

# The Sea Level Change and Human Activities at Sejuk-Ri, Ulsan City, Southeastern Coast of Korea during the Early Neolithic Period

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**Abstract :** The sea level curve and environmental change were reconstructed at Sejuk-Ri during the early Neolithic Age, based on the sedimentary facies, the distribution of remains and carbon datings. Before 6,500 years BP, the sea-level experienced one oscillation. The Neolithic men utilized geomorphic environment which formed according to the sea-level change. They might be occupied in gathering, fishing and hunting including whales hunting. The Neolithic men made acorn hollows in order to remove tannin. Besides, they remained shell mounds which were formed from 6,500 years BP to around 6,000 years BP. They left the living place about 6,000 years BP because of transgression.

**Key Words :** sea level change, shell mound, acorn hollow, middle Holocene, transgression

## I. Introduction

The climate, vegetation and sea level change during the Quaternary period have absolutely influenced on the human lives.

Sea level change among them is estimated to especially an important variable for the decision of human activity space at the coastal alluvial plain. The archeological excavation data could maybe clarify the coastal environment in the relation to the sea level change. Acorn hollows and shell mound are also very effective indicator to reconstruct sea level fluctuation and coastal environment during the Holocene.

This study aims to investigate sea level fluctuation and coastal environment on those days and mutual correlation based on the

sedimentary facies, sedimentary environment, chronology from shell mound and archeological culture layer at Sejuk.

## II. Study area

The Sejuk remains are located at Sejuk-Ri, Onsan county, Ulsan city, southeast Korea, and stands on the month of a inner bay with width 0.5~1km, length 4km. The coast is open to the East Sea southeasterly.

Sandy-, gravelly and rocky coast are developed at Sejuk coast. And wave energy approaching from east and southeast is dominant here. However except summer it is usually in a low energy situation because the site is in a inner bay.

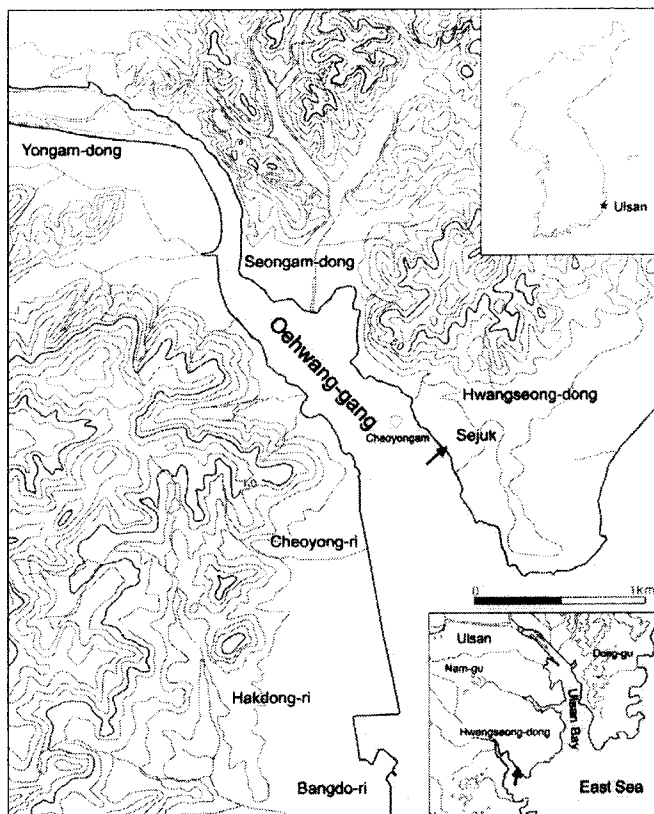


Fig. 1. study area(↑ is location of remains)

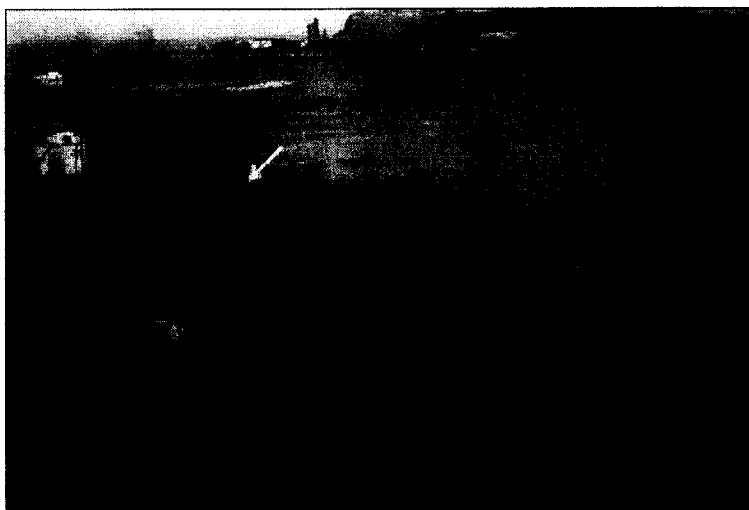


Photo 1. study area(wave-cut terraces of the offshore; remains[ ↓ ])

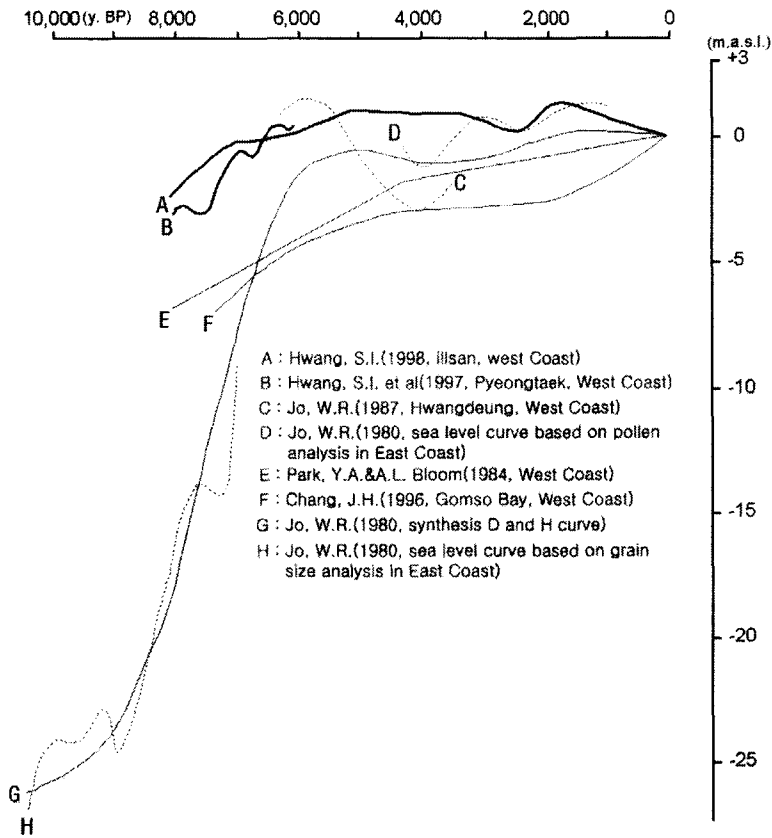


Fig. 2. Holocene Sea level change in Korea

### III. Argument on the sea level change during the middle Holocene of Korean Peninsula

The research result that sea level has fallen to -140m during 20,000~18,000 BP and risen to the present level quickly in 6,000~7,000 BP of the middle Holocene, is known in general based on theory of eustatic sea level change.

But there exist some arguments on the rising pattern such as fluctuation or smooth pattern during the Holocene, the existence of the sea level higher than today in the past, and arrival time to the present level. Therefore some data indicating

sea level during 6,000~7,000 BP will take an important role to solve these problems. For example, the characteristics of sedimentary facies, the distribution of relics, data of carbon dating, archeological data such as shell mound and acorns hollows in study area could clarify coastal environment in relation to the sea level change in those days in Korea.

Since Jo(1980) has reported the sea level change in the East Coast based on the data obtained from several materials ranging on the whole period of the Holocene, Hwang(1984), Jo *et al.*(1985), and Hwang(1995) have researched additionally, but only confirmed the change after 6,000 BP or short

period in fragments. The sea level change curve in the East Sea since 10,000 BP by Jo(1980) indicated to be at 10m below present sea level in 7,000 BP, and at -2m or similar level to the present in 6,000 BP(Fig. 2-D).

Park and Bloom(1984) in the West Coast have reported -8.0m in 8,600 BP, -6.6m in 8,000 BP and -6.0m in 7,400 BP(Fig. 2-E). It is similar result to the report of Bloom(1967) at the Atlantic coast in the U.S.A.

Hwang *et al.*(1997) have reconstructed the curve of sea level change at Pyeongtaek in Gyeonggi-Do of West Coast based on the data from sedimentary facies, diatom analysis, pollen analysis and carbon dating. It indicated -2m in 7,200 BP, -1m in 7,000 BP, 0m in 6,500 BP and +0.8m in 5,000 BP(Fig. 2-B). Chang(1995) has insisted the sea level of -6.6m in 7,000 BP, -3m in 4,000 BP, and -2.5m in 2,000 BP at Gomso bay in the West Sea.

According to the previous data, there are some differences among the sea level curves of the Holocene in Korea Peninsula, especially about 6,500 BP.

#### **IV. Sedimentary facies and Sedimentary environment at the coast of Sejuk village during middle Holocene**

##### **1. sedimentary facies and Sedimentary environment**

Horizon IV is sedimented directly on the bedrock. It is organic silt layer transported from the hills behind including charcoal fragments with a little remains.

Horizons III and II as indicator of human activities are shell mounds with the thickness about 1.5m. Horizons III is divided to 4 subhorizons again. The characteristics are summarized as follows.

Horizons III-4 composed of sand layer mixed of shell fragments and pebbles is called as shell belt of mostly sea mussel. This sediments layer including shell mounds was deposited under marine environment. The sand layer was mixed with shell fragments and gravels included potter's fragments with organic humus. These inner bay environment was probably constructed during the climax of the Holocene transgression. This layer is located -0.8m~-0.2m a.s.l. On its surface there is the layer of acorn hollows. It means that this layer to -0.2m a.s.l. was deposited, then the sea level descended to -1.2m a.s.l. and finally exposed the -0.8m layer of acorn hollows.

Horizon III-3 is composed of organic humic sands with the fragments of woods, charcoal, leaves, carbonated acorn, sea mussel and gastropods. It is estimated to a sand bar in front of shell mounds at Sejuk-Ri and reflects a lagoon environment. As the water level in the bay rises, acorns hollows were moved to the higher sites gradually. The sea level reached at 0 m when the acorns hollow was made on the highest level. The prehistoric human beings threw away the broken fragments and shells in the bay, with these materials this cultural layer was constructed.

Horizon III-2 is a sand layer including some shattered shells, lots of remains and corals and III-1 is also composed of coarse sands and gravels including some shattered shells and corals. And some branch of tree were transported from the lands. This layer is estimated to be sedimented

under the lagoon environment influencing by wave. Corals lived in the Ulsan bay at that time which are not at present. It means that the temperature of sea water at that time was warmer than present.

Horizon III-1 is composed of gravelly coarse sandy layer mixed small shells, coral, and woods. It means the study area was put on the marine environment influenced by strong wave energy. Sea level reached at 0.2m a.s.l. at that time.

Silty sand layer, horizon II including shell fragments should be sedimented under the marine environment as rising sea level. Lower layer of this horizon was formed in deep water by low wave energy. But the upper layer with mostly gravels was deposited at high wave energy. Horizon II was exposed in the air for a long time after sedimentation. The corals were found at Horizon II-1 and II-2. Lots of fragments of Apinmun earthen wares were found in this layer,

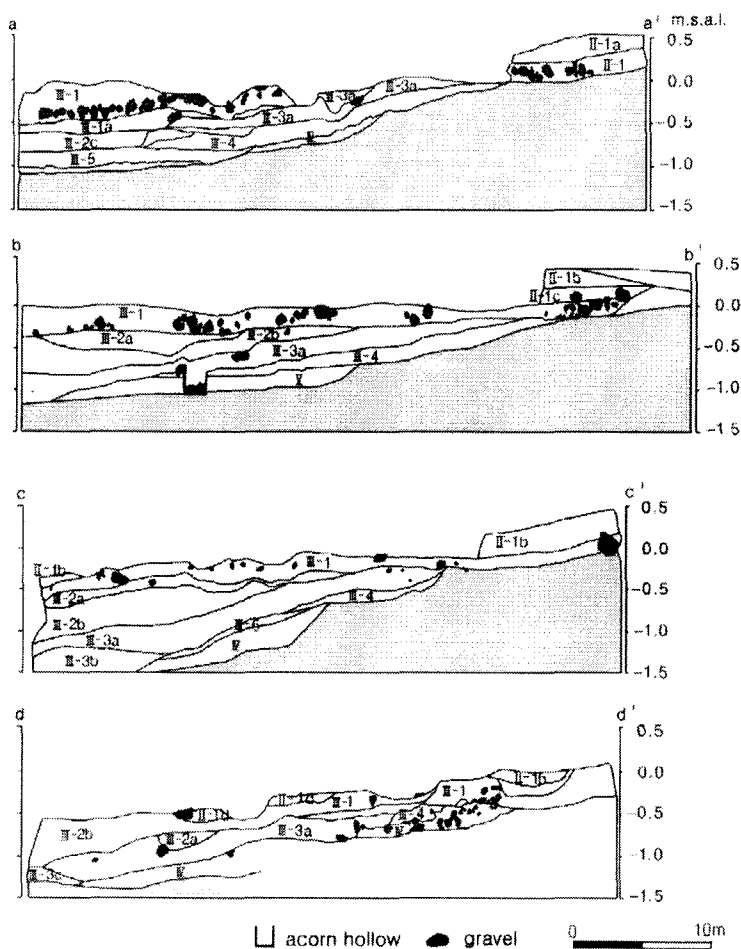


Fig 3. longitudinal profile of Sejuk layer

The sediment layer on the bedrock is classified into 5 horizons.

which indicates one of the remains of early Neolithic Age around 6000 BP.

Horizon I was formed under the strong wave energy environment. The energy was concentrated on the same level for a long time since sea level had reached to the present sea level. The coast of study area has been consisted of this thick gravel layer transported from the headland and rocky coast of the southern part of the study area. The prehistoric men concerned with the archeological culture layer in the Neolithic Age had left the living space during this stage.

On the other hand, horizons III-2 and III-1 contained lots of coral fragments. It means the

temperature of sea water was maybe 2°C higher than present 13.0~14.0°C estimated from corals living near Jeju Island of southern area in Korea. Around 6,300 BP corresponding to the sedimentation period of the horizon III-2, the annual mean temperature in Ulsan city was probably about 15.0~15.5°C (Hwang, 2002). It is concluded the climatic optimum at Ulsan area began about 6,300 BP.

## 2. The characteristics of the sediments including acorn hollows and the result of age dating

The prehistoric people in Sejuk-Ri made acorn hollows in order to eliminate tanin in the sea

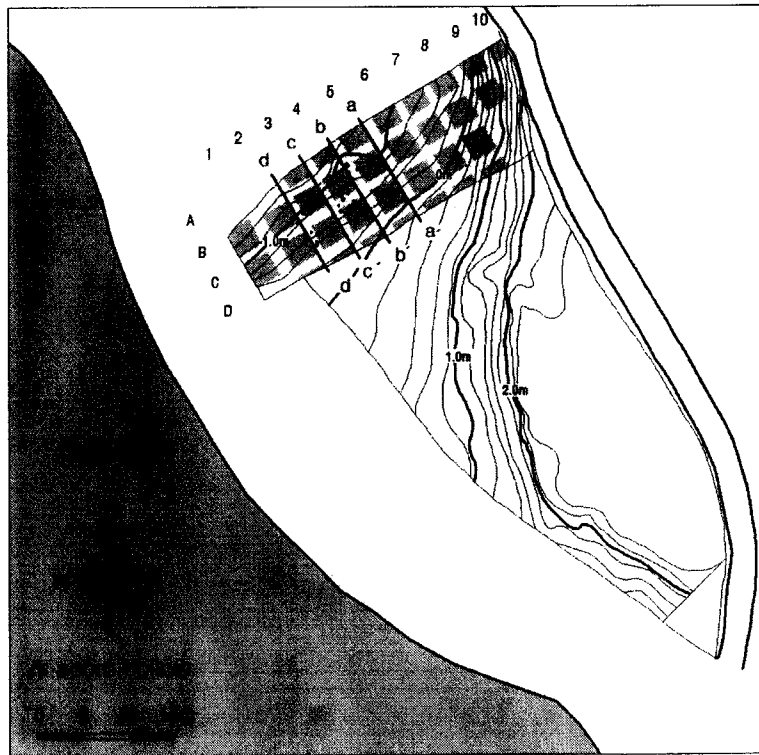


Fig. 4. surface relief with the acorn hollows(revised from Hwang, C.H.; 2002)  
a-a' ~d-d' are vertical lines to the slope

Table 1. C<sup>14</sup> - dating of Shell mound at Sejuk

excavation trench	horizon	C <sup>14</sup> dating (BP)	calibration (BC)	material	presumed m. a.s.l.(cm)*	No.	notes
B2	III-1	6,260 ± 40	5,260	carbon*	-50	DK 2	
B2	III-1	6,280 ± 40	5,270	carbon	-50	DK 1	
A2-A3	III-2b	6,110 ± 80	5,040	carbon	-75	DK 3	
B4	III-2b	6,260 ± 250	5,150	carbon	-45	DK 9	
C1	III-3a	5,930 ± 110		acorn	-55	DK 14	too young
B2	III-3a	6,480 ± 120	5,400	carbon	-115	DK 8	horizon covered acorn hollows
B4	III-3c	5,700 ± 60	4,580	carbon	-125	DK 5-2	too young
B2	III-3c	6,420 ± 110	5,350	carbon	-125	DK 5-1	
	III-4	5,506 ± 137		shell			too young
A8-A9	III-6	6,260 ± 40	5,260	carbon	-45	DK 12-1	too young
A8-A9	III-6	6,330 ± 40		carbon	-45	DK 12-2	too young

Table 2. The sediments characteristics at Sejuk-Ri in the relation to the sea level change

Horizon	soil texture	sediments characteristics	sea level change	sedimentary environment
I	gravel layers 3m in thickness	no relics	stable including micro-fluctuation	gravel beach
II	silty sand	shell fragment earthenware	rapidly rise	marine
III-1	gravel(boulder and cobble) including granule, coarse sand and shell fragment	earthenware, coral, shell fragment	stable	gravel beach, Warmer than present
III-2	sand with shell fragment	earthenware, coral, combined fishhook, bone	stable	lagoon, warmer than present
III-3	dull brown peat with sand	carbonized acorn, bone, spirals, hard-shelled mussel	rise	lagoon
III-4	sand including gravel and shell belt	earthenware, bone, hard-shelled mussel	rise	sand beach, shell mound formation
IV	blackish brown silt including humus	earthenware, charcoal, splinters		terrestrial

water effectively.

Therefore the whole hollows were intended to be made near the shoreline, where could be immersed in the water. It means the sea level at those days could be clarified exactly through the dating of the acorn hollows. The profile c-c' of Fig. 3, 4 shows that the acorn hollows were made on the surface of the horizon III-4. The 18 rounded acorn hollows were found at the study area. The surface layer containing the acorn hollows was

measured after elimination of horizons II and III. As a result, the surface layer was confirmed from -1.5m to -0.4m (Fig. 3, 4)

No. 1 hollow has shaped in U's with width 45cm and depth 30cm. And it was buried with sands overlaid over the acorns and leaves of 5cm thick on its floor. There are also No. 2 and 3 hollows put a gravel on the floor, in shape of U's similarly with width 55cm and depth 11cm. There remained some acorns in the hollows of No. 1, 2

and 3, but remained nothing anywhere. There existed some cinders of charcoal in a hollow No. 4 and stream gravels in the hollow No. 5.

### 3. The construction period of the sediment layer

The carbon dating of Sejuk-Ri was measured with materials of the horizons of III-1, III-2, III-3, III-4, III-6 and the results are shown at Table 2. Some data are inappropriate for example as the age of  $6,330 \pm 40$  from the horizon III-6.

The horizon III-3 was formed at 6,450 BP and the horizons III-2 and III-1 were deposited 6,260~6280 yr BP at the same time. C1 of 5,930 BP(DK 14) and B4 of 5,700 BP(DK 5-2) were measured too young that made to identified and translated for real age. The materials used for the dating is carbonate fragments attached on the pottery. The material of the horizons II and III were sedimented with the fragments of potteries. This means that they were deposited in a stable condition. The materials in them are proper to carbon dating.

The acorn hollow distributes in 4 rows and their differences of the relative height among them is almost 1m. It means that the acorn hollows were constructed successively during the rising period of the sea level accompanied by the oscillation.

## V. Discussion

### 1. The correlation between environmental change and acorn hollows at Sejuk-Ri

Acorn is a fruit of *Quercus*, deciduous oak tree among Fagaceae, which is dominant overall in Korea since middle Holocene. Main element of

acorn are composed of carbohydrate 65%, plant oil 12%, water 8.7%, tannin 6.6%, protein 5.7% and calcium oxide 2%. Acorn yields lots of crops, used as edible food in prehistoric age and relieved famine as foods in the early 20 C.

Raw acorn isn't edible because of astringency of tannin. Tannin is removed in sunken state in water, especially saline water for 4 or 5 days.

Acorn hollows were made by excavation of horizons III-4, III-5, IV. After sedimentation of horizon III-4, the prehistoric men excavated on the surface of the horizon and used acorn hollows there. Because acorn hollows were on the shoreline, they were buried easily by wave energy. It could be repaired or constructed again considering marine environment like water depth.

The floors of the hollows are located on the levels of -1.5m, -1m, -0.7m, -0.4m.a.s.l. The relative height among them ranges 1.1m. It means they wouldn't be constructed at same time.

The acorn in the hollows were collected again after several days in order to cook. Therefore the prehistoric men had to make hollows at the location of mean sea level, although hollows were exposed in the air temporarily in a low tide.

It is difficult to understand that the gap of height between hollows constructed simultaneously exists to 20~30cm. The prehistoric men have put gravels as an indicator at the entrance of hollows in order to find them easily. They had lived for a long time at the same place. As the rising of sea level, acorn hollows were buried gradually from that of lowest level in turn.

As the horizon III-3 was sedimented from 6,500 BP to 6,300 BP, the acorn hollows were also constructed successively during this period.



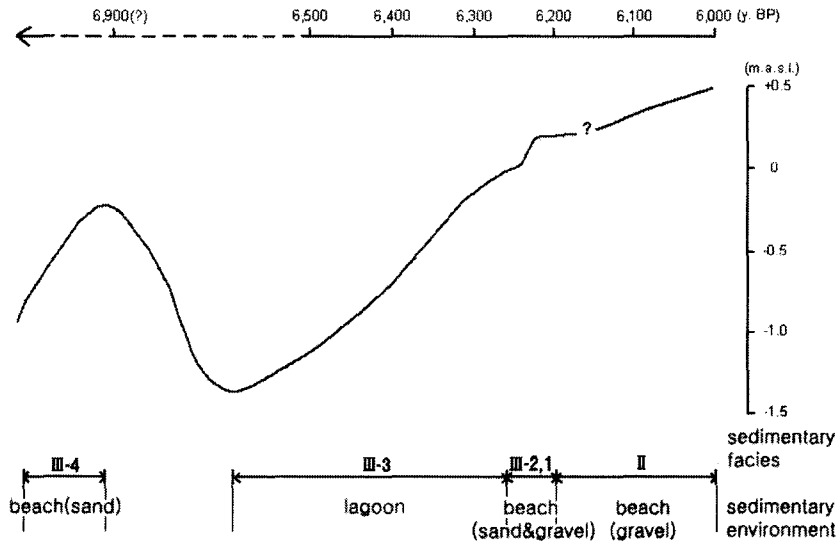


Fig. 5. sea level change and coastal environment at Sejuk village during the middle Holocene

## 2. The sea level fluctuation in Ulsan city during the middle Holocene

The sea level curve and the coastal environment were reconstructed based on the data of carbon dating, sedimentary facies and the level of archeological remains at Sejuk village during the middle Holocene (Fig. 5). Sea level was risen rapidly after the formation of horizons V and IV in a terrestrial environment. It could be confirmed by the surface slope inclined over 60° to the present coast line at the levels of -1m and 0m.

Afterthat the sea level had oscillated, it was risen to the present level and fallen down to -1m a.s.l. again shortly before 6,500 BP. Then it rose continuously and stabilized at the mean sea level in 6,300 BP. It reached to almost +0.2m in 6,200 BP and to +0.5m about 6,000 BP. The horizon III-4 from -0.8 to -0.2m was sedimented on the of acorn hollows marine environment before lagoon formation. Acorn hollows were located on the surface of lagoon. The sea level at the first

construction stage of acorn hollows might be stayed at -1.05m considering collection of acorns at low tide and hollow's depth 30cm, because the floor of the hollow indicated about -1.5m and the tidal range in the field is 60cm range at present. The acorn hollows in the site were constructed in order to treat during 6,500~6,200 BP.

Afterthat the entrance of the inner bay was blocked by sand bar and lagoon was formed at Sejuk village coast. The people who lived around the lagoon were safe escaped from damage from the storm.

Old acorn hollows were buried by sediments according to rising of the sea level, new hollows were constructed on the higher location gradually. Meanwhile horizon III-3 was sedimented continuously during this period. The sea level was stable at 0m after sedimentation of III-3. The lagoon was buried by the beach sediments from the coast.

After horizon III-1 was sedimented rapidly in

stable sea level, lagoon was buried and the coast line was located in the direction of NNW-SSE, parallel to the present coast line.

After that gravels were sedimented at rocky coast, eroded by wave. The sea level was reached 0.2m and probably risen to 0.5m when horizon II was sedimented by the chronology of earthen ware.

The sea level fluctuation which is restored at Sejuk-Ri shows the variation for several hundreds years around 6,500 BP. The sea level had reached to the present level about 6,300 BP and it was higher than present about 6,000 BP.

The results from the sea level fluctuation at the study area is different from those of Park, Y. A. & A. L. Bloom(1984) and Chang, J.H.(1995) during the middle Holocene.

### **3. The human life at Sejuk-Ri during the middle Holocene**

The prehistoric men have maybe lived by fishing and gathering in the Neolithic age. At the climax of transgression, sea level was rising rapidly, the inner bay was formed around Sejuk-Ri. The people lived on the stable living space with gathering shells and mussel and fishing actively. Supposed from the whale catching of Bangudae rockgraving in Ulsan City, the people have probably caught stranded whales driving to the river mouth at the entrance of inner bay. Especially they had collected lots of acorns in autumn, used in the hollows on the border of lagoon in order to eliminate tanin. They had cooked grinding acorns and extra acorns were stored for the next year. The large sand bar of lagoon in front of shell mound made roll on protecting from wave energy and was used as

stable living space. The archaeological culture layer containing shell mound was constructed from 6,500 BP earlier to around 6,000 BP. They had lived at Sejuk-ri until their living area was exposed by the transgression around 6,000 BP. It is confirmed from the fact that any remains weren't found in the sediment related to the later period than pressed patterned earthen ware.

## **VI. Summary and Results**

The coastal sediments at Sejuk-Ri, Ulsan city which is related to the sea level fluctuation during the Holocene were piled up under the several environment conditions such as sand coast, lagoon and gravel coast in turn. Based on the characteristics of sedimentary facies, the distribution of relics, data of carbon dating, the tendency of sea level fluctuation during the 6,500~6,200 BP was investigated. It is confirmed from the analysis's results that sea level experienced one oscillation before 6,500 BP. It was risen to the present sea level and after that it was fallen down to -1m a.s.l. about before 6,500 BP. And then it rose continuously and stabilized at the mean sea level in 6,300 BP. It reached to almost +0.2m in 6,200 BP, followed by to +0.5m in 6,000 BP. Especially the discovered acorn hollows in this area were constructed to treat acorns during 6,500~6,200 BP. The acorn hollow distributes as 4 rows and their difference of the relative heights is almost 1.1m. It means that the acorn hollows were constructed successively during the rising period of the sea level. The period which the coral had lived at the Ulsan bay since 6,300 BP was the climax of the Climatic Optimum and was about 2°C higher

yearly mean temperature than today's. The Neolithic men who had lived near Sejuk-Ri have utilized the geomorphic environment, like sand coast, lagoon and gravel coast developed with the relation to the sea level fluctuation. They might and hunting be occupied in fishing, gathering and hunting including whales. The archaeological culture layer containing shell mound was constructed from 6,500 BP earlier to around 6,000 BP. They had lived at Sejuk-Ri until their living area was exposed by the transgression around 6,000 BP.

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