

and green bolls. Transgenic *Bt*-cotton would certainly be effective in controlling *E. vittella* during early–mid phase of the crop, when toxin expression would be more than adequate for protection against this bollworm. But the spotted bollworm also occurs as a late season pest in some parts of the country and it is likely that *Bt*-cotton may be slightly less effective in its toxic effects on the spotted bollworm in these regions. Because the spotted bollworm is not known to disperse or migrate over large areas, it is possible that localized resistant hot-spot zones may form over a period of time, depending on the extent of selection pressure exerted on the pest.

Bt-cotton is the first transgenic to be introduced in India. Resistance management programmes have to be designed for the Indian situation, with available data. For resistance management programmes to be effective, monitoring and surveillance for early detection of resistance are important. Resistance monitoring is important not only for the detection of any emergent resistant phenotype, but also to determine the efficacy of resistance management strategies over time. It is therefore necessary to regularly monitor shifts in baseline susceptibility of *E. vittella* in regions especially where *Bt*-cotton is grown and also to periodically assess the changes in efficacy of *Bt*-cotton over time. It is also pertinent to develop and initiate implementation of proactive resistance management strategies to ensure that the rate of resistance development is retarded.

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Major turbidity flows in the Western Indus Fan between 290 and 360 kyr

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Calcium carbonate (CaCO₃), aluminium (Al), titanium (Ti), and terrigenous matter analyses were carried on the Ocean Drilling Programme Site 720A from the Indus Fan in the Arabian Sea. CaCO₃, Al, Ti and terrigenous matter values range from 4.5 to 74.4%, 1.4 to 7.8%, 0.03 to 0.4% and 5.5 to 66.7%, respectively. High CaCO₃ (40–60%) in association with low values of Al, Ti and terrigenous matter from 0 to 290 kyr (0 to 18 mbsf) and low CaCO₃ (<10%) with high values of Al, Ti and terrigenous matter suggest that CaCO₃ fluctuations at this site were controlled by terrigenous dilution. Low Al, Ti and terrigenous matter percentages from 0 to 290 kyr and strikingly high values from 290 to 360 kyr reveal that the supply of terrigenous matter to the Indus Fan was significantly higher during 290 to 360 kyr (18 to 28 mbsf depth) due to massive turbidity flows triggered by slumping.

INDUS is one of the largest rivers in terms of drainage area, river discharge and sediment load. It drains an area of $c.1 \times 10^6$ km² from the western Himalayas with sediment discharge of about 400×10^6 metric tons of sediment per year¹. The sediment transported by the river is deposited in the Arabian Sea as the Indus Fan, one of the largest deep-sea fans in the world, totalling $c.5 \times 10^6$ km². Terrigenous input from the Indus river dominates sediments in the northern Arabian Sea. Sediments are characterized by coarse size, low calcium carbonate content and an abundance of quartz and feldspar². The Persian Gulf and Red Sea are not considered to be important sources of sediment to the Indus shelf, but significant contributions may be derived from the dust-bearing winds blowing-off Africa in summer and northern India in winter³.

Sediment discharged by the Indus river into the northern Arabian Sea may be transported farther offshore, accumulate on the continental shelf offshore of the delta, or may be transported by long shore currents to the southeast. Much of the coarse sediment is carried directly offshore to the Indus Fan by way of the Indus submarine canyon⁴. The Fan sedimentary sequences have been deposited since about late Oligocene or early Miocene as a consequence of Himalayan uplift and sea-level lowerings⁵.

The peak discharge of Indus river occurs during summer months as a result of seasonal glacial melting and increased run-off generated by the summer monsoon. The rate of sediment discharge to the Fan has varied through time, depending upon the climatic and monsoon condition in the Asian

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subcontinent. Therefore, the present communication is aimed to addresses changes in terrigenous material supply to the Indus Fan during the Late Quaternary Period.

Ocean Drilling Programme (ODP) site 720A is located on the western part of the middle Indus Fan at a water depth of 4045 m (Figure 1). Calcium carbonate (CaCO₃) was estimated by using gasometric technique. For the analyses of aluminium (Al) and titanium (Ti), finely powdered, overnight oven-dried (at 105 ± 5°C) sample of 0.3 g was transferred to PTFE beakers and added 20 ml HF, 5 ml HNO₃, 2 ml HClO₄ and evaporated on a hotplate. The incipiently dried digest was dissolved and brought to volume (50 ml) with 10 ml of HCl in 1:1 ratio. Repeating the digestion steps until the clear solutions were obtained ensured complete digestion. The 50 ml solutions of the samples and (MAG-1) standard are analysed for major and minor elements on a Perkin Elmer® Plasma-400 sequential ICP-AES. The analyses were accurate and precise to within 5%.

Terrigenous matter (wt%) was estimated using Ti-based normative calculation⁶ and assuming that the terrigenous matter of the sediment is almost similar to average Post-Archean Australian Shale: Terrigenous matter (wt%) = $(Ti_{\text{sample}}/Ti_{\text{paas}}) \times 100$.

The chronology of the core is based on biostratigraphy. The ages were assigned based on the first appearance of *Emiliana huxleyi* and the last occurrence of *Pseudoemiliana lacunosa* (Table 1). The chronology adopted in this study may differ to some extent compared to the chronology based on isotopes. Therefore, to avoid chronological ambiguity we also have referred major events in terms of core depth in metres below sea floor (mbsf).

The calcium carbonate content varied from 4.5 to 74.4%. Higher CaCO₃ values (>30%) were noticed from 0 to 290 kyr, strikingly minimum CaCO₃ values (<10%) were recorded from 290 to 360 kyr (Figure 2). The accumulation of cal-

cium carbonate on the sea floor is mainly controlled by the surface-water biological production, rate of dissolution during its journey through the water column as well as on the sea floor and dilution by the non-carbonate fraction and terrigenous matter⁷.

The ODP Site 720A was drilled at a water depth of 4045 m which is above the calcium carbonate compensation depth; therefore dissolution of calcium carbonate factor can be ruled out. Further the foraminifera fragments data also confirm that calcium carbonate dissolution was insignificant. No evidences exist regarding the fourfold change in productivity in the Arabian Sea over the last 400 kyr⁸. Productivity and dissolution seem to have not played a major role in shaping the carbonate fluctuations at this site. Therefore, we suggest that calcium carbonate changes were controlled by terrigenous dilution.

Al and Ti content in the marine sediment mainly derives from continental origin supplied through eolian and fluvial pathways. Therefore, Al and Ti have been commonly used as geochemical indicators to discover the content of aluminosilicate detritus of continental origin⁹. At this site, Al and Ti content vary from 1.4 to 7.8% and 0.03 to 0.4% respectively (Figure 3). Both Al and Ti show low values from 0 to 290 kyr and high values from 290 to 360 kyr. Low Al and Ti values from 0 to 290 kyr coincide with high calcium carbonate, and high Al and Ti values corresponding with low calcium carbonate suggest that terrigenous material supply from the Indus river was strikingly higher from 360 to 290 kyr. Lowest calcium carbonate content and highest Al, Ti and terrigenous matter values between 360 and 290 kyr (18 to 28 mbsf depth) regime suggest massive turbidity flows to the Indus Fan (Figures 2 and 3).

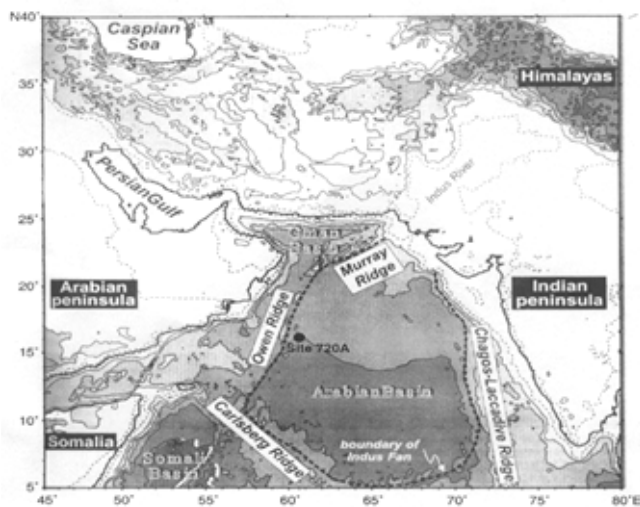


Figure 1. Bathymetry and physiography of Indus Fan and location of ODP Site 720A (modified from Prins *et al.*¹⁰).

Table 1. Chronological list of faunal events used in the study for ODP Site 720A

Event	Depth (mbsf)	Age (kyr)
<i>Emiliana huxleyi</i>	4.0	190
<i>Pseudoemiliana lacunosa</i>	46.5	490

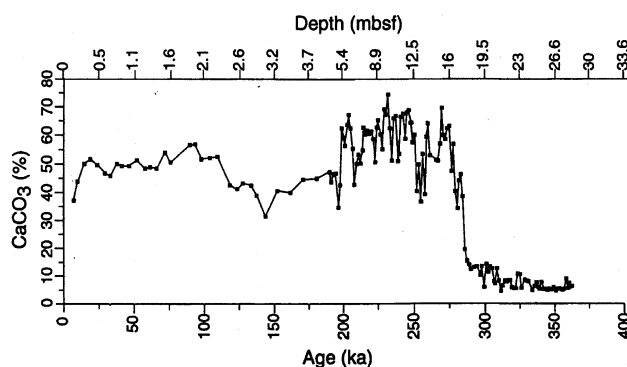


Figure 2. Fluctuations of calcium carbonate (wt%) at ODP Site 720A.

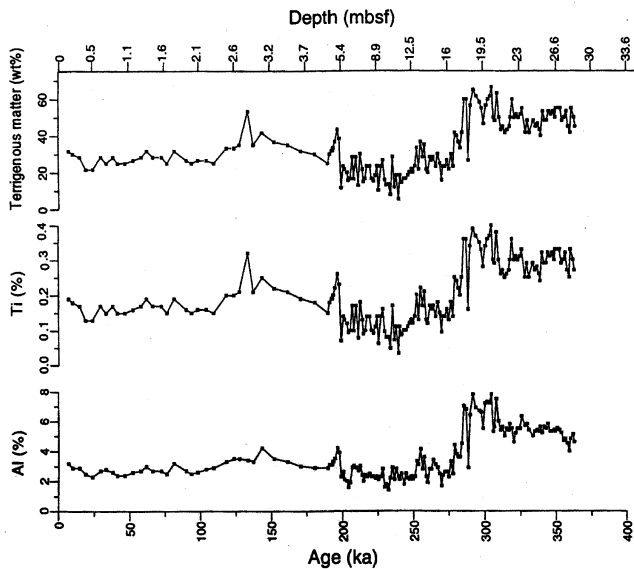


Figure 3. Fluctuations of aluminium, titanium and terrigenous matter at ODP Site 720A.

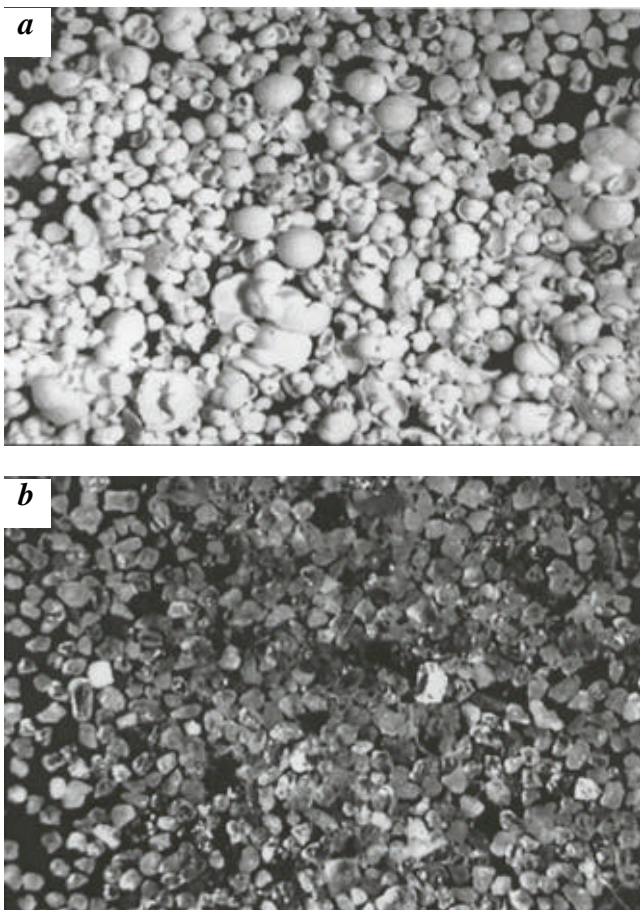


Figure 4. Photograph depicting (a) carbonate-rich coarse fraction from 0 to 290 kyr intervals (0–18 mbsf depth) and (b) terrigenous detritus material-rich fraction from 290 to 360 kyr (18–28 mbsf depth).

Examination of coarse fraction shows that above 18 mbsf corresponding to 290 kyr interval samples mostly contain

foraminifer ooze and terrigenous material (Figure 4a); however below 18 mbsf interval, samples show only turbidity silts and sands (Figure 4b). This observation also supports massive turbidity flows below 290 kyr.

Our data do not show any major turbidity flows from 290 kyr to the Holocene. However, we do admit that the present study cannot rule out minor turbidite sedimentation of a few centimetres thickness within the main feeder channel and Indus Canyon. This kind of turbidite sedimentation was noticed on the eastern part of the Indus Fan during the Last Glacial Maximum when the sea level was low¹⁰. A sharp decrease in turbidity frequency during the late Holocene is observed on the upper continental slope, the deep slope basin and the abyssal plain¹⁰. Along the Makaran Margin, the change in turbidity frequency appears to have taken place synchronously irrespective of physiographic settings.

Sediment transport by turbidity currents is the dominant process on deep-sea fan systems whereby terrigenous sediment is transported from the continents and continental margins to the deep sea. The rate of terrigenous sediment input to the deep sea is controlled by mechanisms including sea level and climate changes, and tectonic activity¹¹. Apart from these processes, autocyclic mechanisms include slumping resulting in channel plugging and sediment build-up within channels, and as a consequence of these sedimentary processes, neither a major sea-level drop¹² nor a strong tectonic activity occurred around 290 kyr¹¹. Therefore, we attribute that the major turbidity flow consisting of silts and sands reached the core location due to slumping of thick sediment built-up within the channel levees without any trigger by allocyclic mechanisms.

Studies on the ODP Site 720A reveal that the down core variations of calcium carbonate were controlled by dilution of terrigenous matter. The terrigenous material supply to the Indus Fan through the Indus river varied over the years. Low terrigenous material supply from 290 kyr through Holocene and higher terrigenous material supply from 290 to 360 kyr is noticed. Highest terrigenous supply to the Indus Fan between 290 and 360 kyr would suggest massive turbidity flows to the Indus Fan system. This kind of major turbidity flow was not noticed from 290 kyr onwards. The autocyclic mechanism would have caused such kind of thick turbidity deposition of about 10 m in the Indus Fan during Late Quaternary Period.

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The 23 September 2003 Varunavat Parvat landslide in Uttarkashi township, Uttaranchal

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Uttarkashi township, located on the right bank of the Bhagirathi river, is known to have had a history of natural disasters, including the mass movement activities. A disastrous landslide in the area on the slopes of the

Varunavat Parvat struck late in the night on 23 September 2003, immediately after the rainy season. The Varunavat landslide has been classified as a classical example of debris slide (debris slide in the crown portion, and rockfall and rockslide in the middle part). Both natural and human-induced factors are responsible for this slide, however, the main triggering factor is the surface and groundwater. The present study lays the foundations for further work to link landslide activity to rainfall – intensity duration trends so that stochastic relationships may be developed to assess high-risk areas around the slide zone.

A landslide is a complex dynamic system. An individual ‘landslide’ characteristically involves many different processes operating together, often with differing intensity during successive years¹. A landslide that struck the hill of the Varunavat on 23 September 2003 and endangered the Uttarkashi township is a living example. The Varunavat Parvat is located at long 30°44′N and lat 78°26′E. It is situated on the right bank of Bagirathi river (Figure 1). At the foot of the parvat lies the Uttarkashi township.

The present study emphasizes description based on objective reality, rather than genetic inference. Such findings attempted to interpret the processes responsible for the failure of slope and to infer the environmental conditions for the operation of such processes. However, it has been recognized that there are limitless opportunities to go astray, twist the failure and its interpretation. The site has been investigated for its potential use as a source to build a threshold model for the failure to occur under a given set of conditions.

Uttarkashi and its environs are made up of two main lithotectonic units, viz. the Higher Himalayan Crystallines and the Lesser Himalayan sediments. The Higher Himalayan Crystallines are thrust over the quartzite and volcanics of the Berinag Formation of the Lesser Himalaya along the Main Central Thrust (MCT). The Berinag Formation is underlain by the Damta Group which is exposed in the antiformal windows². The area is sandwiched between the Srinager Thrust and the MCT located respectively south and north of the study area (Figure 2). The area has been mapped in detail by Agarwal and Kumar³.

The rocks constituting the Varunavat Parvat are mainly quartzite and phyllites of Damta Group, dipping into the hill at 30–35°. These are highly shattered, fragmented, fractured and thinly jointed. These are covered with 20–25 m thick slid material.

Four sets of joints along with the foliation have been recorded. The stereo-plot of these joints is depicted in Figure 3. All the joints have openings of about 0.5 to 1 mm. The 60–65° SSE dipping joint coincides with the slip surface. This joint is filled with clayey material of 1–2 mm.

Annual total rainfall in the area is about 1350 mm, with 60% rainfall falling in the months of July–September. During 2003, the number of rainy days for July is 20; August is 27 and until 23 September, the date of initiation

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