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Bottom Topography and Sediments in the Area Northwest of Borneo Island

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Keywords : Topography, Sediments, Median diameter (Md ϕ), Sorting (So), Skewness (Sk), Bottom current

Abstract

In 1987, T. S. Kagoshima-Maru of the Faculty of Fisheries, Kagoshima University and the University Pertanian Malaysia were engaged in the cooperative survey on the fish resources in the area northwest of Borneo Island. The writers were in charge of surveying bottom topography, sediments and bottom current. The following results were obtained.

1) Continental shelf margin is 175 - 200m in depth. Continental slope is rather gentle in the western one-thirds of the surveyed area, and rapidly changes into the slope with higher angle eastwards.

2) The bottom sediments of this area are mostly of very fine-grained sands. Their median diameter (Md ϕ) is ranging from 2.46 to 3.68.

3) Sorting Coefficient (So) ranges from 0.605 to 1.635. This means well-sorted and rather homogeneous sediments.

4) Skewnesses (Sk) of the most samples are plus value, indicating that the grain size composition of the sediments is, as a whole, biassed toward fine grain sizes.

5) Bottom current velocity is generally low, and its direction is unsteady.

The South China Sea, a marginal sea of the pacific, is surrounded by the Philippine Islands in the east, Borneo and Java Islands in the south and the Chinese Continent, Vietnam and the Malay Peninsula from north to west.

The deep sea bottom encircled by 3000m contour in the South China Sea stretches not in the central part but a little to the east of it, namely, on the Philippine Islands side. The South China Sea is distorted rhomic in outline, and its long axis extends from Bashi Channel southwestward to the southeast of Vietnam (10°N, 110°E), while its short axis extends in the northwest-southeast direction, namely, from off the southeast coast of Hainan Island to Mindoro Strait. The areas of the deepest bottom (5000m - 5200m) are recognized to exist sporadically between Mindoro Strait and westward offshore of Luzon Island. Most part of the South China Sea is represented by the depth of the 4000m level. In the area ranging from west of Palawan Island to the offshore of the west coast of Borneo

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Island, unsurveyed coral reef area including Reed Bank is widely developed. From the offshore of Palawan Island to that of the west coast of Borneo Island, the Palawan Trough extends in the northeast-southwest direction showing the deepest bottom (3000m level) at its central part. Continental shelf is developed off South China and in the area surrounding Hainan Island. To the south, vast Sunda Shelf is developed. Westward offshore of Luzon, Palawan and northern half of Borneo Islands, rather narrow continental shelf is developed showing rapid change in depth from shoreline to the deep sea bottom. The bottom topography and sediments of the South China Sea has been comparatively well-studied in the nearshore areas. On the contrary, the central area, such as the westward offshore of Palawan and Borneo Islands where many reefs and banks are distributed, is not studied enough (Fig. 1).

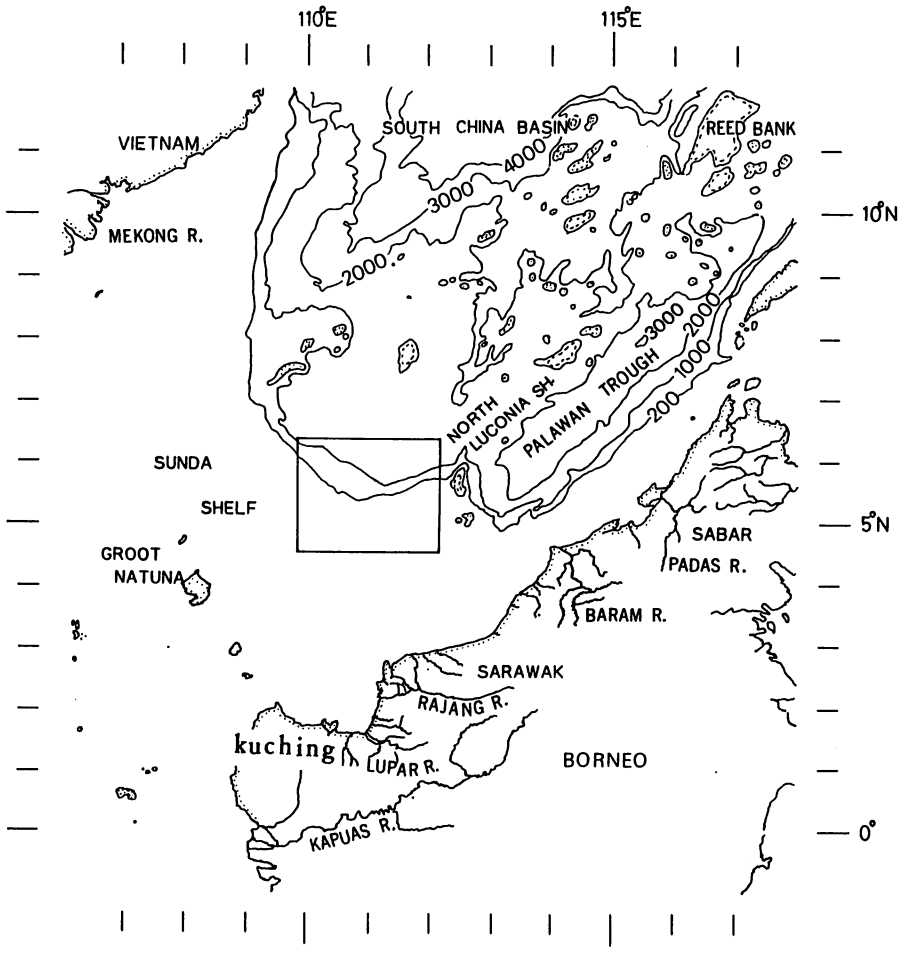

Fig. 1 Index map showing the studied area and the topographic features of the South China Sea.

Making precise sounding and clarifying the detailed bottom topography are indispensable not only for navigation but also for exploration of marine and mineral resources. At the same time, geologically important study on the bottom sediments is closely related to understanding the bottom current and the distribution of bottom fish resources.

Method of Field Survey

The surveyed area, northwest of Borneo Island, is on the slope ranging from continental shelf to deep sea bottom through continental slope. Soundings were performed in the area between 110°E and 112°E in longitude and 4°40'N and 6°20'N in latitude. Soundings were made along the longitudinal lines of every 20 (Fig. 2). The echo-sounder used is the type WD-11M of Kaijo Denki Co. Ltd., for deep sea sounding.

For bottom sampling, the Smith-McIntyre sampler (300mm × 300mm × 200mm) was used. Bottom surface sediments collected at 20 stations (Fig. 3) were kept in refrigerator with 10% formalin. After returning to Kagoshima, each sediment sample was mechanically analyzed making use of the Maruto automatic grain-size analyzer, and the median diameter (Md ϕ), sorting coefficient (So) and skewness (Sk) were calculated based on the Inman's formula.

Direction and velocity of water current were measured by the Doppler Color Graph DCG-20B of the Kaijo Denki Co. Ltd.

The field survey was carried out from 17 to 22 June, 1987.

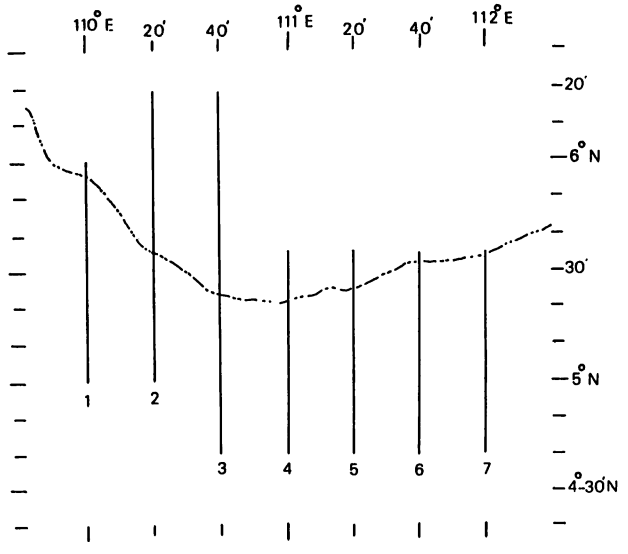

Fig. 2 Lines of sounding and the position of continental shelf margin.

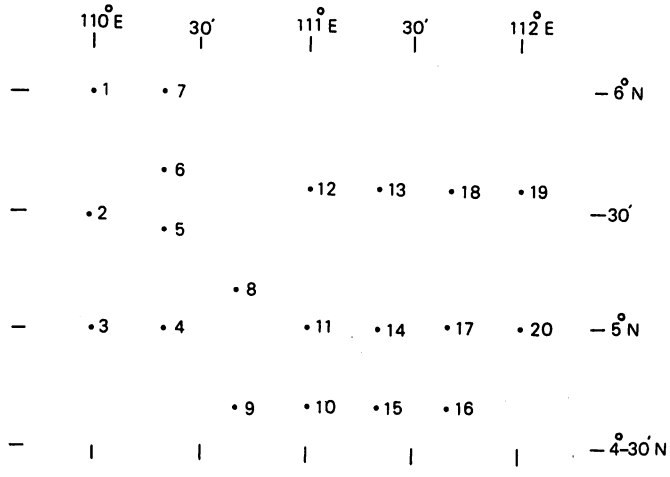

Fig. 3 Locations of the bottom sediments sampling.

Results

Bottom Topography

From the data of soundings carried out around the outer margin of continental shelf, rather gentle change in water depth both on the continental shelf and on the continental slope in the western half of the surveyed area were recognized. On the contrary, in the eastern half of the surveyed area, contours are crowded on the continental slope showing its steepness (Fig. 4). This seems to be resulted from the occurrence of North Luconia Shoal raised from the deep sea bottom with a steep slope on the north side of this shoal in the eastern half of the area.

Profile of bottom topography along each line of sounding is as follows (Fig. 5). Along the line No. 1, the westernmost line, topographic profile is nearly flat throughout. The profiles Nos. 2 and 3 show flat surfaces of continental shelf changing into steep slopes of continental slope at about 200m depths. The continental slope surface along the line No. 2 shows small scale irregularities.

Inclinations of the continental slope along the lines Nos. 2 and 3 are 0.66° and 0.71°, respectively. On the other hand, those along the lines Nos. 4, 5 and 6 are 1.56°, 2.17° and 1.37°, respectively.

From these sounding data, it is concluded that the continental slope is rather gentle in the western one-thirds of the surveyed area, and rapidly changes into higher angle slope eastward (Fig. 4). Depth of the outer margin of continental shelf along the lines Nos. 4, 5 and 6 is about 175m, a little shallower than that along the lines Nos. 2 and 3.

On the other hand, surface of the continental shelf is extremely flat (mean inclination is 0.062°).

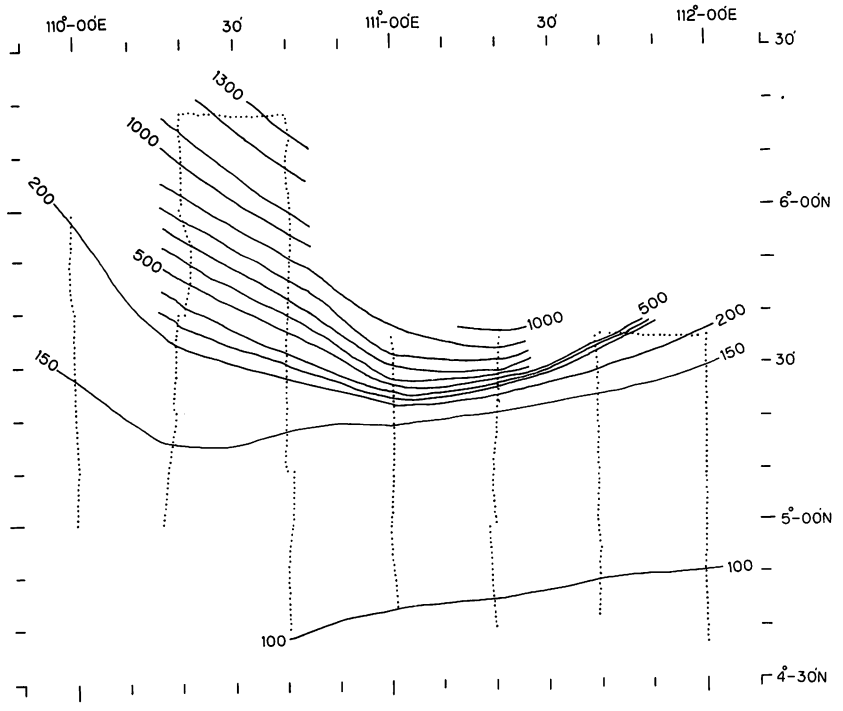

Fig. 4 Bathymetric chart based on the data of echo sounding.

Bottom sediments

(1) *Median Diameter* (*Md*ϕ) *and Sorting Coefficient* (*So*)

The Mdϕ values obtained through the mechanical analyses of 20 bottom samples are ranging from 2.46 (Sta. 1) - 3.48 (Sta. 6), Namely, from fine sand to very fine sand. Among them, fine-grained sand samples were collected from only three stations (Sta. 1 and 9 on the continental shelf and Sta. 10 on the continental slope). The other samples from all other stations are very fine-grained sands (Mdϕ =3ϕ level) (Fig. 6).

Although it is generally said that grain size of bottom sediments changes from fine grained sand to mud as the depth increases, that is not the case in this area. At the shallowest station (Sta. 16, 88m), Mdϕ is 3.54, while at the deepest station (Sta. 13, 959m) it is 3.22. At the same time, relation between grain size of bottom sediments and topographic features is also indistinct in the studied area (Table 1).

Sorting coefficients of the bottom sediments collected from the present area range from 0.605 to 1.635. It can be said that the bottom sediments in the surveyed area are generally well-sorted.

As seen in Fig. 6, samples from most of the stations except for Sta. 1 and 2 represent rather narrow range of Mdϕ (2.8 - 3.7) and of So (1.0 - 1.7), that is, very homogeneous sedimentary facies and depositional environment.

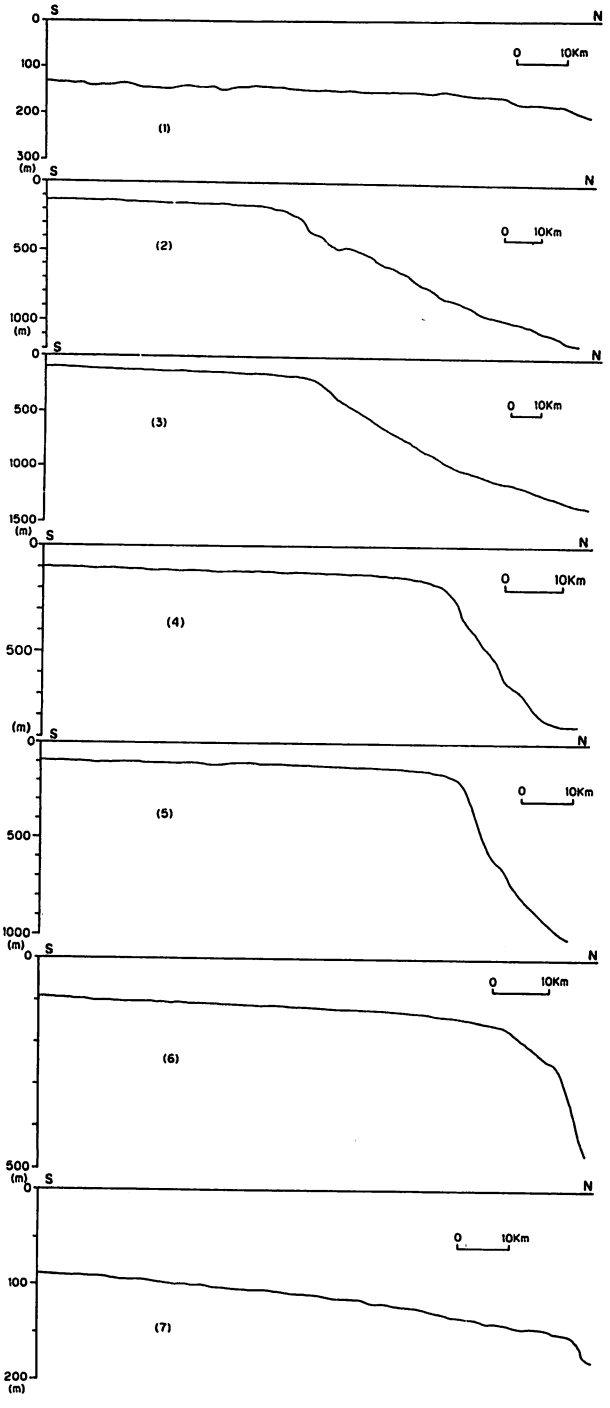

Fig. 5 Seven topographic profiles of the studied area. Lines of sounding are shown in Fig. 2.

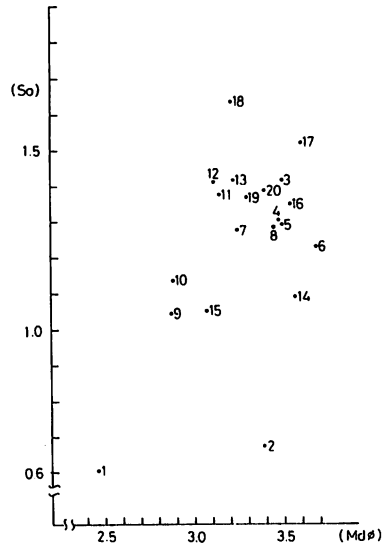

Fig. 6 Relation between the Sorting Coefficient (So) and the Median Diameter (Mdφ).

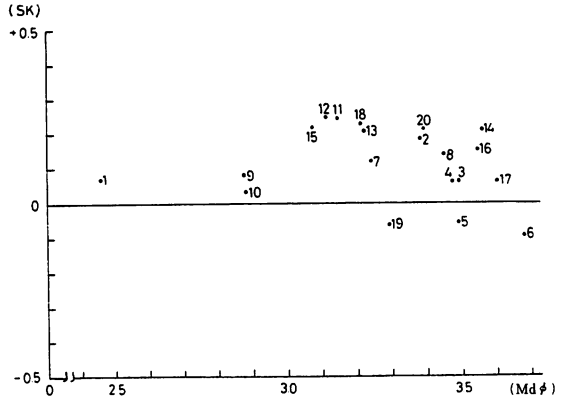

Fig. 7 Relation between the Skewness (Sk) and the Median Diameter(Mdφ).

Table 1. Data on the bottom sediments and the bottom current in the area off the northwest coast of Borneo Island, the South China Sea.

Station No.	Samp. Date	Lat. (N)	Long.(E)	D	Mdφ	So	Sk	Current (50m, Layer) Direction	Speed(KT)
	1987								
1	Jun.17	6−00.2	110−00.1	232	2.460	0.605	0.074	252	0.6
2	Jun.17	5−28.3	109−59.9	160	3.380	0.675	0.185	214	0.4
3	Jun.17	4−59.6	110−00.0	140	3.490	1.415	0.060	218	0.4
4	Jun.18	5−00.0	110−20.2	135	3.470	1.300	0.062	240	0.3
5	Jun.18	5−25.6	110−20.3	166	3.490	1.290	−0.054	321	0.2
6	Jun.18	5−40.1	110−19.9	385	3.680	1.230	−0.089	355	0.7
7	Jun.18	6−00.0	110−18.9	825	3.240	1.275	0.122	287	0.5
8	Jun.19	5−10.0	110−39.9	140	3.440	1.280	0.141	000	0.8
9	Jun.19	4−40.0	110−40.3	108	2.870	1.045	0.081	294	0.4
10	Jun.20	4−39.2	111−00.0	96	2.880	1.135	0.330	280	0.7
11	Jun.20	5−00.1	111−00.1	118	3.140	1.375	0.244	309	0.6
12	Jun.20	5−35.4	111−00.0	845	3.110	1.410	0.248	011	0.7
13	Jun.20	5−35.4	111−20.1	959	3.220	1.415	0.208	—	—
14	Jun.21	5−00.2	111−19.9	106	3.560	1.090	0.211	306	0.3
15	Jun.21	4−40.1	111−20.0	109	3.070	1.050	0.219	280	0.5
16	Jun.21	4−40.0	111−40.1	88	3.540	1.350	0.156	315	0.4
17	Jun.21	5−00.3	111−40.1	108	3.600	1.525	0.062	334	0.3
18	Jun.22	5−35.1	111−40.0	572	3.210	1.635	0.229	—	—
19	Jun.22	5−35.1	112−00.1	181	3.290	1.365	−0.062	—	—
20	Jun.22	5−00.1	112−00.1	110	3.390	1.385	0.213	151	0.1

(2) *Median Diameter* ($Md\phi$) *and Skewness* (*Sk*)

Except for Sta. 1, $Md\phi$ is between 2.9 and 3.7, and Sk is between -0.1 - +0.3. Sk values of the sediments from Sta. 5, 6 and 10 are minus value, and from all other stations are plus. This implies that most of the sediments in the present area are biassed in grain composition to the fine-grained sediments (fine Skewed) (Fig. 7).

(3) *Bottom Current*

Direction and velocity of bottom current was measured during the present survey by the method already described in the writer's previous paper (Higashikawa *et al.*, 1987)[1].

General trend of the bottom current in the area is northward, westward and southwestward, with only one exception at Sta. 20 showing weak bottom current flowing southeastward.

Current velocity is highest at Sta. 8 (0.8KT, northward), and lowest at the foregoing Sta. 20 (0.1KT, southeastward)(Fig. 8).

As far as the current directions and velocities measured in the present area are concerned, constant bottom current throughout the area is very weak and indistinct (Fig. 8). This suggests that the area is under the strong influence of tidal action.

Discussion

Borneo Island, southeast of the surveyed area, has a backbone range with several peaks higher than 2000m extending from Mt. Kinabalu at the northern end southwestward to Mt. Raja (Bukit Raja). The area northwest of this backbone range has been known to have heavy rainfall; the mean annual precipitation at Kuching is 3937mm, and the highest precipitation up to 4046 - 5080mm is known at the seacoast west of Kuching. Great amount

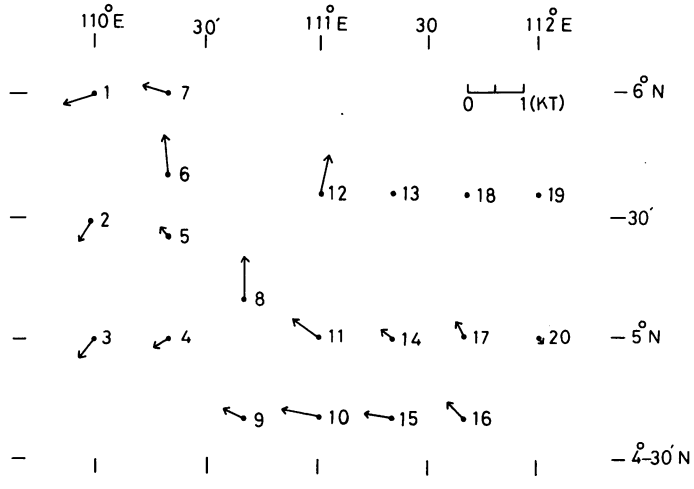

Fig. 8 Vectors showing current velocities and directions measured with the current meter installed on board.

of rainwater flows into the South China Sea through the rivers such as the Rajang River. Through the erosive processes continued by rain and river waters resulted in formation of deep valleys on land, and at the same time, high sedimentation rate on the adjacent sea bottom. It is said that about 10m thick sediments per century is continued to deposit on the bottom near Malaysia. (Ayabe and Nagatsumi, 1985)[2] Terrigenous materials are also brought into the area from the rivers in the other land areas, such as the Mekong river.

Great amount of materials deriverd from the adjacent land area is thought to be dispersed in the studied area. The bottom sediments collected are all brown-colored sandy mud.

Comparing with the bottom current along the east coast of Malay Peninsula showing rather high velocity and north to north-east direction (Higashikawa et al., 1987), the bottom current in this area is much weaker and different in direction. This may be resulted from a seasonal occurence of weak countercurrent against the current flowing northeastward from the Java Sea along the east coast of Malay Peninsula and off the east coast of Vietnam. The influence of tidal energy should also be taken in to account.

The bottom sediments collected off the east coast of Malay Peninsula represents 3.19 ϕ as the mean value of median diameter (Md ϕ) and 1.338 as the mean sorting coefficient (So)(Higashikawa et al., 1987).

On the contrary, Md ϕ and So of the bottom sediments in this area off the northwest coast of Borneo Island are 3.276 and 1.234, respectively.

Skewness is characterized by the plus values in this area, while it is by the minus values off Malay Peninsula. This disagreement is supposed to be due to the differences in source of sediments supply and in bottom current direction and velocity.

Acknowledgement

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References

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