Optically stimulated luminescence dating of artifacts excavated from Kangla, Manipur, India

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Kangla, located at the heart of Imphal city, is almost intersected by 24°N latitude, 94°E longitude, 2619 feet above the mean sea level. An excavation in 2006 at the site by the State Archaeology Department has yielded potteries and bricks at different levels-1.09, 0.72 and 1.64 meter. Using coarse grain of quartz excavated from these artifacts, three samples have been dated using Single Aliquot Regenerative dose (SAR) protocol. A standard commercial Riso (Denmark) TL/OSL reader (model TL DA-15A) has been used for data acquisition. The optically stimulated luminescence (OSL) ages of the samples are in the range 1450-1500 A.D.

Keywords: Kangla, Dating, Single aliquot regenerative dose protocol, Optically stimulated luminescence

1 Introduction

An archaeological excavation conducted by the state Archaeology, Manipur at Sanggai Yumpham inside Citadel enclosure at Kangla Fort revealed structural remains of historical importance and a large numbers of cultural materials as well as sample of potsherds and brickbats (Fig. 1). In order to estimate the age of these potteries and bricks, optical dating technique is applied to the quartz samples extracted from these potteries and bricks. The technique has been successfully applied in the last few years to both sedimentary and heated quartz \(^1\)\(^-\)\(^3\). The amount of optically stimulated luminescence (OSL) observed when irradiated quartz is exposed to blue light, is used to estimate the radiation dose derived from naturally occurring radioactivity and acquired since the time of sediment deposited or heated pottery or stone. This radiation dose is usually calculated by comparing the natural OSL with OSL produced by a known laboratory dose\(^4\).

In this paper, the application of Single Aliquot Regenerative dose (SAR) protocol \(^4\) to the OSL from quartz extracted from two potteries and one brick excavated from different depth at Sanggai Yumpham, Kangla has been reported.

2 Experimental Details

Potteries and brick excavated from Kangla Fort were crushed and from that crusts sand sized grain (90-180 µm) were extracted by sieving. The extracts were treated with HCl, H\(_2\)O\(_2\) and HF in the usual way which yields quartz for OSL measurements.

All the measurements are made in automatic Riso TL/OSL-DA-15 reader using internal Sr/Y-90 beta source. The Riso TL/OSL reader is commercial system used globally for dating and dosimetry\(^5\). Detection filters were the combination of Schott UG-11 and BG-39 filters. OSL measurements were carried out with blue light obtained from LED (470±30) nm array delivering a maximum 90% power.

Fig. 1—The site of Kangla from which the potteries and bricks were excavated
The evaluation of equivalent dose (ED) from the extracted quartz grains used the SAR protocol. In this protocol, the natural OSL signal ($L_o$) is measured after a pre-heat (~160-300°C) until the signal is effectively zero. The sample is then given a test dose ($D_t$), heated to 160°C and the test dose OSL signal ($T_o$) is measured; this complete the natural measurement cycle. To begin the second cycle, a regenerative dose ($D_1$) is first administered; the sample is then heated to the same pre-heat temperature as the first cycle and OSL signal is measured ($L_1$). The sample is then given the same test dose as before ($D_t$) heated to 160°C and the test dose OSL signal ($T_1$) is measured; this regenerative cycle is then repeated as many times as desired with the variation of only regenerative doses. By taking the ratio of the natural and regenerative OSL responses to the subsequent test dose OSL response ($L_o/T_o$ and $L_1/T_1$), a sensitivity corrected measure of the OSL response is obtained. The equivalent dose (ED) is estimated by interpolation of the natural luminescence on to the regenerated curve.

3 Results and Discussion

The sensitivity corrected dose response curve for pottery is shown in Fig. 2 and that of brick is shown in Fig. 3. The average ED obtained for pottery and brick for different grain sizes are presented in Table 1.

The age of the two potteries and one brick are calculated using the age equation

$$\text{Age(a)} = \frac{\text{Equivalent Dose (Gy)}}{\text{Dose rate (Gy per year)}}$$

As the annual dose rate of these potteries and brick are not measured, an average value of dose rate for different samples at different places of Manipur having value 2.47 Gy/Ka, is used in the determination of the age. Using this dose rate the calculated ages of the samples are presented in Table 1.

The ages of the potteries and bricks of Kangla are in the range of 1450-1500 A.D. Historical record tells that the major landmark in the growth of ancient fort were constructed by King Khagamba (1597-1652) A.D., who is known as the conqueror of Chinese in the history of Manipur. This result shows that the site excavated in 2006 excavation was occupied by the King prior to King Khagamba.

Since, Kangla was the ancient capital of Manipur, it is intimately connected with the history of Manipur.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Location</th>
<th>Grain Size (µm)</th>
<th>Depth (m)</th>
<th>ED (Gy)</th>
<th>Age (Yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pottery-1</td>
<td>150</td>
<td>1.09</td>
<td>1.37 ± 0.23</td>
<td>555 ± 98</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td></td>
<td>1.35 ± 0.15</td>
<td>547 ± 82</td>
<td></td>
</tr>
<tr>
<td>Pottery-2</td>
<td>150</td>
<td>0.72</td>
<td>1.32 ± 0.44</td>
<td>534 ± 190</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td></td>
<td>1.29 ± 0.34</td>
<td>522 ± 150</td>
<td></td>
</tr>
<tr>
<td>Brick</td>
<td>150</td>
<td>1.64</td>
<td>1.39 ± 0.96</td>
<td>564 ± 388</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td></td>
<td>1.47 ± 0.08</td>
<td>595 ± 76</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2—Sensitivity-corrected dose response curve for pottery
a – Pottery-1, b – Pottery-2

Fig. 3—Sensitivity-corrected dose response curve for brick

Table 1—Details of the equivalent dose determined by SAR protocol
The place is not only the seat of political power but also a holy place for religious worship and ceremonies. Hence, the results will be helpful to study the ancient history of Manipur.

4 Conclusions
Potteries are most common types of artifacts found at archaeological sites. These contain obvious information of their age if viewed through the window of luminescence dating. In that sense this study will provide a new application of luminescence dating in providing vital information on the early settlement prior to King Khagemba, the famous King of ancient Manipur.

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References