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552-Full3

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Title: Neogene and late Paleogene record of Himalayan orogeny and climate: a transect across the Middle Bengal Fan.

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Keywords: *(5 or less)* Turbidites , Monsoon, Channel levee, Source to Sink

Area: Bay of Bengal

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Abstract: (*400 words or less*)

We propose drilling a transect of holes in the Bay of Bengal to address interactions among the growth of the Himalaya and Tibet, the development of the Asian monsoon, and processes affecting the carbon cycle and global climate. Because sedimentation in the Bengal Fan responds to both climate and tectonic processes, its terrigenous sediment records the past evolution of both the Himalaya and regional climate. The histories of the Himalaya/ Tibetan system and the Asian monsoon require sampling different periods of time with different levels of precision. Accordingly, we propose a transect of six holes in the fan at 8°N with two complementary objectives :

(1) The early stages of Himalayan erosion, which will bear on the India-Eurasia collision and the development of the Himalaya and Tibet as topographic features. We propose a deep hole (MBF-3A ~1500m) in the west flank of the Ninetyeast Ridge where a reflector interpreted as a Paleocene-Eocene unconformity could be reached at a reasonable depth.

(2) The Neogene development of the Asian monsoon and its impact on sediment supply and flux. We propose an east-west transect at 8°N composed of MBF-3A plus two drill sites, each of ~900 m penetration (MBF-1A and 2A), to reach sediment at least as old as 10-12 million years. Records from the Arabian Sea and the Indian subcontinent suggest that at ~7-8 Ma the intensity of the monsoon increased and C4 plants expanded. Moreover, they appear to be linked to changes in the erosional regime as recorded by Leg 116, and possibly to the tectonic evolution of southeast Asia. This transect will allow the study of the extent to which a strengthening of the monsoon encompassed the Bay of Bengal, where increased rainfall, not strengthened wind characterize the monsoon, and will allow quantitative studies of the interrelations of climate change and sediment accumulation.

In addition three Sites (MBF-4A to -6A) will allow to determine, how the depocenter migrates across this transect during the last million year and to ensure complete recovery of channel-derived terrigenous material through this time interval.

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Scientific Objectives: (*250 words or less*)

This proposal addresses the general objective to understand how the Himalayan-Tibet orogenesis interacts with the earth climate. This includes forcing of the climate due to paleogeographic evolution and atmospheric CO_2 uptake as well as retroaction of the monsoon climate on the tectonic via erosion. Because the Bengal Fan has accumulated most of the Himalayan erosion flux since the continental collision, it represents the most complete record of both the uplift and erosion history of the Himalaya and of the monsoon climate. Sediments will document (1) uplift history through erosional flux and deposition patterns and detailed geochronology of minerals, (2) Himalayan evolution from isotopic tracing of particle origin and age, and (3) environmental and climate conditions through sediment granulometry, mineralogy and geochemistry, organic matter composition and $\delta^{18}O$ of microfossils. A reliable quantification of erosional fluxes over the Neogene is essential to assess the role of the Himalayan erosion on the global carbon cycle. The Leg 116 in the distal fan has shown major variations of these proxies over the Neogene and the proposed Leg should allow to test their regional representativeness. The proposed transect at 8°N will allow to construct a complete record of the Neogene Himalayan erosion and monsoon and to complete the present record of Himalayan erosion beyond the Miocene.

Proposed Sites:

Site Name	Position	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
MBF-1A	8°0.42'N / 86°16.97E	3747	900	0	900	Neogene history Depocenter migration
MBF-2A	8°0.4N / 87°38'E	3678	900	0	900	Neogene history Depocenter migration
MBF-3A	8°0.4N / 88°41'E	3620	1500	0	1500	Neogene history Early fan history Depocenter migration
MBF-4A	8°0.4N / 86°47.9E	3694	300	0	300	Depocenter migration
MBF-5A	8°0.4N / 87°10.9E	3687	300	0	300	Depocenter migration
MBF-6A	8°0.4N / 88°06.6E	3672	300	0	300	Depocenter migration

Proposal 552-full3 - Neogene and late Paleogene record of Himalayan orogeny and climate: a transect across the Middle Bengal Fan.

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Proposal 552-full3

Neogene and late Paleogene record of Himalayan orogeny and climate: a transect across the Middle Bengal Fan

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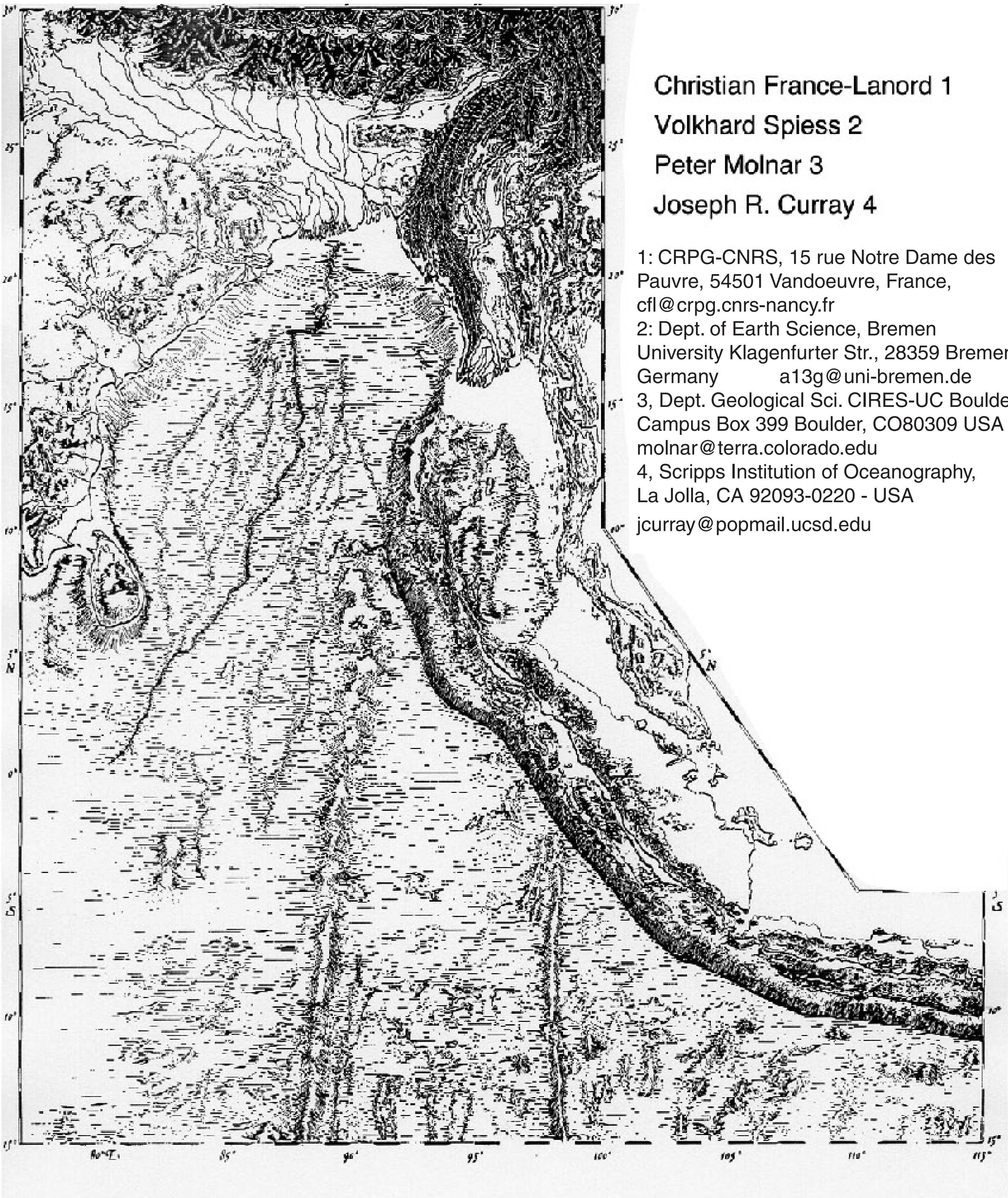

Physiographic Diagram of the
North Eastern Indian Ocean and Adjacent Land Areas
JANUARY 1982 Drawn by jo p. griffith
Data from Franz J. Emmel and Joseph R. Curray

Neogene and late Paleogene record of Himalayan orogeny and climate: a transect across the Middle Bengal Fan.

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Neogene and late Paleogene record of Himalayan orogeny and climate:
a transect across the Middle Bengal Fan.

Preface

This project for drilling in the Bengal Fan was initiated by the Climate and Tectonic PPG of ODP, which selected the Bengal Fan as a principal objective to study the climate - tectonics links in orogenic environments. This second revised version addresses the comments of the SSEPanels. Their most important recommendation was to withdraw or reduce the study of the channel-levee system in the upper part of the Fan and on choice of Site 718 in the distal fan for the long-term record objective. In order to follow these recommendations we focussed the Leg on the transect area in the middle of the Bengal Fan. For a long-term record we suggest a hole on the west flank of the Ninetyeast Ridge at 8° N. We withdrew the channel-levee architecture objectives and we added three shallow holes on the transect to determine depocenter migration.

The present proposal is now focussed on the long-term variations in the Neogene and pre-Neogene sedimentary record. This, however, relies on a better knowledge of the whole system and its dominant processes, both in the fan and on land. In particular, we emphasize that understanding the channel-levee architecture and its time scale is a fundamental issue for interpreting the older records. We view this proposal also as part of a more extended initiative that will be covered by a pre-proposal for multiplatform drilling in the Bay of Bengal in different sedimentary environments, to be submitted in October 2001.

Because the document limitations do not allow a detailed presentation of background knowledge on the Bengal fan and Himalayan history, we have reported only limited information here. Since this proposal relates knowledge from both continental and oceanic domains, however, reviewers and interested readers can find supplemental information that covers the following topics: (1) the Bengal fan and its seismic framework, (2) the growth of the Tibetan plateau and the Himalaya, and (3) the development of the Asian monsoon at ftp://www.crpg.cnrs-nancy.fr/pub/cfl/BengalSummary.pdf .

I – INTRODUCTION

Among regions of the world where tectonics and climate interact, southern Asia seems to illustrate the possible influences of one on the other more dramatically than any other region. The high elevation of the Tibetan Plateau and the rapid rise from the lowlands of northern India across the Himalaya profoundly affect both the average temperature structure of the atmosphere responsible for the seasonal winds and the localization of precipitation that characterize the south Asian monsoon. Concurrently, the large seasonal variations in precipitation along the Himalaya affect erosion rates. Yet, if the Tibetan Plateau and the Himalaya have influenced climate during Cenozoic time, the evidence suggesting such an influence is wholly inadequate to understand quantitatively how the development of these geographical features have done so.

Ocean drilling offers the means for obtaining data that not only can test proposed hypothetical links between climate and tectonics, but also can provide new data not easily anticipated but relevant to understanding a number of processes in the earth. The present proposal is for one leg in the Bay of Bengal, focused on its record of the erosional history of the Himalaya and on the development of the Asian Monsoon over Cenozoic time. Because geology lacks the tools for determining paleo-elevations except in unusual and ideal circumstances, the sedimentary record of material eroded from a mountain belt holds the least ambiguous record of its paleo-topography. Roughly 80% of the material eroded from the Himalaya has been deposited in the Bay of Bengal, making it the most complete recorder. It follows that without a more thorough investigation of the sediment deposited in that bay than that provided by two legs, DSDP 22 and ODP 116, a knowledge of the interactions between climate and the growth of the Himalaya and Tibet will, at best, be incomplete.

One more leg of drilling in the Bay of Bengal is likely to open more questions than it answers, in large part because of lingering questions about how sediment will record both topographic and climate changes in the region. For instance, the signature of the Asian monsoon, if clear in parts of the Arabian Sea and the neighboring continents, is only tentatively understood in the Bay of Bengal. Moreover, the deposition of sediment on a deep-sea fan is not that of steady pelagic deposition commonly sought by paleoceanographers, but comes in bursts along channels that spill onto levees. For sediment obtained in a single drill hole to be interpretable, an understanding of such variations is needed. With the conviction that one IODP leg in the Bay of Bengal cannot resolve all major problems that relate climate and tectonics, we submit this project as one part of an integrated project of drilling in the Himalayan basin. This includes multi-platform drilling in the Bay of Bengal for which we also submit a pre-proposal this year to IODP as well as drilling in the Indus Fan for which a proposal is submitted by another group. In this proposal, we focus on (1) the erosional history of the Himalaya and its bearing on the development of the Himalaya and Tibet as topographic features, and (2) the development of the Asian monsoon in Cenozoic time as recorded in the Bay of Bengal.

II - DRILLING OF BENGAL FAN: DISCUSSION OF OBJECTIVES

We seek a sedimentary record from the Bengal Fan to document the history of both the Himalaya and the Asian monsoon for different periods. In this section we review the different objectives and discuss how this project fits with another proposed Leg to drill the Indus Fan.

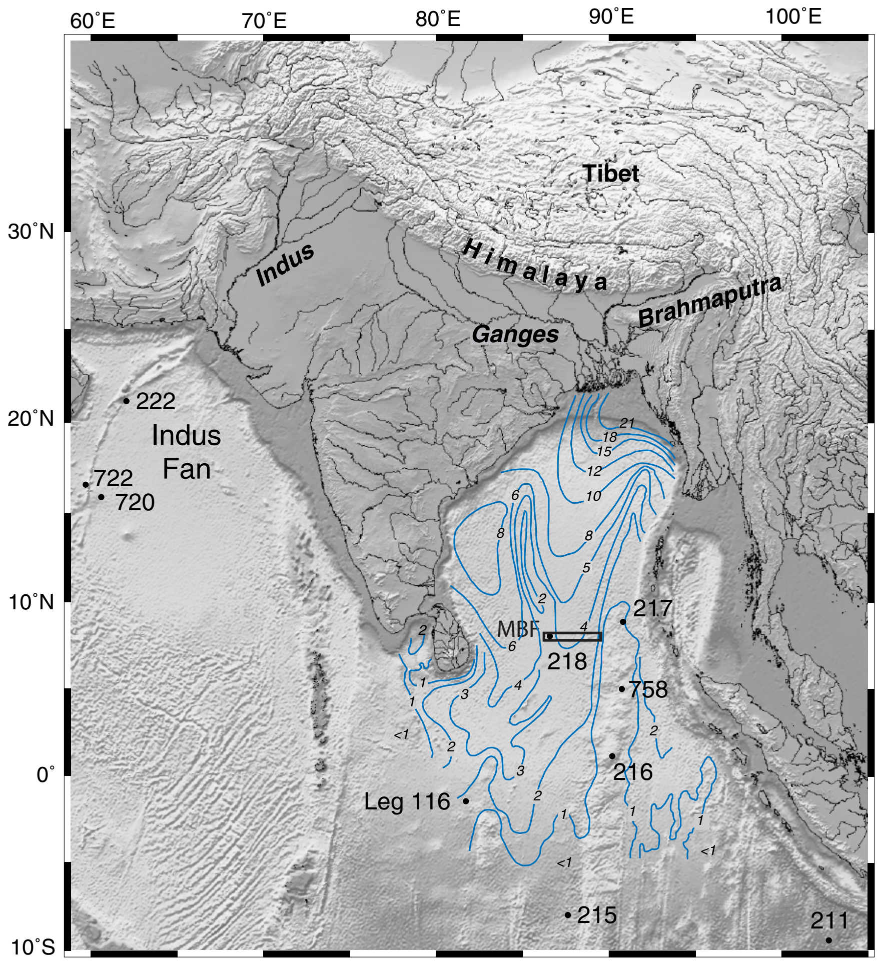

Figure 1 – Map of the Himalayan erosion system showing the positions of the proposed area for drilling in the Bengal Fan: Middle Bengal Fan (MBF), and of the different DSDP and ODP Sites documenting the Bengal and Indus fans or the monsoon history. Isopachs (in km) of the Bengal Fan are simplified from (Curray, 1994). *They represent the total sedimentary and metasedimentary rocks above the oceanic second layer, as interpreted from seismic reflection and refraction data.*

CALIBRATION OF CHANGES AT 7-8 MA AND SINCE THAT TIME

Both tectonic and climate changes seem to have occurred at 7-8 Ma, and both are likely to have written a signature in the Bay of Bengal (France-Lanord et al., 1993; Martinod and Molnar, 1995). Moreover, there have been subsequent changes, both at ~2.5-3 Ma (Zhang et al., 2001), when global cooling led to the growth of ice sheets in the Northern Hemisphere, and at ~0.8-1 Ma, when the 100 ka cycle became strong and the rate and grain size of sediment deposited increased in the Bengal fan. Both tectonic and climate changes have left signatures in accumulation rates, grain sizes, clay mineralogy, isotopic ratios, organic carbon burial, etc., that can be measured (Derry and France-Lanord, 1997; France-Lanord et al., 1993).

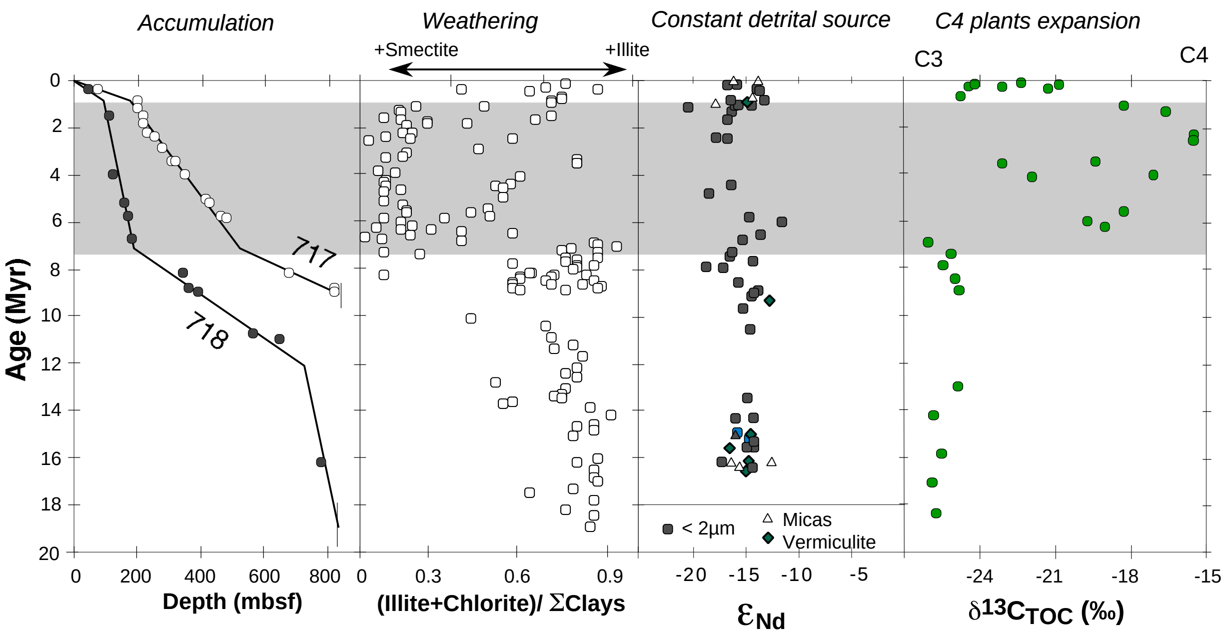

Fig. 2 - Accumulation rate (Gartner, 1990), *clay mineralogy* (Bouquillon et al., 1990), *Nd isotopic data* (Derry and France-Lanord, 1996; France-Lanord et al., 1993; Galy et al., 1996), *and total organic carbon isotopic composition* (France-Lanord and Derry, 1994) *from ODP Leg 116 Holes 717C and 718C. Ages recalculated using time scale of Cande and Kent* (Cande and Kent, 1992). *Low sedimentation rates (A), smectite-kaolinite (SK) clays (B) and organic carbon derived from C4 plants (D) characterize the interval from 7.4 to 0.9 Ma. The Nd isotopic composition (C) remain stable at all periods indicating the stability of the eroded source of material. The biostratigraphic constraints on sediment accumulation are uncertain for the early Miocene.*

First, to what extent are the variations in accumulation rates, clay mineralogy, and grain sizes from Holes 717-719 (Fig. 2) representative of other parts of the fan? Because those holes were drilled on the distal edge within a growing syncline, sediment transport might have been affected both by the large distance from the source and by the barrier imposed by the surrounding anticlines. Recall that the isotopic signature of the sediment allows its source within the Himalaya to be identified. The decreases in accumulation rate and grain size at ~7 Ma and the synchronous increased percentage of smectite (Bouquillon et al., 1990) suggest that if the monsoon strengthened at that time, it apparently did so without creating a more energetic erosive system, as might be expected from the strong seasonal precipitation of the monsoon. Obviously, if we find the same pattern of low accumulation rates, small grain sizes, and a large percentage of smectite at 7-8 Ma in holes drilled at 8˚N (or 11˚N), we must consider the possibility that if the monsoon strengthened at that time, it did so by decreasing, not increasing erosion rates. If we find a sediment history different from that in holes 717-719, we must conclude that the record on the distal edge of the fan does not record faithfully the changes input at the source of the fan.

The present-day monsoon, if named originally for the seasonally steady winds over the Arabian Sea, evokes the image of heavy rain over the Indian sub-continent. We have no evidence to date, and perhaps conflicting evidence, showing that precipitation increased over the Ganga and Brahmaputra drainage basins and the Bay of Bengal at 7-8 Ma (Derry and France-Lanord, 1997; Dettman et al., 2001). Yet, because differences in $\delta^{18}O$ in planktonic foraminifera deposited in the Bay of Bengal in late Quaternary time are related to amounts of precipitation (Duplessy, 1982), and hence to the strength of the monsoon, we should have a tool for detecting such changes earlier in Cenozoic time. Thus, we can assess the extent to which the proxies for climate change in the Arabian Sea (such as increased *G. Bulloides* e.g. (Kroon et al., 1991)) and on the Indian landmass (such as an increase in $\delta^{18}O$ (Quade et al., 1995; Quade et al., 1989)) imply a strengthening of the monsoon as we understand it today.

Obviously, the absence of a change in $\delta^{18}O$ in planktonic foraminifera at 7-8 Ma would cast doubt either on the idea that precipitation changed then, and hence that the monsoon as we know it today strengthened at that time, or on the applicability of in $\delta^{18}O$ in planktonic foraminifera to study of precipitation. Conversely, a demonstration that $\delta^{18}O$ in planktonic foraminifera decreased at 7-8 Ma would suggest a change toward greater precipitation. Such a result would, in turn, pose the question of why the response of sediment accumulation (and erosion) to such a change at 7-8 Ma was opposite to what we expect for increased precipitation.

The main reason for drilling more than one hole at 8˚N is to minimize the effect of varying sedimentation rates associated with a pronounced increase in the vicinity of the active channel at a time and its migration, and hence to avoid the biases that one hole (or a set of adjacent holes) might give. Although the main focus of these holes is on the changes near 7-8

Ma, obviously we will obtain material from a longer period. In one hole in the eastern Bay of Bengal material older than 14 Ma shall be recovered, which will allow the kinds of studies described above to test whether or not the monsoon strengthened during Early Miocene, as proposed by Ramstein et al. (1997; Fluteau et al., 1999).

In addition, we plan to study other temporal, as well as spatial variations, in the sediment over the last 7 Ma. Site 218 and those of Leg 116 show changes that possibly reveal other variations in the erosion regime. Kroon et al. (1991) showed a dip in the abundance of *G. Bulloides* at ~5 Ma, which might indicate a lull in the monsoon, the temporary dominance of another upwelling-sensitive foraminifera (Kroon et al., 1991), or some other inadequacy of *Bulloides* to measure the monsoon strength. We also seek quantitative measures of the interaction between climate change and sedimentation associated with the global cooling and onset of the Ice Age at 2.7-3 Ma and with the change from precession and obliquity-dominated climate variations to the strong 100-ka cycle at 0.8-1 Ma. This latter change appears to be marked in deposition rates, grain sizes, and clay mineralogy in ODP Holes 717-719 (France-Lanord et al., 1993). Again, one objective is to decide how representative the results from holes 717-719 are. The same proxies for monsoon strength and for erosion will be available for study of this period. The results from holes 717-719 reveal no evidence of a change in erosion rate at 2.7-3 Ma, in contrast with what might be expected if glacial erosion were important and increased at that time. Moreover, if the only important change in sedimentation rate, and hence presumably in erosion rate too, occurred at 0.8-1 Ma, such a change would provide a clue to what kind of change was important. We anticipate being able to resolve temporal variations on the time scale of orbital variations, but obviously we must expect large variations in sedimentation rates. Hence, three holes on a transect are proposed to limit the biases on long-term studies associated with penetrating buried channel-levee systems, and another three holes shall be drilled in between to optimize the temporal sampling of terrigenous sediment input and to analyze the impact of depocenter migration on sedimentary facies and recorded signals.

The 7 Ma transition is also marked by the spectacular expansion of C4 photosynthetic plants in the Himalayan basin (Quade et al., 1989). While C4 plant expansion may result from a global decrease in atmospheric PCO_2 (Cerling et al., 1997), recent studies suggest that PCO_2 was already low at that period (Pagani et al., 1999). In the latter hypothesis, C4 plant expansion would rather require a change to more arid conditions in the floodplain. Sediments sampled at Leg 116 show close links among variations in clay mineralogy (smectite/illite ratio), in total organic carbon, and in $\delta^{13}C$ (C3 vs. C4 plants) (France-Lanord and Derry, 1994; Freeman and Colarusso, 2001). These relationships reveal changes in the sediment provenance, with a mountain end-member delivering material unaltered with low organic carbon content of C3 type and with a floodplain end-member delivering altered material with high organic carbon content of C4 type. If confirmed by new drilling at the scale of the whole fan, such relations would favor the hypothesis of a regional climate change toward dryer conditions.

SAMPLING OF THE OLDEST SEDIMENT OF THE FAN

Progress in dating the timing of the collision between India and the rest of Eurasia provides a converging opinion that collision in the western Himalaya occurred between 50 and 55 Ma, but perhaps later (~45 Ma) in the eastern Himalaya, near Everest for instance (Rowley, 1996; Rowley, 1998). When the Himalaya emerged as a mountain range, however, remains less certain. Galy et al.(1996) showed, using differences between Rb/Sr cooling ages (25-30 Ma) of biotite and stratigraphic ages (~18 Ma), that a deeply incised, and therefore significant, mountain range existed at 30 Ma. Extending the record of sedimentation back in time should allow a determination not only of when erosion began, but also of when erosion had penetrated deep into the crust to expose rapidly cooled minerals. In particular, we should be able to determine cooling ages of minerals whose closure temperatures are different, and from the isotopic signature, we should be able to identify what rock of the Himalaya has eroded. Then, the differences between cooling ages and stratigraphic ages will allow an estimate not only of when erosion began, but also of when erosion had exhumed rock from different depths (Copeland and Harrison, 1990; Corrigan and Crowley, 1990; Galy et al., 1996).

Determining when emergence of the Himalaya took place might not provide any surprises. Nevertheless, recall that all of the rock cropping out in the Himalaya was carried by the Indian subcontinent and scraped off it following collision with Eurasia. Thus, given the convergence rate of ~50 km/Myr, which India has moved north toward Eurasia since 45 Ma, if collision occurred at 45 Ma, but erosion began only at 35 Ma, we might infer that as much as 500 km intact lithosphere was subducted beneath southern Eurasia before a significant mountain range formed. Conversely, if deposition of rock with a Himalayan isotopic fingerprint began shortly after 45 Ma, we must infer that some off-scraping of Indian crust had occurred early in the history of the collision to build the initial Himalaya. Finally, we can imagine a flux of sediment early in the history of the collision, but of Tibetan, not Himalayan, origin. This would suggest some, if not necessarily easily quantified, subduction of India beneath southern Tibet before thrust faulting within India created the Himalaya.

The well-known increase in the $^{87}Sr/^{86}Sr$ ratio of sea water beginning at ~40 Ma (DePaolo and Ingram, 1985; Hodell et al., 1989) is commonly attributed to increased erosion and weathering in the Himalaya (Edmond, 1992; Galy et al., 1999; Krishnaswami et al., 1992; Palmer and Edmond, 1989). A strong Himalayan signature, not only beginning at ~40 Ma, but also contributing a pulse near 18 Ma (Richter et al., 1992), should, therefore, be corroborated in the sedimentary record of Himalayan erosion. In particular, detrital silicates with high $^{87}Sr/^{86}Sr$ ratios both should increase at ~40 Ma and again near 18 Ma would support such an attribution.. By extending the sedimentary record in the Bay of Bengal before 20 Ma, we can examine the hypothesized correlation of the increased marine $^{87}Sr/^{86}Sr$ ratio at 18 Ma with weathering of Himalayan rock rich in radiogenic strontium. If we can sample the early history of Himalayan erosion, we can test the assumption that the increasing $^{87}Sr/^{86}Sr$ ratio beginning at 40 Ma also results from weathering of Himalayan rock. The sensitivity of the sea-water Sr isotopic budget to the Himalayan flux is so high (Galy et al., 1999) that the sea-water evolution through time provides a unique system where erosion rate can be estimated using a proxy other than accumulation rates. In particular, the Sr isotopic composition of pedogenic clays sampled in the fan document the isotopic composition of the rivers through time. As Derry and France-Lanord (1996) showed, this information combined with the sea-water Sr isotopic budget should allow us to calculate the riverine flux of Sr. This flux can be used as a proxy of the erosion flux.

The Bengal Fan is one of the thickest sediment sections in the world, and is far too thick for sampling the very old section. The oldest part of the fan sampled to date was in the ODP Leg 116 sites, where Early Miocene sediment (ca. 17 Ma) was sampled at Site 718 more than 2500 km from the present apex of the fan. Because of its southern position and the great water depth, this site may not be adequate to penetrate “the oldest” sediment derived from the Himalaya, because the fan may not have prograded so far south e.g. (Curray, 1994). Therefore we propose a strategy for sampling a pre-Miocene section by drilling on the west flank of the Ninetyeast Ridge, about 1300 km from the apex of the fan, where the section is thinner, and where a possible Paleocene-Eocene unconformity (“P” horizon) could be reached at a reasonable depth (Curray et al., 1982).

SPATIAL DEPOCENTER VARIABILITY

Sediment accumulates in the Bengal Fan largely by deposition in channel levee systems (Fig. 3). On a cross section sampling below the active system, the fan appears to be built by an accumulation of lenses corresponding to distinct channel-levee episodes intercalated by slowly accumulated layers of fine grained sediment. Channels carry a flux of sediment for a brief period, apparently of the order of some 1000 years, and then fill with sediment as a new channel is cut into the levee system or outside it. Thus, accumulation at any point is very irregular, varying from rates >30 m/kyr for periods as long as 3000 years (Hübscher et al., 1997; Michels et al., 1998; Spiess et al., 1998; Weber et al., 1997), to very low accumulation rates in intervening periods. Nd-Sr isotopic signatures demonstrate that sediment accumulated at high rate is dominated by Himalayan material whereas low accumulation periods have distinct isotopic signatures showing that other sources are mixed with Himalayan flux (Pierson-Wickmann et al., 2001). Determining the distribution and typical lifetime of depocenters is vital for interpreting the older sedimentary record of the fan and to assign different types of sedimentary facies and successions found in deep drill holes to structural units. To address this objective, we propose to compare the upper 300 m of sediments across the transect at an interval of appx. 50 km which is near the typical width of channel levee systems at this latitude. This requires adding three shallow holes to the three deeper of the transect.

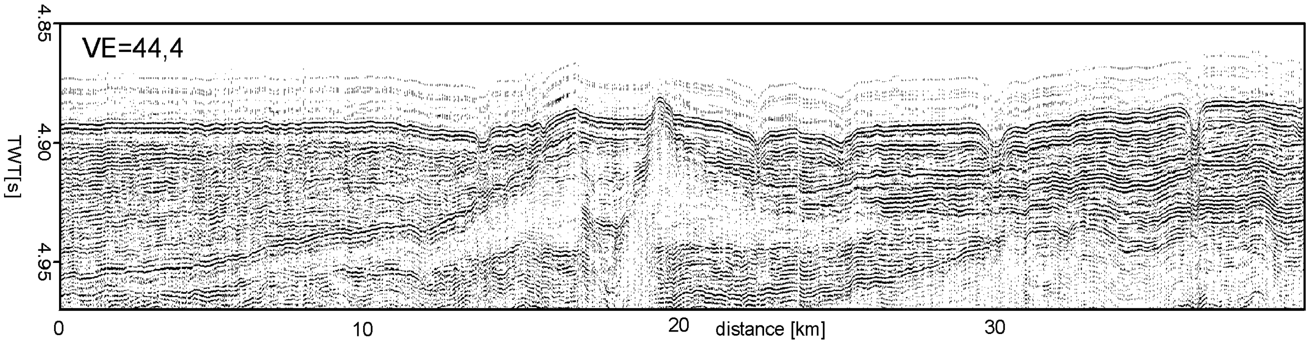

Figure 3: Typical example of a buried channel-levee system from seismic line GeoB 97-027 at 8°N, shot with a 25 cu.in water gun with frequencies up to 1500 Hz. The width of the structure is on the order of 30 km, the maximum height exceeds 50 meters.

FORCING OF THE CARBON CYCLE AND CLIMATE

Drilling the Bengal Fan should allow investigation of the global effect of the Himalayan erosion on the Carbon cycle, which has been debated in the recent literature e.g. (France-Lanord and Derry, 1997; Galy and France-Lanord, 1999; Godderis and Francois, 1995; Goddéris and François, 1996; McCauley and De Paolo, 1997; Raymo, 1994; Raymo and Ruddiman, 1992; Raymo et al., 1988; Ruddiman, 1997). Erosion tends to consume atmospheric carbon by two mechanisms. First, atmospheric CO_2 is consumed by the weathering of silicates in soils to produce a fluvial alkalinity flux that later precipitates as carbonate in sea-water. Second, plants debris and organic carbon adsorbed to clay minerals are transported in the particulate flux and can be buried in deep-sea sediment. Both mechanism will take up carbon from the atmosphere and store it over long term in the sedimentary reservoir. Derry and France-Lanord (1997) suggested that the Himalayan erosion consumes atmospheric CO_2 via the burial of organic carbon preferentially to silicate weathering. Nevertheless it remains impossible to assess the importance these processes at a global scale because the past fluvial fluxes are unknown. The volume and the geochemistry of sediment can provide direct and interpretable records of these fluxes, if their accumulation rates in the Fan can be determined with sufficient accuracy. The proposed transect at 8°N will document a critical period when the accumulation rate decreased but silicate weathering and organic carbon burial increases. These variations observed at Leg 116 Sites do not allow us to establish a budget for the whole fan, but the proposed transect at 8°N will help us to document variations on the regional scale. A record extending back before 20 Ma should also allow study of potential impacts of the Himalaya on climate via both organic carbon burial and silicate weathering.

COMPARISON OF THE BENGAL AND INDUS FANS

Reviewers and panel members will logically ask how drilling in the Bengal Fan relates to drilling of the Indus Fan, proposed by Peter Clift and others, including two of us. First, we do not intend to compete with that other proposal; we see them as complementary with each offering solutions to relevant problems.

Drilling to the base of the Indus Fan, in order to study the early history of Himalayan erosion, seems much easier than drilling the Bengal Fan, simply because the Indus Fan is much the thinner. Yet, because current rates of sediment transport and total accumulations of sediment in the Bengal Fan are roughly four times those of the Indus Fan, drilling of the Bengal Fan might offer a more representative history of Himalayan erosion. Perhaps more importantly, the isotopic record of sediment derived from the Himalaya and deposited in the Bay of Bengal can be matched to that from different parts of the Himalaya, because of the large range in isotopic compositions of source rock e.g. (Pierson-Wickmann et al., 2000). This isotopic signature, however, is less clear in the drainage basin of the Indus River. For instance, whereas the $^{87}Sr/^{86}Sr$ ratio of the Ganga River and its tributaries is notoriously high, but that of the Indus is normal (Palmer and Edmond, 1989; Palmer and Edmond, 1992; Pande et al., 1994). Thus, reconstructing the spatial history of erosion in the Himalaya should be easier using the Bengal Fan than Indus Fan, for the period that we can sample in the Bay of Bengal.

Second, the most convincing evidence of a 7-8-Ma development of the monsoon comes from the Arabian Sea, near the Indus Fan, where the strength of the monsoon seems to be reflected most clearly by proxies that measure upwelling of cold nutrient-rich water, which in turn respond to the strength of the monsoonal winds. It follows that studying that variation might be resolved better than in the Bay of Bengal, where the signature of the monsoon is different and depends on changes in precipitation in the catchment of the Bay. Yet, because the monsoon reveals its history differently, its study in the Bay of Bengal should enhance our understanding of how the monsoon may have changed in time. Moreover, most of the rain that falls during the monsoon flows into the Bay of Bengal, not the Arabian Sea, and most of the sediment created by erosion associated with the monsoon, whose strength has varied with time, will be deposited in the Bengal Fan. Thus, the record of the impact of changing monsoons on erosion will be clearer in the Bay of Bengal than in the Arabian Sea.

Thus, the sedimentary records in the Bengal and Indus Fans should differ from one another and should record different aspects of the growth of the Himalaya and the development of the Indian monsoon. They can be seen as sampling different part of the same elephant and therefore necessary for a full understanding of the beast.

RELEVANCE TO THE INITIAL SCIENCE PLAN OF IODP

This proposal is clearly oriented toward the study of the interactions between climate and tectonic identified as "Internal Forcing of Environmental Change" in the Initial Science plan. The Himalayan erosion offers a rare place of the world where these interactions are potentially so rich. They include geochemical effects on the carbon cycle via processes of erosion, forcing of the climate by the orographic effect of the Himalaya and the thermal effect of the Tibetan Plateau, and forcing of the tectonics by the action of the erosion.

More than one leg will be required to obtain the observations that relate the uplift and the growth of the Himalaya and Tibet to Cenozoic climate in south Asia and the Indian Ocean, necessary for understanding such interactions. A pre-proposal, is submitted in parallel, to present a multi-platform approach of different objectives in the Bay of Bengal region (The Himalaya - Bengal System: Studying links between Land and Ocean, Climate and Tectonics, 'Source' and 'Sink' by a multiplatform approach for drilling in the Bay of Bengal.-by Spiess et al.). The most important objective with respect to this proposal is the study of the active channel-levee complexes which would document processes of sediment transport and fan buildup and could turn up a wealth of information both illuminating how such systems evolve and revealing a detailed climate record over short time scales.

Because the Bay of Bengal offers much to be learned (1) about the tectonics of the Himalaya and Tibet, which cannot be learned from study of the rock exposed in those regions, (2) about the Indian monsoon, and (3) about their interaction, as well as about sediment transport on actively growing deep-sea fans, one leg cannot possibly solve all questions that can be posed now. With that in mind, the leg proposed here is designed to address some specific questions, but also to provide enough new material to design future legs more narrowly focused on such questions.

III SUMMARY OF PROPOSED SITES AND DRILLING STRATEGY

High resolution multichannel seismic data, collected during Cruise SO 125 of R/V Sonne in October/November 1997 (Spiess et al., 1998), with some published deep seismic reflection data of Curray et al. (1982) and Gopala Rao et al. (1994; 1997), provide the basis for selecting sites to drill. The new high resolution seismic data from R/V Sonne Cruise SO

125 reveal fine scale structures within a fan invisible to conventional seismic methods. Therefore we suggest to position all drill along the seismic lines GeoB 97-020/027, crossing the Middle Bengal Fan at 8°N, using older data to define the regional structural framework.

The proposed drilling program is summarized in Table 1 based on specific assumptions on penetration rates. We propose an east-west transect at 8°N of six drill sites which include (Fig. 4 and 5) :

- one deep hole ~1500 m (MBF-3A) to reach pre-fan deposits
- two holes of ~900 m penetration (MBF-1A and 2A), to recover sediment at least as old as 10-12 million years in order to study the Neogene fan evolution and the impact of the monsoonal system on sediment supply and flux.
- in addition three more shallow holes of ~300 m penetration to achieve a complete terrigenous record of the Himalayan flux over the last 1-2 million years.

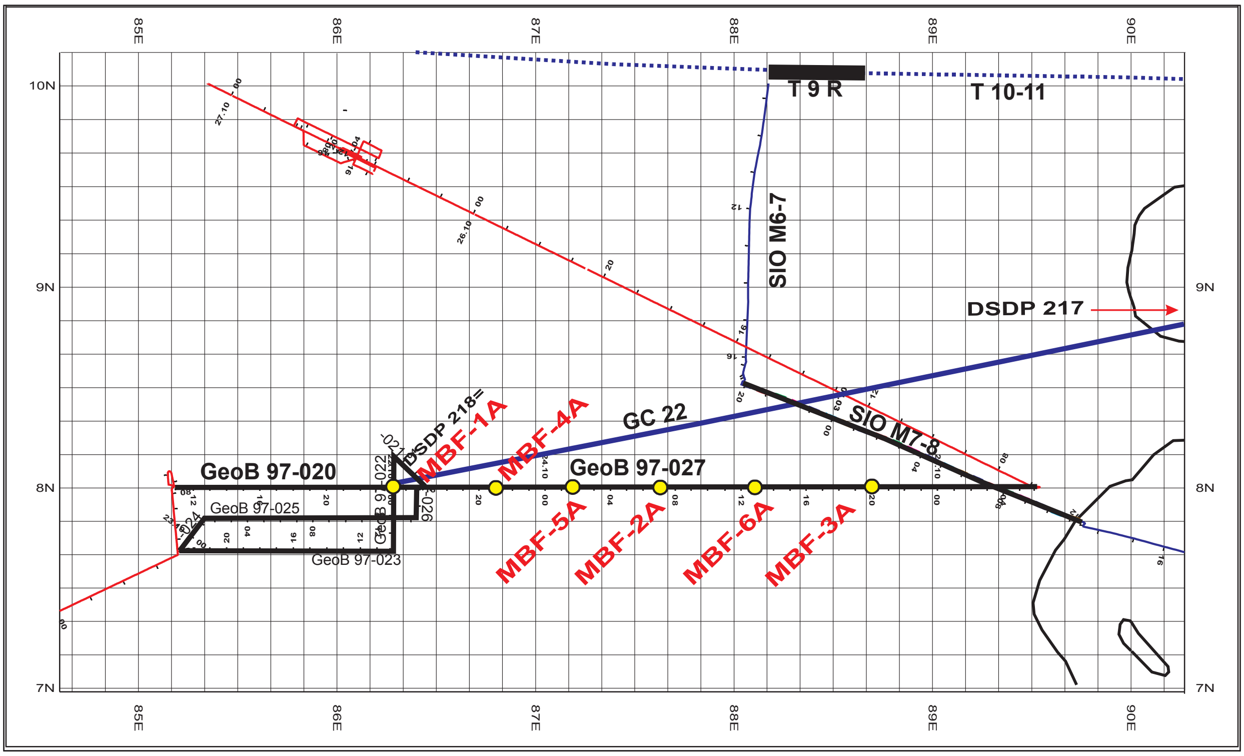

Fig. 4 – Map showing the positions of drill sites MBF-1A to –6A on the 8°N transect and seismic lines 97-20 to 27 and SIO M7-8.

The transect approach is necessary in order to account for lateral variability in the stacking pattern of channel-levee structures through time. Because of the lateral migration of the active channel, longer periods of low sediment accumulation or even non-deposition can occur associated with major longitudinal shifts of depositional bands. To examine potential time lags and numbers of channel-levee systems and to retrieve a more complete record in time, the transect between the two ridges, which also restricts fan sedimentation to a 300 km wide basin, seems to be best located at 8°N. At this latitude, sedimentation rate variations caused by channel-levee systems are less pronounced than further North, and sediments are expected to be sufficiently fine-grained to allow high quality drilling in the surface 300 meters. In addition, DSDP Site 218 provides a sufficiently precise chronostratigraphic reference to ensure the achievement of minimum drilling target ages of 10-14 Ma. This transect will extend northward and back in time the existing record of Neogene fan sedimentation provided by ODP Leg 116 sites and DSDP Site 218, allowing us to reconstruct a continuous record of sediment accumulation across time intervals of major changes. The proposed holes lie between the 85°E and 90°E ridges in a basin with relatively uniform sediment thickness for each of the seismic units (Figs 4 and 5).

Table 1: Summary of proposed drilling in the Bay of Bengal including transit between sites.

Site / Latitude	Objective / Longitude	Water depth	Coring Techniques	Penetration	Drilling time days
Transit between sites					**2.0**
MBF-1A	Neogene sedimentation history				
8°0.42N	86°16.97E	3747 m	APC/XCB	200/900 m	**10.4**
MBF-2A	Neogene sedimentation history				
8°0.4N	87°38'E	3678 m	APC/XCB	200/900 m	**10.4**
MBF-3A	Neogene history - Early fan history				
8°0.4N	88°41'E	3620 m	APC/XCB/RCB	200/900/1500 m	**18.6**
MBF-4A	Depocenter migration				
8°0.4N	86°47.9'E	3694 m	APC/XCB	200/300 m	**2.8**
MBF-5A	Depocenter migration				
8°0.4N	87°10.9'E	3687 m	APC/XCB	200/300 m	**2.8**
MBF-6A	Depocenter migration				
8°0.4N	88°6.6'E	3672 m	APC/XCB	200/300 m	**2.8**
			Total:	**4200 m**	**49.8 days**

Biostratigraphic information from DSDP Site 218 and recalculation of nannofossil ages and zonations from the shipboard report (Von der Borch et al., 1974) provided an accurate age specifically from the *Discoaster hamatus* (NN 9) zone with an age of 9.4-10.4 Ma in core 25, CC at 697 mbsf, which was used for seismic correlation between the proposed sites. The seismic section (see Site Description Forms) as well as the line drawing of reflector segments of R/V Sonne SO 125 seismic line GeoB 97-020/027 (Fig. 5) across the Bengal Fan at 8°N shows the marker horizon of ~10 Ma age. To transfer drilling depth to two-way traveltime, velocity information from multichannel data of Gopala Rao et al. (1997) was used, which provided for the upper 1 to 2 km interval velocity values of 1.7-1.8 km/s for Pleistocene, 1.9-1.95 km/s for Pliocene/Pleistocene and 2.2-2.3 km/s for upper Miocene sediment though having no age constraints on the seismic data. For our calculations a value of 1.9 km/s average velocity was used for the upper 900 meters, an average of 2.1 km/s derived from regional refraction data for the deep hole MBF-3A.

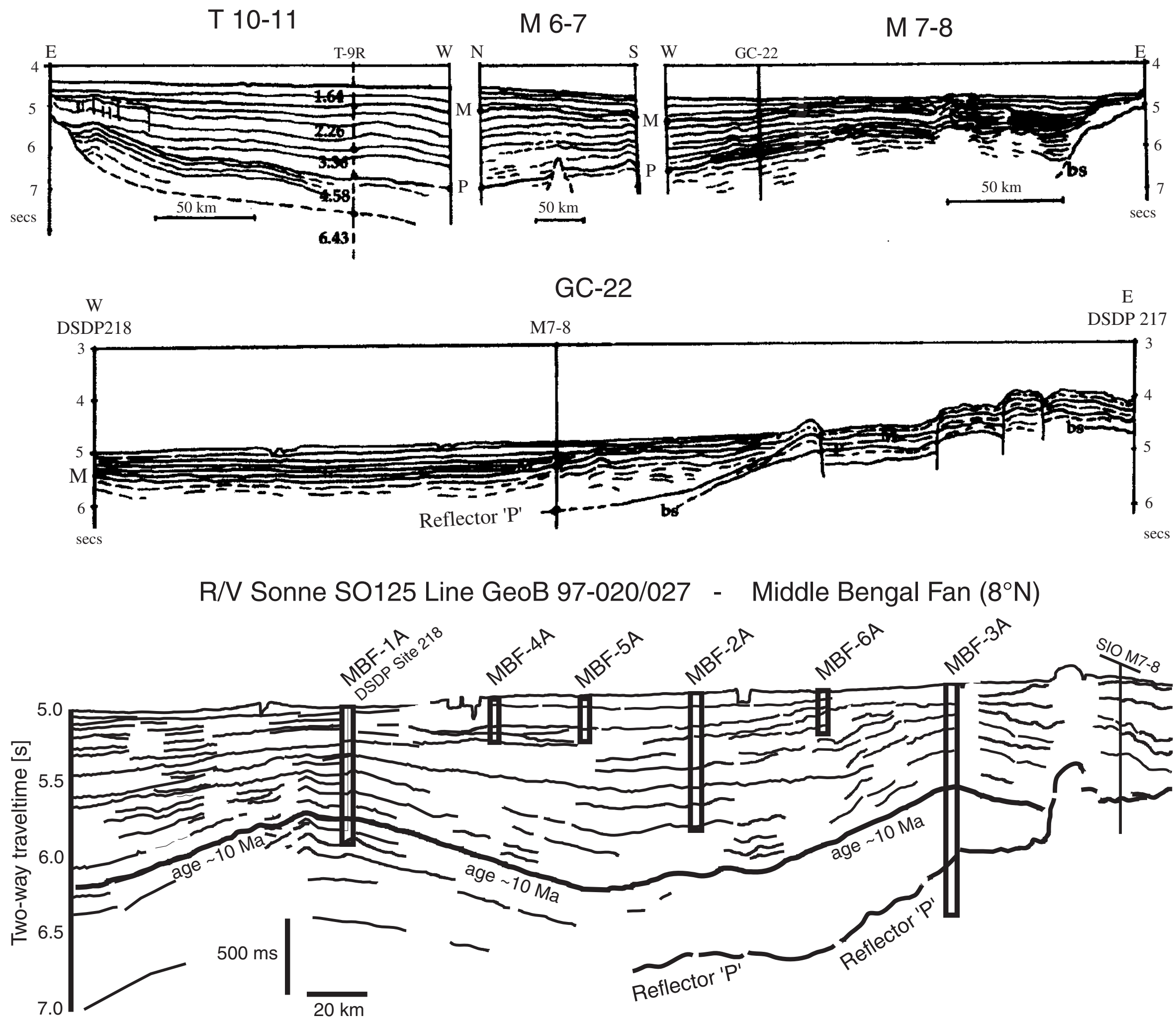

Figure 5: Line drawing of reflector segments of R/V Sonne SO 125 seismic line GeoB 97-020/027 (See Map Fig. 4 and Figure in Site description Forms) across the Bengal Fan at 8°N with positions of proposed drilling sites. Earlier seismic lines between 10 and 8° N are figured for comparison. The marker horizon "M" of ~10 Ma age was correlated to DSDP Site 218 (=MBF-1A). The deeper horizon "P" will be penetrated at Site MBF-3A. The general depositional pattern indicates 50-80% higher sedimentation rates at site MBF-2A than at DSDP Site 218 and 10-20% lower sedimentation rates at the easternmost site MBF-3A.

Drilling time was calculated for a water depth of appx. 3750 m for single APC coring to 200 m, and a change to XCB coring at rates of 30 m/hr from 200 to 500 mbsf and of 20 m/hr from 500 to 900 mbsf. We expect to use only XCB technique to a sub-bottom depth of 900 m based on the experience at ODP Site 718C, where similar fine-grained terrigenous sediment had been drilled and XCB was used to 935 mbsf. Including 2-3 logging runs of 2 days duration, total drilling time adds up to 10.4 days. Seismic data indicate that lithology likely does not differ latitudinally, and calculations can therefore be applied to all sites. For the deep hole MBF-3A, rotary coring is planned beneath 900 mbsf, adding appx. 7 days of drilling and 1 day of downhole logging. Additional sites MBF-4A to 6A are planned for 200 APC coring and another 100 m XCB coring, adding a total of 2.8 days for each drill site.

For this revised version we evaluated all parameters relevant for drilling time, including a recalculated biostratigraphic age for DSDP Site 218, which was used for seismic correlation and for estimating a maximum penetration of 900 mbsf along the MBF transect. Using mostly the higher values of penetration rates provided by ODP, based on previous experience from ODP Leg 116, we estimate a total drilling time of 50 days. Uncertainties derive specifically from the penetration rates at greater depth. We have assumed the sediment at 8°N to be of similar composition and only moderate induration, as was found at ODP Site 718 and DSDP Site 218.

The logging program is planned for two logging runs at each deeper site (MBF-1A to 3A) with the standard tool and the FMS/Acoustic tool. We think that this selection of tools, which is of high-priority, is sufficient to reach the objectives of the proposal. Logging is determinant to assess a continuous record of the relative proportion of clay and silt, the clay mineralogy and the sedimentary structures. This is essential because the core recovery has been problematic during Leg 116 when clay to silt alternation is rapid. In addition it will document important problems of the fan hydrology that are not developed in this proposal. For the evaluation of a more extended logging program we seek advice from the panels.

RELEVANCE OF PROPOSED SITES TO SCIENTIFIC OBJECTIVES

CALIBRATION OF CHANGES AT 7-8 MA AND SINCE THAT TIME - Three proposed sites (MBF-1A to 3A) were positioned such it covers the width of the 300 km wide basin, between the 85 and the 90 East ridges. Site MBF-1A lies in the vicinity of DSDP Site 218. The seismic structures appear to be relatively undisturbed. The latitude of 8°N allows reaching shallower water depths than was possible at the equatorial sites of ODP Leg 116, where biostratigraphic and paleomagnetic methods were difficult to apply. Farther north, however, sediment as old as 10-12 Ma probably cannot be reached within a sub-bottom depth of 1000 m. Final location selection might benefit from further processing of seismic data to identify buried channel-levee systems in the sediment column and may be adjusted. The depositional patterns indicate 50-80% higher sedimentation rates at site MBF-2A than at DSDP Site 218 and 10-20% lower sedimentation rates at the easternmost site MBF-3A, which could allow to reach an age of 14 Ma or older at a depth of 900 mbsf. Site MBF-2A will not reach the same age within the depth range of 900-1000 mbsf.

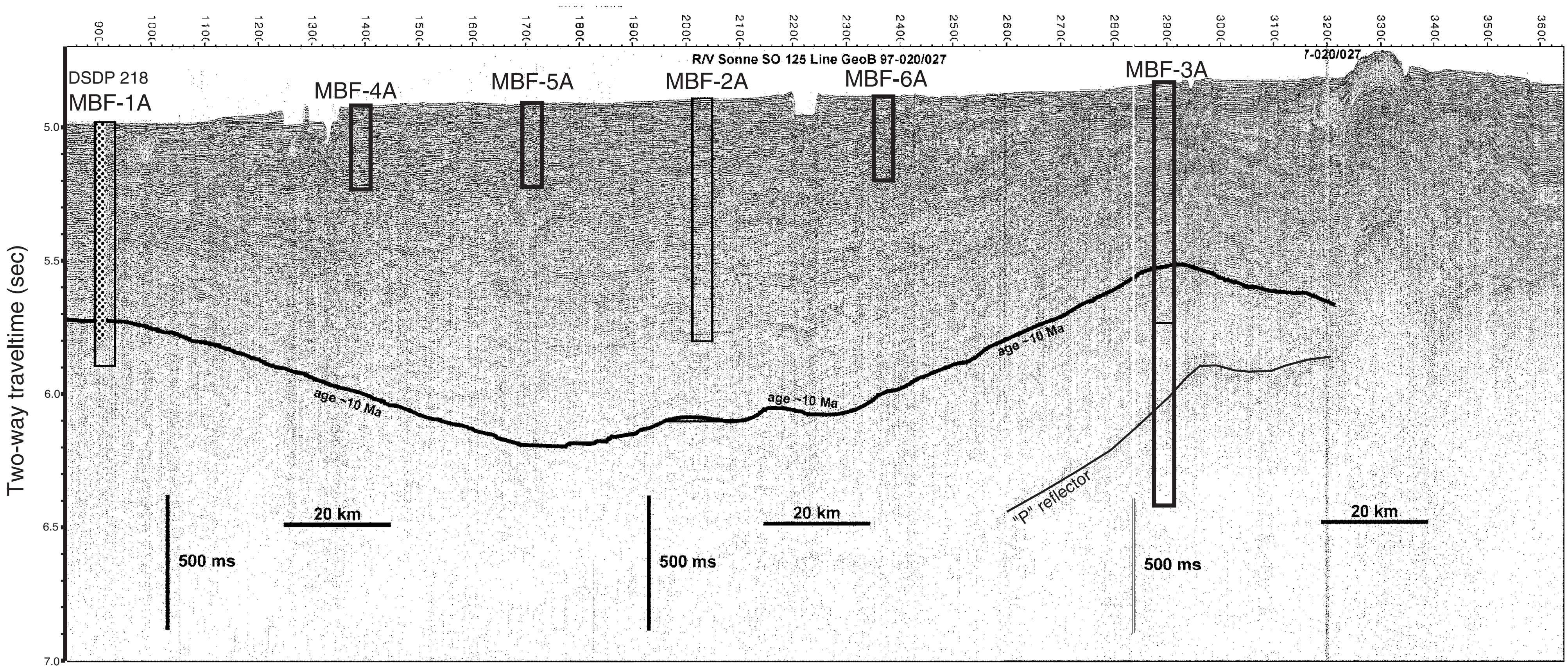

Figure 6: Seismic Line Geob 97/020/027 across the bengal Fan at 8°N. Proposed Site MBF-1A to 6A are indicated with their approximate penetration assuming an average veolocity of 1900 m/s. Although reflector cannot be traced as isochrone across the fan, the basin character is clearly revealed between the 85°E Ridge and the Ninetyeast Ridge. A marker horizon was drawn, which could be corraelated to depth of ~700 mbsf at DSDP Site 218 for an age of roughly 10 Ma. The penetration of DSDP Site 218 of 773 meters (spot coring; 251 m cored) is indicated by the dotted bar.

SAMPLING OF THE OLDEST SEDIMENT OF THE FAN - Two regional unconformities have been identified and correlated throughout much of the Bengal Fan. The upper horizon, “M”, has been shown both in DSDP 218 and in the ODP Leg 116 sites to be upper Miocene, about 7 my old. The onlap unconformity over much of the fan suggests that it correlates with a deformation event that caused uplift over the hills and folds in the central and southern part of the fan. The older unconformity, “P”, has been sampled only in the thin sediment section on the Ninetyeast Ridge, DSDP sites 216 and 217, and in ODP site 358, and possibly in DSDP sites 215 and 211 in the distal fan. It appears to be a hiatus of variable duration: from Paleocene to Middle Eocene at DSDP 217, and from Paleocene to Pliocene in DSDP 211 in the far distal fan. It has been postulated that the “P” horizon marks the onset of fan deposition and progradation seaward, and that the section below the horizon is pre-fan pelagic or hemipelagic sediment.

Seismic line GeoB 97-020/027 (Figs. 5 and 6) shows the “P” horizon at a depth of X to Y sec TWT over the 8°N transect. For this objective, there is a competition between drilling in the center of the transect where the progradation of the fan should be the oldest and drilling thinner lateral site where “P” horizon can be reached at a shallower depth hence more easily and with less diagenesis of the sediments. We selected Site MBF-3A where the “P “ horizon is at 1.2-1.3 sec to be reached above 1500 mbsf.

Velocities at greater depth were also estimated from correlation from refraction station T-9R (Fig. 4 and 5), and a velocity of 2.12 km/s was derived from a compilation of refraction data to “P” from 88 records from all over the fan, this converts to a depth of about 1190 m on seismic line M7-8 and to a depth of 1150 m on line GeoB 97-020/027 near MBF-3A. Extrapolating sediment accumulation rates from DSDP 218 and assuming a constant rate, shows that the sediments overlying the “P” horizon would be of Lower Oligocene age. If the rate of sediment accumulation were slower prior to 11 Ma, as shown in ODP site 718, the age above the unconformity would be older.

SPATIAL DEPOCENTER VARIABILITY - We propose to drill three shallow holes (MBF-4A to -6A) located between the three deeper holes of the 8°N transect. Together with MBF-1A to 3A, this would allow to compare in detail the migration of depocenter over the last one to two million years. Six holes distributed over a transect of 200 km would allow a sufficient spatial resolution on the basis of a typical width of channel levee system on the order of 50 km. Penetration at the shallow holes should reach 300m in order to record the stacking of more than two systems.

SITE SURVEYS

All of the proposed sites are at locations where seismic data are available. The transect at 8°N consists of one long line GeoB 97-020/027 (Fig. 3 and 4) and a grid in the vicinity of DSDP Site 218 and proposed site MBF-1A. Crossing lines are not available for other proposed sites, but additional data from Scripps Oceanographic Institution (Marianas 10, M7-8) were used for the regional stratigraphic and structural framework.

Safety

Neither at Site 718 nor at Site 218 were safety and hydrocarbons an issue. We therefore expect no problems with hydrocarbon or shallow gas. Although potential shallow gas should exist in the fan sediment, so far there is no indication from seismic amplitudes at 8°N.

Summary of sedimentological tracers to be used

In the following, we list the principal sedimentological, mineralogical, and geochemical tracers that will be used to interpret the sedimentary record. Most of them have already been applied to the study of Bengal fan sediment, either over short time scales (Colin et al., 1996, 1998; Duplessy, 1982; Höhndorf et al., in press; Hübscher et al., 1997; Kudrass et al., 1998; Pierson-Wickmann et al., 2001; Van Campo et al., 1982) or long ones (Bouquillon et al., 1989; Bouquillon et al., 1990; Brass and Raman, 1990; Copeland et al., 1990; Derry and France-Lanord, 1996; France-Lanord et al., 1993; France-Lanord and Derry, 1997; Galy et al., 1996; Reisberg et al., 1996). Several of these tracers are sensitive to diagenesis or to the condition of transport such as biogenic carbonates or organic matter.

Some of the interpretations of tracers that can be used in the Bengal fan are based on our knowledge of the modern Himalaya. During the past few years, considerable efforts have been made by groups in India, France, UK and USA, and our knowledge of the river system and the effects of tectonic and climatic constraints on the erosion has improved considerably. Such studies will be used to define the best tools to reconstruct the tectonic and climatic history and the Himalayan basin.

Chronostratigraphy: Dating sediments in formations such as the Bengal fan is a difficult problem because of poor preservation of the biogenic carbonates. However, in the middle fan sediments, nannofossil preservation is sufficient in Site 218 to allow dating at the million year resolution. Magneto-stratigraphy will also be possible in the upper section of the sediments. In addition, Ar-Ar ages on coarse muscovites and feldspars can be used to date exhumation of the metamorphic rocks during erosion (Copeland et al., 1990) and should provide a maximum age for sediments for Lower Miocene and Oligocene sediments.

Origin of detrital material: Determining the provenance of sediment is a major goal, especially in the deep fan site as it documents the structural evolution of the Himalaya.

- Coarse grain mineralogy
- H, O, Sr, Nd and Os isotopic composition of silicate material (whole rock, grain size and mineral fractions). Nd isotopes is the most reliable tracers as it is not sensible to diagenetic overprint which may be significant in a Hole as deep as 1.5 km. Single grain analysis for Pb isotopes using ion probe also allow the identification of the specific sources involved (Clift et al., in press).
- Magnetic properties. Recent studies by Colin et al. (1998) have shown on piston cores of the Bay of Bengal the sensitivity of the tracer to source parameters.
- $\delta^{13}C$ of organic carbon applied on total organic carbon (France-Lanord and Derry, 1994) and on n-akanes (Freeman and Colarusso, 2001) allow to determine the origin (marine vs. continental) of organic carbon and the type of vegetation (C3 vs.C4).

WEATHERING REGIME: By analogy to the modern Himalaya, the state of alteration of the material accumulated in the fan depends on the rate of uplift and the intensity of precipitation. It is therefore one of the indirect proxy for paleo-climatic conditions. It is documented by: major element chemistry (Na/Al, Mg/Al, Ca/Al, etc.), clay mineralogy and isotopic compositions ($\delta^{18}O$ and δD), grain size distribution, accumulation rate, Sr isotopic composition on pedogenic clays. Logging will be important to assess the relative proportion of clay and silt when recovery is poor. Leg 116 had a relatively poor recovery in the 7 to 1 Myr. interval. It is likely that silt abundance has been underestimated in this interval because of lower recovery of silty sediment with regard to mud.

EROSIONAL FLUXES: Accumulation rate is a direct function of the erosional flux. However, contradictory results have been obtained for the Bengal fan depending on the sedimentary records used (Burbank et al., 1993; Gartner, 1990; Métivier et al., 1999; Rea, 1992). We contend that accumulation recorded in the lateral parts of the fan either on the Indian shelf or the Ninety East ridge are not relevant for this problem. One main result of this proposal should be to test the regional representativeness of deposition variations. Also, Sr isotopic composition of pedogenic minerals, document past riverine fluxes of Sr (Derry and France-Lanord, 1996), which can be further related to the general erosion of the range.

RATE OF EROSION AND TRANSPORT AND UPLIFT HISTORY:

- Erosional fluxes
- Geochronology, Ar-Ar dating on feldspars and micas, Rb-Sr on biotite have been used on sediments of Leg 116 to document the rate of exhumation (Copeland et al., 1990; Galy et al., 1996). New methods with low closure temperatures as U-He on apatite or cosmogenic isotopes will be important complement. Cosmogenic isotopes ^{10}Be on quartz for sediments less than 2 Ma and He on garnet allow indirect estimates of transport rate in the modern river system.

MONSOON-CLIMATE AND PALEOVEGETATION: The only known direct tracer of the monsoon intensity in the Bay of Bengal is $\delta^{18}O$ of planktonic foraminifers. This has been determined on Holocene to late Pleistocene piston cores of the proximal fan but it has never been applied to Neogene samples e.g.(Duplessy, 1982). In principle this could be possible in the middle fan sites.

The combination of the variation of the weathering regime, paleo-vegetation determined from the palynological and carbon isotopic studies, and erosional fluxes provides an indirect indication of monsoon strength, based on our knowledge of both the modern erosion system (Galy and France-Lanord, 1999; Galy and France-Lanord, 2001; Goodbred and Kuehl, 2001; Singh and France-Lanord, 2001) and the continental record of the Siwaliks (Dettman et al., 2001; Hoorn et al., 2000).

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iSAS/IODP Site Summary Forms:

552-Full3

Form 1 - General Site Information

(Submitted with Preliminary Proposal)

Please fill out information in all gray boxes

__**New** **Revised**

Section A: Proposal Information

Title of Proposal:	Neogene and late Paleogene record of Himalayan orogeny and climate: a transect across the Middle Bengal Fan.
Date Form Submitted:	1 October 2001
Site Specific Objectives with Priority (Must include general objectives in proposal)	Neogene sedimentation history, Depocenter migration
List Previous Drilling in Area:	DSDP Legs 21, 22, ODP Leg 116

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	MBF-1A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #218	Area or Location:	Middle Bengal Fan
Latitude:	Deg: 8 N	Min: 0.42N	Jurisdiction:	International/India
Longitude:	Deg: 86 E	Min: 16.97E	Distance to Land:	
Coordinates System:	__WGS 84, _Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	3747 m

Section C: Operational Information

	Sediments		Basement
Proposed Penetration: (m)	900 m		no
	What is the total sed. thickness?	? > 2000 m	
		Total Penetration:	900 m
General Lithologies:	Mud turbidites		
Coring Plan: *(Specify or Circle)*	1-APX/XCB 1-APC VPC* XCB MDCB* PCS RCB Re-entry HRGB		

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	■	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	■	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma Ray	☐
Gamma Ray	■	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	■	Side-Wall Core Sampling	☐				
Acoustic	■						
Formation Image	■			Others ( )		Others ( )	

Max.Borehole Temp. :	**Expected value (For Riser Drilling)** _____________ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from	m	to	m,		m intervals
from	m	to	m,		m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring:8.4	Logging:2	Total On-Site:10.4

Future Plan: **Longterm Borehole Observation Plan/Re-entry Plan**

Hazards/ Weather:

Please check flowing List of Potential Hazards

Shallow Gas	☐	Complicated Geological Structures	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Irregular Seabed	☐	Methane Hydrate	☐
Abnormal Pressure	☐	Currents	☐	Diapir and Mud Volcano	☐
Man-made Objects	☐	Fractured Zone	☐	High Temperature	☐
H_2S	☐	Fault	☐	Ice Conditions	☐
CO_2	☐	High Dip Angle	☐		

What is your Weather window? (Preferable period with the reasons)

iSAS/IODP Site Summary Forms:

Form 2 - Site Survey Detail

Please fill out information in all gray boxes

New **Revised**

Proposal #: 552-full3	Site #: MBF-1A	Date Form Submitted: Oct. 2001

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 ch, GeoB 97-020/027, GI Gun 0.4 l, Watergun 0.16 l, trace# 2900 Crossing Lines(s): no
2	Deep Penetration seismic reflection			Primary Line(s): Pre-Site survey data of ODP Leg 116 Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 chGeoB 97-020/027, seismic signal penetration >2 s trace# 2900 Crossing Lines(s):
3	Seismic Velocity†			SO 125 velocity information (750 m Offset) not yet available, velocity model from Gopala Rao et al. (1997)
4	Seismic Grid			no
5a	Refraction (surface)			no
5b	Refraction (near bottom)			Yes 10°N 88.5°E T9R (J. Curray, Scripps)
6	3.5 kHz			yes, digital Parasound Location of Site on line (Time)
7	Swath bathymetry			yes, Hydrosweep
8a	Side-looking sonar (surface)			yes, Hydrosweep scatter amplitudes, 59 beams
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation			
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

iSAS/IODP Site Summary Forms:

Form 3 - Detailed Logging Plan

New □ **Revised** ■

Proposal #: 552-full3	Site #: MBF-1A	Date Form Submitted: Oct 2001
Water Depth (m): 3747 m	Sed. Penetration (m): 900 m	Basement Penetration (m): no

Do you need to use the conical side-entry sub (CSES) at this site? Yes □ No ■

Are high temperatures expected at this site? Yes □ No ■

Are there any other special requirements for logging at this site? Yes □ No ■

If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be:_____________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Yes -Fan hydrology	2
Litho-Density	Yes - Silt/Clay ratio, clay mineralogy	1
Natural Gamma Ray	Yes - Silt/Clay ratio, clay mineralogy	1
Resistivity-Induction	Fan hydrology	2
Acoustic	Yes - Calibration of seismic velocity Fan hydrology	1 2
FMS	Yes - Sedimentary structure and facies	1
BHTV	No	
Resistivity-Laterolog	No	
Magnetic/Susceptibility	Yes - Silt/Clay ratio, clay mineralogy	2
Density-Neutron (LWD)	No	
Resitivity-Gamma Ray (LWD)	no	
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	no	

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New ☐ **Revised** ■

Proposal #: 552-full3	Site #: MBF-1A	Date Form Submitted: 1 october 2001

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Single APC to refusal (~200 m) XCB down to 900 mbsf
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	no
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no
4	Are there any indications of gas hydrates at this location?	no
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	no
6	What “special” precautions will be taken during drilling?	no
7	What abandonment procedures do you plan to follow:	no
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	no
9	Summary: What do you consider the major risks in drilling at this site?	no

iSAS/IODP Site Summary Forms:

Form 5 - Lithologic Summary

New ☐ **Revised** ■

Proposal # 552-Full3	Site #: MBF-1A	Date Form Submitted: October 2001

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Ave. rate of sediment accumulation (m/My)*	*Comments*
0-700	"	0-10Ma	1.9	Mud turbidites	Deep sea fan	70	
700	M" reflector	10 Ma ?					
700-900		>10 Ma	1.9	Mud turbidites	Deep sea fan	70	

iSAS/IODP Site Summary Forms:

Form 1 - General Site Information

(Submitted with Preliminary Proposal)

Please fill out information in all gray boxes

552-Full3

__**New** **Revised**

Section A: Proposal Information

Title of Proposal:	Neogene and late Paleogene record of Himalayan orogeny and climate: a transect across the Middle Bengal Fan.
Date Form Submitted:	1 October 2001
Site Specific Objectives with Priority (Must include general objectives in proposal)	Neogene sedimentation history, Depocenter migration
List Previous Drilling in Area:	DSDP Legs 21, 22, ODP Leg 116

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	MBF-2A	If site is a reoccupation of an old DSDP/ODP Site, Please include	Area or Location:	Middle Bengal Fan
Latitude:	Deg: 8 N	Min: 0.4N	Jurisdiction:	International/India
Longitude:	Deg: 87 E	Min: 38E	Distance to Land:	
Coordinates System:	__WGS 84, _Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	3678 m

Section C: Operational Information

	Sediments		Basement
Proposed Penetration: (m)	900 m		no
	What is the total sed. thickness?	? > 2000 m	
		Total Penetration:	900 m
General Lithologies:	Mud turbidites		
Coring Plan: *(Specify or Circle)*	1-APX/XCB 1-APC VPC* XCB MDCB* PCS RCB Re-entry HRGB		

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	■	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	■	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma Ray	☐
Gamma Ray	■	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	■	Side-Wall Core Sampling	☐				
Acoustic	■						
Formation Image	■			Others ( )		Others ( )	

Max.Borehole Temp. : **Expected value (For Riser Drilling)** ______ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring:8.4	Logging:2	Total On-Site:10.4

Future Plan: **Longterm Borehole Observation Plan/Re-entry Plan**

Hazards/ Weather:

Please check flowing List of Potential Hazards

Shallow Gas	☐	Complicated Geological Structures	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Irregular Seabed	☐	Methane Hydrate	☐
Abnormal Pressure	☐	Currents	☐	Diapir and Mud Volcano	☐
Man-made Objects	☐	Fractured Zone	☐	High Temperature	☐
H_2S	☐	Fault	☐	Ice Conditions	☐
CO_2	☐	High Dip Angle	☐		

What is your Weather window? (Preferable period with the reasons)

iSAS/IODP Site Summary Forms:

Form 2 - Site Survey Detail

Please fill out information in all gray boxes

New ☐ **Revised** ■

Proposal #: 552-full3	Site #: MBF-2A	Date Form Submitted: Oct. 2001

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 ch, GeoB 97-020/027, GI Gun 0.4 l, Watergun 0.16 l, trace# 2900 Crossing Lines(s): no
2	Deep Penetration seismic reflection			Primary Line(s): Pre-Site survey data of ODP Leg 116 Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 chGeoB 97-020/027, seismic signal penetration >2 s trace# 2900 Crossing Lines(s):
3	Seismic Velocity†			SO 125 velocity information (750 m Offset) not yet available, velocity model from Gopala Rao et al. (1997)
4	Seismic Grid			no
5a	Refraction (surface)			no
5b	Refraction (near bottom)			Yes 10°N 88.5°E T9R (J. Curray, Scripps)
6	3.5 kHz			yes, digital Parasound Location of Site on line (Time)
7	Swath bathymetry			yes, Hydrosweep
8a	Side-looking sonar (surface)			yes, Hydrosweep scatter amplitudes, 59 beams
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation			
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

iSAS/IODP Site Summary Forms:

Form 3 - Detailed Logging Plan

New □ **Revised** ■

Proposal #: 552-full3	Site #: MBF-2A	Date Form Submitted: Oct 2001
Water Depth (m): 3678 m	Sed. Penetration (m): 900 m	Basement Penetration (m): no

Do you need to use the conical side-entry sub (CSES) at this site? Yes □ No ■

Are high temperatures expected at this site? Yes □ No ■

Are there any other special requirements for logging at this site? Yes □ No ■

If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be:____________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Yes -Fan hydrology	2
Litho-Density	Yes - Silt/Clay ratio, clay mineralogy	1
Natural Gamma Ray	Yes - Silt/Clay ratio, clay mineralogy	1
Resistivity-Induction	Fan hydrology	2
Acoustic	Yes - Calibration of seismic velocity Fan hydrology	1 2
FMS	Yes - Sedimentary structure and facies	1
BHTV	No	
Resistivity-Laterolog	No	
Magnetic/Susceptibility	Yes - Silt/Clay ratio, clay mineralogy	2
Density-Neutron (LWD)	No	
Resitivity-Gamma Ray (LWD)	no	
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	no	

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New Revised

Proposal #: 552-full3	Site #: MBF-2A	Date Form Submitted: october 2001

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Single APC to refusal (~200 m) XCB down to 900 mbsf
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	no
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no
4	Are there any indications of gas hydrates at this location?	no
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	no
6	What “special” precautions will be taken during drilling?	no
7	What abandonment procedures do you plan to follow:	no
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	no
9	Summary: What do you consider the major risks in drilling at this site?	no

iSAS/IODP Site Summary Forms:

Form 5 - Lithologic Summary

New ☐ **Revised** ■

Proposal # 552-Full3	Site #: MBF-2A	Date Form Submitted: October 2001

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Ave. rate of sediment accumulation (m/My)*	*Comments*
0-900	"	0-<10Ma	1.9	Mud turbidites	Deep sea fan	110	
1150	M" reflector	10 Ma ?					

iSAS/IODP Site Summary Forms:

Form 1 - General Site Information

(Submitted with Preliminary Proposal)

Please fill out information in all gray boxes

552-Full3

__**New** **Revised**

Section A: Proposal Information

Title of Proposal:	Neogene and late Paleogene record of Himalayan orogeny and climate: a transect across the Middle Bengal Fan.
Date Form Submitted:	1 October 2001
Site Specific Objectives with Priority (Must include general objectives in proposal)	Neogene and pre-Neogene sedimentation history, Depocenter migration
List Previous Drilling in Area:	DSDP Legs 21, 22, ODP Leg 116

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	MBF-3A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Middle Bengal Fan
Latitude:	Deg: 8 N	Min: 0.4N	Jurisdiction:	International/India
Longitude:	Deg: 88 E	Min: 41E	Distance to Land:	
Coordinates System:	__WGS 84, _Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	3620 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	1500 m What is the total sed. thickness? ? > 2000 m	no
		Total Penetration: 1500 m
General Lithologies:	Mud turbidites	
Coring Plan: *(Specify or Circle)*	1-APC / XCB / RCB 1-APC VPC* XCB MDCB* PCS RCB Re-entry HRGB	

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	■	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	■	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma Ray	☐
Gamma Ray	■	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	■	Side-Wall Core Sampling	☐				
Acoustic	■						
Formation Image	■			Others ( )		Others ( )	

Max.Borehole Temp. : **Expected value (For Riser Drilling)** ______ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring:16.6	Logging:2	Total On-Site:18.6

Future Plan: **Longterm Borehole Observation Plan/Re-entry Plan**

Hazards/ Weather:

Please check flowing List of Potential Hazards

Shallow Gas	☐	Complicated Geological Structures	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Irregular Seabed	☐	Methane Hydrate	☐
Abnormal Pressure	☐	Currents	☐	Diapir and Mud Volcano	☐
Man-made Objects	☐	Fractured Zone	☐	High Temperature	☐
H_2S	☐	Fault	☐	Ice Conditions	☐
CO_2	☐	High Dip Angle	☐		

What is your Weather window? (Preferable period with the reasons)

iSAS/IODP Site Summary Forms:

Form 2 - Site Survey Detail

Please fill out information in all gray boxes

New Revised

Proposal #: 552-full3	Site #: MBF-3A	Date Form Submitted: Oct. 2001

	Data Type	SSP Requir- ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 ch, GeoB 97-020/027, GI Gun 0.4 l, Watergun 0.16 l, trace# 2900 Crossing Lines(s): no
2	Deep Penetration seismic reflection			Primary Line(s): Pre-Site survey data of ODP Leg 116 Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 chGeoB 97-020/027, seismic signal penetration >2 s trace# 2900 (Fig. 8) Crossing Lines(s):
3	Seismic Velocity†			SO 125 velocity information (750 m Offset) not yet available, velocity model from Gopala Rao et al. (1997)
4	Seismic Grid			no
5a	Refraction (surface)			no
5b	Refraction (near bottom)			Yes 10°N 88.5°E T9R (J. Curray, Scripps)
6	3.5 kHz			yes, digital Parasound Location of Site on line (Time)
7	Swath bathymetry			yes, Hydrosweep
8a	Side-looking sonar (surface)			yes, Hydrosweep scatter amplitudes, 59 beams
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation			
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

iSAS/IODP Site Summary Forms:

Form 3 - Detailed Logging Plan

New ☐ **Revised** ■

Proposal #: 552-full3	Site #: MBF-3A	Date Form Submitted: Oct 2001
Water Depth (m): 3620 m	Sed. Penetration (m): 1500 m	Basement Penetration (m): no

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■

Are high temperatures expected at this site? Yes ☐ No ■

Are there any other special requirements for logging at this site? Yes ☐ No ■

If "Yes" Please describe requirements:______________________________

What do you estimate the total logging time for this site to be: 2 days

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Yes -Fan hydrology	2
Litho-Density	Yes - Silt/Clay ratio, clay mineralogy	1
Natural Gamma Ray	Yes - Silt/Clay ratio, clay mineralogy	1
Resistivity-Induction	Fan hydrology	2
Acoustic	Yes - Calibration of seismic velocity Fan hydrology	1 2
FMS	Yes - Sedimentary structure and facies	1
BHTV	No	
Resistivity-Laterolog	No	
Magnetic/Susceptibility	Yes - Silt/Clay ratio, clay mineralogy	2
Density-Neutron (LWD)	No	
Resitivity-Gamma Ray (LWD)	no	
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	no	

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New ☐ **Revised** ■

Proposal #: 552-full3	Site #: MBF-3A	Date Form Submitted: 1 october 2001

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Single APC to refusal (~200 m) XCB down to 900 mbsf RCB down to 1500 mbsf
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	no
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no
4	Are there any indications of gas hydrates at this location?	no
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	no
6	What “special” precautions will be taken during drilling?	no
7	What abandonment procedures do you plan to follow:	no
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	no
9	Summary: What do you consider the major risks in drilling at this site?	no

iSAS/IODP Site Summary Forms:

Form 5 - Lithologic Summary

New ☐ **Revised** ■

Proposal # 552-Full3	Site #: MBF-3A	Date Form Submitted: October 2001

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Ave. rate of sediment accumulation (m/My)*	*Comments*
0-660	"	0-10Ma	1.9	Mud turbidites	Deep sea fan	66	
660	M" reflector	10 Ma ?					
660-1100		>10 Ma	1.9	Mud turbidites	Deep sea fan	<50 ?	
~1100	"P" reflector	Oligocene ?					
1100-1500				Turbidites	Early fan sediments	?	

iSAS/IODP Site Summary Forms:

552-Full3

Form 1 - General Site Information

(Submitted with Preliminary Proposal)

Please fill out information in all gray boxes

__**New** ■ **Revised** □

Section A: Proposal Information

Title of Proposal:	Neogene and late Paleogene record of Himalayan orogeny and climate: a transect across the Middle Bengal Fan.
Date Form Submitted:	1 October 2001
Site Specific Objectives with Priority (Must include general objectives in proposal)	Depocenter migration
List Previous Drilling in Area:	DSDP Legs 21, 22, ODP Leg 116

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	MBF-4A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site	Area or Location:	Middle Bengal Fan
Latitude:	Deg: 8 N	Min: 0.4N	Jurisdiction:	International/India
Longitude:	Deg: 86 E	Min: 47.9E	Distance to Land:	
Coordinates System:	__WGS 84, _Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	3694 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	300 m What is the total sed. thickness? ? > 2000 m	no
		Total Penetration: 300 m
General Lithologies:	Mud turbidites	
Coring Plan: *(Specify or Circle)*	1-APX/XCB 1-APC VPC* XCB MDCB* PCS RCB Re-entry HRGB	

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	☐	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	☐	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma Ray	☐
Gamma Ray	☐	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	☐	Side-Wall Core Sampling	☐				
Acoustic	☐						
Formation Image	☐			Others ( )		Others ( )	

Max.Borehole Temp. : **Expected value (For Riser Drilling)** ________ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring:2.8	Logging:-	Total On-Site:2.8

Future Plan: **Longterm Borehole Observation Plan/Re-entry Plan**

Hazards/ Weather:

Please check flowing List of Potential Hazards

Shallow Gas	☐	Complicated Geological Structures	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Irregular Seabed	☐	Methane Hydrate	☐
Abnormal Pressure	☐	Currents	☐	Diapir and Mud Volcano	☐
Man-made Objects	☐	Fractured Zone	☐	High Temperature	☐
H_2S	☐	Fault	☐	Ice Conditions	☐
CO_2	☐	High Dip Angle	☐		

What is your Weather window? (Preferable period with the reasons)

iSAS/IODP Site Summary Forms:

Form 2 - Site Survey Detail

Please fill out information in all gray boxes

New ■ Revised ☐

Proposal #: 552-full3	Site #: MBF-4A	Date Form Submitted: Oct. 2001

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 ch, GeoB 97-020/027, GI Gun 0.4 l, Watergun 0.16 l, trace# 2900 Crossing Lines(s): no
2	Deep Penetration seismic reflection			Primary Line(s): Pre-Site survey data of ODP Leg 116 Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 chGeoB 97-020/027, seismic signal penetration >2 s trace# 2900 Crossing Lines(s):
3	Seismic Velocity†			SO 125 velocity information (750 m Offset) not yet available, velocity model from Gopala Rao et al. (1997)
4	Seismic Grid			no
5a	Refraction (surface)			no
5b	Refraction (near bottom)			Yes 10°N 88.5°E T9R (J. Curray, Scripps)
6	3.5 kHz			yes, digital Parasound Location of Site on line (Time)
7	Swath bathymetry			yes, Hydrosweep
8a	Side-looking sonar (surface)			yes, Hydrosweep scatter amplitudes, 59 beams
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation			
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

iSAS/IODP Site Summary Forms:

Form 3 - Detailed Logging Plan

New ■ **Revised** ☐

Proposal #: 552-full3	Site #: MBF-4A	Date Form Submitted: Oct 2001
Water Depth (m): 3694 m	Sed. Penetration (m): 300 m	Basement Penetration (m): no

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■

Are high temperatures expected at this site? Yes ☐ No ■

Are there any other special requirements for logging at this site? Yes ☐ No ■

If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be:_____________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	no	
Litho-Density	no	
Natural Gamma Ray	no	
Resistivity-Induction	no	
Acoustic	no	
FMS	no	
BHTV	no	
Resistivity-Laterolog	no	
Magnetic/Susceptibility	no	
Density-Neutron (LWD)	no	
Resitivity-Gamma Ray (LWD)	no	
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	no	

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms: **Form 4 – Pollution & Safety Hazard Summary**

Please fill out information in all gray boxes

New ■ **Revised** □

Proposal #: 552-full3	Site #: MBF-4A	Date Form Submitted: october 2001

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Single APC to refusal (~200 m) XCB down to 300 mbsf
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	no
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no
4	Are there any indications of gas hydrates at this location?	no
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	no
6	What “special” precautions will be taken during drilling?	no
7	What abandonment procedures do you plan to follow:	no
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	no
9	Summary: What do you consider the major risks in drilling at this site?	no

iSAS/IODP Site Summary Forms:

Form 5 - Lithologic Summary

New ■ **Revised** □

Proposal # 552-Full3	Site #: MBF-4A	Date Form Submitted: October 2001

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Ave. rate of sediment accumulation (m/My)*	*Comments*
0-300		0-2/5 Ma	1.9	Mud turbidites	Deep sea fan	60-150	

iSAS/IODP Site Summary Forms:

552-Full3

Form 1 - General Site Information

(Submitted with Preliminary Proposal)

Please fill out information in all gray boxes

__**New** **Revised**

Section A: Proposal Information

Title of Proposal:	Neogene and late Paleogene record of Himalayan orogeny and climate: a transect across the Middle Bengal Fan.
Date Form Submitted:	1 October 2001
Site Specific Objectives with Priority (Must include general objectives in proposal)	Depocenter migration
List Previous Drilling in Area:	DSDP Legs 21, 22, ODP Leg 116

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	MBF-5A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site	Area or Location:	Middle Bengal Fan
Latitude:	Deg: 8 N	Min: 0.4N	Jurisdiction:	International/India
Longitude:	Deg: 87 E	Min: 10.9E	Distance to Land:	
Coordinates System:	__WGS 84, _Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	3687m

Section C: Operational Information

	Sediments		Basement
Proposed Penetration: (m)	300 m		no
	What is the total sed. thickness?	? > 2000 m	
		Total Penetration:	300 m
General Lithologies:	Mud turbidites		
Coring Plan: *(Specify or Circle)*	1-APX/XCB		
	1-APC VPC* XCB MDCB* PCS RCB Re-entry HRGB		

Wireline Logging Plan:	Standard Tools	Special Tools		LWD
	Neutron-Porosity ☐	Borehole Televiewer ☐	Formation Fluid Sampling ☐	Density-Neutron ☐
	Litho-Density ☐	Nuclear Magnetic Resonance ☐	Borehole Temperature & Pressure ☐	Resistivity-Gamma Ray ☐
	Gamma Ray ☐	Geochemical ☐	Borehole Seismic ☐	Acoustic ☐
	Resistivity ☐	Side-Wall Core Sampling ☐		
	Acoustic ☐			
	Formation Image ☐		Others ( )	Others ( )

Max.Borehole Temp. :	**Expected value (For Riser Drilling)** ______ °C
Mud Logging: *(Riser Holes Only)*	Cuttings Sampling Intervals from m to m, m intervals from m to m, m intervals *Basic Sampling Intervals: 5m*

Estimated days:	Drilling/Coring:2.8	Logging:-	Total On-Site:2.8

Future Plan:	**Longterm Borehole Observation Plan/Re-entry Plan**

Hazards/ Weather:	**Please check flowing List of Potential Hazards**			*What is your Weather window? (Preferable period with the reasons)*
	Shallow Gas ☐	Complicated Geological Structures ☐	Hydrothermal Activity ☐	
	Hydrocarbon ☐	Soft Seabed ☐	Landslide and Turbidity Current ☐	
	Shallow Water Flow ☐	Irregular Seabed ☐	Methane Hydrate ☐	
	Abnormal Pressure ☐	Currents ☐	Diapir and Mud Volcano ☐	
	Man-made Objects ☐	Fractured Zone ☐	High Temperature ☐	
	H_2S ☐	Fault ☐	Ice Conditions ☐	
	CO_2 ☐	High Dip Angle ☐		

iSAS/IODP Site Summary Forms:

Form 2 - Site Survey Detail

Please fill out information in all gray boxes

New ■ **Revised** ☐

Proposal #: 552-full3	Site #: MBF-5A	Date Form Submitted: Oct. 2001

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 ch, GeoB 97-020/027, GI Gun 0.4 l, Watergun 0.16 l, trace# 2900 Crossing Lines(s): no
2	Deep Penetration seismic reflection			Primary Line(s): Pre-Site survey data of ODP Leg 116 Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 chGeoB 97-020/027, seismic signal penetration >2 s trace# 2900 Crossing Lines(s):
3	Seismic Velocity†			SO 125 velocity information (750 m Offset) not yet available, velocity model from Gopala Rao et al. (1997)
4	Seismic Grid			no
5a	Refraction (surface)			no
5b	Refraction (near bottom)			Yes 10°N 88.5°E T9R (J. Curray, Scripps)
6	3.5 kHz			yes, digital Parasound Location of Site on line (Time)
7	Swath bathymetry			yes, Hydrosweep
8a	Side-looking sonar (surface)			yes, Hydrosweep scatter amplitudes, 59 beams
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation			
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

New ■ **Revised** ☐

Proposal #: 552-full3	Site #: MBF-5A	Date Form Submitted: Oct 2001
Water Depth (m): 3687 m	Sed. Penetration (m): 300 m	Basement Penetration (m): no

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■

Are high temperatures expected at this site? Yes ☐ No ■

Are there any other special requirements for logging at this site? Yes ☐ No ■

If "Yes" Please describe requirements:______________________________

What do you estimate the total logging time for this site to be:____________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	no	
Litho-Density	no	
Natural Gamma Ray	no	
Resistivity-Induction	no	
Acoustic	no	
FMS	no	
BHTV	no	
Resistivity-Laterolog	no	
Magnetic/Susceptibility	no	
Density-Neutron (LWD)	no	
Resitivity-Gamma Ray (LWD)	no	
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	no	

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms: Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New ■ **Revised** ☐

Proposal #: 552-full3	Site #: MBF-5A	Date Form Submitted: october 2001

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Single APC to refusal (~200 m) XCB down to 300 mbsf
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	no
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no
4	Are there any indications of gas hydrates at this location?	no
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	no
6	What “special” precautions will be taken during drilling?	no
7	What abandonment procedures do you plan to follow:	no
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	no
9	Summary: What do you consider the major risks in drilling at this site?	no

iSAS/IODP Site Summary Forms:

Form 5 - Lithologic Summary

Proposal # 552-Full3	Site #: MBF-5A	Date Form Submitted: October 2001

New **Revised**

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Ave. rate of sediment accumulation (m/My)*	*Comments*
0-300		0-2/5 Ma	1.9	Mud turbidites	Deep sea fan	60-150	

iSAS/IODP Site Summary Forms:

Form 1 - General Site Information

(Submitted with Preliminary Proposal)

Please fill out information in all gray boxes

552-Full3

__**New** **Revised**

Section A: Proposal Information

Title of Proposal: Neogene and late Paleogene record of Himalayan orogeny and climate: a transect across the Middle Bengal Fan.

Date Form Submitted: 1 October 2001

Site Specific Objectives with Priority (Must include general objectives in proposal): Depocenter migration

List Previous Drilling in Area: DSDP Legs 21, 22, ODP Leg 116

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	MBF-6A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site	Area or Location:	Middle Bengal Fan
Latitude:	Deg: 8 N	Min: 0.4N	Jurisdiction:	International/India
Longitude:	Deg: 88 E	Min: 6.6E	Distance to Land:	
Coordinates System:	__WGS 84, _Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	3694 m

Section C: Operational Information

	Sediments		Basement
Proposed Penetration: (m)	300 m		no
	What is the total sed. thickness?	? > 2000 m	
		Total Penetration:	300 m
General Lithologies:	Mud turbidites		
Coring Plan: *(Specify or Circle)*	1-APX/XCB 1-APC VPC* XCB MDCB* PCS RCB Re-entry HRGB		

Wireline Logging Plan:	Standard Tools	Special Tools		LWD
	Neutron-Porosity ☐	Borehole Televiewer ☐	Formation Fluid Sampling ☐	Density-Neutron ☐
	Litho-Density ☐	Nuclear Magnetic Resonance ☐	Borehole Temperature & Pressure ☐	Resistivity-Gamma Ray ☐
	Gamma Ray ☐	Geochemical ☐	Borehole Seismic ☐	Acoustic ☐
	Resistivity ☐	Side-Wall Core Sampling ☐		
	Acoustic ☐ Formation Image ☐		Others ( )	Others ( )

Max.Borehole Temp. :	**Expected value (For Riser Drilling)** __________ °C	

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from ____ m to ____ m, ____ m intervals

from ____ m to ____ m, ____ m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring:2.8	Logging:-	Total On-Site:2.8
Future Plan:	**Longterm Borehole Observation Plan/Re-entry Plan**		

Hazards/ Weather:

Please check flowing List of Potential Hazards			*What is your Weather window? (Preferable period with the reasons)*
Shallow Gas ☐	Complicated Geological Structures ☐	Hydrothermal Activity ☐	
Hydrocarbon ☐	Soft Seabed ☐	Landslide and Turbidity Current ☐	
Shallow Water Flow ☐	Irregular Seabed ☐	Methane Hydrate ☐	
Abnormal Pressure ☐	Currents ☐	Diapir and Mud Volcano ☐	
Man-made Objects ☐	Fractured Zone ☐	High Temperature ☐	
H_2S ☐	Fault ☐	Ice Conditions ☐	
CO_2 ☐	High Dip Angle ☐		

iSAS/IODP Site Summary Forms:

Form 2 - Site Survey Detail

Please fill out information in all gray boxes

New **Revised**

Proposal #: 552-full3	Site #: MBF-6A	Date Form Submitted: Oct. 2001

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 ch, GeoB 97-020/027, GI Gun 0.4 l, Watergun 0.16 l, trace# 2900 Crossing Lines(s): no
2	Deep Penetration seismic reflection			Primary Line(s): Pre-Site survey data of ODP Leg 116 Location of Site on line (SP or Time only) R/V Sonne Cruise SO 125 Multichannel, 48 chGeoB 97-020/027, seismic signal penetration >2 s trace# 2900 Crossing Lines(s):
3	Seismic Velocity†			SO 125 velocity information (750 m Offset) not yet available, velocity model from Gopala Rao et al. (1997)
4	Seismic Grid			no
5a	Refraction (surface)			no
5b	Refraction (near bottom)			Yes 10°N 88.5°E T9R (J. Curray, Scripps)
6	3.5 kHz			yes, digital Parasound Location of Site on line (Time)
7	Swath bathymetry			yes, Hydrosweep
8a	Side-looking sonar (surface)			yes, Hydrosweep scatter amplitudes, 59 beams
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation			
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

iSAS/IODP Site Summary Forms:

Form 3 - Detailed Logging Plan

New ■ **Revised** □

Proposal #: 552-full3	Site #: MBF-6A	Date Form Submitted: Oct 2001
Water Depth (m): 3672 m	Sed. Penetration (m): 300 m	Basement Penetration (m): no

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■

Are high temperatures expected at this site? Yes ☐ No ■

Are there any other special requirements for logging at this site? Yes ☐ No ■

If "Yes" Please describe requirements:______________________________

What do you estimate the total logging time for this site to be:____________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	no	
Litho-Density	no	
Natural Gamma Ray	no	
Resistivity-Induction	no	
Acoustic	no	
FMS	no	
BHTV	no	
Resistivity-Laterolog	no	
Magnetic/Susceptibility	no	
Density-Neutron (LWD)	no	
Resitivity-Gamma Ray (LWD)	no	
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	no	

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New ■ **Revised** ☐

Proposal #: 552-full3	Site #: MBF-6A	Date Form Submitted: october 2001

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Single APC to refusal (~200 m) XCB down to 300 mbsf
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	no
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no
4	Are there any indications of gas hydrates at this location?	no
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	no
6	What “special” precautions will be taken during drilling?	no
7	What abandonment procedures do you plan to follow:	no
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	no
9	Summary: What do you consider the major risks in drilling at this site?	no

iSAS/IODP Site Summary Forms:

Form 5 - Lithologic Summary

Proposal # 552-Full3	Site #: MBF-6A	Date Form Submitted: October 2001

New ☐ **Revised** ■

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Ave. rate of sediment accumulation (m/My)*	*Comments*
0-300		0-2/5 Ma	1.9	Mud turbidites	Deep sea fan	60-150	