© Kamla-Raj 2015 Anthropologist, 19(1): 131-138 (2015)
PRINT: ISSN 0972-0073 ONLINE: ISSN 2456-6802 DOI: 10.31901/24566802.2015/19.01.15

# Anthropological Study on the Cremated Bones of the Late Silla Kingdom Period in Korean History

Do Seon Lim[1], Eun Jin Woo[2], Jae-Hoon Bae[3], Yongjun Kim[4], Na Li Lee[5], Kyung Hwangbo[6], Chang Seok Oh[7], Yi-Suk Kim[8], Soon Chul Cha[9] and Dong Hoon Shin[7]

*[1]Department of Dental Hygiene, College of Health Science, Eulji University, 553 Sanseong-Daero, Sujeong-Gu, Seongnam-Si, Gyeonggi-Do 461-713, South Korea*
*[2]Division in Anatomy and Developmental Biology, Department of Oral Biology, BK21 PLUS Project, Yonsei University College of Dentistry 120-752, Seoul, South Korea*
*[3]Korea National University of Cultural Heritage, 367, Baekjemun-Ro, Gyuam-Myeon, Buyeo-Gun, Chungcheongnam-Do 323-812, South Korea*
*[4]Department of Archaeology, Deccan College Post Graduate and Research Institute, Deccan College Road, Yerwada, Pune - 411006, Maharashtra, India*
*[5]Gangwon Research Institute of Cultural Properties, 296-3, Udu-dong, Chuncheon-shi, Gangwon-do 200-020, South Korea*
*[6]Sejong University Museum, 209, Neungdong-Ro, Gwangjin-gu, Seoul 143-747, South Korea*
*[7]Bioanthropology and Paleopathology Lab, Institute of Forensic Science, Seoul National University College of Medicine, 28, Yongon-Dong, Chongno-Gu, Seoul 110-799, South Korea*
*[8]Department of Anatomy, Ewha Womans University School of Medicine, 911-1, Mok-6-Dong, Yangcheon-Gu, Seoul 158-710, South Korea*
*[9]Dongguk Institutes of Cultural Properties, 1436, Yulha-Dong, Dong-Gu, Daegu 701-847, South Korea*

**KEYWORDS** Forensic Science. Cremation. Scanning Electron Microscopy. East Asia. Human Bones

**ABSTRACT** Anthropological studies on burnt bones revealed patterns by which the nature of archaeological cremation cases can be hypothesized. However, there have been very few histological analyses performed on cremated bones obtained from archaeological sites in East Asia. The researchers, therefore, endeavored to isolate the heat-induced changes in *Late Silla Kingdom* bones that probably had been subjected to post-mortem cremation. When the researchers examined the bone samples by S-4700 scanning electron microscope (SEM), color changes in the bones were observed, showing that the cremation temperature might have reached a high level. By the detailed SEM study on bony microstructure, the researchers estimated that the temperature in one case (*Gangneung*) reached about 800°C and in another (*Pyeongtaek*), possibly as high as 1000-1400°C. The histological nature of ancient cremated bones in Korea is revealed for the first time ever in the present study, by which the cremation temperature of them could be successfully estimated.

## INTRODUCTION

The recent strides made in burnt-bone research have both enriched and sharpened the scientific interpretation of cremation in human history. Even the highly-sophisticated researches such as a DNA or stable isotope analyses have been successfully performed on the burnt bones from archaeological sites, nowadays, (Pusch et al. 2000; Harbeck et al. 2011). Nevertheless, many key issues relating to cremated-bone samples discovered in the archaeological field still require clarification by anthropologists. In fact, the researchers must acknowledge that simple observation of heat-induced color changes cannot reveal every aspect of past cremation, as there is considerable color variation under different cremation conditions (Spennemann et al. 1989).

Ultra microscopic study by scanning electron microscopy (SEM), therefore, is crucial to researchers studying the nature of archaeologically obtained burnt bones. Heat-induced changes actually are very dramatic under SEM, even if macroscopic examination does not show the telltale changes in color, the shrinkage, or the frac-

*Address for correspondence:*
Dr. Dong Hoon Shin
Bioanthropology and Paleopathology Lab
Institute of Forensic Science/Department of Anatomy
Seoul National University College of Medicine
103 Daehak-ro, Jongno-gu, Seoul 110-799, South Korea
*Fax:* 82-2-745-9528
*E-mail:* cuteminjae@gmail.com

turing and distortions (Holden et al. 1995). SEM, thus, has been applied over the past several years for in-depth study of heat-damaged bones or teeth (Holden et al. 1995; Bonavilla et al. 2008; Ubelaker 2009; Absolonova et al. 2012; Amadasi et al. 2012).

Post-mortem cremation is a long-established cultural practice in East Asian countries. Whereas many societies and individuals have followed Buddhist funeral rites in this regard, many others have observed traditions more characteristic of each country. Korea is no exception in either respect. However, whatever the cultural background behind historical cremations in East Asia, we must note that there have been very few scientific studies on cremated bones found in those countries, despite the abundance of such information accumulated. Recently though, we had the opportunity to examine two cremated-bone cases dating to the *Late Silla Kingdom* ($8^{th}$–$9^{th}$ century CE) in Korean history. As no data of this sort has yet been reported from any East Asian country, a scientific study on the historical cremated bones in Korea must be important for concerned forensic anthropologists to examine similar cases burnt under similar circumstances. It will doubtlessly prove useful to anthropologists interested in historical cremation within shared or similar funeral traditions.

### Objective of the Study

The nature of ancient cremated bones in Korea is studied by scientific method for the first time, by which the cremation temperature of ancient times in East Asia could be successfully estimated.

## MATERIAL AND METHODS

Both cases were of human bones that had been burnt in ancient cremation rites. The *Gangneung* (*Ipam-dong*) case involved bone fragments discovered in an earthenware cinerary urn. Based on its typology, it is likely that the urn was buried between the $8^{th}$ and $9^{th}$ centuries. The second set of fragments, also in a cinerary urn, was discovered in *Pyongtaek* (*Dogok-ri*), a mid-western county in Korea. Many burnt-bone fragments were collected in both cases (Fig. 1).

Where possible, the cremated bones were reconstructed prior to the anthropological examination. According to the duplication of skeletal elements and indications as to size, age and sex, we endeavored to determine the minimum number of individuals (MNI). The age at death was estimated by reference to the diaphysis size, the cortical bone thickness of long-bone diaphysis and/or cranial vault, and the degenerative changes of the joint surfaces and enthesis sites. The sex was estimated based on the standard morphological criteria (Buikstra and Ubelaker 1994). The researchers also studied the bone fragments' size and color and the post-cremation manner of fragmentation, following the method of Subirà et al. (2011).

After the researchers sorted the burnt-bone types from each cinerary urn, they performed SEM examinations based on the methods of Hayat (1970) and Bozzola and Russell (1992). The samples had been pre-fixed by immersion in 2% paraformaldehyde / 2.5% glutaraldehyde in neutral 0.1 M phosphate buffer, and post-fixed for 2 hours in 1% (w/v) osmic acid dissolved in phosphate-buffered saline (PBS). They were next treated in a graded ethanol series and isoamyl acetate, dried in a critical point dryer (SCP-2, Hitachi, Japan), and Pt-Pd-coated using an anion coater (E-1030, Hitachi, Japan). The samples finally were observed under S-4700 SEM (Hitachi, Japan).

During the SEM examination, the researchers also measured the bone-crystal sizes. For the *Gangneung* case, the hexagonal-crystal size was measured in three different areas of the bones. They measured 17 to 22 crystals in each area, and calculated the means and standard deviations. In the same manner, they measured the hexagonal-crystal (n=27) sizes for the *Pyeongtaek* case.

## RESULTS

### General Features

It was found that the bone fragments, rendered fragile possibly by their combustion, had been piled up randomly in various sizes in cinerary urns during the period of the *Late Silla Kingdom* (Fig. 1). The burnt bones showed deep longitudinal fractures, transverse cracks and a certain range of shrinkage in the long-bone diaphysis. The majority of the fragments were calcined with some white and grey spots.

### *Gangneung* Case

The skull was fragmented and somewhat shrunken by cremation. The intact postcranial

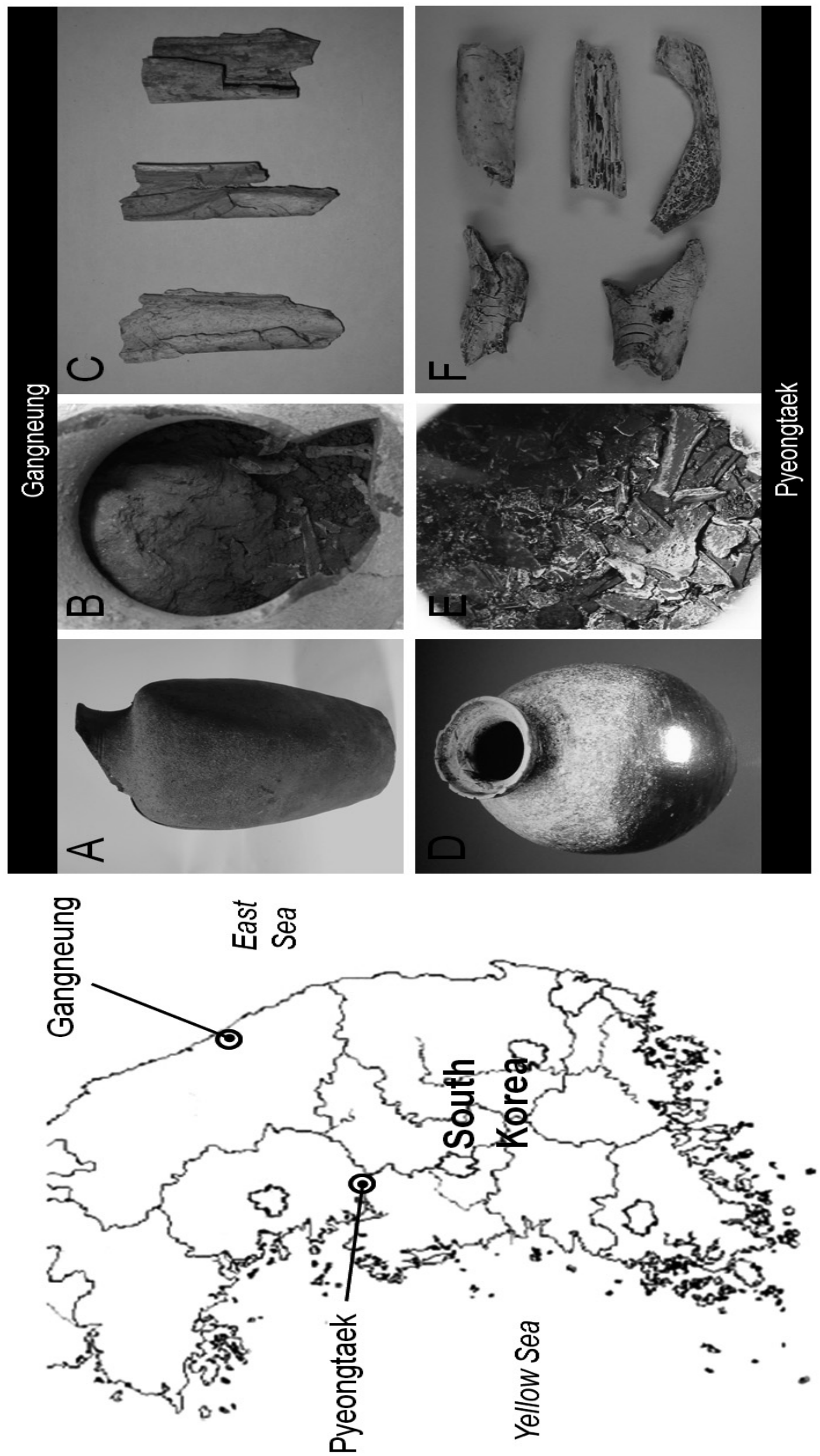


**Fig. 1. Information on cremated human bones examined in this study. (A) The area (red dots) where the cremated bones were discovered. Upper row (A to C): Gangneung case. Lower row (D to F): Pyeongtaek case. (A) and (D): the earthenware in which the cremated bones were found. (B) and (E): Inside the earthenware, the cremated bones were observed. (C) and (F) The collected cremated bones.**

remains were limited to both sides of the talus, hand bones and foot bones. Those with fractures and/or missing pieces included the scapula, the right humerus, the right radius, the right femur, both sides of the tibia and fibula, some pelvic fragments and vertebrae mainly of the lower thoracic and lumbar regions. The majority of the long bones also showed patterns of fracture and distortion.

Interestingly enough, the researchers found duplications of the atlas and fibular distal end. The co-mingled bones were mainly those of adults; some, probably those of a child or adolescent, also were identified. The child/adolescent bones were postcranial, and included the diaphysis of the long bones. the researchers, thus, concluded that this *Gangneung* case contained the cremated bones of *at least two different individuals*.

In the case of the adult bones, the researchers could estimate the sex and age. Briefly, the shape of the pelvic bone indicated that the individual was most likely to have been a female. At the time of death, she probably was in at least her 30s, judging from the degenerative changes of the supracondylar line in the right femur.

### *Pyeongtaek* Case

In this case, badly fragmented skulls and postcranial bones again were identified. Unlike the *Gangneung* case though, there were no evident duplications; accordingly the researchers concluded that, these bone fragments originated from only one individual. In the skull vault fragments, porotic hyperostosis was observed. The postcranial bones included a fragmented radius and fibula as well as the diaphysis and the distal end of the humerus diaphysis. The fragmented bones were seriously distorted and showed spiral cracks in the diaphysis. Among the dental remains, the researchers observed only the root of a maxilla molar and the crown of a maxilla incisor, along with some other fragments. Such a poor preservation status in this case made our bony-indicator-based estimations of sex and age very difficult.

The only tentative conclusions that could be drawn from this *Pyeongtaek* case were that the individual might have been an adolescent, judging from the attrition pattern on the crown of the maxilla incisor. This speculation was further supported by the size of cranial vault bones and the thinness of the diaphysis cortical bone. the researchers also noted a small number of animal bones in this case.

### SEM Findings

In the SEM results, we could find no evidence of collagen fibers in any of the cremated bones. The Harversian canals and osteocyte lacunae had retained their integrity in both cases. As for the lamellar structure of osteon, the *Gangneung* bones showed weak osteon patterns, whereas those in the *Pyeongtaek* case had not maintained any. The magnified images in both cases revealed that most of the fracture surfaces were covered with newly-formed bone crystals (Fig. 2). These bony changes, possibly caused by high temperature, were observed both on the Harversian canal walls and fractures: specifically, various ultramicroscopic patterns suggestive of the disintegration process resulting from heat damage (for example, lifting, shrinkage and splitting), were evident on the endosteal surface (Figs. 3A to 3C).

Re-crystallization was widely evident for all of the cremated bones; however, the crystal type differed between the two cases. In the *Gangneung* samples, most of the crystals showed hexagonal patterns of similar size (Figs. 3D, 3E). The average sizes of the crystals in the three different areas measured were $349.50 \pm 50.99$ nm, $342.76 \pm 46.40$ nm, and $396.72 \pm 76.07$ nm, respectively. In the *Pyeongtaek* samples meanwhile, there were many different types of crystals mixed together in the same area. The hexagonal pattern (mean size: $390.70 \pm 87.43$ nm) was not the major type; rather, most of the crystals were irregular types (for example, tetragonal or irregular morphologies). Even new-type crystals of rhombohedral morphology appeared in this case (Figs. 3F-3H). Fusion of crystals also was observed (Fig. 3I).

## DISCUSSION

Irrespective of their historical and cultural significance, burnt bones discovered at archaeological sites in Korea and in the other East Asian countries have received relatively little scholarly attention. One of the few exceptions is a pioneering study focusing on a cinerary urn dating to the *Late Silla Kingdom*. Kim and Kim (2005) postulated that their burnt-bone samples might

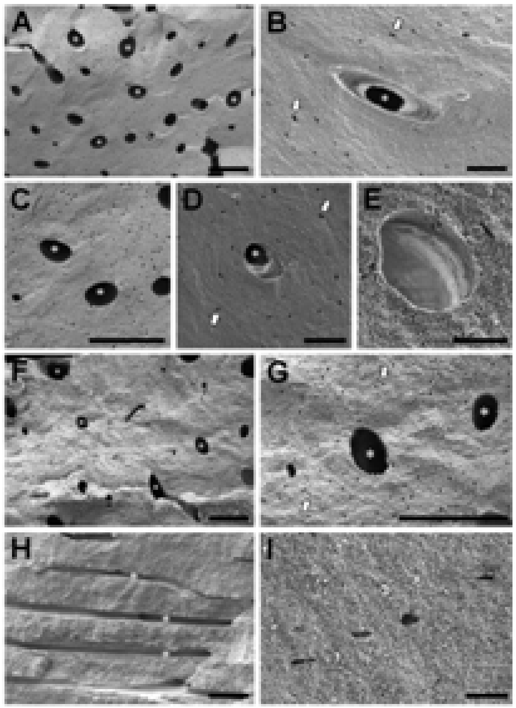


**Fig. 2. Scanning electron microscope (SEM) results on (A to E) Gangneung and (F to I) Pyeongtaek samples. (A) and (B) Osteocyte lacunae (indicated by arrows) are scattered in the burnt bone. Harversian canal (indicated by asterisks) could be clearly seen. (C) and (D) Lamellar structure is still observed in Gangneung bones. Lacunae indicated by arrows; Harversian canal indicated by asterisks. (E) On higher magnification, crystals were dispersed on the fracture surface. (F) to (H) In Pyeongtaek case, Harversian canals (asterisks) and lacunae (arrows) are clearly observed. Lamella structures were not evident. (I) On higher magnification, crystals were dispersed on the surface. Scale bars: (A) to (C) and (F) to (H) 200 um; (D) 50 um; (E) and (I) 20 um.**

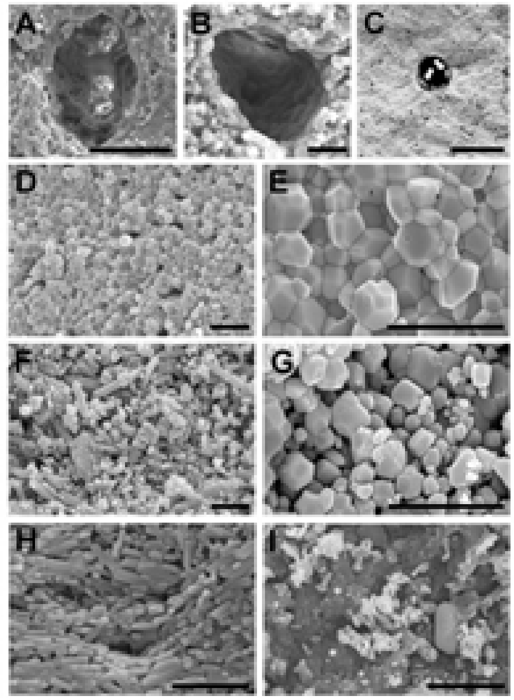


**Fig. 3. The changes on the Harversian canal walls, possibly caused by high temperature. (A) *Shrinkage and splitting* is present on the endosteal surface of canal wall. (B) The crystals formed by re-crystalization process were found on the canal wall surface. (C) Lifting (indicated by arrows) is seen on the Harversian canal wall. (A) and (B) for Gangneung; (C) for Pyeongtaek. Re-crystallization observed in (D and E) Gangneung and (F to I) Pyeongtaek bones. (D) and (E) Most crystals found in Gangneung bones are hexagonal. (F) to (H) Different types of crystals were found in Pyeongtaek case. Crystals of spherical, hexagonal, tetragonal, rhombohedral and irregular types were mixed in the same area. (I) Crystal fusion could be also observed (indicated by asterisks). Scale bars: Scale bars: (A) and (B) 20 um; (C) 100 um; (D) to (I) 2 um.**

have been subjected to very high (above 1,200°C) temperatures, possibly in a process of cremation. Certainly, fracture patterns and changes in bone color are known signs of cremation (Subira et al. 2011; Van Vark 1970). However, the researchers also admit that temperature estimation based only on gross morphology can only be very tentative, because it is known to be variable case by case and according to environment (Spennemann et al. 1989).

In the current study, the researchers performed a gross examination on cremated bones from the *Late Silla Kingdom* ($8^{th}$–$9^{th}$ century CE) in Korean history. The researchers, fortunately, were able to obtain invaluable scientific information simply from the morphologies of the cremated bones. In the *Gangneung* case, they found evidences that the bones might not have been originated from a single individual but rather from a child/adolescent/adult (female) combination, or in other words, at least two individuals. Why the cremated bones of two (or more) different persons were buried together in a single cinerary urn remained a mystery to the researchers.

In a previous report, considerable warping, transverse and curvilinear fracture patterns were regarded as typical signs of cremation (Ubelaker 2009). The study on the *Late Silla Kingdom* bones likewise revealed deep longitudinal fractures, many transverse cracks and a range of shrinkage in long bones. Also pertinent is the fact that white fragments in burnt bones increase in number with longer heat-exposure time (Fairgrieve 2008; Ubelaker 2009; Van Vark 1970). Most of the bones in our *Gangneung* and *Pyeongtaek* samples were calcined fragments with white, grey-blue or grey spots (Fig. 1). These discolorations indicated that the temperature to which the bones had been subjected might, by the standard of Subira et al. (2011), have been at least as high as 650–700°C; or above 500°C by the standard of Absolonova et al. (2012).

Notwithstanding all of the scientific clues to cremation temperature, the researchers were able to obtain for the cases; the researchers did not have any ideas on how high the temperatures were. For reasonably accurate estimation of the exact cremation-temperature ranges operative, the researchers turned to SEM. In fact, scientists know that the ultramicroscopic patterns of bone morphologies are closely correlated with each temperature range attained during cremation. Using SEM patterns, therefore, researchers have estimated cremation temperatures (Holden et al. 1995; Absolonova et al. 2012).

For instance, SEM study has clearly established that no organic component of bones can survive temperatures above 400°C (Holden et al. 1995). Other SEM results have confirmed that an organic portion of burnt bones (for example, collagen fibril) was completely consumed at 400°C (Koon et al. 2003). This finding supports Herrmann (1977)'s position that perfect cremation, which is to say the complete combustion of all organic materials, can be achieved at a heat of 700–900°C. Considering these and this study's SEM results together, the cremation temperatures in this study's cases, in which no remnant organic matter could be observed, must have reached higher than 400°C at the minimum.

The present results are consistent also with previous SEM reports showing that heat-induced morphological changes always accompanied crystal formation within the 600–1400°C temperature range. In Holck's study (1986), small spherical crystals began to be observed in burnt bones at 600°C, and at temperatures between 800 and 1400°C, hexagonal-type crystals predominated. In studies of Holden et al. (1995), Jarcho et al. (1976) and Asada et al. (1987), the sizes of bone crystals grew as temperatures rose. Holden et al. (1995) discovered that hexagonal-type crystals that were 0.30 ± 0.05 mm at 800°C had increased to 1.2 ± 0.10 mm at 1200°C. It is also known that within the 1000–1400°C range, not only do crystals fuse, but various other types (for example, rhombohedral, rosette-lie, and irregular morphologies) emerge (Holden et al. 1995).

Since this study's results showed crystals throughout all of the bones, they considered that the temperatures could have reached 600–1400°C, though the exact levels might have differed in each case. First, as for the *Gangneung* bones, most of the crystals were of the hexagonal pattern. Given their sizes (for example, 349.50 ± 50.99 nm, 342.76 ± 46.40 nm, and 396.72 ± 76.07 nm), the temperature attained, based on the findings of Holden et al. (1995), must have been about 800°C. Another helpful finding in the *Gangneung* case was the lamellar pattern. Holden et al. (1995) discovered that this pattern in burnt bones was lost at 800°C due to rapid crystal growth. Since we could confirm, on the basis of the ultramicroscopic images of the *Gangneung* bones, that the lamellar pattern remained, the cremation temperature must not have ranged higher than 800°C.

Likewise, in the *Pyeongtaek* case, the ultramicroscopic evidence was very suggestive as to cremation temperature. First, the crystal patterns observed were much more variable in shape and size than in the *Gangneung* case. In the same bone fragments, various types of crystals, spherical, tetragonal and atypical patterns, additionally to hexagonal ones, were mixed together. This means that the temperatures might have ranged as high as 1400°C (that is, 800–1400°C).

In addition, in the *Pyeongtaek* case, unlike the *Gangneung* case, the researchers could find no lamellar patterns in the ultramicroscopic images, which also implicated cremation temperatures significantly higher than 800°C. Crystal fusion furthermore, which is another very suggestive clue to cremation temperature occurring between 1000 and 1400°C (Holden et al. 1995), was also observed. Therefore, it seems very likely that the cremation temperature in the *Pyeongtaek* case was actually within that range.

Still the other clues to temperature are the morphological integrities of Haversian canals and osteocyte lacunae. In general, microstructures in the bones were known to be maintained at the temperature of 1000°C. However, each microstructure in burned bones was difficult to be identified and differentiated from each other. At the same temperature, the only microstructures that could be reliably identified were the intact osteons and the Haversian canals (Absolonova et al. 2012). According to Holden et al. (1995), Harversian canals and osteocyte lacunae are maintained at temperatures as high as 1400°C, but when subjected to temperatures of 1600°C or more, they completely disappear as the results of total melting and subsequent recrystallization of bone minerals on cooling. In the *Pyeongtaek* case, Harversian canals and osteocyte lacunae were clearly evident under SEM, which means that the cremation temperature did not exceed 1400°C. Taken together, this study's SEM results indicate that the cremation temperature in the *Pyeongtaek* case was as high as 1000°C (fusion of crystals) but not higher than 1400°C (maintenance of Harversian canal and osteocyte lacunae).

From the anthropological, archaeological, cultural or historical perspective, the researchers could not determine conclusively the heritage related to the style of cremation practiced in these cases. In fact, various cremation customs have been performed within the different cultural traditions of the East Asian nations. Even so, they could not completely rule out Buddhism, particularly in light of the profound influence that tradition has had in Korea.

Buddhist cremation rites as practiced throughout Asia disseminate from the recorded funeral of *Sakyamuni*, the founder of the religion (Strong 2007). According to *Mahaparinirvana Sutra*, the ancient Indian Buddhist script that documents the final days of the Buddha, the founder's body was cremated on a pyre along with various kinds of precious woods. His relics were collected after the cremation, to be enshrined inside *Stupa*, his funerary mound (Gnanarama 1997; Sister et al. 1998).

By the early first millennium CE, *Jhapita*, the Buddhist cremation rite originating in India, had been adopted by most of the East Asian peoples (Fig. 4). Certainly, many high-ranking nobles, monks and commoners have been cremated over the course of Korea's long history (Prebin 2012). Regardless, as this archaeological data was not sufficient, the researchers were not able to establish definitively that the current cremation cases were Buddhist. For now, the researchers will have to be satisfied with what they have achieved thus far: the first scientific data on historical cremation in an East Asian country.

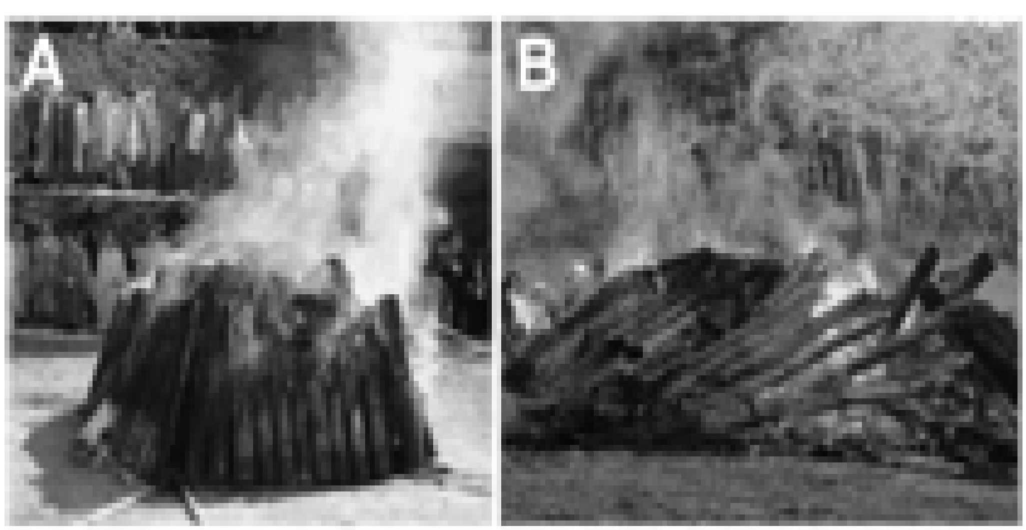


**Fig. 4. Buddhist cremation in Korea**

## CONCLUSION

By this SEM study on the burnt bones of the *Late Silla Kingdom* period in Korean history, we successfully estimated the cremation temperature of them. The current scientific study on the historical cremated bones, the first report ever performed in East Asia, is important for concerned forensic anthropologists to study cremation cases formed under similar cultural heritage.

## RECOMMENDATIONS

Interdisciplinary collaborations are needed for studies on the cremated specimens from the archaeological sites in East Asian countries. The researchers hope that, more information on the burnt bones' micro structural changes made by ancient Buddhist cremation could be obtained by future SEM analysis.

## ACKNOWLEDGEMENTS

First two authors contributed equally to this study. The Figure 4 on Buddhist cremation in Korea is generously provided by Research Institute of Buddhist Cultural Heritage, Korea. This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2013R1A1A2009688).

## REFERENCES

Absolonová K, Dobisiková M, Beran M, Zocová J, Velemínský P 2012. The temperature of cremation and its effect on the microstructure of the human rib compact bone. *Anthropol Anz*, 69: 439-460.

Amadasi A, Brandone A, Rizzi A, Mazzarelli D, Cattaneo C 2012. The survival of metallic residues from gunshot wounds in cremated bone: A SEM-EDX study. *Int J Legal Med*, 126: 525-531.

Asada M, Oukami K, Nakamura S, Takahashi K 1987. Effect of powder characteristics on the sinterability of calcium hydroxyapatite. *J Ceram Sot Jap*, 95: 703-709.

Bonavilla JD, Bush MA, Bush PJ, Pantera EA 2008. Identification of incinerated root canal filling materials after exposure to high heat incineration. *J Forensic Sci*, 53: 412-418.

Bozzola JJ, Russell LD 1992. *Principles and Techniques for Biologists.* Boston: Jones and Bartlett Publishers Inc.

Buikstra J, Ubelaker D 1994. Standards for Data Collection from Human Skeletal Remains. *Arkansas Archaeological Survey Research Series* No. 44. Fayetteville: AR.

Fairgrieve SI 2008. *Forensic Cremation: Recovery and Analysis.* FL, Boca Raton: CRC Press.

Gnanarama VP 1997. *A Historical Analysis of the Mahaparinibbana Sutta of the Digha Nikaya of the Pali Canon*. Singapore: Ti-Sarana Buddhist Association.

Harbeck M, Schleuder R, Schneider J, Wiechmann I, Schmahl WW, Grupe G 2011. Research potential and limitations of trace analyses of cremated remains. *Forensic Sci Int*, 204: 191–200.

Hayat MA 1970. *Principles and Techniques of Electron Microscopy. Biological Applications.* Volume 1. New York: Van Nostrand Reinhold Company.

Herrmann B 1977. On histological investigations of cremated human remains. *J Human Evol*, 6: 101-103.

Holck P 1986. *Cremated Bones: A Medical and Anthropological Study of an Archeological Material on Cremation Burials*. PhD Thesis. Oslo: University of Oslo.

Holden JL, Phakey PP, Clement JG 1995. Scanning electron microscope observations of heat-treated human bone. *Forensic Sci Int*, 74: 29–45.

Jarcho M, Bolen CH, Thomas MB, Bobick J, Kay JF, Doremus RH 1976. Hydroxyapatite synthesis and characterization in dense polycrystalline form. *J Mater Sci*, 11: 2027-2035.

Kim HS, Kim JH 2005. Analysis for structure and human bone ashes from cremation tomb in Silla's Capital. *Silla Mun Hwa Jae Hak Sul Non Mun Jip*, 26: 291-317.

Koon HEC, Nicholson RA, Collins MJ 2003. A practical approach to the identification of low temperature heated bone using TEM. *J Archaeol Sci*, 30: 1393–1399.

Prébin E 2012. Cremation's success in Korea: Old beliefs and renewed social distinction. In: AD Natacha (Ed.). *Invisible Population: The Place of the Dead in East Asian Megacities*. UK: Lexington Books, pp. 138-164.

Pusch CM, Broghammer M, Scholz M 2000. Cremation practices and the survival of ancient DNA: Burnt bone analyses via RAPD-mediated PCR. *Anthropol Anz*, 58: 237–251.

Sister V, Story F 1998. *A Last Days of the Buddha: The Mahaparinibbana Sutta*. Kandy: Buddhist Publication Society.

Spennemann DHR, Colley SM 1989. Fire in a pit: The effects of burning of faunal remains. *Archaeozoologia*, 3: 51–64.

Strong JS 2007. The Buddha's funeral. In: BJ Cuevas, JI Stone (Eds.): *The Buddhist Dead: Practices, Discourses, Representations.* Hawaii: Kuroda Institute, pp. 32-59.

Subirà ME, Ruiz J, Guardiola-Bufì M 2011. Fire and bones: Bronze Age III in the north-eastern Iberian Peninsula. *Coll Antropol*, 35(2): 565-576.

Ubelaker DH 2009. The forensic evaluation of burned skeletal remains: A synthesis. *Forensic Sci Int*, 183(1-3): 1-5.

Van Vark GN 1970. *Some Statistical Procedures for the Investigation of Prehistoric Human Skeletal Material.* Groningen: Rijksuniversiteit te Groningen.