sediment (SWIB) layer	Size Classes (cm)					
	0-2	2-4	4-6	6-8	8-10	>10
Very thin (~ 1 cm)	Partly		Fully exposed			
Thin (~ 3 cm)	Not exposed	Partly exposed	Fully exposed			
Inter-mediate (~ 5 cm)	Not exposed		Partly exposed	Fully exposed		
Thick (~ 7 cm)	Not exposed		Partly exposed	Fully exposed		
Very thick (~ 9 cm)	Not exposed		Partly exposed	Fully exposed		
Extremely thick (> 10 cm)	Not exposed					

for larger nodules (Frazer *et al.* 1978), there are chances of more nodules being buried under actual conditions.

#### Effect of SWIB layer on Abundance Estimates from Photos

The Lesser the thickness based on photographs of SWIB layer, more accurate are the estimates (Table VI). No single correction factor can be applied to all samples.

TABLE VI Relation of SWIB thickness to Relative Abundance for nodules

SWIB layer	Relative Abundance (RA) (Accuracy)
Very thick (> 8 cm)	< 20%
Thick (6-8 cm)	20-40%
Intermediate (4-6 cm)	40-60%
Thin (2-4 cm)	60-80%
Very thin (0-2 cm)	> 80%

A number of standard relationships have, therefore, to be established for different seabed conditions, i.e., thickness of SWIB, diameter and coverage of nodules from photos and abundance from grabs.

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