CHAPTER 4: High resolution Studies: Sampling and Chronology

4.1 Introduction

The response of rivers in a given dynamical system, over the continent, would vary due to various reasons leading to complexity. Decoding these complex characteristics from a sediment archive is the biggest challenge for a fluvial geologist. Lateral and vertical variations in the sediment facies over a short distance ensnare correlation of sediment characteristic. High resolution multi-proxy approach is an important tool for understanding transition within the sediment characteristics that signifies "trend in sediment facies" and thereby the energy conditions. The "trends in sediment facies" in the present study refers to any noticeable relationship existing between different proxies of sediment archive that can further be used for the correlation across landforms under study.

The present study is an earnest attempt to decode the continental response to the late Holocene climate change recorded over various large and small continents. To achieve this primary objective, the most important issues are: 1. the selection of appropriates site, 2. Sampling method and 3. Chronological background. The present section of the thesis discusses the hierarchy of sample location, sampling method and dating technique used for the study.

4.2 Hierarchy of Sample Location

The hierarchy for the selection of site for carrying out high resolution sampling was derived by identifying, mapping of the landforms, and understanding their status both geographically and dynamically within the fluvial system. Geomorphology and overall variation in the sediment facies along LrNV was compiled based on earlier works (Section 1.5.2) as well as newer observations at both macro and micro level were gathered from field. Based on these records the course of River Narmada in LrNV is classified into three main segments viz., (1) Straight to sinuous course, Gravel sector: Kevadia dam to Chanod (2)

Meandering course, Sandy sector: Chanod to Bharuch and (3) Estuary, Muddy sector: downstream of Bharuch (Figure 4-). Table 4- summaries the characteristics of River Narmada in its different segments.

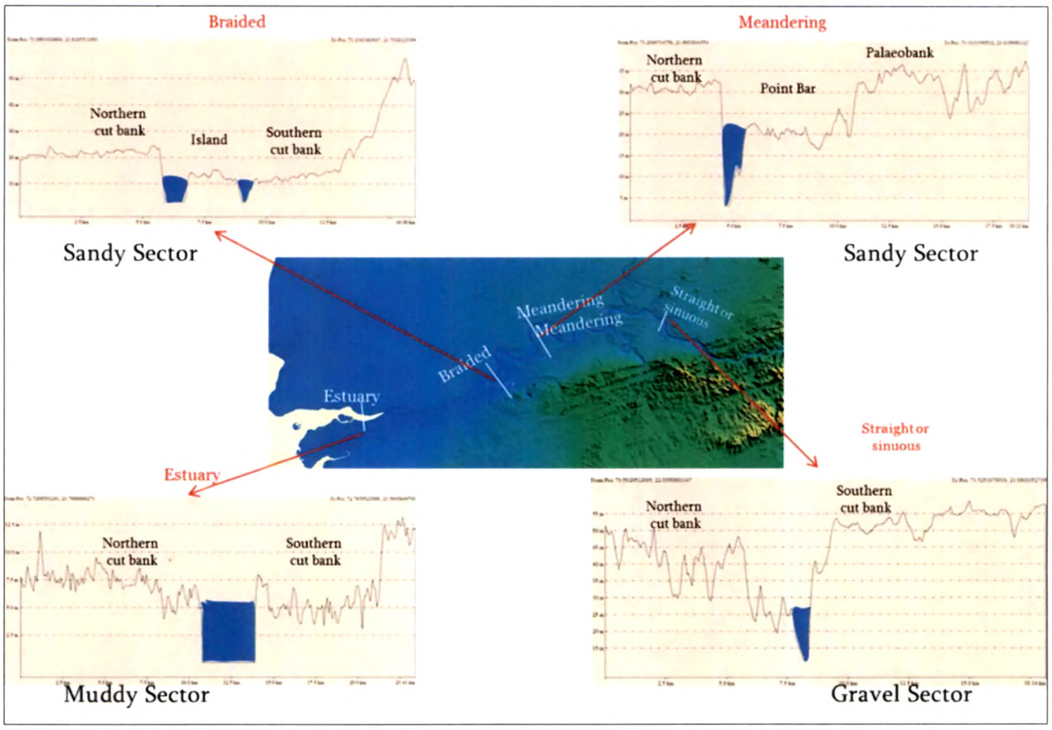

Figure 4-: Cross-section of Narmada channel at different segments.

Table 4-: Characteristics of Narmada channel in its different segments

Channel Type	Soil Type	Bank Attribute	Average Bank Height	Erosion/Deposition Feature	Morphological Features	Stability
Straight	Deccan basalt, Mesozoic sedimentary rocks and Gravels	Locally cultivated, Ravine and Pasture	37.00 m	Resistant to erosion and Bed load dominated channel	Lateral sand bars	Stable
Meandering	Sandy Quaternary sequence	Regionally cultivated and Ravines	25.00 m	Under cutting of erosional bank and aggradation along depositional bank	Point bars and Cutting banks	Moderately stable
Braided	Sand-Clay Intercalated Sequence	Extensively Cultivated	20.00 m	Bar accretion and channel bifurcation	Cut banks , channel bars and Islands.	Unstable
Estuary	Silty – Clayey sediments	Extensively Cultivated	7.00 m	Tidal influx	Estuary	Moderately Unstable

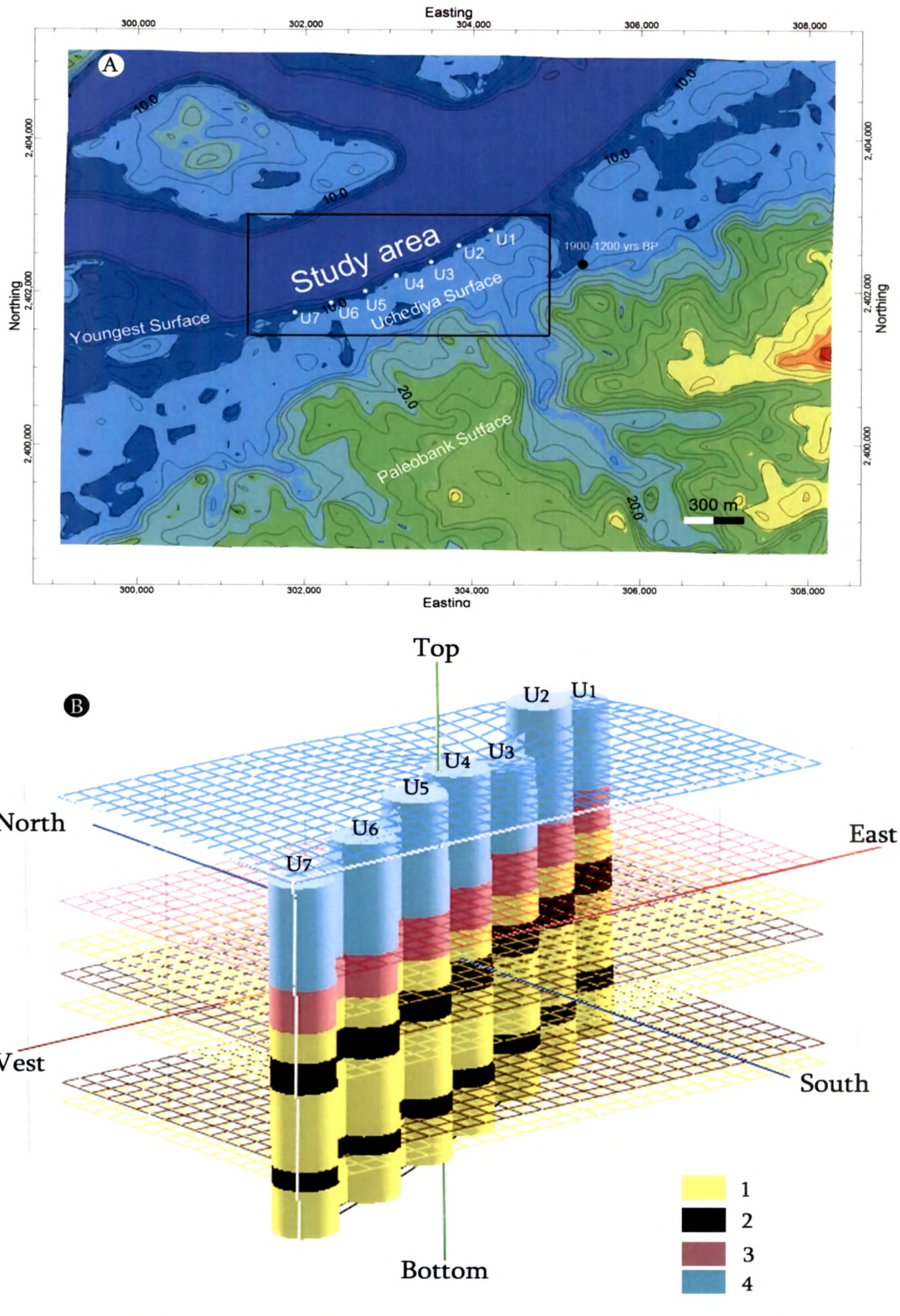

Figure 4-: (A) Contour map of Sandy sector showing Uchediya surface and palaeobank surface;(B) Lithologs showing uniform lithology, wireframe shows the possible extension of the different lithounits, 1, 2, 3 and 4 indicates visually distinguishable sedimentary units.

In the Gravel sector (from Kevadia dam to Chanod), the river channel carves straight to sinuous course through exposures of Deccan basalt, Bagh Beds and thick Gravel deposit till village Chanod. The gravel deposits overlie as well as occur as infill within the older rocks. In the Sandy sector (from Chanod to Bharuch) initially the river carves large looping meandering course (till Sukaltirth). Thereafter, the channel braids till it reaches Bharuch. Downstream of Bharuch, the Narmada River flows into Muddy sector forming an Estuary where it dominates in silty clayey sediment facies.

The present site for high resolution sampling is identified over QS_2 along southern bank of the river, in the sandy sector between two northerly flowing tributaries River Amravati (in the west) and River Kaveri (in the east). The site selected is along a straight, eroding segment carved by the Narmada River, exposing a cliff of about 8m. The continuity of sandy and muddy litho facies were mapped laterally for 4 km. The observations testify that the microforms, mesoforms and macroforms of these units and their upper and lower bounding surfaces are similar (Figure 4-). It further provides understanding that the site selected for high resolution sampling represents near core portion of a regionally significant landform QS_2 "Uchediya Surface".

4.3 Sampling for Multi-proxy Analysis

A representative site for Uchediya surface was selected along the channel of Narmada (21° 43' 2.22" N, 73° 6' 26.22" E; 10 m a.s.l.). High resolution sampling was carried out in the cut-open trench over four benches across the 802 cm vertical profile. Each trench was approximately 200 cm in length and 50 cm in width; cut vertically along plumb line (Figure 4-). The trench was further dressed and cleaned to record field based sedimentological details (sedimentary facies, their transition and sedimentary structures). After cleaning the bench face properly, markings were made in each two centimetres with a sharp tool and each two centimetre depth of samples was collected. A total of 401 samples were collected in two sets, each weighing approximately 500 grams and one set was packed in plastic bottles and another in air tight plastic bags with aluminium foils. The samples packed in plastic bottles were used for analysis, whereas, the samples packed in aluminium foils in air tight plastic bags were preserved as undisturbed library sample.

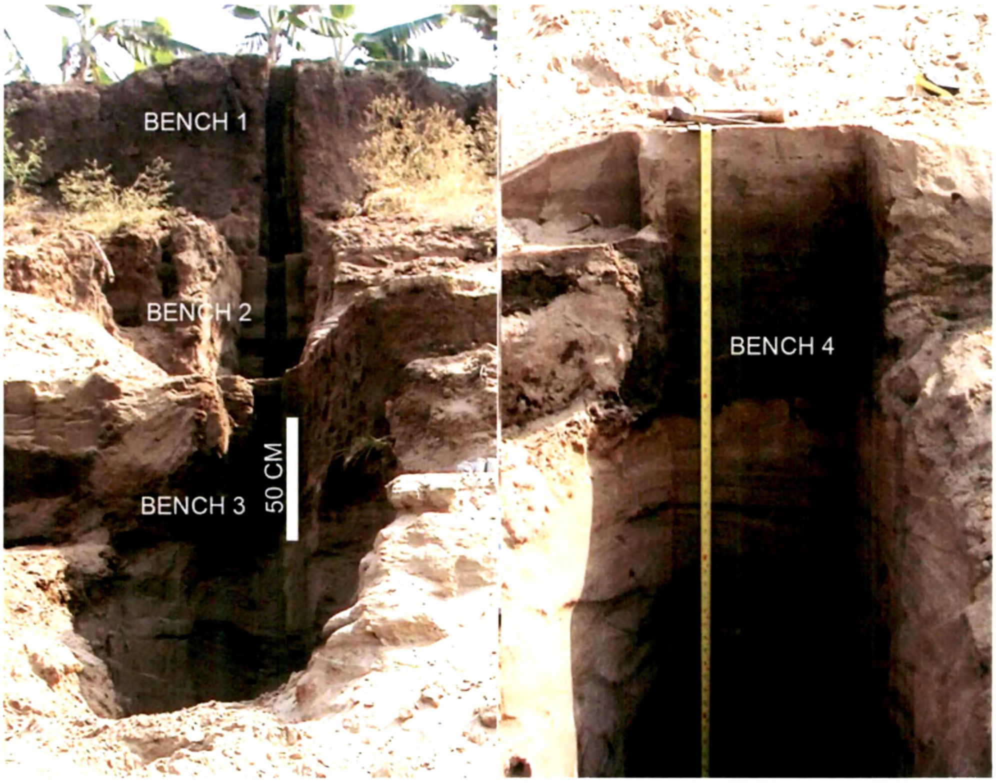

Figure 4-: Field photographs showing four trench sequence.

4.4 Sampling for OSL Dating

A total of 16 samples were collected at an interval of 50cm from the 8 m section at the southern bank of Narmada at Uchediya sequence. Samples were collected from the planar surface of the cleaned trench. The sampling tube consisted of a one inch diameter GI pipes with one edge was closed using steel capes and another edge open. The open edge of the sampling pipe was then driven into the cleaned surface (Figure 4-). Utmost care was taken to avoid the exposure of the samples to sunlight during shutting up of the GI pipe cap. The sample collection was scheduled during late evening so that the intensity of the sunlight was relatively low. Out of the sixteen samples, three samples from the depths of 750 cm, 600 cm and 0 cm (Figure 4-5) were sent to Luminescence Dating Laboratory at the Research Laboratory for Archaeology and the History of Art, University of Oxford for analysis.

Figure 4-: Photograph showing sampling technique adopted for OSL chronology

4.4.1 General Principles of Luminescence Dating

Luminescence is a process in which materials convert energies of various kinds such as optical, nuclear, electrical or chemical into light emission.

Luminescence dating regulates the absorption of nuclear energy by natural mineral and emission of luminescence on thermal or optical excitation. This method is termed as Thermo Luminescence method (TL) or Optically Simulated Luminescence (OSL) method based on the type of excitation. The basis of luminescence dating is as follows:

1. Quartz and Feldspar grains in the sediment serve as sensitive radioactive dosimeter which records the irradiation from the natural radioactivity and preserves this record over a long geological time.
2. Natural radioactivity of ^{238}U, ^{232}Th and ^{40}K in the rocks and soil gives a constant source of irradiation to natural minerals in the sediment.
3. During exposure to light, the minerals lose all the previously acquired luminescence and they began luminescence acquisition afresh during the burial due to irradiation from natural radioactive sources. This luminescence acquisition continues till the exposure of these materials to the surface.

The luminescence age equation can be simply written as,

$$\text{Age} = \frac{L}{l}$$

Where,

L - Total Luminescence

l - Annual rate of Luminescence acquisition or Dose/year

4.4.2 Result

The results of the analysis show a relatively younger age for the sequence. It gives an age of 130± 30 years before 2009 at 750 cm depth (sample id DUCH 1; Oxford laboratory code X3543), 515±40 years before 2009 for the 600cm depth (sample id DUCH 4; Oxford laboratory code X3544) and 495±60 years before 2009 for the 0cm depth (sample id DUCH 16; Oxford laboratory code X3545)(Figure4-5). The obtained chronology record shows age reverse for the sample at depth of 200 cm. Dr.Jean-Luc Schwenninger, who dated the sediments, opined that *"I was* *surprised at the relatively young age of the dates but after double checking the luminescence measurements and the dosimetry data the results remain unchanged. I don't have a precise altitude for the site and the calculations are based on a mean site elevation of 10 m above sea level.*

Unless, the site is over100m, I don't expect any changes to the calculated dates due to variations in the cosmic dose rate. There may be a slight age overestimate for sample DUCH4 [X3544] because the sample was collected near a sedimentary boundary and in the absence of in situ radioactivity measurements with a calibrated gamma-ray spectrometer it is not possible to correct for variations in the external gamma dose contribution to the total dose received by the sample. The sedimentary facies illustration which you sent me indicates that the overlying sediment has a finer texture and therefore, I suspect that the dose rate of

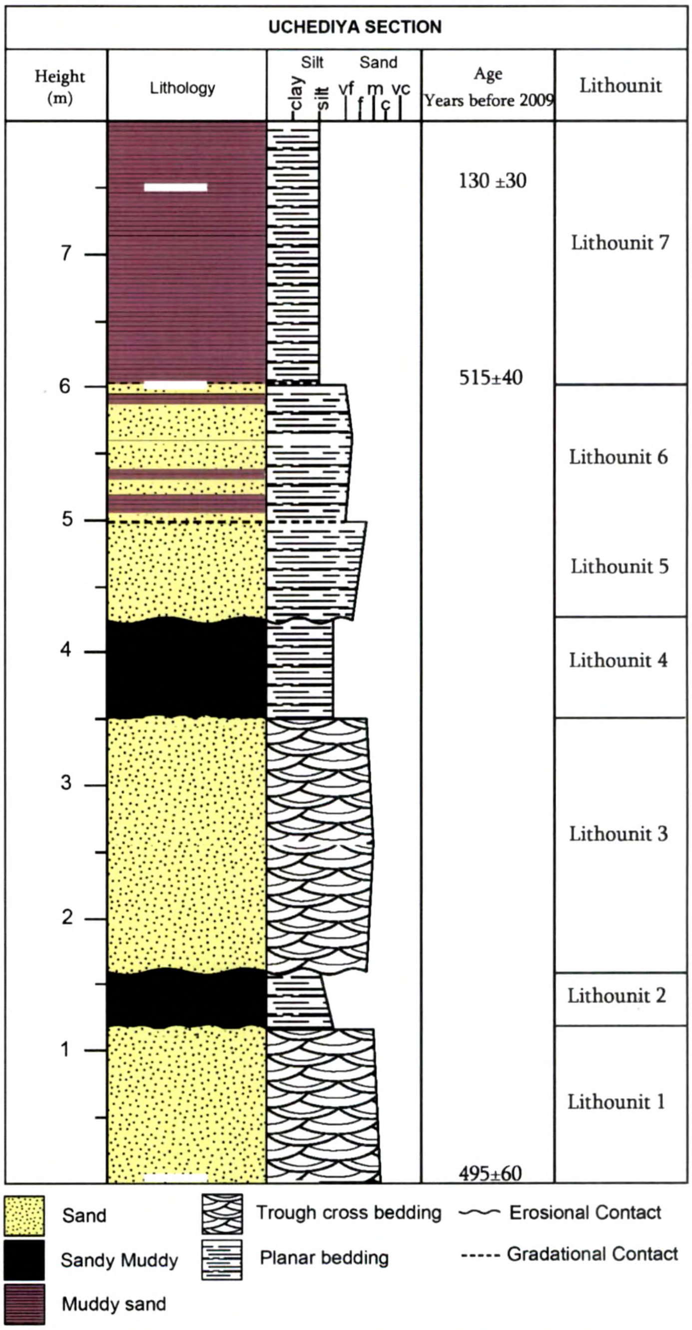

Figure 4-: Sediment log of Uchediaya sequence, visual observations along with OSL dates.

this unit is higher. Our dosimetry measurements are based on the concentrations of radio-isotopes within the OSL sample which according to your diagram, originates from coarser textured sand and therefore, we may have underestimated the true dose rate for this sample. If you can supply us with a sample from the overlying sediment then we might be able to make suitable correction. However, I don't expect the difference to be more than 100 years and therefore there might be little merit in doing this additional work (the cost would be circa £80). If for example I use the dosimetry data from sample DUCH1 [X3543] which was taken from an even finer textured sedimentary unit then the revised date would be ~490 ± 35. Basically, it is suggesting that the bulk of the sediment (+/- 6 m) was deposited within a relatively short time span".

With this background the present thesis considers a relatively short time span of around 100 years for the 0-600 cm section of the Uchediya surface.