Table 1. Biomass, sulphate and sulphide levels in enrichment culture from downstream sewage sample. Glutaraldehyde was added after 24 h of growth in regular medium

Time ⟶	0 h			3 h			24 h		
	CM*	SO_4 (mM)	$S^=$ (mM)	CM	SO_4	$S^=$	CM	SO_4	$S^=$
Control	35	8 5	2.5	45	7 0	3 0	144	1 5	7.5
Glutaraldehyde (mM)									
12.5	35	8 5	2.5	49	8 5	1 6	56	8.5	0 4
25 0	35	8 5	2 5	49	8 5	1.5	56	8 5	0 2
37 5	35	8 5	2 5	49	8 5	1 4	49	8.5	0 16
50 0	35	8 5	2 5	49	8 5	1.16	49	8 5	0 03

*Cell mass mg dry/l.

Table 2. Biomas, sulphate and sulphide levels in axenic cultures isolated from upstream sewage and biofilm samples Glutaraldehyde was added after 24 h of growth in medium

Time ⟶	0 h			3 h			6 h		
	CM*	SO_4 (mM)	$S^=$ (mM)	CM	SO_4	$S^=$	CM	SO_4	$S^=$
Sewage									
Control	70	5 8	4.2	77	4 4	5 6	98	4.2	5 8
Glutaraldehyde (mM)									
0 25	70	5.8	4.2	87	5 8	3.4	120	5 8	2.9
0 50	70	5.8	4 2	87	5.8	3.7	120	5 8	2.6
0 75	70	5 8	4 2	87	5 8	3 7	132	5 8	2 6
1 00	70	5 8	4.2	87	5 8	3 7	132	5 8	2 6
Biofilm									
Control	70	5.8	4 2	80	4 8	5.2	100	3 2	6.8
Glutaraldehyde (mM)									
0 25	70	5 8	4 2	90	5.8	3 6	123	5.8	2.6
0 50	70	5 8	4 2	90	5 8	3 6	123	5 8	2 6
0.75	70	5.8	4.2	90	5 8	3 6	130	5 8	2 6
1 00	70	5 8	4 2	90	5 8	3.6	130	5 8	2 2

*Cell mass mg dry/l

dehyde may be used as an effective inhibitor of sulphide production without affecting the growth. Glutaraldehyde at 2% concentration (0.2 M) is used as a bacteriocide; however, at lower concentrations it does not affect the growth of SRB.

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Radiocarbon dates of sediment cores from inner continental shelf off Taingapatnam, southwest coast of India

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Radiocarbon dating of carbonized wood samples from three sediment cores from the inner continental shelf off Taingapatnam, in the southwestern coast of India, indicates ages in the bracket 8400–9400 YBP. These radiometric ages correlate well with the ages of carbonized wood from inner continental shelf off Ponnani (Kerala) and Karwar (Karnataka). The occurrence of carbonized wood in widely spread offshore areas probably represents a regional transgressive event in the west coast which resulted in submergence and destruction of coastal mangroves.

The rate of sedimentation in the study area varies between 0.12 and 0.37 mm/yr, much lower than those reported from shelf areas north of Mangalore. The slow accumulation of sediments in the southern parts of the western continental shelf of India, as exemplified from the present study, may be due to very poor discharge and low bed load sediments of the west-flowing small rivers of this part of the peninsula and low concentration of suspended particulate matter in them.

THOUGH a large number of radiocarbon dates are available for the outer continental shelf sediments, particularly north of Bombay and for the algal ridges[1], information on radiocarbon dates of modern sediments of the inner shelf of the west coast of India is limited. The only published data on ^{14}C dating of inner continental shelf sediments of the west coast are those on Karwar[2] and Vengurla[1]. Based on these dates, the average sedimentation rates in these areas have also been estimated. Sediment accumulation rates based on ^{210}Pb activity are available for the Gulf of Cambay[4,5], the Bombay High Region[6], Kalinadi river mouth[7] near Karwar and inner shelf areas of Mulki[8] and Mangalore[9]. Sedimentation rates in shelf areas off the Malabar coast south of Mangalore, based either on ^{210}Pb activity or on ^{14}C, are in need.

In the western continental shelf of India, the bottom topography and sedimentation pattern differ from north to south. The shelf in the northern part is one of the broadest in the world, with a width of 350 km off the Gulf of Cambay, which progressively narrows down towards south to a minimum of 60 km off Cochin. The rock types in the hinterland areas are different and the climatic conditions also vary, which result in differences in mode and susceptibility of the rocks to weathering. This, together with differences in catchment areas, gives rise to variations in river discharge and amounts of bed load sediments and suspended particulate matter (SPM) brought by the rivers to different parts of the shelf. Further, waves, tides and currents, which influence the along-shore and across-shore sediment transport, also differ from place to place and show seasonal variations. All these factors combined together may result in variable rates of sediment accumulation in different shelf regions of the west coast of India. In the present communication, new radiocarbon dates of three sediment cores from the inner shelf off Taingapatnam, north of Cape Comorin, are reported. The average sedimentation rates based on these dates are compared with the published data from the other shelf areas of the west coast.

Though the surficial sediments of the inner shelf off Taingapatnam are fine to medium sands, vibrocores from the area have revealed subsurface occurrence of silty clay, clay and/or carbonaceous clay, occassionally with carbonized wood at places. The lithology of the three sediment cores along with the location of the carbonized wood samples dated is shown in Figure 1. Four samples were dated from three cores (Table 1) at the Radiocarbon

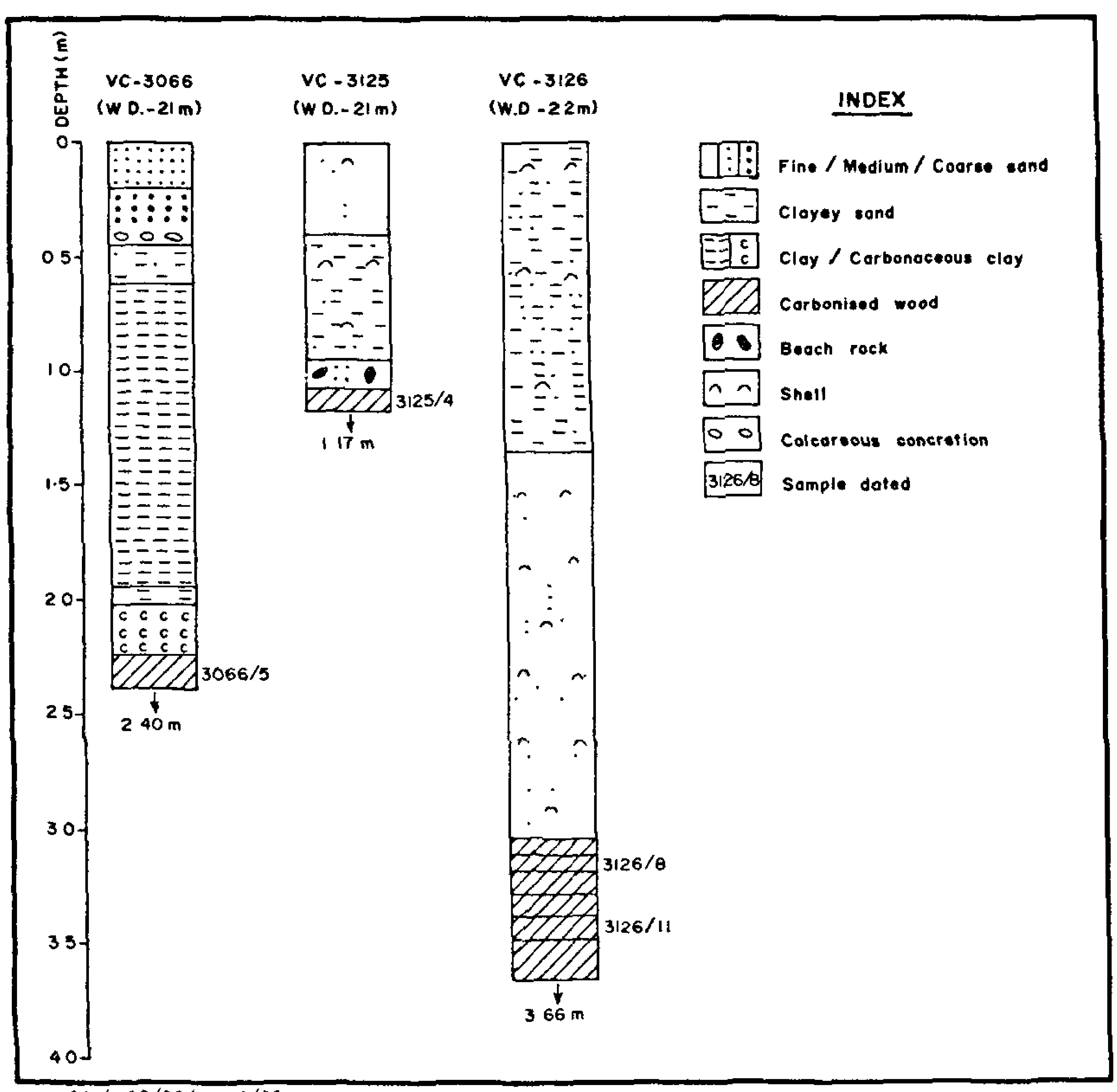

Figure 1. Lithology of cores with locations of the subsamples dated

Table 1. Radiocarbon dates of carbonized wood samples from Taingapatnam offshore area

Core/sub-sample no.	Location		Water depth (m)	Depth of dated material (cm)	Age* (YBP)
	Latitude	Longitude			
VC-3066/5	8°12'48 405"	77°9'58 697"	21	224–240	9390 ± 150
VC-3125/4	8°14'34.784"	77°9'03.328"	21	107–117	8850 ± 140
VC-3126/8	8°14'25.211"	77°9'21.128"	22	312–320	8420 ± 160
VC-3126/11	8°14'25 211"	77°9'21 128"	22	340–350	8750 ± 130

*Age based on a half-life value of 5730 ± 30 yr.

Dating Laboratory of the Birbal Sahni Institute of Palaeobotany, Lucknow, using the pretreatment, chemistry and radioactive counting techniques as described elsewhere[10]. Sample no. VC-3126/8 was mixed with 3.2% dead CO_2 to have enough methane for counting.

The radiocarbon dates of the carbonized wood samples lie between 8400 and 9400 YBP (Table 1). Though these dates are insufficient to make a computation of accurate sedimentation rates, as a first approximation the average rates have been computed assuming a uniform rate of accumulation at the sites subsequent to the deposition of dated material. The sedimentation rate estimated is 0.24 mm/yr at VC-3066 and 0.37 mm/yr at VC-3126. Two dates are available for VC-3126 which indicate a higher rate of 1 mm/yr for peat admixed with carbonaceous clay occurring at depths of 3.2–3.4 m in between the dated samples. The lowest rate of sedimentation of 0.12 mm/yr occurs at site VC-3125.

The marginally higher rate of sedimentation of 0.37 mm/yr at VC-3126 compared to 0.24 mm/yr at VC-3066 may be due to the dominance of sandy sediments at the former (Figure 1), which accumulate at a rate faster than that of clayey sediments. However, the low sedimentation rate at VC-3125 cannot be explained by the lithological differences in different cores.

Occurrence of carbonized wood/peat beds generally associated with carbonaceous clay has been recorded in late Pleistocene–Holocene sediments from many offshore areas of the west coast. These beds occur at varying bathymetric levels and distances from the present shoreline. Peat beds are also known to occur in onshore areas close to the present coast from Goa to Cape Comorin[11–13].

The onshore and offshore occurrences of peat/carbonized wood show that peat formation was a regional phenomenon of the west coast of India during late Pleistocene–Holocene period. Enclosed basins, sheltered bays, lagoons and wet tropical plains are the favoured environments for peat formation and indicate the growth of luxurious vegetation in the area. Mangroves are the most remarkable vegetation that fringe tropical coasts and are known to be the most prolific producers of peat[14,15]. Pollen studies of core samples from Arabian Sea have indicated a humid climate with maximum mangrove vegetation in the west coast around 11,000 YBP, which declined considerably by 6000 YBP (ref. 16). Relicts of mangrove vegetation occur even today, especially inside creeks and estuaries all along the west coast[17].

The ages obtained for carbonized wood samples from Taingapatnam shelf area (8420–9390 YBP) correlate well with the ages of carbonized wood from inner continental shelf off Karwar[2] (8620–9630 YBP) and of carbonaceous clay with decayed wood from Ponnani[18] (8230–10,240 YBP). The sea level transgressed rapidly on the west coast during early Holocene, which resulted in destruction of coastal mangroves, giving rise to carbonized wood/peat beds. The radiocarbon age data indicate that this transgression occurred within a time span of 8000–10,000 YBP in the west coast. An allochthonous origin by erosion and transportation of onshore peat beds and deposition in marine regime has also been attributed for the peat occurrences of Karwar–Kumta shelf[19].

A perusal of the data on sedimentation rates of the western continental shelf of India (Figure 2, Table 2) reveals that a very high rate of sedimentation of 19 mm/yr has been recorded in the mouths of Narbada and Tapti rivers in the Gulf of Cambay, which decreases to 1.8 mm/yr towards deeper waters of the shelf[4,5]. Further west in the upper continental slope at a water depth of 343 m, clay accumulation rate of 3.8 mm/yr has been estimated[5].

A sedimentation rate of 2.5 mm/yr was recorded in the Bombay High Region[6], and in the near-shore parts of Bombay offshore the rates vary between 5.5 and 6.2 mm/yr (ref. 5). Further south in Vengurla inner shelf[3] the sedimentation rate varies between 0.85 and 1.00 mm/yr, and in Karwar[2] between 0.44 and 0.89 mm/yr. However, a higher rate of 2.6 mm/yr has been recorded at 20 m water depth, close to Kalinadi river mouth[7] near Karwar. An accumulation rate of 0.72 mm/yr has been reported for Mulki inner shelf[8], and for Mangalore[9] the estimated rate varies between 0.56 and 0.72 mm/yr. The sedimentation rates calculated for Ponnani inner shelf[18] vary from 0.11 to 0.20 mm/yr, and for Taingapatnam from 0.12 to 0.37 mm/yr.

The above review shows that sedimentation rates in the northern parts of the western continental shelf of India, particularly north of Karwar, are considerably

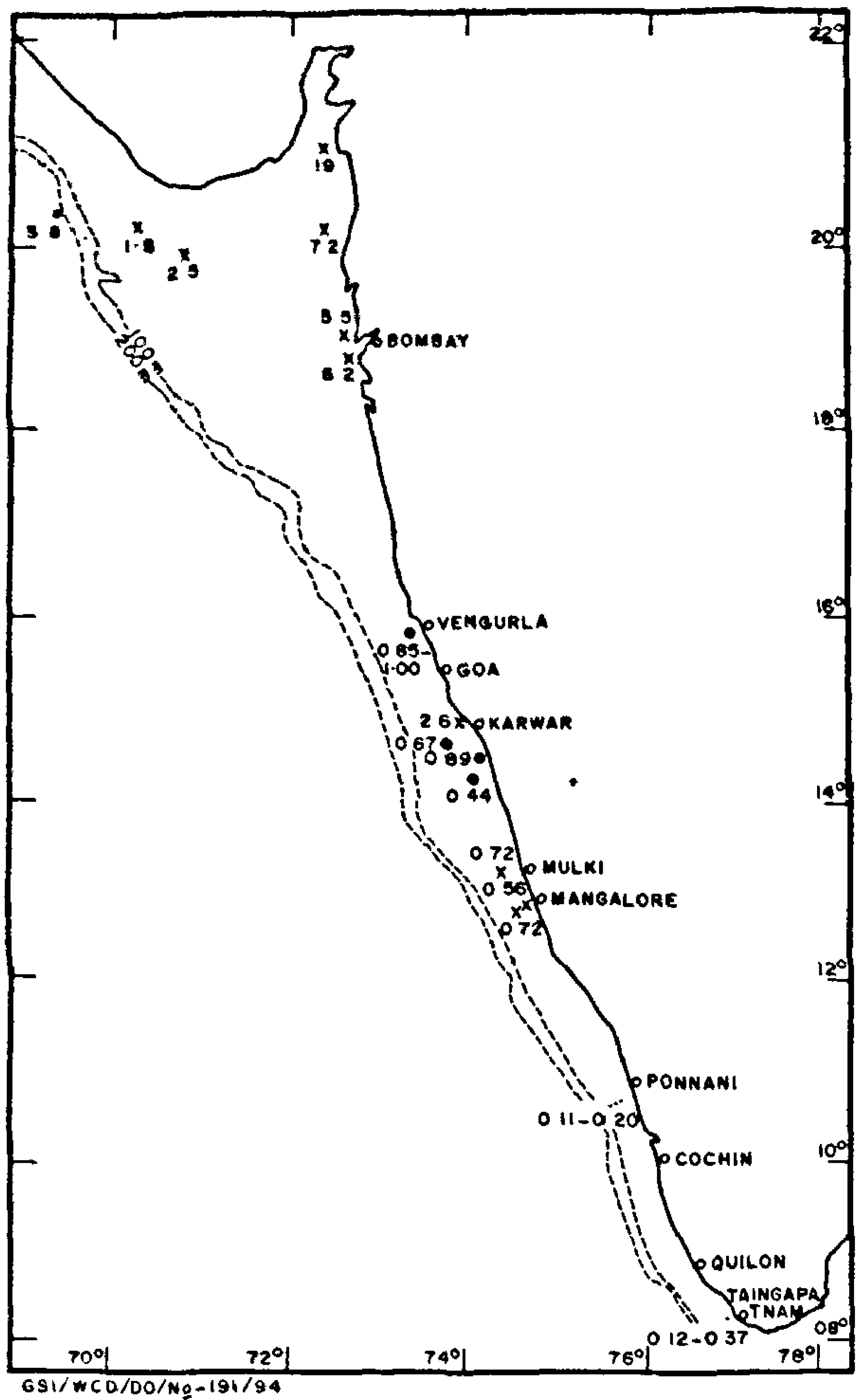

Figure 2. Rates of sedimentation (mm/yr) along the western continental shelf of India. × – estimations by ^{210}Pb excess dating; ● – estimations by ^{14}C dating.

higher than those of the southern areas. The factors chiefly responsible for variation in sediment accumulation rates in coastal seas are the river discharge, sediment supply, SPM concentration of rivers and oceanographic conditions. In addition to Narbada and Tapti, which contribute together 0.6×10^8 m.t. of sediments annually to the ocean[4], the northwest continental shelf of India and adjoining slope may also receive sediments from the river Indus[20], with an annual sediment supply of 0.44×10^9 m.t. But the tidal barrier at the mouth of the Gulf of Kutch restricts the transport of Indus sediments to near-shore shelf areas[20, 21]. The large and small rivers that flow into the Gulf of Cambay together account for about 45% of the total discharge of all the west-flowing rivers of India[22]. Further, Tapti and Narbada rivers have higher SPM concentrations[4] (4345 and 1154 mg/l, respectively). This explains the very high accumulation rates

Table 2. Sedimentation rates in the inner shelf off Taingapatnam and other parts of the western continental shelf of India

Location	Sedimentation rate (mm/yr)	Method of dating	Reference
Off Taingapatnam	0.12	^{14}C	This study
	0.24	^{14}C	
	0.37	^{14}C	
Off Ponnani	0.11	^{14}C	18
	0.14	^{14}C	
	0.17	^{14}C	
	0.20	^{14}C	
Off Mangalore	0.56	^{210}Pb	9
	0.72	^{210}Pb	
Off Mulki	0.72	^{210}Pb	8
Off Karwar	0.44	^{14}C	2
	0.67	^{14}C	
	0.89	^{14}C	
Off Kalinadi river mouth	2.60	^{210}Pb	7
Off Vengurla	0.85	^{14}C	3
	1.00	^{14}C	
Offshore of Bombay	5.5	^{210}Pb	5
	6.2	^{210}Pb	
Bombay High	1.8	^{210}Pb	5
	2.5	^{210}Pb	6
	3.8	^{14}C	5
Gulf of Cambay	7.2	^{210}Pb	5
	19.0	^{210}Pb	4

of sediments in the Gulf of Cambay, particularly at Narbada and Tapti river mouths. The southwest monsoon drift appears to be largely responsible for sediment transport in the area, resulting in greater accumulation rates at down-current sample locations[4]. The clay accumulation rates decrease from near-shore region to deeper water regions of the northwest continental shelf. Clay mineralogical studies have indicated that the cross-shelf transport of sediments in this area is very insignificant[23]. If so, the higher clay accumulation rate of 3.8 mm/yr at a water depth of 343 m (Figure 2) cannot be attributed to terrigenous influx from Narbada and Tapti and the possible source could be the Indus river[4].

The rivers debouching in the southern parts of the west coast are smaller and contribute only a small amount of sediments to the shelf. The SPM concentrations of these rivers are significantly lower, because they drain granitic gneisses and charnockites, which are less susceptible to mechanical weathering than the Deccan basalts that form the catchment of Tapti and Narbada rivers[9]. Hence, the very slow accumulation of sediments in the inner-shelf areas of southwest coast of India, as shown by the present study, may be due to very poor discharge, short supply of sediments and low concentrations of SPM in the small rivers that debauch into the sea. As a result, the Holocene sediments in the southwestern continental shelf are thin, as indicated in numerous sediment cores, whereas in the northern parts, sedimentation of thick Holocene sequence has taken place as recorded off Vengurla[3] (12 m) and Bombay[24] (30 m).

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Effective utilization of geomorphology in uranium exploration: A success story from Meghalaya, northeast India

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The southern fringe of Meghalaya plateau displays a spectacular development of erosional landforms in the thick sedimentary cover of Cretaceous–Tertiary formations. Mahadek formation, the lower member of this sequence, comprises both continental and marginal marine sediments while all the overlying formations are mainly of marine origin. In the study area all the Tertiary formations are eroded away, leaving exposed the continental part of the Mahadek formation, which comprises channel-filled and floodplain sediments. Geomorphologically, both these units express themselves as cuestas but significant textural differences were observed, enabling us to discriminate them in aerial photographs. It is known that the channel-filled sedimentary unit incorporates many favourable geological and geochemical characters to host uranium mineralization. The Domiasiat uranium deposit occurs in this unit only. By virtue of its distinct geomorphology, three domains of channel-filled sediments were demarcated in aerial photographs. Follow-up radiometric field checks on one of these domains, near the confluence of Wah Blei and Kynshiang rivers, have led to the discovery of significant uranium occurrences, opening up promising new avenues for uranium exploration in Meghalaya.

MEGHALAYA plateau is a horst-like feature bounded by Brahmaputra graben, Dawki fault, Yamuna fault and Naga thrust in the north, south, west and east, respectively (Figure 1). The plateau incorporates three major geological provinces[1], viz. (i) the cratonic massif of Archean gneissic rocks, (ii) the Proterozoic Shillong group of metasediments with intrusive mafic rocks and granite batholiths, and (iii) the rift-related basalts and alkaline rocks of late Jurassic to early Cretaceous age and a late Mesozoic to Tertiary sedimentary cover occurring along the southern margin.

The deposition of Cretaceous sediments along the southern fringe of the plateau began with the accumulation of alternate sandstone–conglomerate beds. Con-

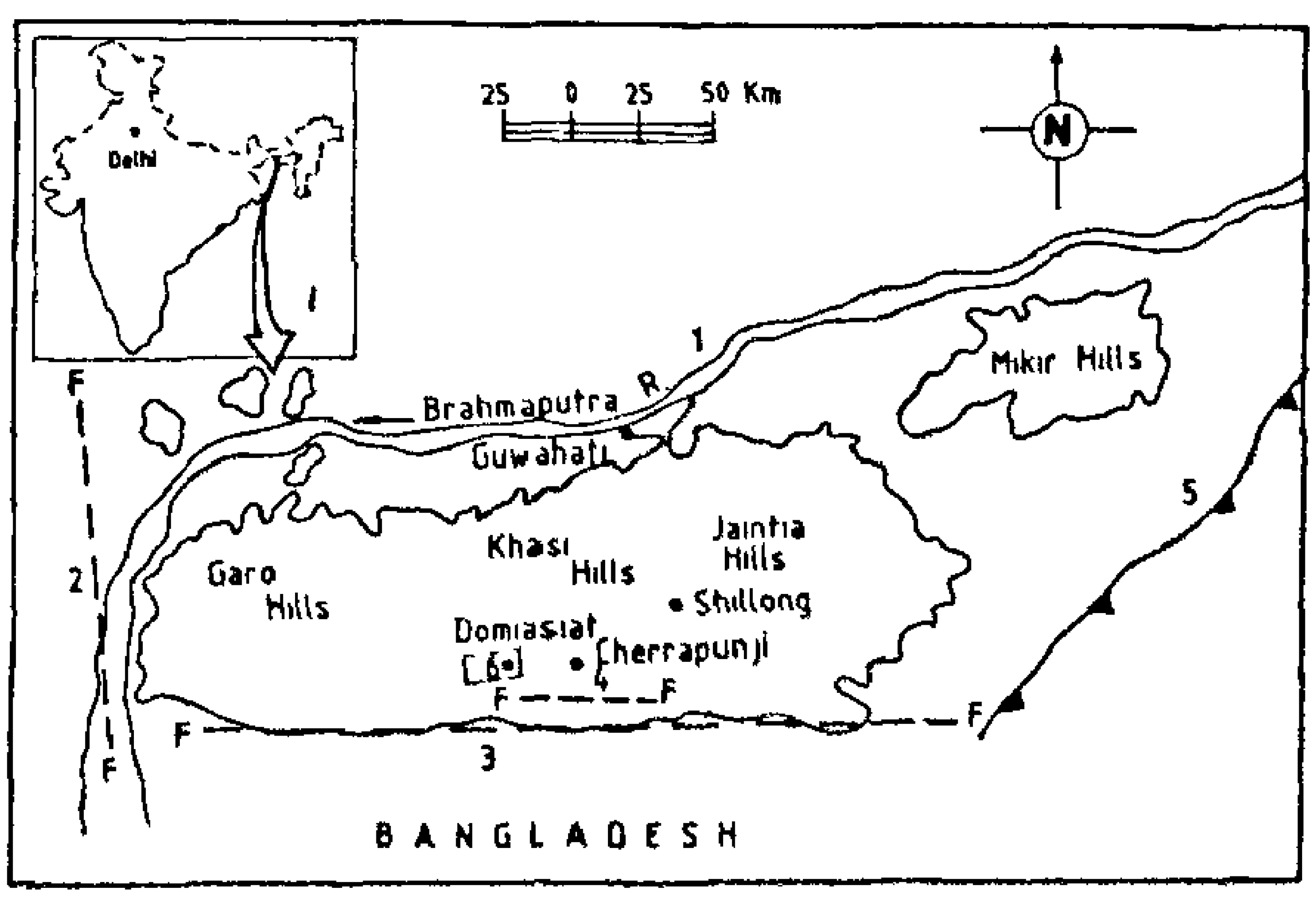

Figure 1. Location Map 1 Brahmaputra alluvium, 2 Yamuna fault 3 Dawki fault, 4 Kahba fault, 5 Naga thrust 6 study area