

PRELIMINARY STUDY OF THE AGE OF THE LANNA PERIOD BY THERMOLUMINESCENCE DATING: A CASE STUDY FROM THE WIANG KAEN ANCIENT SITE, CHIANG RAI, NORTHERN THAILAND

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ABSTRACT. The ancient Wiang Kaen site was a colony of Lanna -- a once famous Kingdom in Northern Thailand between 1296 and 1558 AD. The dates of occupation of the city were determined by using a regenerative thermoluminescence (TL) dating technique. Five brick samples were collected from remaining basements of the ancient ruins. Quartz extracted from these bricks was the material dated by TL. The TL-dating results came out in two ranges of 1127 to 1295 AD and 1312 to 1416 AD which confirmed that the bricks from the ancient ruins were made during the Lanna period.

Introduction

The investigation of cultural heritage is a multidisciplinary work that incorporates researchers from various fields of study. Archaeological considerations are important to classify the aesthetic styles and to identify the historical and geographical context in which an artistic object was made. The identification of compositional characteristics specific to a certain set of samples have led to information about production techniques, production sites, and the dates of objects under investigation (Chaivari et al., 2001; Barilaro et al., 2006).

Lanna, established in 1296AD, was once a famous Kingdom in Northern Thailand. Wiang Kaen city, one of the many colonies of Lanna, is located at the present Chiang Rai prefecture. The lack of the dates for the main building in the ancient city does not allow study of the history and developing of the society in the same period. Thermoluminescence (TL) dating is one of many techniques used to date ancient bricks, artefacts, burnt flints, etc. (Mahaney, 1984; Aitken, 1985; Ikeya, 1993). Recently, Veronese et al. (2008) and Blain et al. (2007) applied the TL technique to date bricks from ancient ruins which yielded satisfactory results.

Method

Sampling and preparation

The geomorphological setting around the ancient city of Wiang Kaen was divided into six units. These units consisted of flood plain, undulated terrain, natural levee, low terrace, middle terrace and a high terrace unit. The ancient city of Wiang Kaen was found on the high river terrace unit at 360 – 390 masl. The size of the city is 640 x 972 m² (Fig. 1).

The areas available for sample collection were very limited because of a high vegetation cover. For this preliminary study, only five bricks were collected from two basements of the ancient ruins covered by rough and abundant vegetation (see Fig. 2a, b). Sample WKW001 and WKW002 were collected from the West remaining area of the basement and followed the upper and lower construction profile. In the Eastern remaining area of the basement, sample WKE001, WKE002 and WKE003 were collected from the sequential collection of the brick samples from the upper to lower layers.

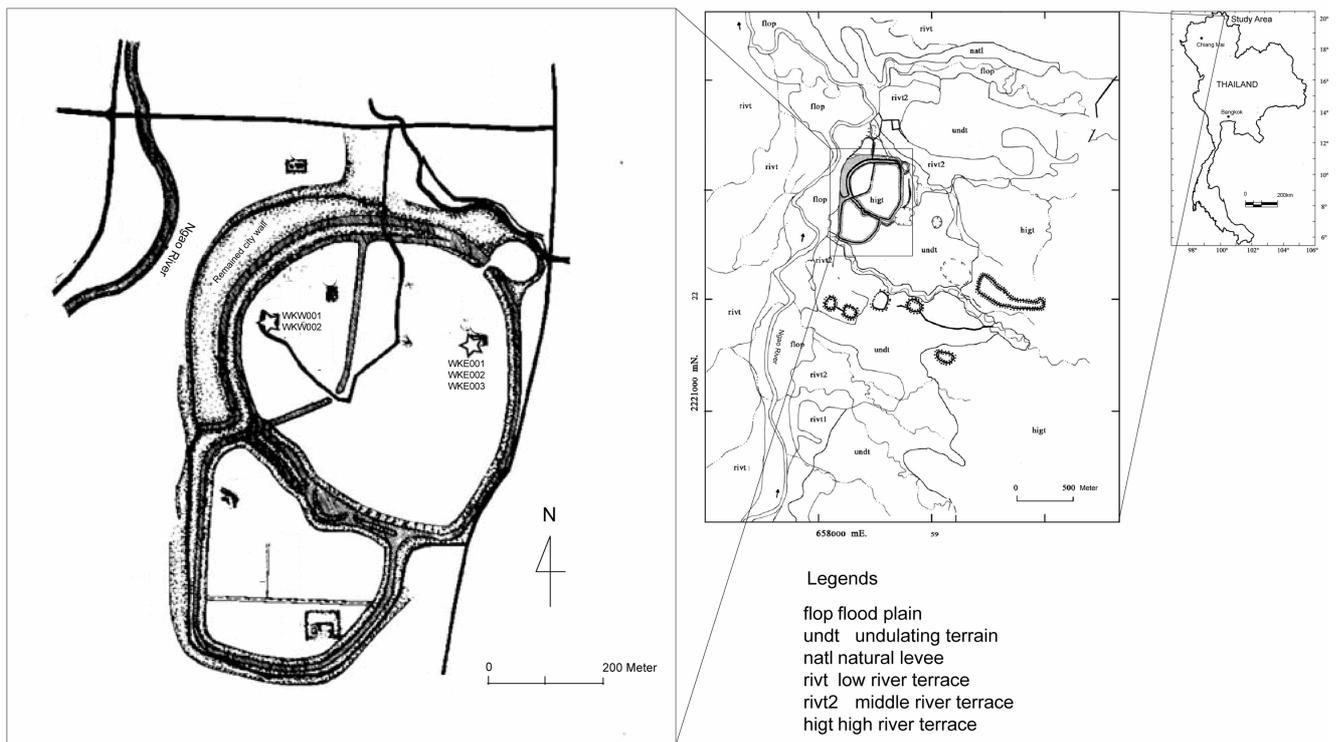


Fig. 1. The sampling location in the ancient city of Wiang Kaen , Chiang Rai prefecture, Northern Thailand



a



b

Fig. 2. (a) The ancient Buddha image in the ancient city of Wiang Kaen showing the dense vegetation cover in the investigation area; (b) Location of the sample bricks in the Eastern part of the ancient city of Wiang Kaen

The material for thermoluminescence (TL) dating was coarse grain quartz (diameter 74-250 μm). The procedure is the same as described by Takashima and Watanabe (1994). The outer surfaces of the bricks were removed. Only the inner central parts of the bricks were crushed and sieved to obtain 74-250 μm grains. Then they were separated into magnetic and non-magnetic portions by using an isodynamic magnetic separator. The non-magnetic grains were treated with 35% HCl for 1 hour at 50-60°C. Subsequently, the sample was washed several times in distilled water. After that, the sample was etched in 24% HF for 40 minutes at 50-60°C and re-washed several times in distilled water. The partial grains were treated with 35% HCl for 2 hours at 50-60°C, again. The sample grains were rinsed several times in distilled water. After drying the samples, the quartz quantity was checked by XRD analysis. If

the quartz samples contained more than 99% of minerals, they were stored in aluminum foil for dating.

TL measurement

The TL emission from the coarse-grained quartz was measured using the C1230 photon counter (Hamamatsu Photonics), SU-11 temperature controller (Chino Co.) with heating rate at 120°C per minute in a well-equipped N₂-purge condition at Akita University. About 10 mg of sample was placed on a molybdenum heater. A combination of a blue filter (Toshiba IRA-10) and a long wave pass filter (ESCO Products, OG-550) with bi-alkaline photomultiplier tube filtering is applied. The emitted wavelength of the system is around 550-650 nm.

Regenerative dose determination of the growth curve method (Takashima, Honda, 1989) was used for the determination of equivalent-dose of coarse-grained samples. Both natural and gamma ray irradiated samples were measured. The gamma ray source for irradiation is a ^{60}Co with the intensity of 1.1×10^{14} Bq. In the pre-heated condition at 320°C for 5 hours, natural samples were irradiated at different doses. After irradiation, the unstable signals from the samples must be excluded by heating at 130°C for 1 day. We selected the peak of the TL glow curve by considering the plateau test (Aitken, 1985). A constant ratio between natural and artificial glow-curves can give an indication throughout the plateau region. The $350\text{--}375^\circ\text{C}$ peak height and non-peak of the TL glow curve (Fig. 3) for the coarse-grained sample is selected for the determination of equivalent dose (ED) (Fig. 4).

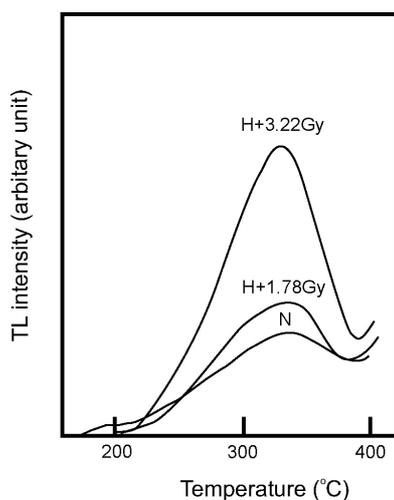


Fig. 3. TL glow curve of WKE001 quartz sample: N – natural; H+1.78 Gy – data for 1.78 Gy of gamma ray irradiated to heated (320°C ; 5 hours) sample

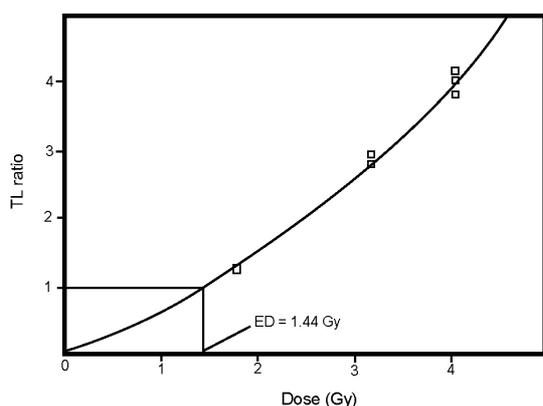


Fig. 4. TL growth curve of WKE001 quartz sample for determination of equivalent dose

The annual dose rate (AD) determinations were determined by gamma ray spectrometry. The 290 g sample is put in the 75 mm-diameter NaI scintillator unit with multi-channel analysis. Standard samples are NBL (0.5% U and 0.5% Th), chemical

reagent (K_2CO_3) and blank powder ($\text{SiO}_2\text{:Fe}_2\text{O}_3$, 95:5 in weight). We made 50 ppm and 5% standards for U/Th and K_2O powder, respectively, and mixed with blank powder. The annual dose rate is calculated from the chemical data of U, Th, K_2O and the water contents were calculated using the method proposed by (Aitken, 1985) as shown in equation (1):

$$AD = D_{\alpha} + D_{\beta} + D_{\gamma} + D_{\text{cosmic ray}} \quad (1)$$

Where AD is the total annual dose rate (mGy/year) including the doses of alpha, beta, gamma and cosmic ray irradiation contents from the surrounding environment.

The age of the bricks was determined by simple equation (2) below;

$$\text{Age} = ED/AD \quad (2)$$

Where ED is the equivalent dose accumulated during the age of the brick.

Results and discussion

The evaluation of ED is made by the straight-forward procedure of measuring the natural TL intensity from the natural sample and comparing it with the artificial TL intensity from the same sample (subjected to three different irradiation dosages). The TL glow curve of quartz from the brick is shown in Fig. 4. The TL dating results of this investigation are shown in Table 1. The chemical results of the uranium content vary from 2.45 to 2.82 ppm, thorium content from 7.16 to 8.27 ppm and potassium content from 0.77 to 1.31%. Sample WKW001 and WKW002 from the Western flank, the annual dose rates are 2.16 ± 0.22 and 2.08 ± 0.21 mGy/year. The Eastern flank, the annual dose rates of sample WKE001, WKE002 and WKE003 are 2.03 ± 0.20 , 2.12 ± 0.21 and 1.59 ± 0.16 mGy/year, respectively. The TL age of WKW001 and WKW002 are 588 ± 65 and 692 ± 80 years. In the Eastern flank, TL ages of WKE001, WKE002 and WKE003 are 709 ± 80 , 877 ± 121 and 767 ± 66 years, respectively.

From the preliminary TL dating data, we could interpret the remains of a basement in the ancient city of Wiang Kaen as constructed in 1312-1416 AD in the Western part, while the Eastern part was constructed in 1127-1295 AD. The range of the dates shows that the two constructions were built in the different periods. The comparison between the obtained TL dates and the Lanna historical record, suggests that the ancient city of Wiang Kaen was built before the time of the Lanna Kingdom. Afterward, it had abandoned and migration was recorded again during the Lanna period. The Western Wiang Kaen was built before the Lanna period. When the Lanna Kingdom was established in 1296 AD, many religion buildings were constructed. The Eastern Wiang Kaen was built in 1312-1416 AD which corresponds to the Lanna Kingdom period (1296-1558 AD).

Table 1

The results of the composition, dose and TL age of the brick samples

Sample	Composition				Dose		TL age	
	U (ppm)	Th (ppm)	K ₂ O (%)	Water (%)	AD (mGy/year)	ED (Gy)	ka	year
WKW001	2.62	8.24	1.31	9.70	2.16±0.22	1.27±0.06	0.588±0.065	1416
WKW002	2.74	8.16	0.96	3.10	2.08±0.21	1.44±0.07	0.692±0.080	1312
WKE001	2.57	7.73	1.23	10.8	2.03±0.20	1.44±0.07	0.709±0.080	1295
WKE002	2.82	8.27	1.16	8.90	2.12±0.21	1.86±0.09	0.877±0.121	1127
WKE003	2.45	7.16	0.77	13.0	1.59±0.16	1.22±0.06	0.767±0.066	1237

Conclusion

TL dating of brick samples from the basement of the ancient city of Wiang Kaen in Northern Thailand was carried out using quartz extracted from five brick samples. The TL measurement resulted in two ranges of dates demonstrating that the ancient constructions of the Western and Eastern Wiang Kaen were built in different periods. To establish the history of the ancient city of Wiang Kaen, multidisciplinary studies including the TL dating method were applied.

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