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The Development of the Hantan River Basin, Korea and the Age of the Sediment on the top of the Chongok Basalt

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한탄강유역의 발달과정과 전곡현무암 위의 퇴적물의 연대

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ABSTRACT

The development of the Hantan river basin can be divided into three stages. The first stage include the ancient Hantan channel system prior to the Chongokni basalt which yielded dates of about 0.6 mya from the K/Ar dating method. During this period the Baekuyri formation was formed. The Baekuyri formation is widely observed under the Chongokni basalt along the current river system. The second stage is the period when stream channels stayed on the top of the basalt plateau. Aggradation and deggradation were continued by meandering and braiding channel systems until major stream channel was formed. The currently remaining deposit on the top of the basalt was formed by lacustrine and fluvial systems in this period. During this period Pleistocene hominid was present on edge of water and flood plain and left Paleolithic mateial. This period was begun at the time of the final basalt flow dated about 300,000 BP.The third stage is designed for the time when the Hantan river channel was dropped down to a level from which the channel could not influence the top of the basalt any more. No more deposit could be formed but erosion by surface water has been continued on the top of the basalt since then. The dropping of the Hantan river channel was probably not very long after the final flow of the basalt. Because of frost action and heavy concentrated precipitation in the basin area along with blocky and clumnar joint structure of the basalt, erosional process of the basalt is believed to have been carried out within a relatively short time. The lowering of the Hantan river channel was probably completed in a cycle of major fluctuation of world cimate. Also,the red clay on the top of the basalt is believed to have been formed during a warm period around 200,000 BP,which accords with the climatic change suggested above fairly well. The Paleolithic materials in the deposits fell accordingly into aproximately same time period.

要 約

한탄강유역의 발달과정은 3단계로 나누어질 수 있다. 제1단계는 60만년전 한탄강－임진강유역에 현무암이 회복하기 전에 존재하던 古한탄강의 단계를 말한다. 이 시기에 백의리층이 형성되었는데 이 古期河成層은 현재의 한탄강 유로를 따라 현무암아래에 여러지점에서 확인되고 있다. 제2단계는 流路가 새로이 형성된 현무암대지 위를 흐르면서 水性堆積層을 形成한 시기이다. 이 시기동안 고인류는 물가 또는 강변대지에 살면서 현재 발견되는 구석기를 남긴 것으로 보인다. 이 시기는 마지막 현무암분출이 있었을 것으로 보이는 30만년전에 시작되었다고 보여진다. 제3단계는 현재의 한탄강이 현무암 대지에서 멀어져 홍수시에도 현무암대지 상면에 퇴적물을 운반하거나 또는 河川에 의한 침식이 끝난 시점에서 시작되는데 현재로서는 정확한 연대추정이 불가능하지만, 이 지역의 기상상태－서리작용·집중강우등－과 함께 물리적인 침식이 용이한 현무암의 구조로 보아서 여러차례의 기후변동을 겪지 아니하였을 것으로 보고 커다란 하나의 기후변동 사이클이 지난 20만년 전후로 생각된다. 이는 현무암대지상에 넓게 분포하는 赤色調의 粘土층이 더운 기후에서 퇴적된 것으로 볼 때 중국의 황토퇴적중에 보이는 20만년 전후의 적색띠와도 잘 부합되고 있다. 고인류의 서식 또한 이 적색점토층의 연대범위를 크게 벗어나지는 않을 것이다.

INTRODUCTION

The development process of the Hantan river basin becomes one of the most important and hot topics in Paleolithic archaeology, geomorphology and geology of Korea. Unlike other river systems in Korea, the Hantan river basin has been developed relatively recently because of basalt flows filling the river basin during the Quaternary. Age of the basalt flows, erosional process of the basalt bed by river, environments under which the sediment on the top of the basalt formed, etc. are of a great interest among Quaternary scientists. In particular, because of the presence of Acheulean-typed Paleolithic artefacts at many localities in the basin including the Chongokni site, the topics suggested above are ciritical in understanding hominid behavior in Paleolithic archaeology. Currently, many different ages have been suggested of the sediment on the top of the basalt and of Paleolithic material in the sediment. The range of the suggested ages is very wide from the middle Middle Pleistocene to the middle Upper Pleistocene, which is from 400,000 BP to 40,000 BP. An extensive review was made by Bae (1987) and an age of late Middle Pleistocene for the sediment containing Paleolithic material was suggested on the basis of geomorphological process of the Hantan river basin and the dates of the Chongok basalt. In this paper, the geomorphological process of the Hantan river basin is going to be focused as a basis of the suggested age of the sediment in my previous paper (Bae 1986).

Geographical Environment of the Hantan River Baisn

The Hantan river originates in the northern range of the Taebaek Mountains in the eastern part of the Korean peninsula and flows into the Chugaryong Rift Valley. At about 3 km west of the Chongokni, the Hantan river merges with the Imjin river and flows to the Yellow Sea. Major tributaries of the Hantan river have developed along the fault lines connecting to the Chugaryong Rift Valley. Currently, most of the upper reaches are in the north of the DMZ line, which divides North and South Korea. The catchment area of the Hantan river in the east of the Chongokni is approximately 4,000 km^2.

The climate of the basin area is characterized by its distinctive four seasons. Like most part of the Korean peninsula, wet and dry seasons are clearly distinguished in the basin. Most of the precipitation in the basin area is concentrated in Summer season. While twenty to thirty mm of rainfall is recorded in January or Feburary, three to four hundred mm in July in Cholwon, Yonchon and Hwachon (Kim ed. 1977; Hwachongun Munhwawon 1988; Yonchon-gun 1987). During wet season, extremely

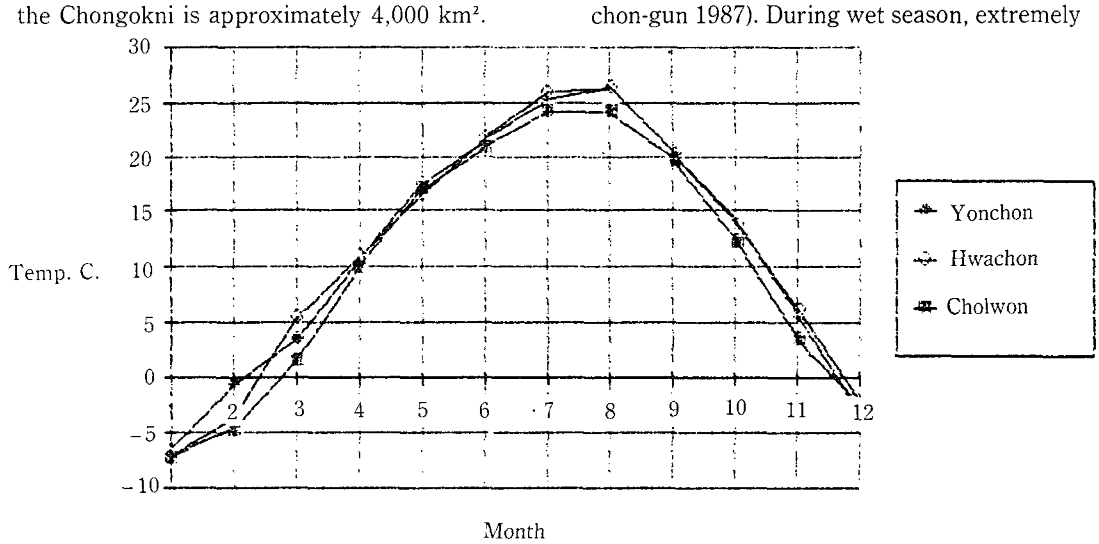


Fig. 1. Monthly Mean Temperature; Hantan River Basin

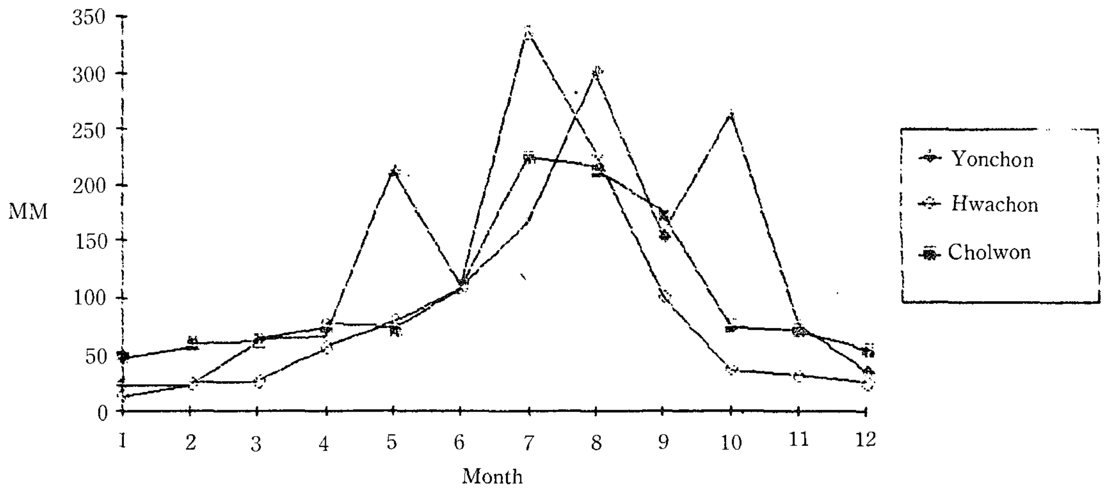


Fig. 2. Monthly Rainfall-Hantan River Basin

high precipitations in a short period of time are sometimes recorded. Rainfall was measured 406 .nm within 24 hours on July 17, 1925. Annual "ean temperature is about 10° to 12°C. ɔwever, it is very cold during winter season. The mean temperature of January in the basin area is about-6° to-7°C, while about 30°C during hot season, usually August (Fig. 1 and 2).

The basement of the Hantan river basin is made up of the Kyounggy metamorphic complex which is thought to have been formed during the Precambrian era (Na 1977). Gneiss and granite are the main components of the complex. In addition, complicated tectonic and igneous activities were going on in the Chugaryong Rift valley which formed a biotite grandiolite system, the Jangtan basalt and the Tongjai basalt, and a tuff breccia system in the Jijangbong Mt. during the Jurassic and the Cretaceous of the Mesozoic. The Chongok basalt which is believed to have originated from two volcanoes in Pyounggang and filled the basin floor. A maximum 6 flows have been observed in the area near the source, in Cholwon, while one flow in Munsan (Lee 1983). In Chongokni where the Paleolithic site is located, two flows are clearly identified by stepped profile of the basalt cliff. Some dates were obtained from the basalt by K/Ar dating method (Table 1). The dates indicate the Chongokni basalt was formed in two different time periods of the Middle Pleistocene. Most of the rivers in Korea flow along tectonic valleys formed in relatively early geologic periods and few of them have experienced subsequent tectonic movements. It is very difficult to understand the developmental history of these river systems, because sediments deposited in a previous stage

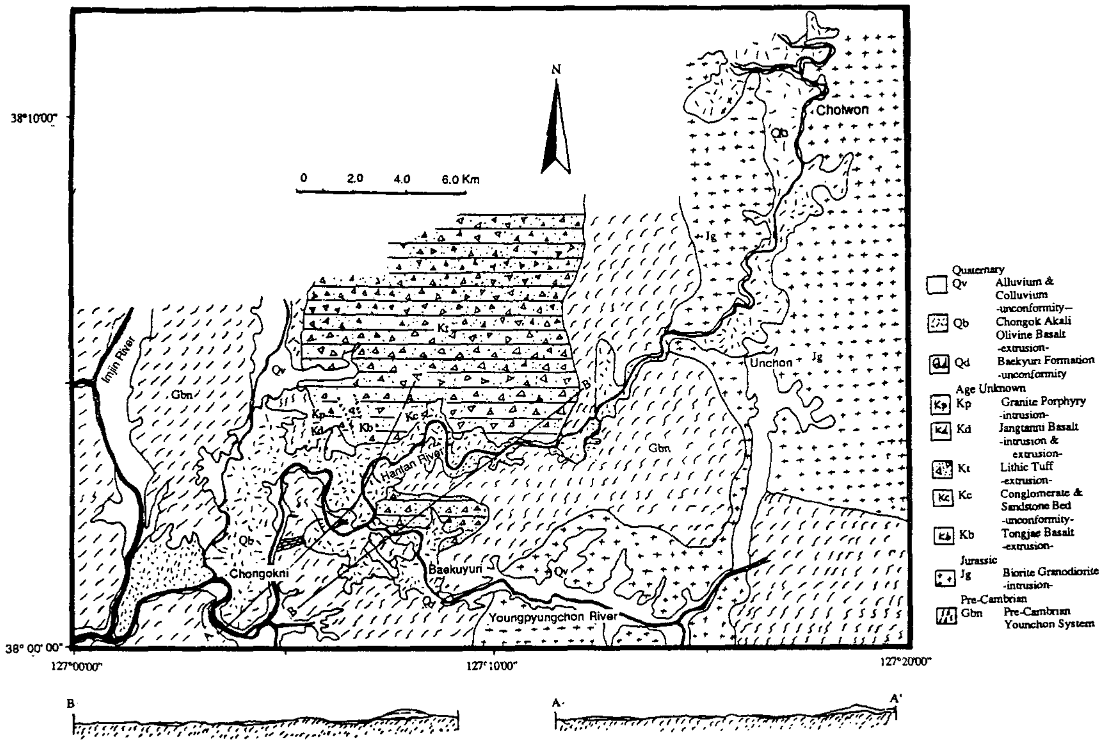


Fig. 3. Geology Map of Hantan River Basin (Cholwon-Chongok)

of development are often removed later by erosion. Owing to the active tectonic movement in the Chugaryong Rift Valley during the Pleistocene, deposits of the ancient channel system of the Hantan river have been preserved and eventually have kept Paleolithic materials in it. In this paper, for a convenience, the geomorphological development of the Hantan river basin will be divided into three stages; the ancient channel system before the basalt flows, the channels on the basalt plateau and the development to current channel.

Stage I: The Ancient Hantan Channel System prior to the Quaternary Basalt Flows (before approximately 0.6 mya).

Ancient channel deposits are found under the basalt flows at many localities along the Hantan and Imjin river in the south of the Pyounggang area where these flows originated. The horizontal location of the channel before the basalt flow, the ancient channel, is believed to have not been very different from that of the current system. An unconsolidated river gravel layer is exposed under the basalt cliff near Baekyuri village, in the valley of the Youngpyungchon, a tributary of the Hantan river. The current stream level of the Youngpyungchon river is about 2 to 3m lower than the top of the gravel layer. This ancient fluvial deposit is called "The Baekuyri Formation" by Korean geologists (Kim et al. 1984). In addition to this locality, a thick gravel deposit is exposed under the eroded basalt in the northwestern part of the Chongokni town. Three test pits were dug to check the stratigraphies alongside the basalt cliff in the north of the research station of the Chongokni Paleolithic site. The basalt cliff facing the Hantan river is the eastern end of Locality 1. These excavation pits revealed a series of channel deposits which are stratified in the order of gravel, sand and silt on the top of the gneiss bedrock (Fig. 4). It is interesting to note that the silt deposit is composed of three bands of different color, black, red and yellow from the top. There was no difference in the composition of the sediment. The black and red bands (about

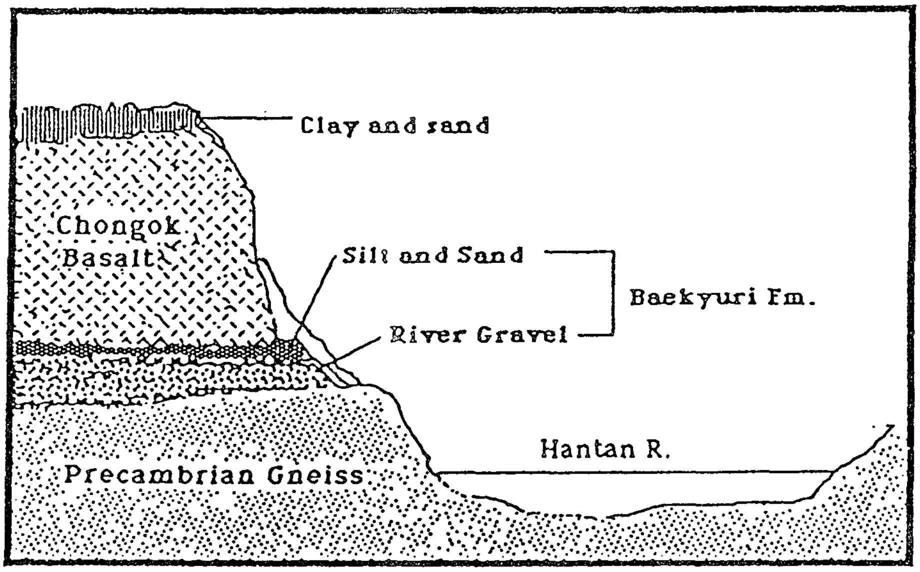


Fig. 4. Geological Section of Hantan R. near Chongokni site

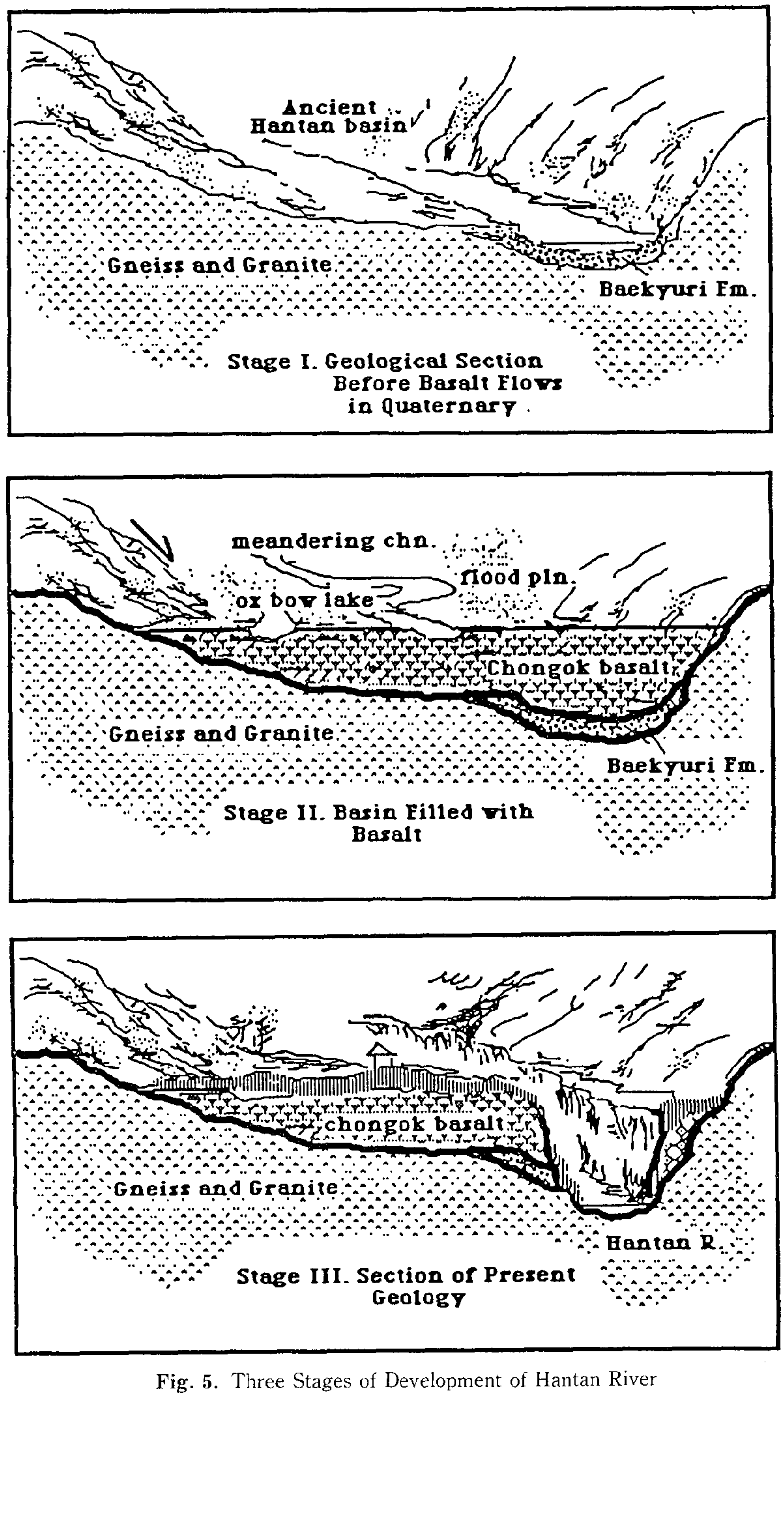


Fig. 5. Three Stages of Development of Hantan River

60cm thickness) is believed to have been probably burnt when the lava flow contacted it. Same sequential deposits are observed in the northwestern part of the Chongokni town and near the Yonchon Dam in Shindapni. The ancient Hantan river channel is thought to have been formed by selective incision on different bedrocks along the joint line of the geological structure in this area. This is indicated by the fact that the ancient river flowed along the foothill line of the steep side of the river valley.

Stage II: The Hantan River Channel System on the Basalt Plateau.

When the basalt filled in the lowland of the river valley, a plateau was formed. In the early part of this stage, running water on the surface of the basalt could not form a major channel but formed ephemeral streams during rainy season and left some small lakes in dry season on the widened basin floor. Fluvial and colluvial sediments began to fill in the valley, and the river flowed over these deposits. Aggradations and degradations were probably occurred alternatiely at some localitites. A certain type of sediment could have been formed at a certain locality and next flush could have washed away it completely. In fact, all sort of sediments are observed in the Chongokni site except gravel layers consisted of cobbles. Layers of laminated sand, cross-bedded sand and small gravel indicate relatively high energy active streams. Laminated layers of fine gray and yellow fine silt was probably formed in a small lakes left by ephermeral stream. The thick reddish and brownish clay deposit is believed to have been overbank deposit when flooded. Also some of the different type of sediments were deposited simlutaneously in a channel system, because grain size is changed gradually at some

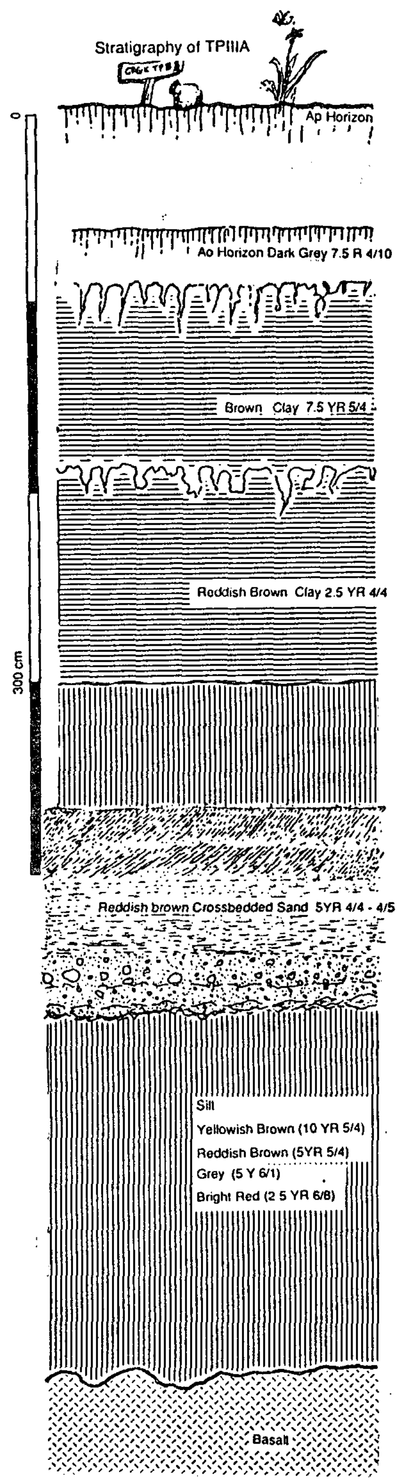


Fig. 6. Stratigraphy of TPIIIA

localities. The stream channel of the Hantan river was moved laterally within the flattened basin floor until the channel was fixed by the major incision. The direction of the stream was determined by the topography of basalt during the early stage. If the annual pattern of precipitation was not very different from today, the river channel must have been much wider and more shallow than the current Hantan river. During this time, the meandering or braiding channel left cross-bedded, coarse, sandy material on the basalt bed and some fine silty and clay materials in low energy streams. This depositional environment explains the different types of sediments overlying the top of the basalt.

The major deposits of the Chongkni and the adjacent area including Namgyeri, are composed of silty sediments in the lower part and clay in the upper part. These well-sorted and fine grained sediments are thought to have been deposited by low energy streams. However, coarse materials are found in the upper reaches of the river. In Shindapni, which is located about 10 km upstream of the Chongokni, sandy gravel with angular cobbles is found on the top of the basalt plateaus on both sides of the river. Around the Komuni area, farther north, the particles of the sediments are relatively fine, but the percentage of sandy materials in much higher that in the Chongokni area. Clayish silty material was found in a small test pit on the basalt plateau in the north of the Unchon, which is about 30 km upstream from Chongokni. Farther up the river, at the Dongsong site, a profile of the sediment accidently exposed by a military construction demonstrates that a thick stratified coarse sandy material is overlain by about 1 m of silty deposit. Particle size can vary within a section of a stream because transporting energy is not the same in each part of the section. In the middle part of a stream, coarse materials will be deposited and much finer materials will be closer to the edge of the stream. The variation of the particle size of the sediments along the Hantan river basin is thought to have resulted from the different valley morphology and the changing gradient of

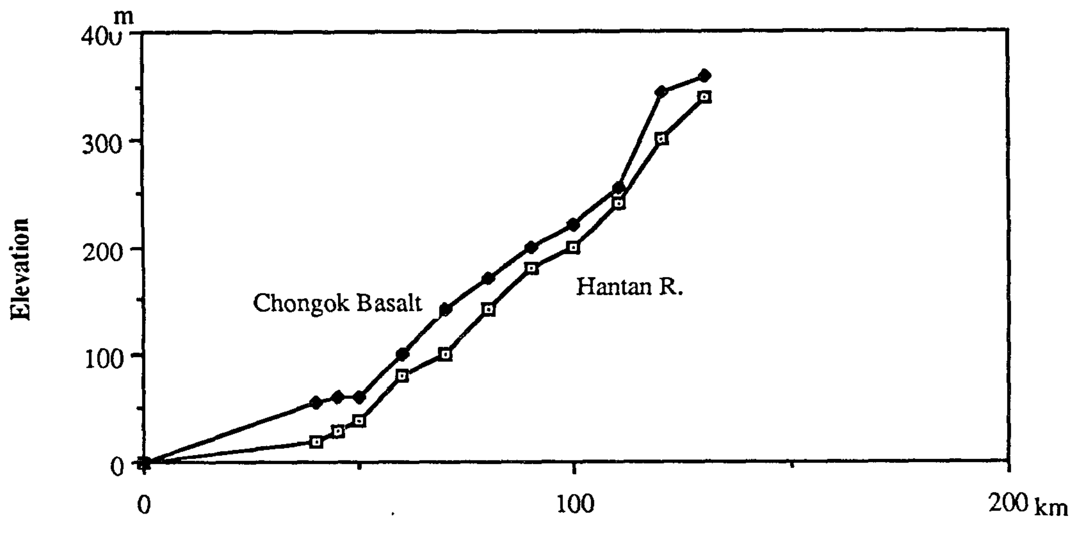


Fig. 7. Gradient of the Hantan river and the Chongok basalt

the ancient Hantan river, which can be determined by the gradient of the basalt plateau. Accordingly, no gradual change of particle size along the section of the river valley has been observed, although similar sequences of sedimentation, that is a sequence from coarse to fine material, are found on some locations.

The gradient of the ancient Hantan river increases abruptly in the south of the Pyunggang area near the source of the basalt (Fig. 7). Particularly, there is an almost 80 m difference in the elevation of the basalt surface between Majangni and Songhari, which are only about 10 km apart. This means that the elevation drops 8 meters in every one km, while the basalt surface in the next 50 km drops 2 to 4 meters in every one km. The gradient of the basalt surface decreases slightly more in the area from the Songhari to the Sohoesanni than in the area from Sohoesanni to the Komuni. However, downstream of the Komunni area, the slope of the basalt plateau along the Hantan river becomes much more gentle than in the upper reaches. The basalt plateau in the Komunni area is nearly the same level as in the Namgyeri which is about 10 km downstream. The variation of the valley morphology of the Hantan river also affected the types of sediments. From the source of the basalt to the Unchon area, the Hantan river flows on a wide valley floor between two parallel mountain ranges. Although the gradient of the stream was high, relatively fine sediments were observed. Between the Sohoesanni and the Komunni area where the river transects the fault systems, narrow and deep downcutting of the river formed a valley with steep walls and a narrow floor. The steep side walls of the Hantan river valley around the Sohoesanni area must have blocked the flow of basalt. In this area, increased discharge by the joining tributaries into the narrow valley is believed to have formed a turbulent flow in spite of the low gradient in this part. In this part of the river valley, as the suspension load would have been very large, no massive sedimentation is observed. In this section, the walls of the valley are very steep and very little basalt remains on the terraces on either side of river. However, the valley floor in the lower reach of the Komunni area becomes wide and flat, especially in Chongokni and Namgyeri. Assuming total discharge is constant on each station along the river, channel morphology is the mos important factor deciding stream velocity. Around the Chongokni and Namgyeri area, not only the wide, flat valley floor results in a very wide channel, but on top of that, the channel gradient drops markedly downstream of Komunni. The decreased velocity in this area reduced the suspended load in the stream and eventually deposited silty and clay material in this area.

Currently remaining deposits on the top of the basalt at some localities were influenced by tributary systems. In the Shindapni which is a little downstream of the Komunni, angular gravels with coarse sandy material are widely distributed on the top of the basalt surface. These sediments are believed to have been transported by the Yongpyungchon river which is a tributary of the Hantan river merging in the Shindapni area. These kinds of fluvial materials were also found in the Baekyuri area, a little upstream of the Youngpyungchon river. It is particularly interesting to note that a seidment fill in the lake is observed on the upper terrace of the Youngpyungchon river valley north of the Chungmun birdge. When the Youngpyungchon had been dammed by the basalt flows, the lake was very rapidly filled with the materials transported, and the channel bed was elevated to establish equilibrium with the basalt surface.

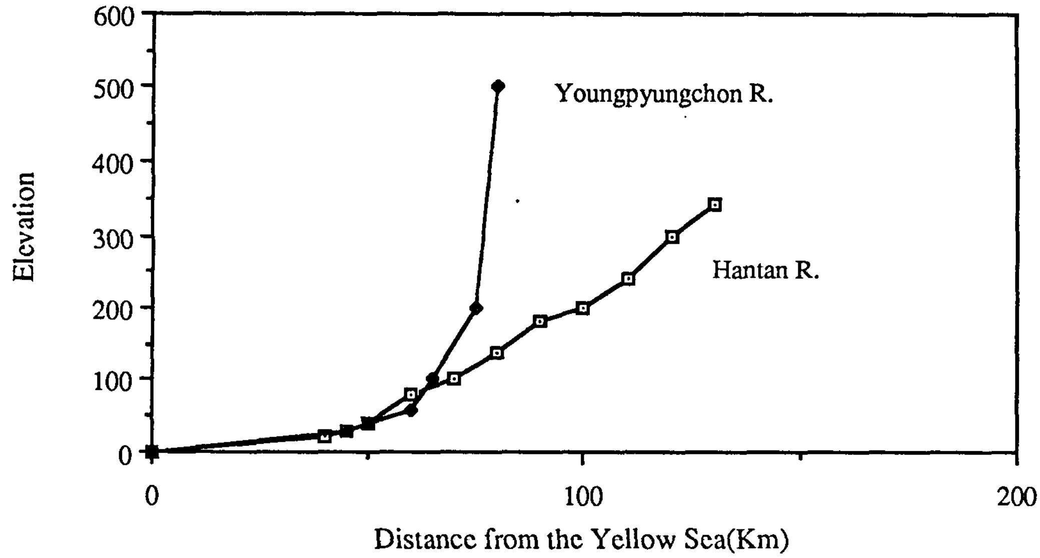


Fig. 8. Gradient of the Hantan R. and Youngpyungchon R.

It is believed this process did not take a long period of time. The channel gradient of the Youngpyungchon is much steeper than that of the Hantan river (Fig. 8). It originates in the high mountain ranges in the east and flows straightly eastward to the Hantan river. Turbulent flows caused by high precipitation might have brought eroded materials downstream from the upper mountain range. The exposed section of the deposits show that a sandy gravel has been deposited about 25m high above the present channel bed and a sandy clay layer of about 5 m thicknes has overlain the gravel. The same structure in the sediments is observed in many locations on terraces along the Youngpyungchon river. Heavy precipitation could have brought the small angular gravel with sand to the downstream reaches of the Youngpyungchon river due to the decreased channel gradient by the raised channel bed by the basalt dam.

Stage III: Developed to Present Channel

The basalt flows raised the valley floor and increased the channel gradient. After the final flow of basalt, the channel bed was raised up to 40 m above normal near the Chongokni site, if the present level was same as the channel bed before the first basalt flow. The current channel is much lower than the base of the basalt. We can observe along the Hantan river that the channel cut down the Precambrian gneiss leaving a narrow terrace, which is about 12 m above the stream at the Chongokni site. Two kinds of erosional processes are believed to have been involved in forming the current channel of the Hantan river; local downcuttnig and headcutting. Firstly, selective erosion occurred on the joint line of the basalt and Precambrian gneiss. It is not difficult to imagine that down cutting of fluvial system was probably continued at many parts of the basalt plateau. However, the selective erosion is particularly notable from the fact that the current river channel has been developed mostly along the joint line of the two geologic systems. Because of contact of two different materials, the part of basalt flow adjacent to the joint probably became weak. The basalt cooled relatively fast as a result of the contact, and the unconsolidated materials between the two rock systems made this area relatively easy to be eroded. The water in the channel must have also been a factor affecting the cooling process of the basalt. Considering the current Hantan river coincides the ancient one in many localities, the low surface level of the basalt in the area of the previous channel is thought to have also contributed to the formation of the current Hantan river system.

The Chongok Basalt is composed of at least 2 flows. Dates from the basalt flows indicate that time intervals existed between them. Old basalt in channel is believed to have been eroded completely before the second one. Next basalt flow could travel farther in the channel than on the high terrace or flood plain, because its volume flow would be much greater in the channel. When eruption stoped, the basalt flow moved funther in the channel and lowered the surface of the basalt. Cooling was faster on the high surface. Although there might not have been so great a difference in levels between the two parts of the valley, the slightly low parts in the valley have many more chances of being influenced by fluvial action. Secondly, the slope of the basalt surface probably increased near the front of the basalt flow in the lower reaches of the river, forming a "knick point." Heavy erosion was carried out around the knick point because of high energy stream, and it moved upstream as downcutting proceeded. The process of erosion continued until the river regained the previous channel system.

The erosion and excavation of the old channel system probably did not take a long time. Several factors accelerated the process. First of all, basalt often has a joint structure, such as columnar joint, when it cools. This kind of structure is very easily broken down by erosion. It is observed that tiny waterfalls along the edge of the basalt plateau cause the edge to retreat by breaking off pieces of basalt showing the columnar joint structure. The second factor in the erosional process is frost action. The present mean temperature during the winter season in this area is ca. 0°C. Alternate freezing and thawing in the fissures of the basalt during a year probably borke down the mass very rapidly. The last major erosional factor is concentrated precipitation. Two thirds of total annual rainfall is concentrated in several months of summer. In particular, cyclones cause high precipitation within a short period of time. The abruptly increased discharge transported the eroded materials away and also eroded the basalt. The composite action of these factors accelerated the process, and in the area near the knick point, a catastrophic erosion might have occurred. Many hanging valleys along the edge of the basalt plateau are evidence of the rapid process of erosion.

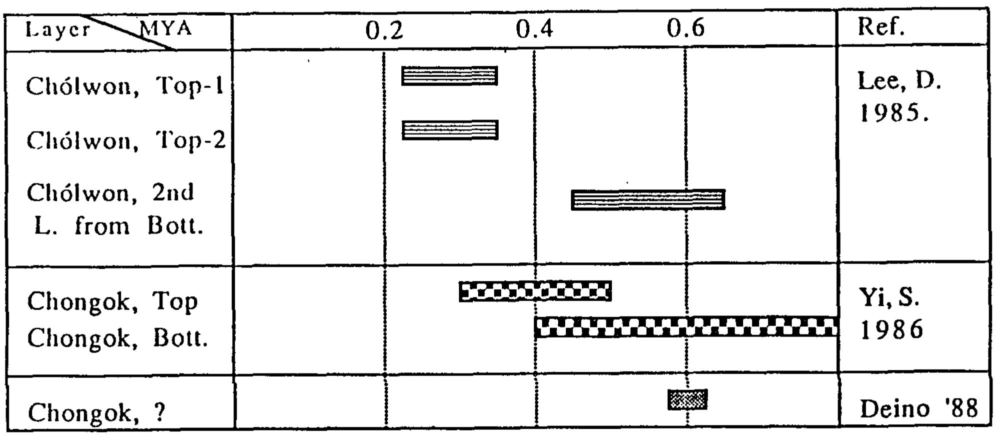
It is not clear yet whether the fluvial deposits between the gneiss and the basalt indicate the level of the ancient channel before the basalt was laid down. The level of the present stream is about 10 to 15 m below the ancient fluvial deposits. At one time, the fluvial material exposed at base of the basalt cliff was thought to be remains of a terrace aggraded before the channel was lowered to its present level. The exposed fluvial deposits were subsequently kown to be part of a thick series of sediments overlain by the basalt flows. It is unlikely that down cutting to the present level was directly caused by the lowering sea level during the Last Glaciation, because the coast line was too far from Chongokni to be affected by the sea level change. More probably, downcutting of the channel around the Chongokni area probably took place as a result of the change on the fluvial regime caused by the climatic changes during the Last Glaciation. The fact that the Precambrian gneiss was incised to form a V-shaped hanging valley by a small tributary stream near the site supports this explanation.

The Age of Sediment on the Top of the Basalt: When the Channel Was Dropped?

What, then, is the most reliable date for the sediments at the Chongokni site? How can we know it? The age of the basalt provides only a lower limit of the age of the Chongok sediments. A sample taken from the bottom of the lower flow was dated 0.6+/-0.2 MYA and an age of 0.4+/-0.1 MYA was obtained from the lower part of the upper flow. A weathered basalt boulder collected near Locality 2 was dated 2.9+/-0.3 MYA (Yi 1983: 584). Another series of dates was obtained from basalt flows in the upper reaches of the Hantan river near Cheolwon. The location from which the samples were taken is about 20 km south from the volcano that is considered to be the source of the basalt (Lee *et al.* 1983: 19-23). Six basalt flows are present in this region (Lee D.Y., personal communication). Two identical K/Ar dates of 0.28+/-0.07 MYA were obtained from the top flow of this sequence. A K/Ar date of 0.69+/-0.06 MYA was obtained from the second flow (Lee 1986; unpublished data, see Bae 1988). Another K/Ar result obtained by the Berkeley Geochronology Center probably from the lower flow near the Chongokni gave a date of 0.6231±0.018 MYA (Deino 1988; see Bae 1988). It is unknown which one of the flow in the upper reach of the Hantan river reached the Chongokni area which is located about 50 km downstream from the location where the samples were taken. According to Dr. Lee who investigated the Chongok basalt, the second and the top ones are thicker than the other flows. It is, therefore quite likely that these two flows reached to the Chongokni area. The three K/Ar dates obtained from the top part of two sequences fall within a period from 0.21 MYA to 0.5 MYA namely the middle part of the Middle Pleistocene. If the two top flows were formed at the same period, the most probable time period is some time between 0.3 MYA and 0.35 MYA on the basis of the overlapping part of the three dates.

Ever since the formation of the basalt plateau, the Hantan river has continued to cut down into the basalt until it has reestablished

Table 1. The K/Ar Dates of the Chongok basalt



a normal channel gradient. As the process went on, at a certain point of time the stream was lowered down sufficiently that it could no longer meander and so deposit more sediment on the basalt plateau. This point of time can be regarded as an upper boundary of the age of the site. Now, the question is how long did the river remain flowing on the top of the basalt and able to deposit sediment? When was the river lowered sufficiently that it was below the top of the basalt? Answering these questions would directly indicate the upper limit of the age of the sediment and also the upper limit of the formation of the archaeological sites in Chongokni, because deposition could only be possible while sediments were transported to the basalt plateau by river action or other natural agency. As discussed upto now, the erosional process of the basalt bed probably did not take a long period of time. One or two major fluctuation of climate is believed enough for the Hantan river channel eroded basalt completely. A big climatic depression during the late Middle Pleistocene is observed in the V28-238 deep sea core (Shackleton & Opdyke 1976) and a valley cut is recorded in the Korean peninsula during the same period of time of the Middle Pleistocene (Lee 1985). Therefore, it is believed that no more sediment was deposited after the climatic depression in the late Middle Pleistocene, but surface erosion has been being continued until present time. Some of the sediments, in particular the reddish clay deposit, found at the Paleolithic sites were believed to have been formed underwarm and humid climate. In eastern Asia, this type of climate is believed to have prevailed about 200,000 BP. The core from Biwa lake in central Japan, which is one of the most extensively investigated lakes in the world, shows two high peaks of temperate climate during the last 300,000 years: one from about 210,000 years BP to 150,000 years BP and one from 90,000 years BP to 80,000 years BP (Fuji 1974, 1976: 400-412). The time range of these two episodes roughly coincides with the dates of the deep sea core V28-238, but the age of the second episode in Biwa Lake is a little earlier. In addition, solar radiation achieved high peaks during the period from about 220,000 years ago to about 170,000 years ago and again from about 120,000 years ago to 85,000 years ago (Berger 1978: 139-167). These two warm periods correspond to the transgressive sea level changes on the eastern coast of northeastern China. During the last 300,000 years, five transgressive cycles were observed in the drilling cores on the eastern coast of China (Zhao & Chin 1982: 147-154). The Third and the Fourth transgressions occurred roughly at the same time as the two warm periods observed on the piston cores from Biwa Lake and on the deep sea core V28-238. The two marine transgressions were well dated, because the Jamaica reversal event (215,000-198,000 years BP) and the Blake reversal event (114,000-108,000 years BP) were observed in each formation. These two periods of warm climate would be the most likely time during which the reddish sediment of the Chongokni site was formed. The "Three Red Bands" in the Luochuan loess section, which was dated from 180,000 to 210,000 years by the TL method, is believed to have been formed during the warmest stage of the Pleistocene (Xu 1984: 227). As the red soil is restricted to southern China today, Chinese geologists believe that the climate was as warm as in southern China during the time the red soil was formed. The evidence suggested above indicates the reddish sediments at the Chongokni site were more likely formed during the same warm periods in the late part of the Middle Pleistocene as the "Three Red Bands" of the

Luochuan Loess in Shansi

Conclusion

The Quaternary deposits along the Hantan river basin could have been preserved owing to the unusual geomorphology of the basin area caused by the basalt fllings. The dropping of the Hantan river channel left thick fluvial deposits containing Paleolithic materials on the top of the basalt plateau. The elapsed time for the river channel to be dropped was not probably long, because current geomorphology of the Hantan and Imjin river indicates an abrupt change which can be reasoned by the climatic factors of the basin area and the petrological characters of basalt. Therefore, the river channel probably could not influenced the top of the basalt plateau after the major claimtic depression during the late Middle Plesitocene. The major part of the sediment is believed to have been formed under a warm and humid climate which prevailed about 200,000 BP. This age is also supported by some climatic evidences recorded in piston cores from the Biwa lake and the Yellow Sea, and in loess deposit in China.

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