Dating of Paleochannel Sediment of Jorhat District of Assam, North Eastern India

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Abstract - *Limited studies have made to date fluvial sediments of Assam, India. Assam being a river valley, exists between two active tectonic zones i.e. the Himalaya and Naga Patkai mountain range, has developed numerous fluvial landforms. There are scopes for mapping these landforms and dating its sediments to know the stages of landform development with respect to time and space. Dating fluvial sediments of paleochannels of southern part of the Jorhat district of Assam using Optical Stimulated Luminescence (OSL) dating method is an effort to understand the fluvial geomophological processes of this area. The plaeochnnels of southern parts of the Jorhat district, a part of the Brahmaputra basin, were identified through remote sensing imageries and available fluvial landforms. OSL dates were estimated using the single aliquot regenerative-dose (SAR) protocol for five palaeo-channel samples. The OSL ages were obtained between 0.5ka to 1.0 ka. The radiocarbon dating of fossil wood found in the area is dated as 500 +/-30 years BP.*

Key Words: **Paleochannel, Fluvial geomorphology, OSL dating, Radiocarbon dating.**

1. INTRODUCTION

The area under study is situated at southern part of Jorhat District which is in the East Central part of Brahmaputra valley of Assam, India (Fig. 1). The area is situated within latitude 26°30′ N and 26°50′ N and longitudes 94°00′ E and 94°00′ E covering an area of about 100 sq. km. The area consists of few signature of paleochannel. At places sand deposits are exposed, which are used by local people for different purposes. The Bhogdoi is the only major river passing through the Jorhat district and flowing about 5 km away from the area. The Bhogdoi river basin is situated within latitude 26°15′ N and 26°55′ N and longitudes 93°40′ E and 94°30′ E covering an area of around 2521 sq. km. The Bhogdoi River has its origin at Naga Hills and flowing through the hills it comes out to the Assam valley at Jorhat District. Flowing for a distance of about 35 km toward north in the hills and about 78 km in the plains toward north and then west, the Bhogdoi culminates at a swamp, known as Gelabill. Gelabill drains out to the Dhanshri River, which confluence with the mighty Brahmaputra.The present course of Bhogdoi is in existence since last decade of 18th century. So far, the old course of Bhogdoi is not identified. The paleochannel and sand deposits are found about 5 to 30 km away from the present course of Bhogdoi. Though, present Bhogdoi is flowing in the area mainly from south to north direction, the orientation of the paleochannelsfound in the area are mostly east to westwhich is similar to the small channels found in the area. Sporadic small scale sand mining on the paleochannels of the area leads to identification of few sand deposits. The sediment characteristics and sedimentary structures found in these sand bodies along with the size of the deposits indicatethat the sand deposits are of fluvial origin,indicating existence of old rivers in the area, where, at present, no major river is flowing. OSL dating of these sediments is an effort to know the age of the old rivers.

Though several studies have been made in India on OSL dating of fluvial sediment, little is known about the OSL dating of fluvial sediment in the Northeastern part of India, especially in Assam.Optical dating of liquefaction features developed by earthquake in Upper Assam was done by Thomas, *et. al.* (2007).

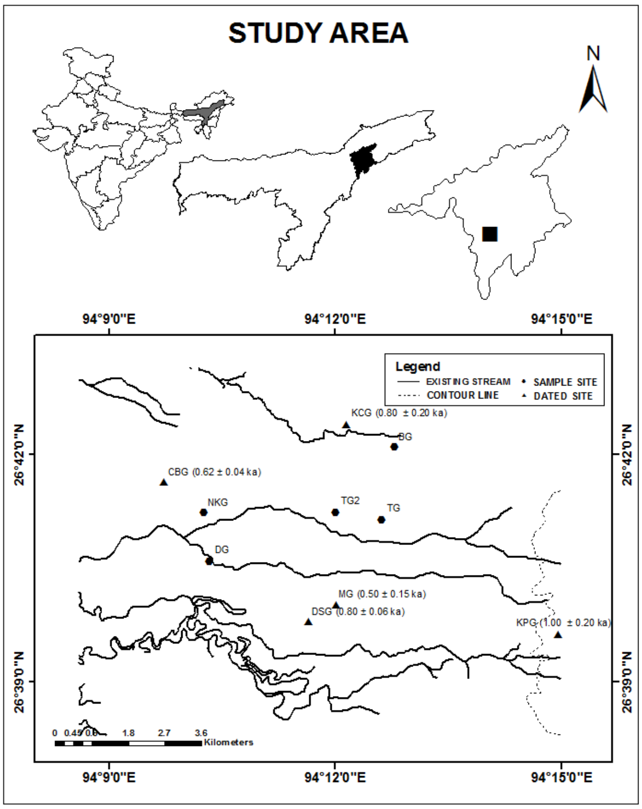


Fig 1: Location map with sampling points

1.1 Sample locations

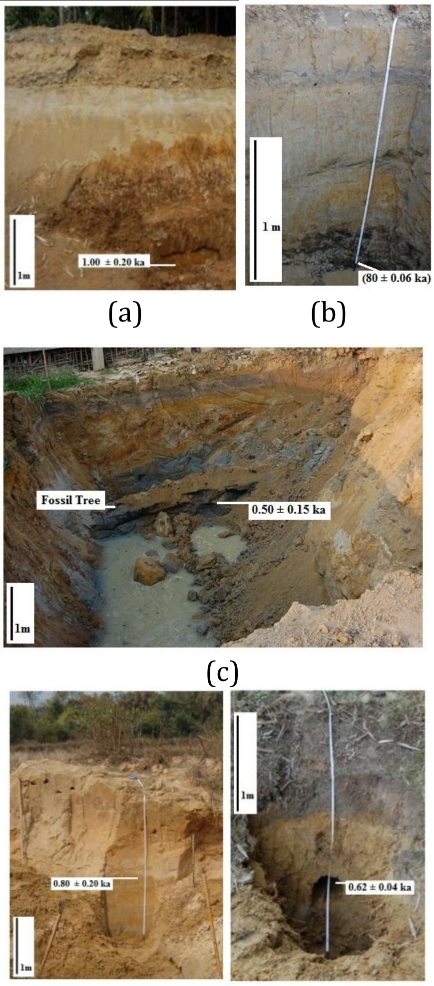
Ten locations (Table 1) were selected in the area for study of vertical profile and collection of samples. These locations were at Kukura Pahia Gaon (KPG), Dakshin Sonari Gaon (DSG), Maj Gaon (MG), Timtimia Gaon (TG), TimtimiaGaon 2 (TG2), Baghmariya Gaon (BG), Kuwaripukhuri Chetia Gaon (KCG), DuliaGaon (DG), Namoni KoharGaon (NKG), Charaibahi Bahek Gaon (CBG) (Fig 1). Selections of these sampling points were made on the basis of the availability of the exposed and identified sand deposits. The sampling locations were prepared by drawing vertical profile, mostly along naturally exposed sections. But at places pits had to made manually to get a workable vertical section (Fig. 2). However, samples for OSL dating were collected from five locations. These locations were KPG, DSG, MG, KCG and CBG. Each OSL samples were collected in 2.5 inch deep blue PVC pipes of 1 feet length and covered both the end by black tapes.

The grain size analyses is has been done for the five samples collected for OSL dating. The sediments are found to be medium to fine sand (Fig. 3).The sediment deposits shows prominent horizontal lamination as well as current bedding. At KPG and DSG the sand deposits shows clear lamination and current structures (Fig. 4). At NKG, which is close to DSG, the width of the sand body is measured as about 98 mts across the current direction.

Table -1: Sample locations with latitude and longitude

1. Kukura Pahia Gaon(KPG)	(N 26^{0}39'37.3"/E 094^{0}14'57.7")
2. Dakshin Sonari Gaon (DSG)	(N 26^{0}39'49.4"/ E 094^{0}11'39.1")
3. Maj Gaon (MG)	(N 26^{0}40'0.7"/E 094^{0}12'0.7")
4. Timtimia Gaon (TG)	(N26^{0}41'08.5"/E 094^{0}12'37.3")

5. Timtimia Gaon 2 (TG2)	(N 26⁰41'14.3"/E 094⁰12'56")
6. Baghmariya Gaon (BG)	(N 26⁰42'06.1"/E 094⁰12'48.2")
7. Kuwaripukhuri Chetia Gaon (KCG)	(N 26⁰42'23.9"/E 094⁰12'9.2")
8. Dulia Gaon (DG)	(N 26⁰40'35.6"/E 094⁰10'20.5")
9. Namoni Kohar Gaon (NKG)	(N 26⁰41'13.9" / E 094⁰10'16.1")
10. Charaibahi Bahek Gaon (CBG)	(N 26⁰41'38.3"/E 094⁰09'44.0")



(a) (b)

(c)

(d) (e)

Fig -2: Vertical Sections made at the sampling points for OSL dating– at a) KPG, b) DSG, c) MG, d) KCG, e) CBG

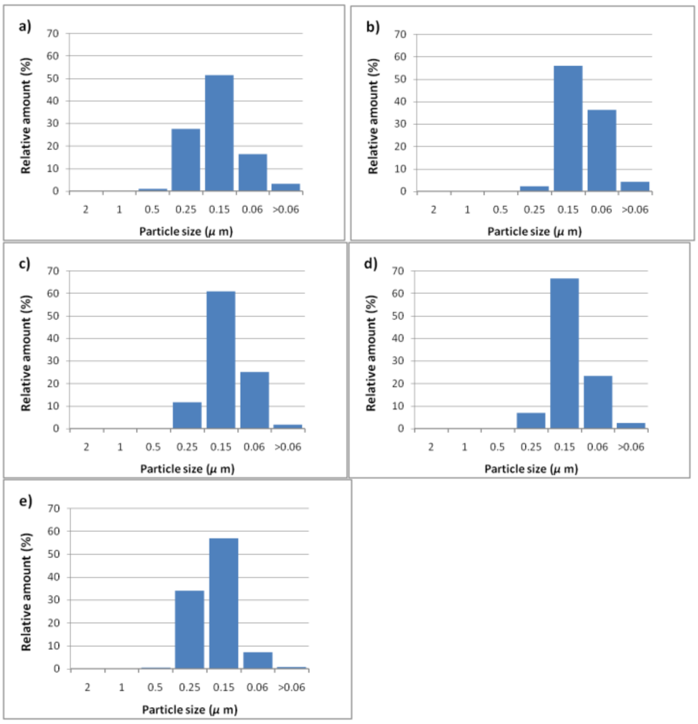
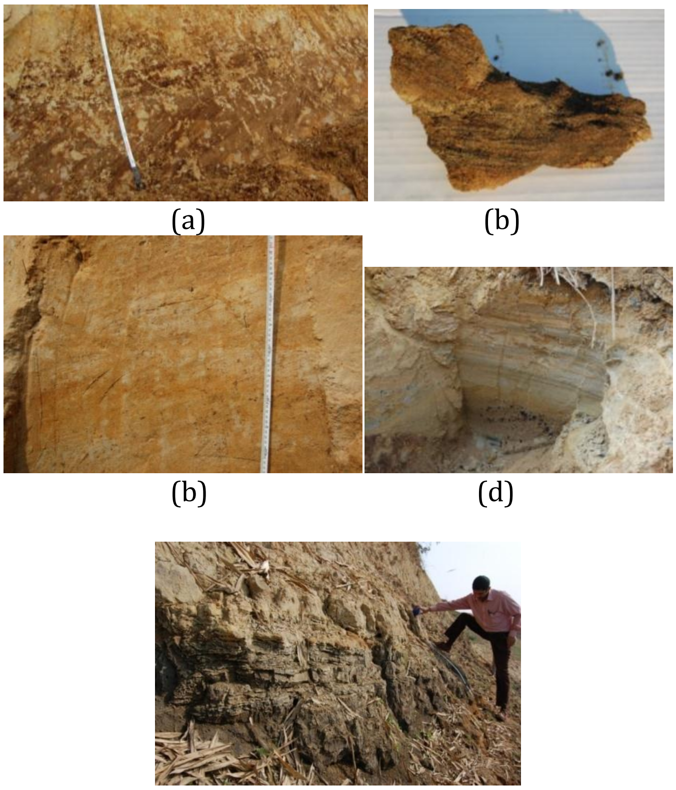


Fig -3: Grain size distribution of the OSL dated samples-a) DSG, b)KPG, c) KCG, d) CBG, e) MG



(a) (b)

(b) (d)

Fig 4. Paleocurrent structure at a) KPG, b) DSG and c) KCG. Horizontal lamination d) near Jorhat Mariani Road. e) Paleochannel deposits

2. METHODOLOGY OF OSL AND RADIOCARBON DATING

OSL Dating

Luminescence dating is the dosimetry of natural radiation environment, using natural minerals. The technique relies on the measurement of natural radiation induced trapped charges in the naturally occurring minerals. Most commonly used minerals that occur in all geological environments are quartz and feldspar, and these have appropriate dosimetric properties, that enable their application for dating. On account of mean lives of natural radionuclides being $\geq 10^9$years, the radiation flux arising from the decay can be taken constant over million year time scales. This implies that as a first approximation the rate of ionization remains constant and hence the total numbers of trapped charges are proportional to the elapsed time since the time irradiation began (Huntley et al., 1985; Aitken, 1998).

Luminescence measurements enable quantification of trapped charges in terms of equivalent radiation dose. Estimation of elemental abundance of natural radioactivity, enables computation of annual radiation dose and ratio of the two provide the age. Three type of geological events can be dated using the luminescence technique (Singhvi and Wagner, 1986) these are, i) the most recent daylight exposure of the minerals in the sediment, ii) heating event and iii) authegenic precipitation event (mineral formation). All these events refer to the "zeroing" of preexisting geological luminescence to zero or near zero (residual value).

In the first case, when minerals are exposed to day light during their weathering and transport, which results in to photo-bleaching of the trapped charges to a zero or near zero residual level? On burial, further day light exposure ceases and reacquisition of the trapped charges is initiated by irradiation from ambient radioactivity. Acquisition of trapped charges continues till the mineral is exposed to daylight or is stimulated in the laboratory. The event dated is the time of burial (last deposition of the sediment e.g. loess deposits, dune sand and glaciers). In sediment dating the most important criteria is that geological luminescence should be zero or residual level before burial. This is largely achieved for sediment deposited by wind. However, for sediment transported by water (aqueous sediments) there are chance of inadequate photo-bleaching or it could be heterogeneous. The reason being water column and sediment load can attenuate the day light flux. In the second case the luminescence clock is reset to zero by heating, such as pottery fired by ancient men, burnt bricks, sediment contact backed by lava flows or forest fires when temperature goes to 500° C or so. The third case is authegenic precipitate, where the accumulation of luminescence signal initiated at time of crystal nucleation, and the event dated is the formation time of minerals (gypsum, halite, carbonate etc.).

The amount of nuclear (ionizing) radiation delivered per unit time to a material is called dose rate and for dating application is usually expressed as Gy/ka. The dose rate is estimated by measuring concentration of natural radioactive elements (U, Th, and K). U and Th concentration can be measured using thick source ZnS(Ag) alpha counting whereas K is estimated by gamma spectrometry. Cosmic rays contribution is computed using the latitude, longitude, altitude and the average burial depth and equations proposed by Prescott and Hutton (1994). The dose rate computation assumed an infinite matrix. This implies that within a volume having dimensions greater than the ranges of the ionizing radiations (α, β, γ and cosmic rays), rate of energy absorbed per unit mass is equals the rate of energy emitted per unit mass (conservation of energy) (Aitken, 1985). Another assumption is that the dose rate is constant since the luminescence clock reset to zero. This would mean that radioactive elements uranium (U) and thorium (Th) and their daughter nuclides were in equilibrium and there was no change in the potassium (K) concentration through time.

The chemical treatment of the sample starts with sequential pretreatment with 1N HCl (to remove carbonates) and 30% H_2O_2 (to remove organic matter). After removal of carbonates and organic matter sediments are dried and sieved in order to obtain the desired grain size. Given that the dose absorbed from the beta source is grain size dependent (Mejdahl, 1979), a narrow size distribution (90−150 μm) is generally used. Following this, quartz is separated using sodium polytungstate ($\rho \geq$ 2.58 gm/cm^3) solution where quartz (ρ = 2.65 gm/cm^3) sink and feldspar (ρ = 2.56 gm/cm^3) float. The quartz fraction thus separated was etched with 40% HF for 80 min to remove the outer alpha dosed 10−15 μm skin followed by 12N HCl treatment for 30 minutes to convert insoluble fluorides to soluble chlorides. Mejdahl (1979) suggested that due to etching a small attenuation in external beta also occurs and proposed appropriate correction factors for various grain sizes. Typical attenuation of beta dose is ~ 5%, for a 100 μm grain size (Aitken, 1985). Etched and cleaned quartz grains were deposited using silicon oil (silkospray™) onto stainless steel disc (~9.65 mm diameter). Stainless steel disc was chosen over aluminum disc because it is reported that silicon oil on aluminum discs can give spurious signal especially after irradiation (Aitken, 1998). The basic advantage of using quartz over feldspar is it lack internal radioactivity and that it does not show anomalous fading. On the other hand feldspar provides a possibility of higher dating range due to its significantly higher saturation dose.

The luminescence measurement were performed on Riso TL/OSL-DA-20 reader using blue light stimulation (470±30 nm) and a Hoya U-340 detection filter. For laboratory irradiation the system has a mounted beta irradiator (^{90}Sr/^{90}Y, calibrated source) on top of it.

Single Aliquot Regeneration (SAR) method (Murray and Roberts 1998; Murray and Wintle, 2000, 2003) used for equivalent dose (D_e) estimation. In SAR method, $D_e$is estimated on a single aliquot by recording its natural luminescence and then a regeneration growth curve is made through a cycle of measurements that involve, increasing irradiation, preheat and measurement. At each stage a sensitivity measurement is included to ensure that any lab induced sensitivity is corrected for. The intensity of the natural sample is then read on the regenerated growth curve to obtain a D_e. Recording $D_e$on many such aliquots and appropriately treating the data provide statistical firmness and also helps to identifying poor/heterogeneous bleaching. The change in sensitivity caused due to OSL readout, preheat and irradiation of the samples is monitored via the response of 110° C peak to a fixed test dose (Murray and Roberts, 1998). The natural and regenerative OSL measurements are carried out at 125° C in order to keep the 110° C trap empty during the OSL stimulation (Murray and Wintle, 2000). Table 2 provides the details of SAR protocol which was used. The resulting shine down curve was collected over 40 or 100 seconds, the first 0.8 seconds were used for signal integration (Banerjee et al., 2000) and the final 4 seconds were used for background subtraction. The growth curves were appropriately fitted with a linear or saturating exponential equation. In order to ensure the quality of the data only those aliquots were considered for D_e for which the recycling ratios were within the range 0.95−1.05. It was also observed that the recuperation was less than 3% corresponding L_N/T_N signal induced by the lowest given dose as well for higher given doses.

Table -2: SAR protocol used (Murray and Wintle, 2000)

Steps	Treatment	Observation
1	Preheat (160–300° C) / 10 (s)	
2	OSL (Natural)	L_N
3	Test Dose	
4	Cut heat (160° C) / 10 (s)	
5	Test dose OSLT_N	
6	Illumination (240–280° C) / 100 (s	
7	Regeneration dose (R_1)	
8	Preheat (160–300° C) / 10 (s)	
9	OSL (R_1)	L_1
10	Test Dose	
11	Cut heat (160° C) / 10 (s)	
12	Test Dose OSL	T_1
13	Illumination (240–280° C) / 100 (s)	
14	G o to position, 7 and repeat it for R_2, R_3......	

Radio carbon dating

There were reports of encountering fossil woods during making pits in the area for different purposes. During present study, two fossil trees were found at location MG while making pits for vertical profile (Fig. 2 c). Wood samples were collected and sent for radiocarbon dating. All work on this sample was performed in the laboratories in Beta Analytic Inc., Miami under strict chain of custody and quality control under ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 accreditation protocols. Samples were analyzed in the same chemistry lines by professional technicians using identical reagents and counting parameters within own particle accelerators. The result contains the Conventional Radiocarbon Age (BP), which age has been corrected for total isotopic fractionation effects (natural and laboratory induced).

All results (excluding some inappropriate material types) which fall within the range of available calibration data are calibrated to calendar years (cal BC/AD) and calibrated radiocarbon years (cal BP). Calibration was calculated using the one of the databases associated with the 2013 INTCAL program (cited in the references on the bottom of the calibration graph page provided for each sample.) Multiple probability ranges may appear in some cases, due to short-term variations in the atmospheric 14 C contents at certain time periods. Looking closely at the calibration graph provided and where the BP sigma limits intercept the calibration curve helps in understanding this phenomenon.

Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference and consistent with all past Beta Analytic radiocarbon dates. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result.

3. RESULT AND DISCUSSION

The age of the samples were determined by two different methods; OSL and radiocarbon dating .The OSL age of the sand bodies are found between 0.05 ka to 1.0 ka from the present (Table 3).

Table -3: OSL age of the five sediment samples collected from the area.

Sample location	Name of the Place	Calculated OSL age from the present
DSG	DakshinSonariGaon	0.80 ± 0.06 ka
CBG	CharaibahiBahekGaon	0.62 ± 0.04 ka
KPG	KukurapahiyaGaon	1.00 ± 0.20 ka
KCG	KuwaripukhuriChetiaGaon	0.80±0.20 ka
MG	Maj Gaon	0.50 ± 0.15 ka

The wood fossil samples and sediment samples were collected from the same depth of sample point MG and the wood samples were sent for radiocarbon dating. The radiocarbon age of the wood fossils is found as 500 +/- 30 BP (Table 3). So, the radiocarbon age of the wood fossil is found to be same as the OSL age of the sediment sample and both the samples were collected from the same depth at MG.

Table -4: Report on Radiocarbon Dating Analyses.

Sample : MG
Analysis: AMS-Standard delivery
Material/Pre Treatment : (wood): acid/alkali/acid
2 Sigma Calibration : Cal AD 1405 to 1445 (Cal BP 545 to 505)

Sample Data	Measured Radio Carbon age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 393986	500 +/- 30 BP	-25.10/00	500 +/- 30 BP

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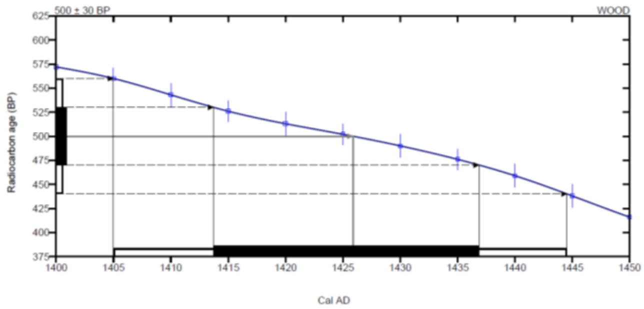

Chart -1: Calibration of Radiocarbon age to Calendar years [2 Sigma calibrated result (95% probability): Cal AD 1405 to 1445 (Cal BP 545 to 505)

Intercept of radiocarbon age: Cal AD 1425 (Cal BP 525) with calibration curve

1 Sigma calibrated results (68% probability):Cal AD 1415 to 1435 (Cal BP 535 to 515)]

Though, there are numbers of paleochannels present in the area with active channels of smaller size, the size of the paleochannels seem to be of considerable size. The reasons for changes in the size to the rivers to small channels are not studied till date. The cause of change may be either natural or manmade. In this context, relation between these paleochannels with the Bhogdoi may be of importance. The present course of Bhogdoi is believed to be in existence since the last part of the 18th century and the course of BhogdoiRiver before that period is not identified so far. The sediment characteristics like grain size and sedimentary structures indicate that there were few rivers flowing in the area which were bigger in size than the present streams. The courses of the paleochannels are also not same with the present streams which indicate that the old rivers had abandoned their courses. The OSL age of the river deposited sediments are 0.5 to 1.0 ka from the present. Whereas, the present course of the Bhogdoi, as described in the history, is about 0.3 ka from the present.

Another important observation is the debouching points of all the paleochannelsand the present course of Bhogdoiappears to be the same. It gives an impression that the paleochannels were older course of the Bhogdoi.This pattern of paleochannels can be well observed in the satellite imageries (Fig 5). It indicates that theriver Bhogdoihas changedits courses only in the plains. To know the actual causes of such changesneed further studies, but as per some chronicles and reports (Edited by Tamuli, 2007, page 156), the changes in the courses of the Bhogdoi is due to some anthropogenic activities took place in the late 18th century. The question is not yet answered whether only anthropogenic activities were sufficient to divert a river of such dimension. It is also worth mentioning that the area under study is very near to the Naga Hill, which is formed along the Indo-Myanmar plate boundaries and it is still tectonically active.

The frequent occurrence buried trees in large scale indicate mass destruction of trees by some natural events. The trees found during our studies are of considerable in size. It gives an idea about the intensity of the event which leads to such mass destruction of large trees. So, the role of neo-tectonics cannot be ruled out here.

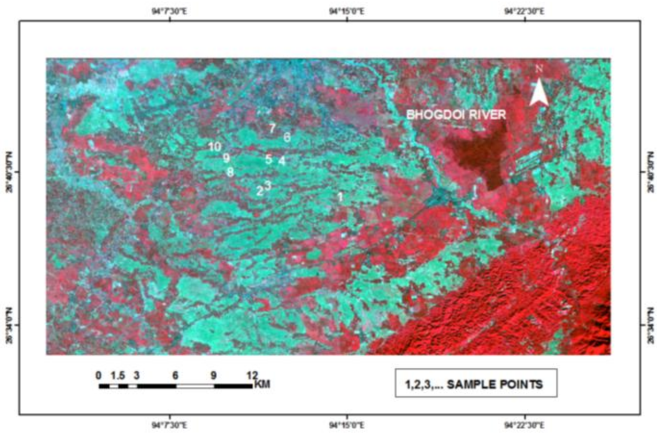

Fig -5: The Bhogdoi river and its relation with the paleochannels and sample sites

3. CONCLUSIONS

We measured OSL ages using the SAR protocol for sand of five palaeo channel samples. The obtained OSL ages were, between 0.5 ka to 1.0 ka. As no previous OSL studies were made in the area, the acquired data could not be compared. The radiocarbon age of the wood fossils collected from the same horizon is found as 500 +/- 30 BP. The major rivers of the area might be existed till less than 500 years back. The causes of shifting of the rivers are not yet known.

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