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LUMINESCENCE DATING OF SOME HISTORICAL / PRE-HISTORICAL NATURAL HAZARDS OF INDIA.

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ABSTRACT

The Indian sub-continent is characterized by host of natural hazards like earthquake, tsunami, cyclones, floods, landslides / mudflows. It is necessary to build-up a database of historical / pre-historical natural hazards for planning scenarios for emergency response to various them. In short, there is a vast scope of providing chronology to hazardous events by using known techniques of dating including luminescence dating which has an excellent window span down from few hundred years to one hundred thousand years. In this work we report the dates of some historical / pre-historical natural hazards of India. In particular we focus on three kinds of natural hazards namely, earthquakes, tsunami, and mudflows. For example of earthquake we cover a historical earthquake of Manipur that created two massive fissures at Kumbi, 25 Km from the state capital, Imphal. For pre-historical ones, we cover Assam-Shillong area known for its highest levels of seismicity in India. We demonstrate the evidence of a paleo-tsunami that devastated Mahabalipuram near Chennai. Incidentally, Mahabalipuram was badly affected by the great tsunami of 26th Dec 2004. Finally, luminescence dating technique has been applied to some historical / pre-historical mudflows of Manipur. A recent mudflow on 10th July 2004 damaged more than 90 houses, block National Highway-39, the life-line of Manipur for more than a fort-night.

INTRODUCTION

Dating methods applicable to late Quaternary are of immense help in providing chronology of pre-historic natural hazards like earthquake, tsunami, cyclone, landslide, or flood etc. The central role of dating in assessing hazards has been widely recognized [1].

Keeping this in mind various quaternary dating methods like the well-established method of radiocarbon dating, as well as AMS dating, tree-ring dating as well as luminescence dating has been developed to date pre-historic earthquakes [2-9].

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In this work we present the OSL dates of some historical / pre-historical natural hazards of Indian sub-continent obtained in Luminescence Dating Laboratory of Manipur University, Imphal. The laboratory came into existence with the financial support of DST, Seismology Division (Earth Science), New Delhi essentially to explore the possibility of dating paleoearthquakes in Manipur and adjoining areas.

The 2001, Bhuj, Gujarat earthquake generated large scale liquefaction and provided enough materials to check the feasibility of TL/OSL dating of very young sediments. Samples collected from liquefied sand of thickness 6-8 inches, north of Choubori, at an aerial distance of 18.6km from the epicenter dated by TL technique gave an age 32±5 years [10]. This scenario of Indian sub-continent gave evidence of datability of sand blows as young as 50 years. Subsequently, study established the occurrence of a pre historical earthquake 3000 years back in Bhuj, Gujarat [11].

In addition to earthquakes, we present OSL date of a paleo-tsunami that hit Mahabalipuram in the past as well as a recent devastating mudflow on 10th July 2004 that caused havoc in the NH-39, the lifeline that connects Imphal, the capital of Manipur to the rest of India. Some unknown age mudflows are also dated.

EXPERIMENTAL DETAILS

Quartz grains of size 100-150μm were extracted from the sediment deposits following the standard techniques. Organic materials were removed by treating with H_2O_2 while carbonates with HCl. Etching of quartz grain with 40% HF for 40 min at 20°C is done in the usual way to remove the feldspar component as well as etching the outer layer of the quartz grain which eliminates the α-particle contribution to the paleodose [12].

Measurement was made in well known Risø TL/OSL-DA-15 reader using internal Sr/Y-90 beta source [13]. A combination of Schott UG 11 and BG-39 filters was used as a detection filter. Signal integration of first few channels after background subtraction are used in conformity with SAR protocol [14].

GEOLOGICAL BACKGROUND OF THE HAZARDS

KUMBI, MANIPUR

In 1957 an earthquake of magnitude 7.25 caused two massive fissures of length ~ 1km and width ~ 1m with a maximum depth of ~ 3.4 m at Kumbi, Manipur, India. The fissure because of its origin from the mountain, gave rise to the birth of streams that continue to flow, depositing sediments every rainy seasons even today (Fig. 1a, b). A trench cut at the base of the hill shows the original laterite over which lies a thick layer of dark peaty colluviums (Fig. 1c). Thus Kumbi site becomes a permanent archive for studies the historical earthquake.

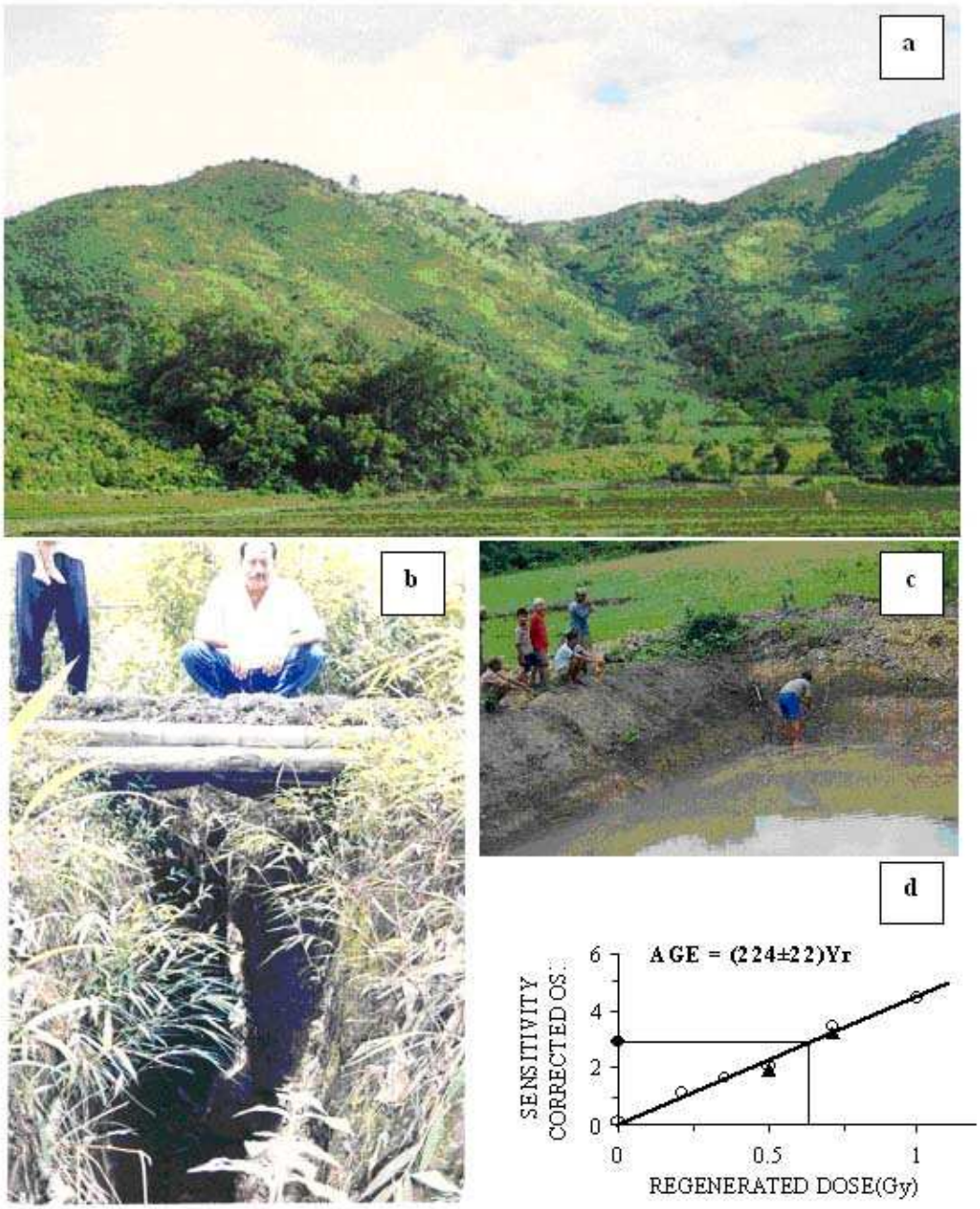

Fig. 1: a) Panaromic view of the origin of a fissure in Kumbi, Manipur.
b) A closer view of the fissure
c) View of the trench with OSL age.
d) A sensitivity – corrected dose response curve

● Natural o Regeneration ▲ 7th Regeneration

SHILLONG –ASSAM

The North – East India is tectonically one of the most active zones (Zone – V) of the sub-continent. Historically it has experienced two well documented great earthquakes that devastated the region in 1897 and 1950. The 1897 Shillong (Assam)

Fig. 2. Sandblows of the Assam – Shillong earthquake (Chedrang).

earthquake generated massive liquefaction in the Brahmaputra Valley, leaving an area of 1,50,000 square miles in ruins. Field investigations of the area, shows sandblows induced by earthquakes (Fig. 2). As pointed out earlier in the introduction sand blows can be dated by luminescence technique. Hence, this site is ideal for establishing the paleoseismicity of the region by luminescence dating for long term planning of bridges, large dams and industrial activities in North East India.

MAHABALIPURAM, TAMIL NADU

Mahabalipuram whose literal meaning is *"The City of Great Wrestler"* and also *"The City of Great Bali"* is situated about 55 km south of Chennai. It is a

Fig. 3a. View of one excavation of ASI, Chennai

"World Heritage Site". Its monolithic temple structure were built during the 8th century AD by the Pallava Kings. In the past Mahabalipuram was known to ancient mariners as *"Seven Pagodas"*. The ravages of the ocean has destroyed all but one, the Shore Temple (Fig. 3a) overlooking the mighty Bay of Bengal whose fury, triggered by the 26th Dec 2004 tsunami has shaken the confidence of people as well as the government of India in terms of preparedness to handle tsunami hazards.

Recent underwater archaeological evidences show the presence of apparently man-made structures around 1,500 years old, present in 5-8 m below the water level about 800 m from the present shore line [15]. The excavations of ASI, Chennai Circle, conducted after the 2004 tsunami has revealed the destruction of the original structure of some temples by suspected paleotsunami (Fig. 3b).

Fig. 3b

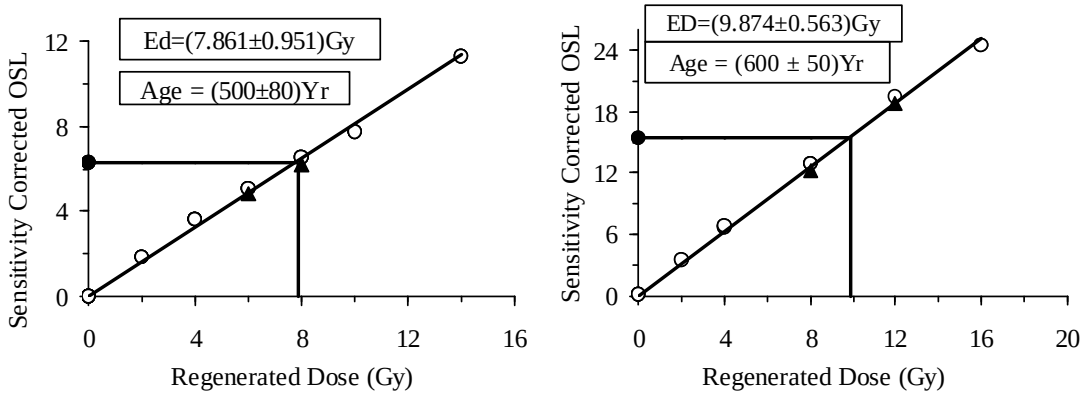

Fig. 3c. Sensitivity corrected Dose Response Curve.

- ● Natural
- o Regeneration
- ▲ 7th Regeneration

MUDFLOWS ON THE KOUBRU HILL SLOPES

It was on Saturday, the 10th July, 2004, in the evening that inhabitants of Keithelmanbi, Gopibung, Parsai, Chandramalpukhri, Makuli and Toribari villages of Sadar Hills area faced the natural calamity due to landslide at three different places (Fig. 4a, b). The devastation took place in the lower reach spreading the mudflow with huge deposition. The NH-39 was closed for a fort-night because of the

Fig. 4a, & b. Scenes of 2004 mudflow hazards.
(Source: 2001-2003 KanglaOnline Internet & Engg Services. http://www.kanglaonline.com/)

mudflow. The mudflow fanned out and extended upto the Imphal River. The violent current of mudflow also smashed two school building and one HT electric tower post.

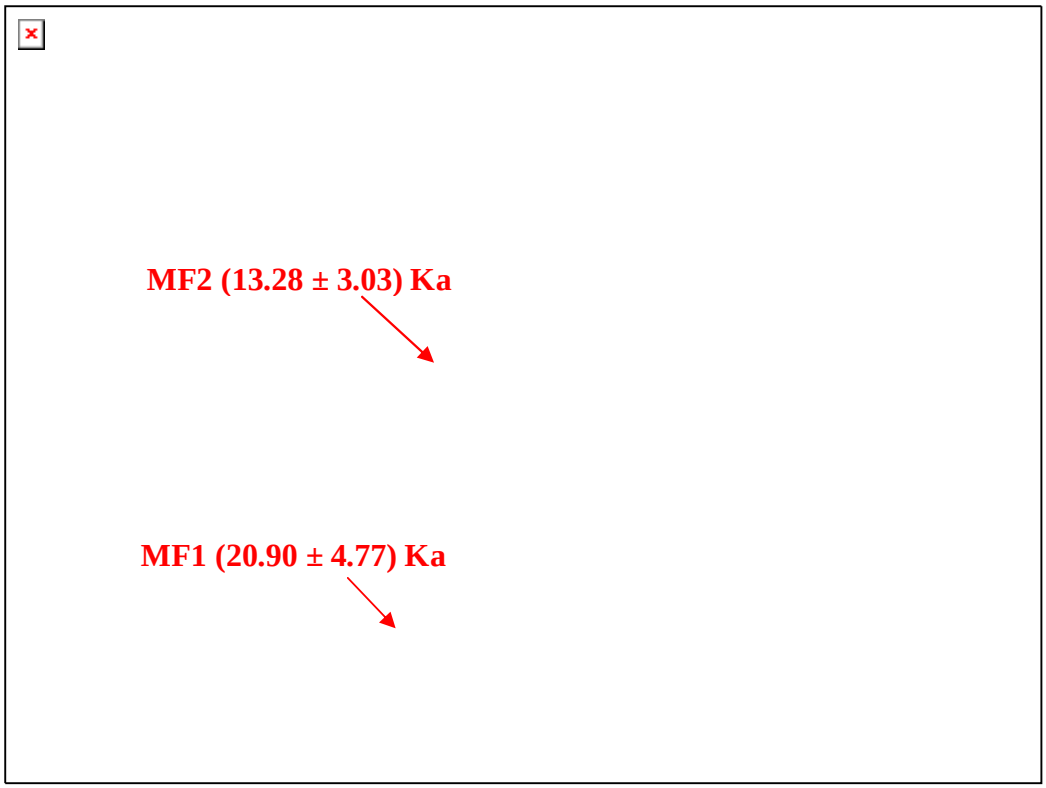

Fig. 4c. Photograph of ancient mudflow deposit.

RESULTS AND DISCUSSION

As a very preliminary as well as important step in checking the potentiality of luminescence dating technique in earthquake dating creating fissures that transports fresh sediments and redeposits over the base soil we have recorded the NTL of the 1957 Kumbi earthquake deposited soil as well as that of the base soil. The TL signals are plotted in the same figure for comparision (Fig. 5). The results clearly show that the two events

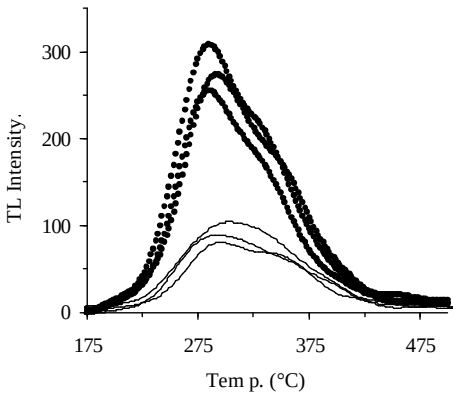

Fig. 5. NTL of 10mg of quartz extracted from 1957 Kumbi earthquake site.
——— earthquake sediment
•••••••• base soil

can be discriminated by TL. The OSL age of the base sediment (red laterite soil) is found to be (1880 ± 450) years while that of the water-laid fresh deposits of 1987 earthquakes provided age (224 ± 22) years. This leads us to believe that earthquake induced water-laid sediments under favourable conditions can provide dates of young earthquake as old as 200 years. It also shows that under such situations complete zeroing is not possible, which is expected if one keeps in mind the bleachability of quartz TL peaks used for luminescence dating [16]. The OSL dates of some unknown age earthquakes are presented in table 1.

Table 1. MU OSL ages of historic / prehistoric hazards of India.

Earthquake	Kumbi, Manipur (1957)	(224 ± 22) years
	Loharghat, Assam – Shillong	(140 ± 15) years
	Jagi, Assam – Shillong	(220 ± 18) years
	Chedrang, Assam – Shillong	(1500 ± 300) years
Tsunami	Mahabalipuram – Soil sample facing west	(180 ± 18) years
	Mahabalipuram – Ancient Brick and Sand	(500 ± 80) years
	Mahabalipuram – 165 cm south (side of encl.)	(600 ± 50) years
	Mahabalipuram – Along the brick wall	(3224 ± 415) years
Mudflow	Gopibung – MF0′	(1400 ± 330) years
	Gopibung – MF0	(8200 ± 1900) years
	Gopibung – MF2	(13000 ± 3000) years
	Gopibung – MF1	(20000 ± 4800) years

The relevant data for OSL age of an unknown age paleo-tsunami that was supplied by NIOT-ASI Chennai team is shown in Fig. 3c.

This leads us to believe that Mahabalipuram was severely affected by a paleo-tsunami 26th Dec 2004 that brought destruction to old monuments.

Finally, we present the OSL ages of some historical / pre-historical mudflow of Manipur (table 1)

The results show that most probably mudflow because of their very nature of origin like originating during rainy seasons covered with clouds and being muddy in nature does not get enough solar radiation to bleach TL signal significantly. The ages presented in table 1 seems to be the age of the source sediment.

Summarizing the work one can say that

i) OSL dating has immense potential in providing reliable / useful ages for hazard assessment as of earthquake / tsunami which is in line of many excellent studies India [17,18,19].
ii) It may not possible to date mudflows / landslide with existing state of OSL dating using quartz as the chronometer.

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