Optical dating of potteries excavated from Pungnabtoseong earthen wall, Seoul

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1. Introduction

Thermoluminescence (TL) and optically stimulated luminescence (OSL) emitted from natural crystalline mineral, usually quartz, feldspar, and so on, are mainly used to evaluate the paleodose for the age determination of archaeological and geological sample and the equivalent dose for retrospective dosimetry. TL/OSL age can be calculated as the ratio of paleodose to total annual dose rate which is determined from surrounding soil [1].

In this study, we chemically extracted the quartz samples from potteries excavated in Pungnabtoseong earthen wall and observed the TL/OSL characteristics for paleodose determination. With the converted annual dose rate from the concentration of radioactive isotopes in its surrounding soil, optical date was evaluated and finally illustrated for interpreting the construction stage of Pungnabtoseong.

2. Experimental details

2.1 Site and samples

Pungnabtoseong earthen wall, near Hangang River was built during the Baekje Dynasty (18 B.C~660 A.D.). Originally it was 4 km around but part of it was washed away by flood before 1900's, leaving only 2.7 km. This site was the capital of Baekje at the earliest stage until invasion of Goguryeo (475 A.D.). Many consider the site in relation with other Baekje remains in Seoul such as Mongchontoseong earthen wall and Seokchon-dong tomb complex [2].

For optical dating, five pottery pieces were collected at the different contextual earthen layers, as shown in Fig. 1. In the laboratory's dark room, each quartz sample for paleodose determination, grain size 125~250 µm, was extracted by chemical treatment with concentrated HF acid [3]. Powdered samples of pottery and surrounding soil were prepared for assessing the annual dose rate of beta and gamma, respectively.

2.2 Equipments

All luminescence measurements were made using an automated Neo TL/OSL system (Model NMTO20) composed of computer control of sample position, exposure to a mini X-ray irradiator, a heater, blue/IR power LEDs for stimulation and a photomultiplier. With UV filter combination around 340 nm, luminescence was detected at 125℃ in order to prevent retrapping of charges from the shallow trap corresponding to the 110C TL peak. The concentrations of the major radioactive isotopes of the uranium and thorium series and of potassium for beta and gamma annual dose rate were estimated by using a high-purity germanium detector (P-type HPGe detector, Canberra Ltd.).

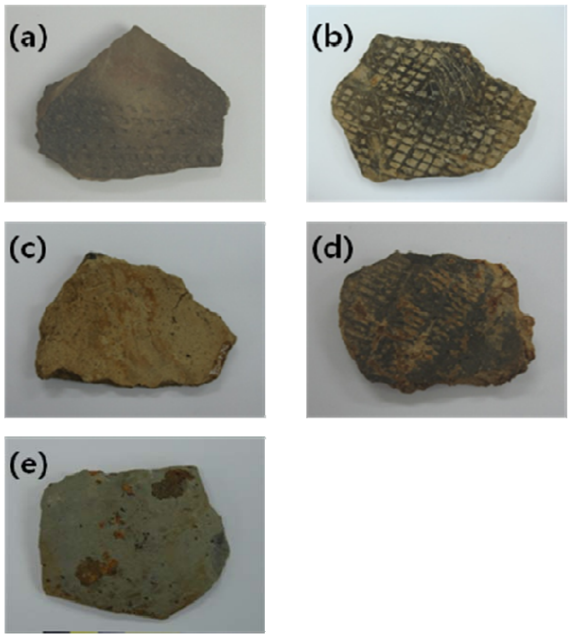

Fig. 1. Photograph of pottery pieces collected in Pungnabtoseong earthen wall for optical dating: NCH-PN1 (a), NCH-PN2 (b), NCH-PN3 (c), NCH-PN4 (d) and NCH-PN5 (e).

3. Results and discussion

3.1 Paleodose

One of the basic hypotheses in optical dating is of thermal zeroing before burial. It is known that the firing temperature of pottery excavated from Pungnabtoseong earthen wall is over 800℃ even though soft pottery [2]. Since the main TL peak of quartz exists below 400℃ [1], it is estimated that all pottery samples was completely bleached.

The single aliquot regenerative-dose protocol based on OSL measurement (SAR-OSL) was used for paleodose determination [4]. The procedure used in this research involves using the same aliquot, the natural signal is measured, successively larger known laboratory regenerative doses are administered and the resulting luminescence measured. The sensitivity changes of the sample due to successive measurements are corrected by monitoring the luminescence response of the sample to a subsequent small constant radiation dose, after the natural and each regeneration step. Samples received a total of 40s blue light exposure and the first 0.8 s of OSL signal measured at 125℃ was integrated to make growth curves.

The reliability of SAR-OSL protocol was shown in Fig. 2 and the resultant paleodoses were finally summarized in Fig. 3.

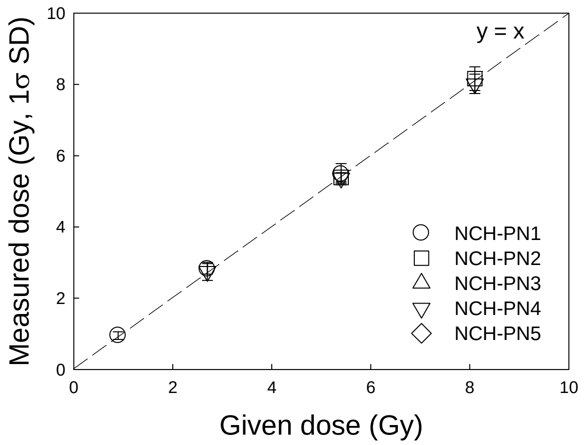

Fig. 2. Dose recovery test for proving the reliability of SAR-OSL protocol.

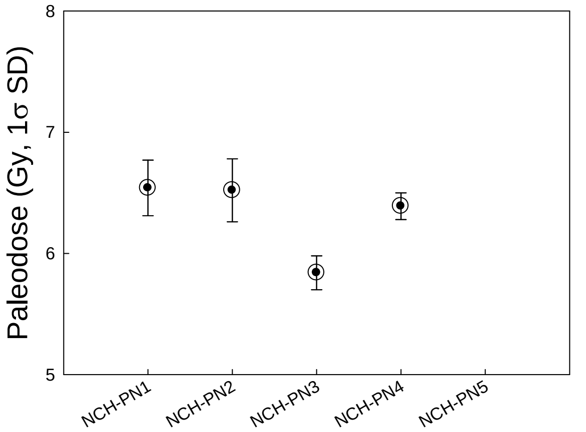

Fig. 3. Summary of paleodoses calculated from each pottery quartz sample using SAR-OSL protocol.

3.2 Annual dose rate

The total annual dose rates for age calculation are comprised of the beta dose rate, gamma dose rate and cosmic ray component. The beta and gamma dose rates were estimated by the concentrations of the major radioactive isotopes of the uranium and thorium series and of potassium within pottery and surrounding soil, respectively. A small correction for probable water content was applied to both the beta and the gamma dose rates measured. In calculations of the beta dose rates a factor of 0.9 was considered to allow for beta dose attenuation [5]. The cosmic ray contribution was calculated using the equation given by Prescott and Hutton [6].

4. Conclusion

Construction era of Pungnabtoseong earthen wall is one of the most popular controversial issues in the Korean archeology. For the purpose of defining the period of construction and settlement, OSL dating was carried out using five potteries collected from each contextual earthen layer. OSL age was determined with the paleodose obtained from SAR-OSL protocol and the total annual dose rate calculated from the concentrations of U, Th and K. Finally, the resultant OSL ages will provide important information for the formation and evolution of the Baekje Dynasty.

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