

## RADIOCARBON DATES DOCUMENTING THE NEOLITHIC-BRONZE AGE TRANSITION IN KOREA

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**ABSTRACT.** We report radiocarbon dates for ~150 archaeological sites in Korea belonging to the Neolithic-Bronze Age transition period. From the present compilation, we find that the Neolithic-Bronze Age transition in Korea started as early as ~2300 BC and continued over the course of 800–900 yr with peaks representing population increases occurring 2–3 times. Compared with cases in other regions of the world, the Neolithic-Bronze Age transition in Korea was similar in both magnitude and transition time. However, the process in Korea appears to have occurred about 2000 yr later. Further, we find that the attempt to explain the Neolithic-Bronze Age transition in Korea as a migration hypothesis based only on a sudden population increase is not tenable.

### INTRODUCTION

One of the most debated topics in Korean archaeology is the nature of the Neolithic-Bronze Age transition, a transition that is primarily from a hunting-gathering-fishing lifestyle to reliance on full-scale plant and animal domesticates (W Y Kim 1986; Heu 1991; Nelson 1992, 1993; Rhee and Choi 1992; Norton 2000, 2007; Lee 2001; J S Kim 2002a,b). In particular, there are 2 main arguments currently being debated: 1) the transition is due primarily to an influx of farmers migrating from the north; and 2) the transition is due to increasing indigenous population growth (see above references). Unfortunately, these interpretations have often relied on a limited number of excavations and a paucity of  $^{14}\text{C}$  dates from the time period in question (about 2800–4900 BP). The intent of our paper is to present an updated compilation of  $^{14}\text{C}$  dates from sites in Korea that date to the Late Neolithic and Early Bronze Age. These data are primarily derived from the Seoul National University Accelerator Mass Spectrometry (SNU-AMS) laboratory (Kim et al. 2006a,b) and culled from published literature (Nelson 1993) when applicable. Thus, we present a comprehensive range of  $^{14}\text{C}$  data currently available in Korea for this time period. In Korea, the Neolithic is sometimes referred to as the Chulmun period, and the Bronze Age is sometimes referred to as the Mumun period (similar to the Japanese Jomon and Yayoi). Chulmun means having comb decorations and Mumun means no decoration on the pottery surface. Thus, the presence/absence of pottery decoration is the primary way of discerning whether a Korean site belongs to the Neolithic or the Bronze Age (for reviews see W Y Kim 1986; Nelson 1993; Norton 2000; Choe and Bale 2002; J S Kim 2002b).

### MATERIALS AND METHODS

The  $^{14}\text{C}$  dates reported here are derived primarily from charcoal samples. Marine samples such as shells from middens are excluded since the marine calibration has not been well established in Korea. However, charcoal samples from shell middens were included. A total of 148  $^{14}\text{C}$  dates are presented in Table 1, with each  $^{14}\text{C}$  date representing a particular settlement (see Figure 1 for locations). The number of settlements coincides only approximately with the number of excavation sites, since in some cases, 1 site produced 2 or more settlements of different occupation periods. If there are 2 clusters of  $^{14}\text{C}$  dates in a certain site, we regard them as 2 settlements, thus, 2 represen-

tative dates. Here, we designate a set of  $^{14}\text{C}$  dates as a cluster when they are distributed continuously without any significant interruption.

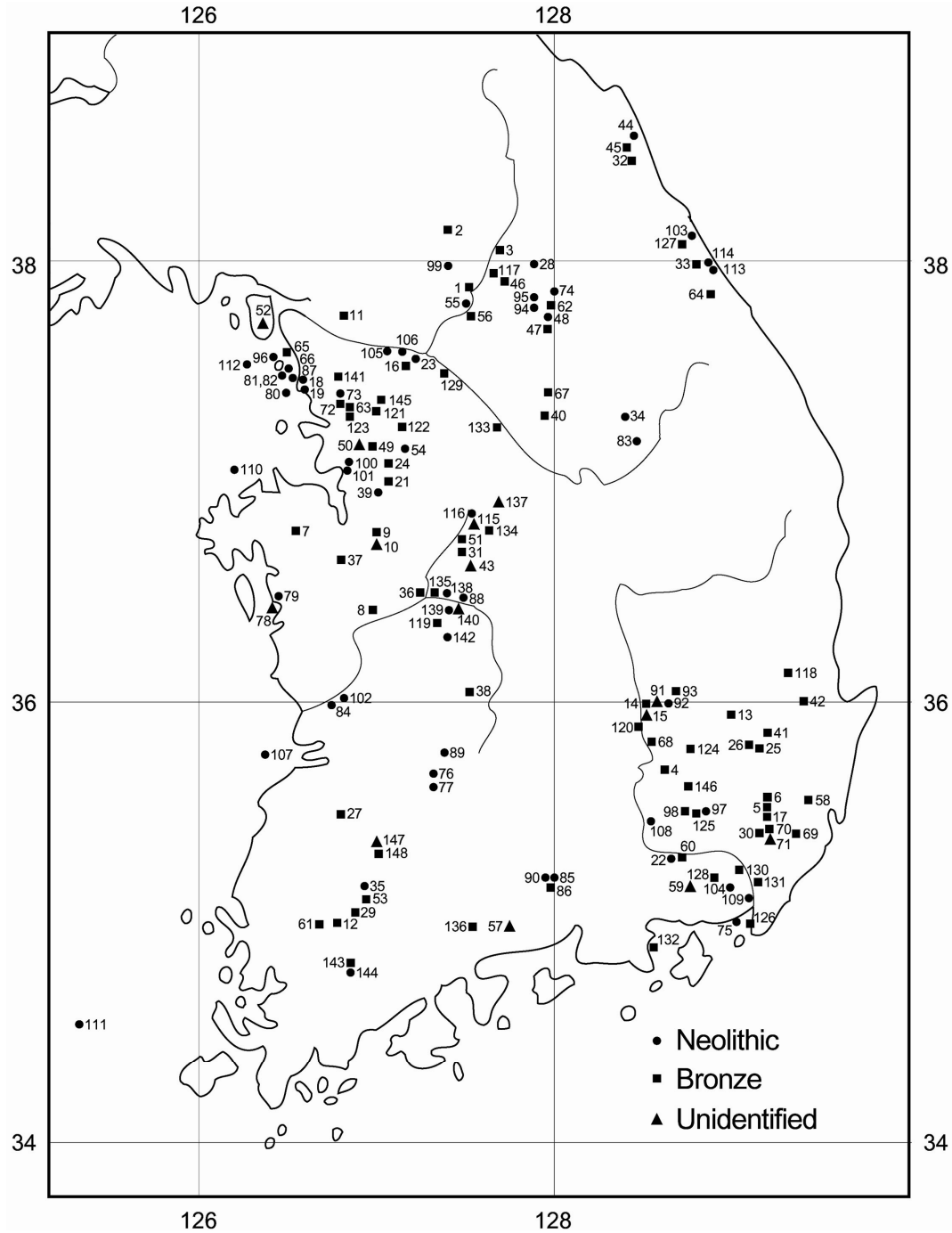


Figure 1 Approximate locations of settlements studied in this work. Numerical IDs taken from the first column of Table 1.

The particular dates chosen for a particular settlement were the oldest  $^{14}\text{C}$  date in the case of Early Bronze Age settlement, and the youngest  $^{14}\text{C}$  in the case of Late Neolithic settlement. The rationale for this selection was because we were interested in evaluating the variation between the upper bound of the Bronze Age and the lower boundary of the Neolithic in Korea.

Table 1 Korean Neolithic and Bronze Age  $^{14}\text{C}$  dates used in this study.

Nr	Site	Coordinates (lat, long)	Lab code	Date (BP)	Culture
1	Daljeonri	37°49'N, 127°31'E	SNU04-499	3110 [60]	Bronze Age
2	Wasu	38°10'N, 127°25'E	SNU04-681	3260 [80]	Bronze Age
3	Yongam	38°05'N, 127°43'E	SNU04-1036	2990 [60]	Bronze Age
4	Jinlari	35°40'N, 128°44'E	SNU04-761	3000 [40]	Bronze Age
5	Kulhwari	35°32'N, 129°14'E	SNU04-775	3140 [80]	Bronze Age
6	Kummaul	35°32'N, 129°14'E	SNU04-800	3150 [80]	Bronze Age
7	Bujangri	36°47'N, 126°30'E	SNU04-837	3150 [40]	Bronze Age
8	Hakamri	36°23'N, 126°57'E	SNU04-839	2940 [50]	Bronze Age
9	Punggidong	36°46'N, 127°01'E	SNU04-981	3270 [40]	Bronze Age
10	Songhakri	36°41'N, 127°00'E	SNU05-037	3320 [70]	Unidentifiable
11	Donyangdong	37°33'N, 126°46'E	SNU05-212	3050 [70]	Bronze Age
12	Sanjeongdong	35°02'N, 126°43'E	SNU05-396	2960 [60]	Bronze Age
13	Sinliri	35°53'N, 129°00'E	SNU05-447	3040 [60]	Bronze Age
14	Wolsungdong	35°50'N, 128°32'E	SNU05-473	3910 [80]	Unidentifiable
15	Wolsungdong	35°50'N, 128°32'E	SNU05-470	3100 [60]	Bronze Age
16	Deokpung	37°32'N, 127°13'E	SNU04-208	2970 [50]	Bronze Age
17	Gulhwa	35°32'N, 129°14'E	SNU05-667	3010 [50]	Bronze Age
18	Sammokdo	37°27'N, 126°42'E	SNU05-741	4530 [50]	Neolithic
19	Sammokdo	37°27'N, 126°42'E	SNU05-742	3830 [50]	Neolithic
20	Yongsandong	36°10'N, 127°24'E	SNU05-1000	3060 [80]	Bronze Age
21	Sosa	36°59'N, 127°06'E	SNU05-1025	2990 [50]	Bronze Age
22	Bibongri	35°24'N, 128°38'E	SNU06-202	3560 [60]	Neolithic
23	Saneonghopyung	37°32'N, 127°13'E	SNU06-187	3560 [120]	Neolithic
24	Seokuri	37°11'N, 127°05'E	SNU06-244	3130 [80]	Bronze Age
25	Deokcheonri	35°45'N, 129°11'E	SNU06-152	2950 [60]	Bronze Age
26	Hwacheonri	35°47'N, 129°08'E	SNU06-164	2960 [50]	Bronze Age
27	Naju-iam	35°02'N, 126°43'E	SNU06-349	3070 [50]	Bronze Age
28	Sinmaeri	37°55'N, 127°42'E	SNU06-434	4160 [60]	Neolithic
29	Yongdudong	35°02'N, 126°43'E	SNU06-574	3150 [80]	Bronze Age
30	Sinhwari	35°34'N, 129°08'E	SNU06-691	2900 [60]	Bronze Age
31	Undongcho	36°39'N, 127°29'E	SNU06-872	3050 [60]	Bronze Age
32	Sacheonri	38°34'N, 128°23'E	SNU06-897	3040 [50]	Bronze Age
33	Hyunnammyeon	37°55'N, 128°42'E	SNU06-986	2980 [50]	Bronze Age
34	Jucheon	37°11'N, 128°15'E	SNU06-1138	3860 [60]	Neolithic
35	Hyocheon	35°10'N, 126°51'E	SNU06-1027	4130 [50]	Neolithic
36	Jaecheonri	36°30'N, 127°14'E	SNU06-1082	2960 [60]	Bronze Age
37	Duri	36°41'N, 126°44'E	SNU06-1102	2950 [50]	Bronze Age
38	Sudangri	36°07'N, 127°30'E	SNU06-1130	3020 [80]	Bronze Age
39	Seongnaeri	36°52'N, 126°59'E	SNU06-1132	4510 [50]	Neolithic
40	Taechangdong	37°20'N, 127°55'E	SNU06-1175	3050 [60]	Bronze Age
41	Deokcheonri	35°51'N, 129°13'E	SNU07-042	3010 [60]	Bronze Age
42	Weondong	36°00'N, 129°22'E	SNU07-051	2950 [60]	Bronze Age
43	Bihadong	36°39'N, 127°29'E	n/a	4180 [60]	Unidentifiable
44	Kosung	38°34'N, 128°24'E	SNU07-122	3940 [60]	Neolithic
45	Kosung	38°34'N, 128°24'E	SNU07-128	2900 [50]	Bronze Age
46	Keoduri	37°52'N, 127°46'E	SNU07-196	2970 [50]	Bronze Age
47	Oesampori	37°45'N, 127°58'E	SNU07-209	3340 [60]	Bronze Age
48	Oesampori	37°45'N, 127°58'E	SNU07-07-208	4470 [50]	Neolithic
49	Donghwari	37°13'N, 126°58'E	SNU07-225	2860 [50]	Bronze Age
50	Donghwari	37°13'N, 126°58'E	SNU07-225	3420 [60]	Unidentifiable

Table 1 Korean Neolithic and Bronze Age  $^{14}\text{C}$  dates used in this study. (Continued)

Nr	Site	Coordinates (lat, long)	Lab code	Date (BP)	Culture
51	Haksori	36°44'N, 127°29'E	SNU07-242	3300 [80]	Bronze Age
52	Kanghwa	37°45'N, 126°29'E	SNU07-283	3300 [50]	Unidentifiable
53	Hyocheon	35°10'N, 126°51'E	SNU07-312	3060 [50]	Bronze Age
54	Kihung-up	37°17'N, 127°07'E	SNU07-462	4340 [60]	Neolithic
55	Pajudangdong	37°49'N, 127°31'E	SNU07-525	3390 [100]	Neolithic
56	Yunhari	37°49'N, 127°31'E	SNU07-543	3090 [60]	Bronze Age
57	Ungokdong	34°59'N, 126°42'E	SNU07-680	3680 [50]	Unidentifiable
58	Kangdong waterpark	35°37'N, 129°25'E	SNU07-713	3010 [50]	Bronze Age
59	Kwandongri	35°10'N, 128°48'E	SNU07-754	3270 [60]	Unidentifiable
60	Bugok	35°26'N, 128°36'E	SNU07-746	2920 [70]	Bronze Age
61	Hwaengsan	35°00'N, 126°43'E	SNU07R-039	3060 [60]	Bronze Age
62	Cheoljeong	37°49'N, 127°59'E	SNU03-840	3840 [50]	Bronze Age
63	Jangeumdong	37°27'N, 126°42'E	SNU07R-110	3640 [60]	Bronze Age
64	Bangnaeri	37°52'N, 128°50'E	SNU07R-127	3100 [60]	Bronze Age
65	Yungjong	35°30'N, 126°32'E	SNU08R-097	3370 [50]	Bronze Age
66	Yungjong	35°30'N, 126°32'E	SNU08R-094	4490 [60]	Neolithic
67	Kayundong	37°23'N, 127°55'E	SNU08-003	3400 [50]	Bronze Age
68	Sangindong	35°50'N, 128°32'E	SNU08-029	3140 [50]	Bronze Age
69	Deoksinri	35°26'N, 129°19'E	SNU08-175	3090 [60]	Bronze Age
70	Oekwangri	35°26'N, 129°15'E	SNU08-187	2920 [60]	Bronze Age
71	Oekwangri	35°26'N, 129°15'E	SNU08-189	3700 [60]	Unidentifiable
72	Neonggokdong	37°22'N, 126°49'E	SNU08-256	3060 [50]	Bronze Age
73	Neonggokdong	37°22'N, 126°49'E	SNU08-244	4520 [80]	Neolithic
74	Yuknaeri	37°50'N, 128°03'E	SNU04-703	3890 [50]	Neolithic
75	Tongsanmdong	35°05'N, 129°04'E	SNU00-86-1	3800 [60]	Neolithic
76	Galmeori	37°47'N, 127°18'E	SNU01-143	3650 [40]	Neolithic
77	Galmeori	37°47'N, 127°18'E	SNU01-139	4200 [100]	Neolithic
78	Konamri	36°25'N, 126°24'E	SNU99-016	3300 [130]	Unidentifiable
79	Konamri	36°25'N, 126°24'E	SNU99-017	3990 [60]	Neolithic
80	Ulwangri	37°27'N, 126°23'E	SNU02-462	3810 [40]	Neolithic
81	Nambukdong	37°27'N, 126°25'E	SNU02-455	3500 [40]	Neolithic
82	Nambukdong	37°27'N, 126°25'E	SNU02-457	4440 [50]	Neolithic
83	Yeondang Cave	37°11'N, 128°24'E	SNU04-409	3520 [80]	Neolithic
84	Noraeseom	35°58'N, 126°44'E	SNU00-245	3980 [40]	Neolithic
85	Okbang	35°14'N, 127°58'E	SNU00-48	4290 [30]	Neolithic
86	Okbang	35°14'N, 127°58'E	SNU00-44	3280 [30]	Bronze Age
87	Nundul	37°29'N, 126°32'E	SNU00-139	4480 [30]	Neolithic
88	Yonghodong	36°26'N, 127°27'E	SNU00-259	4200 [100]	Neolithic
89	Jeongcheon	35°47'N, 127°25'E	SNU01-184	3700 [100]	Neolithic
90	Sangchon	35°13'N, 127°58'E	SNU01-303	4150 [60]	Neolithic
91	Tonghodong	35°58'N, 128°34'E	SNU01-395	3760 [40]	Unidentifiable
92	Tonghodong	35°58'N, 128°34'E	SNU02-477	4700 [40]	Neolithic
93	Tonghodong	35°58'N, 128°34'E	SNU01-393	3020 [150]	Bronze Age
94	Hahwageri	37°42'N, 127°51'E	SNU02-319	4450 [60]	Neolithic
95	Hahwageri	37°42'N, 127°51'E	SNU02-213	3630 [110]	Neolithic
96	Sammokdo	37°29'N, 126°32'E	SNU03-261	4310 [50]	Neolithic
97	Salnae	35°30'N, 128°45'E	SNU03-296	4960 [40]	Neolithic
98	Salnae	35°30'N, 128°45'E	SNU03-287	3000 [60]	Bronze Age
99	Hwaderi	37°58'N, 127°21'E	SNU03-342	4870 [40]	Neolithic
100	Oido Salmag	37°19'N, 126°49'E	SNU99-128	4270 [60]	Neolithic
101	Oido Anmal	37°19'N, 126°49'E	SNU03-635	4690 [60]	Neolithic
102	Naehungdong	36°00'N, 126°46'E	SNU03-899	3880 [60]	Neolithic
103	Osanni	38°05'N, 128°40'E	n/a	4230 [50]	Neolithic
104	Sugari	35°10'N, 128°52'E	N-3456	4170 [90]	Neolithic

Table 1 Korean Neolithic and Bronze Age  $^{14}\text{C}$  dates used in this study. (Continued)

Nr	Site	Coordinates (lat, long)	Lab code	Date (BP)	Culture
105	Amsadong	37°33'N, 127°08'E	U of Washington	3430 [250]	Neolithic
106	Amsadong	37°33'N, 127°08'E	KAERI	4610 [200]	Neolithic
107	Sonyudo	35°48'N, 126°21'E	AERIK	4812 [45]	Neolithic
108	Sandaldo	35°28'N, 128°36'E	KSU-618	4440 [40]	Neolithic
109	Chodo	35°11'N, 129°05'E	n/a	4190 [120]	Neolithic
110	Soyado	37°15'N, 126°12'E	n/a	3750 [40]	Neolithic
111	Taehuksando	34°30'N, 125°15'E	n/a	3240 [120]	Neolithic
112	Sido	37°29'N, 126°23'E	AERIK	2870 [60]	Neolithic
113	Yangyang Chikyeongni	37°55'N, 128°48'E	Beta 120739	4420 [60]	Neolithic
114	Yangyang Gapyeongni	38°05'N, 128°39'E	KOP-144	4240 [60]	Neolithic
115	Songsanni	36°48'N, 127°35'E	SNU08-432	3730 [60]	Unidentifiable
116	Songsanni	36°48'N, 127°35'E	SNU 08-434	4770 [60]	Neolithic
117	Seomyun	37°55'N, 127°43'E	SNU00-02.F.17	3200 [50]	Bronze Age
118	Youngnam	36°05'N, 129°20'E	SNU00-31.PC-6	3300 [50]	Bronze Age
119	Noeun	36°22'N, 127°18'E	SNU00-196	3000 [70]	Bronze Age
120	Seobyundong	35°54'N, 128°32'E	SNU00-274	3190 [40]	Bronze Age
121	Gwanyangdong	37°24'N, 126°58'E	SNU01-354	2950 [60]	Bronze Age
122	Jukjeon	37°19'N, 127°07'E	SNU02-034	2920 [80]	Bronze Age
123	Angol	37°26'N, 126°49'E	SNU02-042	2830 [30]	Bronze Age
124	Okgok	35°48'N, 128°44'E	SNU03-254	3070 [40]	Bronze Age
125	Salnae	35°30'N, 128°45'E	SNU03-287	3000 [60]	Bronze Age
126	Tongsamdong level B	35°05'N, 129°04'E	GX-0492	3400 [215]	Bronze Age
127	Osanni layer 1	38°05'N, 128°40'E	KSU?	3360 [180]	Bronze Age
128	Sugari	35°10'N, 128°51'E	N-3453	3290 [70]	Bronze Age
129	Yangsuri	37°33'N, 127°19'E	KAERI-95	3900 [200]	Bronze Age
130	Kumgokdong	35°15'N, 129°00'E	N-2135	3580 [75]	Bronze Age
131	Tongnae	35°12'N, 129°05'E	AERIK-3	3570 [80]	Bronze Age
132	Namdongri	34°50'N, 128°36'E	AERIK -7	3573 [50]	Bronze Age
133	Hunamni	37°14'N, 127°41'E	KAERI-70	3210 [70]	Bronze Age
134	Songsanni	36°48'N, 127°35'E	SNU08-426	3070 [50]	Bronze Age
135	Songwonni	36°28'N, 127°15'E	SNU08-382	2950 [50]	Bronze Age
136	Bokseongni	34°57'N, 127°33'E	SNU02-122	3400 [40]	Bronze Age
137	Hadang	36°35'N, 127°41'E	SNU02-448	3370 [50]	Unidentifiable
138	Sandanni	36°35'N, 127°21'E	SNU02-449	4490 [70]	Neolithic
139	Yongsandong	36°25'N, 127°24'E	SNU02-266	3910 [110]	Neolithic
140	Yongsandong	36°25'N, 127°24'E	SNU02-267	3380 [80]	Unidentifiable
141	Kogangdong	37°32'N, 126°47'E	SNU02-360	3010 [40]	Bronze Age
142	Daedeok	36°21'N, 127°25'E	SNU02-395	4250 [50]	Neolithic
143	Sinpungri	34°48'N, 126°51'E	SNU02-712	3000 [80]	Bronze Age
144	Sinpungri	34°48'N, 126°51'E	SNU02-713	4680 [70]	Neolithic
145	Yuljeon	37°18'N, 126°58'E	SNU03-212	3160 [60]	Bronze Age
146	Numnae	35°38'N, 128°44'E	SNU03-242	3010 [60]	Bronze Age
147	Damyang	35°19'N, 126°59'E	SNU04-319	3880 [30]	Unidentifiable
148	Damyang	35°19'N, 126°59'E	SNU04-320	3210 [40]	Bronze Age

We present some representative examples of how we analyzed the Korean data.

#### Example 1: Saneung-Hopyeong Site (Figure 2)

This site contains both Neolithic and Bronze Age settlement periods. The date 3500 BP represents the Neolithic period and is one of the latest Neolithic dates in Korea. The Bronze Age date of 2800 BP is not used since it is too late for the present study.

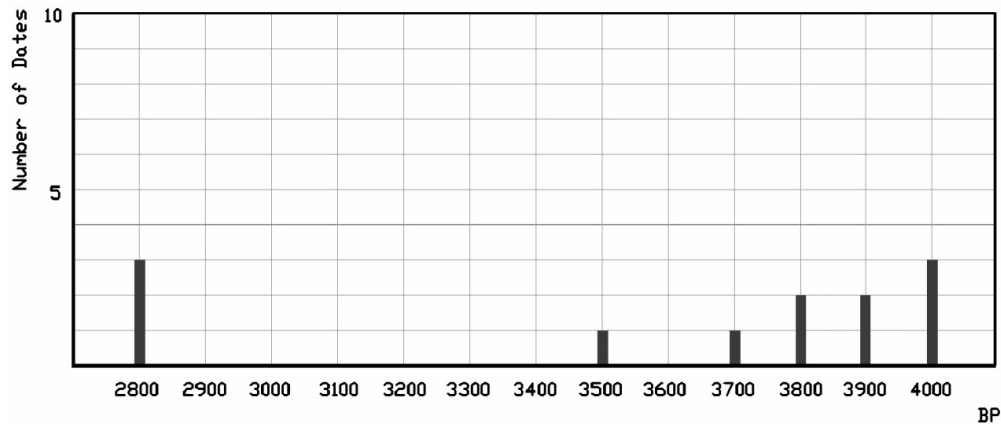


Figure 2  $^{14}\text{C}$  dates distribution of the Saneung-Hopyeong site

### Example 2: Siheung Neungmok-dong Site (Figure 3)

Two settlements are separated by a ~1500-yr hiatus. We take 2 representative dates from these 2 settlements, 3000 BP for the Early Bronze Age and 4500 BP for the Late Neolithic.

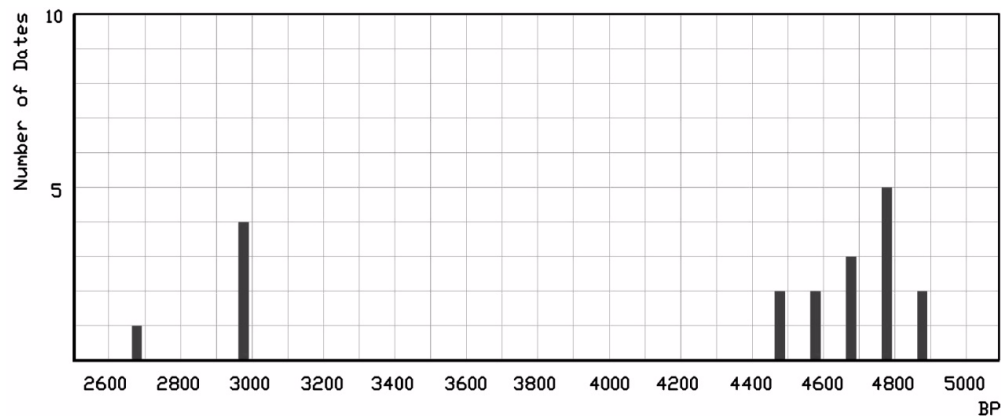


Figure 3  $^{14}\text{C}$  dates distribution of the Siheung Neungmok-dong site

### Example 3: Sinmaeri Site (Figure 4)

Two Late Neolithic settlements with  $^{14}\text{C}$  dates of 4100 and 4800 BP, respectively. These 2 settlements are well separated with a ~700-yr hiatus in between. The Bronze Age date of 2700 BP is not used since it is beyond the scope of the present study.

### Example 4: Janggeum-dong Shellmound (Figure 5)

This Bronze Age site is located in Incheon, a Yellow Sea coastal city due west of Seoul. The site is a shellmound and samples used for dating were charcoal fragments excavated from the shellmound. The date 3600 BP was chosen as representative for this settlement and is one of the earliest Bronze Age dates.

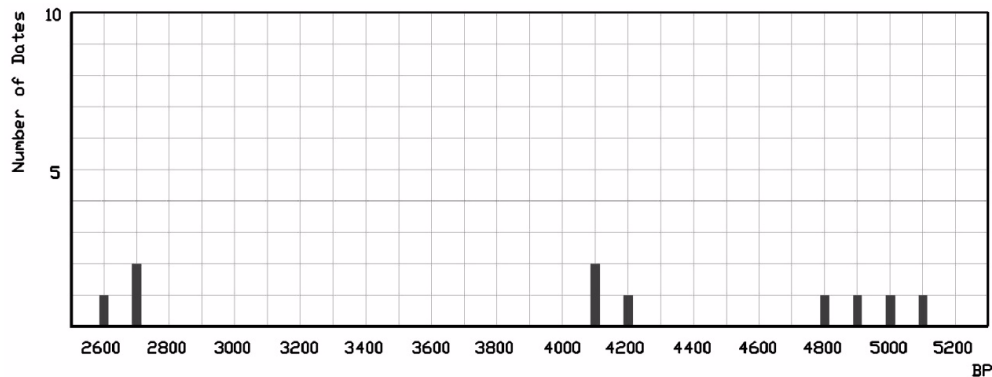


Figure 4 <sup>14</sup>C dates distribution of the Sinmaeri site

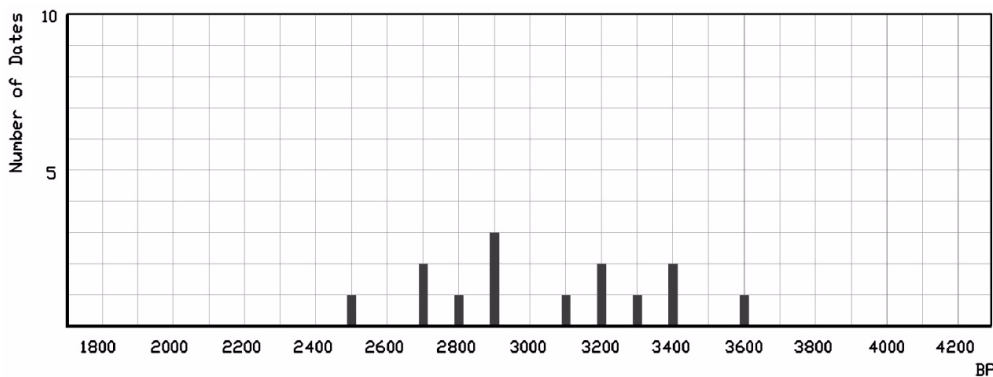


Figure 5 <sup>14</sup>C dates distribution of the Jangeun-dong shellmound

### Example 5: Cheoljeong Site (Figure 6)

The earliest Bronze Age site is reported from the inland Kangwon Province area. We interpret this site as a continuous Bronze Age settlement beginning at 3800 BP and lasting up to 1900 BP. The date 3800 BP could have been anomalous, but since the 2 <sup>14</sup>C dates are concordant, we interpret this age to be representative for this Bronze Age settlement. The date 3800 BP marks the upper boundary of the incipient Bronze Age together with the date of 3600 BP of Jangeun-dong mentioned above.

## RESULTS AND DISCUSSION

Figure 7 shows the distribution histogram of representative dates for the 148 settlements. In this histogram, all BP values were truncated in units of 100 yr. Three different bars represent the Neolithic, Bronze Age, and Neolithic-Bronze Age, respectively, with each bar shaded differently. Settlements not clearly identifiable as either Neolithic or Bronze Age were denoted as “Neolithic-Bronze Age,” and the <sup>14</sup>C dates for these settlements were usually regarded as outliers. As evidenced in Figure 6, although the Bronze Age is clearly observed by ~3000 BP, the inception of the Bronze Age may have started as early as about 3800–3900 BP. This early age for the beginning of the Bronze Age in Korea would make the Korean case contemporary to those of the Longshan and Erlitou Bronze Age cultures in China (Lu and Yan 2005; Shao 2005).

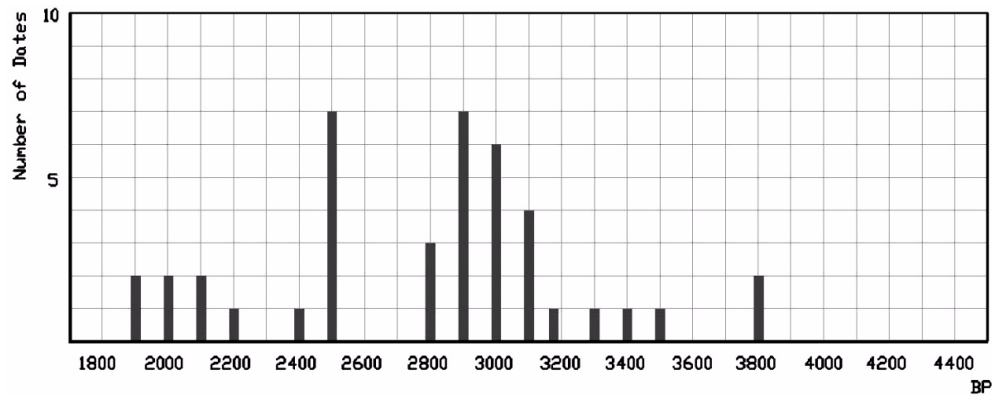
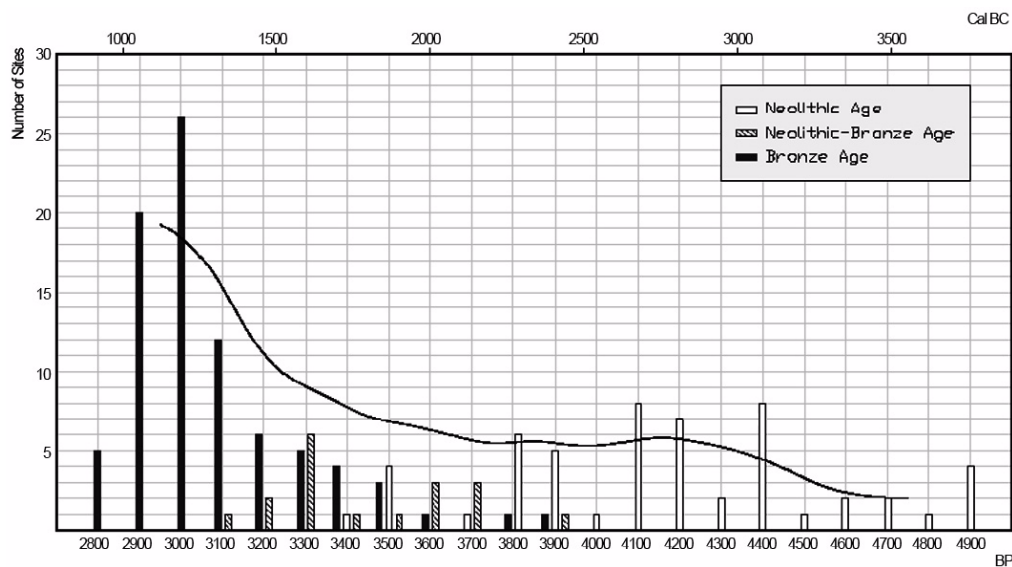
Figure 6  $^{14}\text{C}$  dates distribution of the Cheoljeong site

Figure 7 Distribution histogram of representative dates for the 148 settlements

Further support for an earlier Neolithic-Bronze Age transition in Korea can be found in archaeological sites in the Tumen River basin (North Korea) and neighboring regions. For example, Incipient Bronze Age settlements have been identified in the Yanbian area in Jilin Province in China and the Southern Primorye region of Russia, which have been dated to about 4000 and 3500 BP (Kang 2007). This is comparable to the dates for the Korean Neolithic-Bronze Age transition period observed in the present study.

The solid line in Figure 7 is a smoothed curve denoting the total number of settlements as a function of years BP and could be interpreted in terms of trends in population growth and decline. It is interesting to note that there are 2 major increases in this curve during the Neolithic-Bronze Age transition. The first one, a slight increment, occurs at ~4500 BP. The second increase begins at ~3700 BP and triples by 3000 BP. The second one is due to the gradual growth of the Incipient Bronze Age cul-



ture, which began around 3800–3900 BP, and is therefore associated with the Neolithic-Bronze Age transition in Korea.

In some  $^{14}\text{C}$ -based demographic studies, the number of settlements was weighted by settlement duration. For example, Fiedel and Kuzmin (2007) segmented each settlement into 1000- $^{14}\text{C}$  yr intervals and the number of occupancy (number of centroids) is weighted accordingly. Settlements in the Neolithic-Bronze Age transition in the Korean Peninsula have a duration ranging from about 100 to 1000 yr. These duration times are just in the range of the old-wood effect. Therefore, it could be disputable to associate the measured  $^{14}\text{C}$  date spreads with the actual duration time of the settlement. Furthermore, duration times for most of sites in the present study have not been determined yet. For this reason, the duration time has not been taken into account in our analysis above.

## CONCLUSIONS

From the present compilation, we find that the Neolithic-Bronze Age transition in the Korean Peninsula began as early as ~2300 BC and continued over the course of 800–900 yr with peaks representing population increases occurring 2–3 times. Compared with cases of transition to farming in other regions of the world (Hanson 2000), the Neolithic-Bronze Age transition in Korea was similar in both magnitude and transition duration. However, the Korean transition occurred about 2000 yr later. Thus, we find that the attempt to explain the Neolithic-Bronze Age transition as a migration hypothesis based only on a sudden population increase in Korea is not tenable.

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