

Thesis Abstracts

Author: Gloria I. López
Thesis Title: The late Quaternary evolution of the Apalachicola barrier island complex, north-east Gulf of Mexico, as determined from optical dating¹
Grade: Ph.D.
Date: September 2007
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Optically stimulated luminescence (OSL) studies of clastic-rich coastal environments have been increasingly the focus of attention, mostly over the past five years, due to the improvement of protocols used to obtain reliable and accurate optical ages on minerals such as quartz. Using 55 quartz-separate samples extracted from at least two different depth intervals on sediment cores (long vertical and short horizontal) retrieved from multiple beach/dune ridges that decorate four Holocene coastal barriers and a Pleistocene lower mainland, the supra-tidal evolution of the western portion of the Apalachicola Barrier Island Complex, on the NE region of the Gulf of Mexico, has been re-evaluated. This study not only provides new reliable OSL ages for the region but also addresses the feasibility of a) quantifying rates of coastal aggradation and progradation; b) interpreting the temporal chronology of the coastal geomorphology; and c) constraining the results with other geochronometric data available at a more precise level (e.g. inter-correlations with accurate [x,y,z] parameters).

OSL results show equivalent doses (D_e) ranging between 0.01 ± 0.00 and 52.28 ± 1.26 Gy, associated to samples linked to both wind- and water-lain processes, depicting the two principal components of these ridges: a most probable swash-built ridge base and an aeolian cap. The optical ages obtained range from 22 ± 4 to $154,200 \pm 10,400$ years ago (based on 2004 to 2006 datum), representing terminus ante quem ages of formation of the base of the ridge and the ages of the aeolian component at that particular depth. The sedimentary deposits hosting the cores collected show minimal contents of Uranium and Thorium ($\ll 4$ ppm with an average of 0.5 ppm). The

Potassium content seems to be more linked to temporal variations (i.e. different stages of evolution of the barrier islands) than to geographical position relative to the Apalachicola River mouth.

D_e distribution analyses show that frequency histograms coupled with cumulative frequency (%) curves and radial plots should be used together to better evaluate the overall behaviour of the distribution. For most of the samples OSL-dated for this research, one or two outliers (i.e. aliquots outside $\pm 2\sigma$) were present upon analysis of the D_e distribution, but excluded from the final D_e calculation used to compute the optical age of each sample. Skewness coefficient ranges were determined and skewness values were calculated to quantify the degree of symmetry of the D_e distribution for each sample. This parameter was used to assess the analytical error to be associated with each final D_e value, as well as the heterogeneity or homogeneity of the dose within each sample and see any indications of possible incomplete zeroing or biogeoturbation. Moreover, and associated with the latter, the use of smaller aliquots (e.g. 3 and 1 mm mask sizes) was also implemented to detect if the samples had undergone any significant post- or pre-depositional disturbance. None was found; rather, analyses show that with decreasing mask size, an increasing resolution in the D_e distribution was obtained where the values obtained for the larger aliquots (i.e. 8 and 5 mm mask size) were encompassed within those obtained for the smaller aliquots (i.e. 3 and 1 mm mask size).

This dissertation presents the first assessment of supra-tidal coastal evolution using optical ages to determine both the vertical accretion and lateral progradation rates throughout different segments of the coastline. The multidirectionality, patterns and truncations shown by the hundreds of beach and dune ridges and ridge sets demonstrate the morpho- and hydro-dynamic complexity of these coastal barrier systems, located on the apex of the Floridian Panhandle. Assessments of such morphological characteristics as well as detailed analyses of air-photographs, satellite imagery, ancient nautical and topographic charts/maps, and previous studies were also incorporated in this research to better constraint the proposed Late Holocene spatial-temporal history of this ~ 60 km-long coastal complex perched on the NE corner of the Gulf of Mexico. Six major time intervals were differentiated with the chronological evolution of these barrier islands since the last ~ 4,000 years.

¹ The full text of this thesis is available online at www.aber.ac.uk/ancient-tl

Author: Damian Steffen
Thesis Title: Quaternary accumulation and erosion of sediment in the drainage basins of the western escarpment of the Andes of Peru: The role of climatic variations
Date: December 2008
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This thesis investigates the role of climate on the formation of terraces and fans based on two case studies in southern Peru. Two valleys, the Pisco (~13.5°S) and Majes (~16°S) valleys that extend in an east-west direction from the Altiplano to the Pacific coast, and where terraces and fans are numerous, were investigated in detail. Both valleys are characterized by a dry climate along the coast and in the lower reaches and a semi-arid climate in the headwaters. In order to interpret the formation of the terraces and fans, it was essential to establish a detailed chronological framework, and for this study, this was done using luminescence dating. During the analysis of the luminescence samples, it became clear that the quartz OSL (optically stimulated luminescence) ages from terraces and fans underestimate the true depositional age. Deconvolution of OSL signals revealed that the fast component was not dominant in the luminescence signal and, in addition, determination of thermal lifetimes using pulse annealing showed that the medium component was thermally unstable, with both problems resulting in age underestimation. Testing suggested that the weak fast component and thermally unstable medium component may be related to the young sedimentary history of the quartz grains that are directly derived from weathered plutonic and volcanic rocks. Multiple cycles of bleaching, heating and irradiation of the quartz grains may improve their characteristics for luminescence dating. A possible solution to circumvent problems related to a thermally unstable medium component is to isolate the fast component. This was done using different approaches, including mathematical extraction as well as direct sampling of the fast component using a modified SAR (single aliquot regenerative) protocol. None of these techniques proved robust enough to allow its routine application to the dating of quartz from the Pisco and Majes valleys, and it was found preferable to use feldspar IRSL (infrared stimulated luminescence) instead. Extensive testing of feldspar IRSL was also

conducted after which it was successfully applied to date the terraces and fans. While anomalous fading is often seen to affect the feldspar signal, testing of this confirmed that it was not present for these particular samples.

IRSL dating of the terraces and fans in the Pisco and Majes valleys revealed that phases of sediment aggradation were contemporaneous with humid periods on the Altiplano. Aggradational phases occurred during the Ouki (~110-100 ka), Minchin (~55-40 ka), Tauca (26-15 ka) and Coipasa (12-8 ka) paleolake cycles. The sedimentologic and geomorphic data suggest that enhanced precipitation in the headwaters and middle part of the catchment resulted in increased erosion and transportation of sediment from the hillslopes into the channel network and towards the lower reaches. An imbalance between sediment supply from hillslopes, and sediment transport capacity of the receiving trunk stream, in combination with a decreasing river gradient and an increasing valley width beneath the knickzone most probably resulted in deposition of the sediment. Not only were the headwaters affected by this climate change but also tributary catchments and hillslopes in the lower reaches that are currently arid. There, controls on sediment discharge in the tributary systems and mechanisms driving fan construction were considered to be local. Due to the absence of vegetation cover, sediment discharge in the tributary drainage basins is very sensitive to changes in the rainfall pattern. A change towards a climate with a higher frequency of high-magnitude precipitation events most likely initiated the construction of fans. While the onset of erosion of previously deposited sediment cannot be directly inferred from the luminescence data, field evidence suggests that the erosion may have started in the later stages of a wet period as sediment availability on the hillslopes tapered off. We conclude that terrace and fan systems therefore record the combined effect of allo- and autogenic mechanisms initiated by a shift towards a more humid climate. Supply of sediment and formation of terraces and fans not only depends on climate and water discharge, but also to a large extent on the availability of unconsolidated material on hillslopes. Bedrock weathering, therefore, has presumably been the most important limiting process for terrace and fan construction, particularly in arid regions. This implies that the number of periods during which terraces and fans in the Majes valley were formed only provides a minimum estimate of climate cycles, and it is possible that further wet periods occurred that are not recorded in the sedimentary deposits where the time scale of climate change was shorter than the time required for weathering and the production of new sediment.

Author: Yu-Xin Fan
Thesis Title: A study on the evolution of the Jilantai-Hetao Megalake: focusing on optical dating of lakeshore sediments
Grade: PhD
Date: December 2008
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The Jilantai Salt Lake is located in the southwestern part of the Jilantai-Hetao Basin, a Cenozoic fault basin to the north and northwest of the Ordos plateau and to the east of the Alashan plateau in western China. The Jilantai-Hetao basin is about 560 km long and 80 km wide. Most of the lake basin is now dry and covered by aeolian sand. A series of lakeshore remnants were found around the Jilantai Salt Lake, especially on its western bank. Altitudes of these shorelines are at 1080-1070m, 1060m, 1050m, 1044m and 1035m asl. It could be inferred that at the highest lake level stage, a huge lake, the Jilantai-Hetao Megalake, was developed to cover the Jilantai area and most of the Hetao Plain along the Yellow River at its square bend around the Ordos block. However, many questions remain unsettled. For instance, can this hypothesis be supported by geological and geomorphologic evidence? When and how was such a huge lake formed? Researches of above questions are of great importance to study the development of Ulan Buh and Kumbuqi Deserts, and the evolution of the Yellow River as well.

In this study, geomorphologic, sedimentary and biological evidence of the Jilantai-Hetao Megalake were summarized based on our previous studies. OSL dating of lakeshore sediments was studied in detail and the reliability of these OSL dates was discussed on the basis of luminescence chronology and the comparison with radiocarbon dating. A preliminary chronological frame of the paleolake's major shorelines was determined based on forty-nine OSL dates from a series of sediments on different shorelines. From analyzing the potential water sources to the huge lake, the probable formational mechanism of this huge lake was also discussed. The following main results were reached:

1) Geological and geomorphological evidence.

Barrier bar, wave-cut terrace and spit are the typical geomorphological evidence of the lakeshore in the Jilantai and Hetao area. Barrier bars are widely distributed in the Jilantai area, especially on the west

bank of the Jilantai Salt Lake. Lacustrine sediments and wave-cut terraces were found on the southern piedmont of the Langshan-Seertengshan-Daqingshan Mountains where was proved to be the north margin of the lake basin, and on the piedmont of Zhuozi Mountains east to the Wuda District, the south margin of the lake basin. Geomorphologic features of lakeshores were poorly preserved on the south bank of the Yellow River, but lacustrine deposits were found in several excavated sand quarries, for example in quarries east to Sanshenggong Bridge, in quarries southeast to Balagong Town in the western bend of the Yellow River, and especially in quarries near Shilazhao south to the Urad Qianqi which is on a sub-upleft of the basin. Spits are mainly distributed in the Jilantai area, for example, two typical spits are existed with specific geomorphological features at sites west to the Jilantai Salt Lake and seventy kilometers northeast to the Jilantai Town respectively. In addition, there is a delta at the west-south mouth of the lake basin to the east of the Wuda district, which was probably formed by the Yellow River inferred from geomorphological evidence. The exposed profiles on lakeshores have a general vertical prograding sequence. Shells of aquatic mollusk, such as *Corbicula*, *Radix* and *Gyraulus* were found in most of lakeshore sediments. These observations support that there was once a unified huge lake covering the Jilantai area and most of the Hetao Plain, referred to as the Jilantai-Hetao Megalake.

Based on spatial distribution of these shorelines and their altitudes in the Jilantai area, an area weakly influenced by tectonic movement, it was deduced that Jilantai-Hetao Megalake underwent three evolutionary phases as the Jilantai-Hetao Megalake phase with shorelines at altitudes 1080-1070m asl, the Jilantai-Hetao Main Lake phase with shorelines at altitudes of 1060-1050m asl and the Jilantai Paleolake phase with shorelines at altitudes of 1044-1035m asl.

2) Luminescence dating of the lakeshore sediments.

From profiles on different altitudes of shorelines, forty-nine OSL samples of different kind lakeshore sediments were collected. These samples were measured by using the OSL technique. For improving the reliability of OSL dating results of lakeshore sediments, the relationship between quartz grain-size and equivalent dose (D_e) values is studied from five littoral sediments samples. The creditability of all OSL results is discussed from D_e and dose-rate determination. And the reliability of these OSL dates is also validated through the comparison with radiocarbon dating in six profiles.

Lakeshore sediments were suggested to be potentially well-bleached suitable for OSL dating by the comparison of D_e in the 1990's. However, recent comparison of dating results from different

chronological methods has shown that the luminescence technique may underestimate the age of lakeshore sediments. To investigate the reliability of OSL dating of lakeshore sediments, five lakeshore samples in the Jilantai area were examined by comparing D_e values of quartz fractions in the size ranges of 63-90, 90-125, 125-150, 150-180, 180-250 and 250-300 μm in each sample. The D_e values were measured by using medium aliquots. There are two different relationships between D_e values and grain sizes of these samples. The first relationship is that the D_e values obtained from various grain sizes are in agreement within 1 delta errors. The second relationship is that D_e values are similar to each other for fractions between 125 and 300 μm , while the D_e value of the 63-90 μm fraction is 40~55% smaller than others. For example, the D_e values obtained for sample #3 are 20.15 ± 1.19 Gy, 19.80 ± 0.83 Gy and 20.93 ± 1.06 Gy for fractions of 90-125, 125-150 and 250-300 μm respectively, but are 10.79 ± 0.84 Gy for the 63-90 μm fraction. The second relationship can't be interpreted by previous studies of both dosimetry and heterogeneous bleaching. It is deduced for sample #2, #3 and #6 that fine particles (<90 μm) intruded after the dominant sedimentation. We compared the OSL ages of the 63-90, 90-125, 125-180 and 180-300 μm quartz fractions of sample #2 with a radiocarbon age from aquatic mollusk shells with both bivalves well preserved collected in the same lithologic layer (sample #7) in profile HS4, and results show that OSL ages from the 125-180 μm and 180-300 μm fractions are in the same time span very close to the radiocarbon dating result and those apparent ages of the 63-90 and 90-125 μm fractions are obviously 2800-3600 years younger than the radiocarbon dating result even when radiocarbon reservoir was considered. The comparison supports that fractions coarser than 125 μm yield more reliable burial ages, while the fraction finer than 90 μm yields underestimated ages for some lakeshore sediments from this arid region.

To obtain reliable chronological frame of the Jilantai-Hetao Megalake, OSL dating was applied to lakeshore sediments mainly for quartz fraction of 90-400 μm by using medium aliquots. The dating results show that the blue OSL signal of quartz fraction was near saturated in five samples. To these samples, IRSL dating was also carried out from k-feldspar fraction. The IRSL signals of these samples are unsaturated and their IRSL ages are about 15-50% younger than blue-OSL ages from quartz. For these five samples, OSL ages from quartz are used as the minimum age though their ages were potentially underestimated. The reliability of OSL results are also validated through the comparison with radiocarbon dating in six profiles. In three Holocene profiles, OSL dates are accordant with radiocarbon

ages of bulk organic matter or aquatic mollusk shell carbonates when radiocarbon reservoir was considered. In other three MIS 3 profiles, OSL dates of beach sand are also consistent very well with radiocarbon ages. For profile S39, the OSL age is 42.44 ± 4.20 ka with radiocarbon age of 41619~42241 cal a BP (two sigma deviation) of mollusk shells from the same lithologic layer. These comparisons indicate ages obtained from OSL dating of lakeshore sediments can be reliable as radiocarbon ages obtained from either bulk organic matter or aquatic mollusk shells, and that chronological frame can be established by means of OSL dating method.

The reliability of all OSL dates was summarized on the basis of above discussion. Finally, the chronological frame of the Jilantai-Hetao Magalake is reconstructed on these OSL ages, and the history of the megalake is recovered by the consideration of geomorphologic and geological evidence in this region. The OSL data demonstrate that the lake level came to rise from 120-100 ka or so, and subsequently a unified huge lake came into being, namely, the Jilantai-Hetao Megalake, covering the Jilantai Basin and almost the entire Hetao Basin before 60-50 ka. Then it gradually descended with its altitude remaining at about 1060-1050 m, and the lake still covered the Jilantai Basin and parts of the Hetao Plain. Thereafter the unified lake was separated into pieces. At around 10 ka ago, there were small separated lakes, possibly ponds in certain areas of Jilantai.

3) Formational mechanism of the megalake.

The changes of the unified Jilantai-Hetao Megalake into a dry lake basin indicate that the water system changed greatly in northern China. The cause of such a profound environmental change is an important issue that we are investigating through a number of research approaches. Based on field observations, we think it probable that the primary water source feeding the Megalake Jilantai-Hetao was the Yellow River. This assumption requires further testing, as does the possibility of contributions derived from other sources. We collected aquatic mollusk shells from littoral sediments at different altitudes around Jilantai and measured their strontium isotope compositions. $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in shell carbonates are different between the high lake phase (~1080-1050m asl) and the low lake phases (~1044-1030m asl), with a small shift in average strontium ratios to more radiogenic values during the low lake phase. Based on regional hydrology and physical geography, we conclude that water from the Yellow River was the dominant water source supplying this mega lake. $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of modern water samples suggest the Yellow River was the dominant water source during the high lake phase, but that the relative contribution of Yellow River water to the megalake was reduced,

and that the relative contributions of local precipitation and groundwater increased, during the low lake phase. Incision rates of the Yellow River indicate that the Ordos Plateau started to uplift rapidly on its western margin at about 120 ka with rapid uplift as a whole at about 100 ka. Lake levels in Jilantai and Hetao started to rise simultaneously as the rapid uplift of the Ordos Plateau. It is thus concluded that the Yellow River was possibly dammed by the rapid uplift of the Ordos plateau at the exit of the megalake, which resulted in the formation of the Jilantai-Hetao Megalake.

Author: Henrik Friis
Thesis Title: Luminescence spectroscopy of natural and synthetic REE-bearing minerals
Grade: PhD
Date: July 2009
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This study investigates the photoluminescence (PL), cathodoluminescence (CL), radioluminescence (RL) and ionoluminescence (IL) of natural and synthetic minerals. The natural minerals (fluorapatite, leucophanite, meliphanite and zircon) are mostly from Ilímaussaq Alkaline Complex in South Greenland, Langesundsford in Norway and from different localities within Scotland. Synthetic fluorapatite (manufactured as part of the present study) and zircon doped with rare earth elements (REE) were used to compare single and multidoped materials. This study has shown that many of the generally accepted applications of luminescence are not as straightforward as often suggested by the current literature.

For example, the study demonstrates how site distribution of REE, based on luminescence, is greatly affected by the dopant level and structural changes, and that different conclusions can be drawn on the same sample depending on method applied. Furthermore, it is clearly demonstrated that using luminescence as a tool for quantitative trace element determination is not going to be a standard technique in the near future if ever. The two main findings supporting this conclusion are the nonlinear intensity decrease between different REE activators in the

same sample and a large variation between activators at the concentration at which self-quenching starts. In contrast to the general perception that luminescence related to REE is mostly independent of the host, this study has shown a strong interaction between host and REE activators.

This conclusion is supported by the change in the activator's coordination polyhedron observed with single-crystal and powder X-ray diffraction combined with full chemical characterisation. When combining the weak interaction between some REE with the strong host interaction this study has shown the potential for designing new types of colour tuneable and "white light" LEDs based on natural minerals. This study also reveals that zircon doped with Gd³⁺ and Eu³⁺ can potentially have quantum-cutting properties.

Author: Martina Demuro
Thesis Title: Optically stimulated luminescence dating of tephra-bearing deposits from eastern Beringia
Grade: PhD
Date: July 2009
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Eastern Beringia (Alaska and the Yukon Territory) represents a unique high-latitude setting in that it has remained largely ice-free throughout the major global glaciations of the Quaternary. As a result, it contains extensive terrestrial palaeoenvironmental records in the form of perennially-frozen loess and loess-derived deposits, which span the last 3 million years. Numerous tephra horizons across eastern Beringia also provide invaluable chronostratigraphic markers that are capable of correlating regional stratigraphic sequences over large areas. These preserved records offer a unique opportunity to reconstruct detailed palaeoenvironmental, palaeoclimatic, palaeobiological and archaeological histories for this region. However, there remains a need to improve and expand the chronological approaches used to interpret these Quaternary records, particularly over timescales that lie beyond the upper age range of radiocarbon (¹⁴C) dating.

The main aim of this thesis is to provide an improved, numerical-age, chronostratigraphic framework for Quaternary environmental

reconstructions in eastern Beringia. For this purpose, optically stimulated luminescence (OSL) and infrared stimulated luminescence (IRSL) dating techniques are used to provide chronological constraints on key stratigraphic units containing correlative tephra horizons within Pleistocene loess and glaciofluvial gravels from eastern Alaska and the Yukon Territory. Importantly, the suitability of OSL dating of tephra-bearing deposits in this region remains to be fully investigated, and this forms an integral part of the research undertaken in this thesis. To do this, single-grain and multi-grain OSL dating techniques were applied to 140,000 to 30,000 year-old deposits associated with geochemically-characterised Late Pleistocene tephra layers from the Yukon Territory (Klondike district, Ash Bend, Ch'ijee's Bluff) and eastern Alaska (Chester Bluff), which have been constrained by independent age control (^{14}C and fission-track ages). Multi-grain feldspar IRSL dating was also conducted on these known-age tephra-bearing deposits using a range of emission bands (ultraviolet, blue, yellow and orange-red emissions). An additional objective of the research was to investigate the OSL behavioural characteristics and grain-to-grain variability of sedimentary quartz grains from this region, as a means of developing more reliable single-grain and multi-grain OSL chronologies.

The single-aliquot regenerative-dose protocol was found to be well suited for dating both quartz and feldspar fractions of these tephra-bearing deposits. Sedimentary quartz grains from this region were, however, generally characterised by dim OSL signals. A key finding of this study was that multi-grain OSL dating of known-age deposits typically resulted in severe age underestimation. Several possible reasons for this were explored through signal-component investigations and the construction of 'synthetic' aliquots from single-grain measurements. Single-grain OSL dating produced widely spread (overdispersed) dose distributions, but ages that are in broad agreement with independent age control when using either of two well-established models to estimate the burial dose (the central and minimum age models). The findings of this thesis indicate that single-grain quartz OSL techniques are better suited to dating loess deposits in this region than are multi-grain quartz OSL techniques, because the former allow for the exclusion of aberrant grains that are particularly prominent in these samples. A major source of uncertainty in the OSL dating of these perennially-frozen deposits was the long-term water content during their burial periods. In some instances, the OSL ages obtained using the 'as measured' water content greatly underestimated the expected ages of the deposits. Investigations into the multi-grain feldspar IRSL characteristics showed that

anomalous fading was ubiquitous in these samples, regardless of the emission band. In most cases, however, it was possible to derive IRSL ages that were in agreement with the corresponding single-grain quartz OSL ages by applying suitable fading-correction procedures.

This thesis represents the first comprehensive study to apply single-grain OSL dating techniques to eastern Beringian deposits and provides some of the first OSL-based numerical-age constraints for both existing tephrochronologies and newly-identified tephra across Alaska and the Yukon Territory. The OSL chronologies established in this study include (i) maximum and minimum age constraints on the Reid glacial deposits (which represent the penultimate advance of the Cordilleran ice sheet) in central Yukon Territory; (ii) a depositional age for numerous, but previously undated, Late Pleistocene tephra in this region; (iii) the first numerical ages for the interglacial deposits and Old Crow tephra at Ch'ijee's Bluff; and (iv) numerical age constraints on extensive Pleistocene loess and organic beds at Chester Bluff.

Author: Jin Cheul Kim
Thesis Title: Geochronology and geochemical characteristics of sediments at the Jeongokri archaeological site, Korea²
Grade: PhD
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This study presents the depositional ages and geochemical characteristics of unconsolidated Quaternary sediments collected from the Jeongokri archaeological area, Korea. For decades, many paleolithic artifacts have been excavated from this area, which provided important data for the East Asian Lower Palaeolithic with occurrence of the so-called "Acheulian-like" handaxe (Yi and Clark, 1983; Bae, 1988). Unconsolidated sediments from a total of 12 localities at the Jeongokri were collected from the sediment sequence overlying unconformably the Quaternary Jeongok Basalt. Among them, 25 samples were selected from three places for age dating. Age

² The full text of this thesis is available online at www.aber.ac.uk/ancient-tl

estimate was made by applying of optically stimulated luminescence (OSL) dating, with results showing a large range of age distribution. The samples collected from fluvial sandy sediments at locality 1 have an age range of 34 to 66 ka, while those from fine-grained silty-clay sediments (localities 2 and 3) are with a range of 100 to 200 ka. Localities 2 and 3 do not show ages younger than 100 ka. The altitude of the Jeongok Basalt beds indicates the possible existence of least three different basalt levels at 48~49 m, 52 m, 53~54 m above the sea-level. Previous age-dating suggested that the lava flow could have occurred during a prolonged period between 0.1 and 0.5 Ma (Kojima, 1983; Danhara et al., 2002; Yi et al., 2005). The current study demonstrates that the deposition of the unconsolidated fine-grained sediments on the basalt bed began at least 200,000 years ago. Re-measurement of the artifact horizon by OSL dating suggests that a hominin occupation could be younger (less than 200 ka) than previously suggested. The results of geochemical analyses suggest that the most dominant sources of the deposit could be the Chinese loess and local material of fluvial origin from the Korean Peninsula. A possible source area of deposition of wind-blown materials is the Yellow Sea locating between China and Korea. Also, geochemical compositions of the deposit indicate the influence of monsoonal activities on the Quaternary paleoenvironment in Korea, which are closely related with sediments origin.

