Astronomical signs of Korean tombs

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<Abstract>

Korea has a long tradition of depicting constellations on the ceiling and walls inside tombs. It is reported that 25 Goguryeo and 9 Goryeo tombs have mural star paintings such as the Sun, the Moon, and 28 oriental major constellations. In particular two Goguryeo tombs of Deokwhari #2 and Jinpari #4 are known to have the whole 28 oriental constellations with various sizes of star. Dolmens are representative tombs of the Bronze age in Korean peninsula and Korea has the greatest number of dolmens in the world. It is known that many European and northern Korean dolmens have astronomical aspects such as alignment of chambers to the sunrise (South-East), and constellation-like cup-marks. Recently dolmens in southern Korea are being studied in astronomical aspects. It is reported that cup-marks in Korean dolmens are generally carved at the South-East direction on the cover stone regardless of the direction of long-axis of cover stone. And many patterns of cup-marks depicting constellations are found in southern dolmens.

I. Introduction

Korea has a long history of astronomy and there remains various and amount astronomical relics. For a long time, Korean saw heavens on the observatories and recorded amount astronomical phenomena in their history books such as Samguksagi (三國史記), Goryeosa (高麗史), Joseonwangjosillok (朝鮮王朝實錄) and so forth. These history books contain various astronomical records such as solar and lunar eclipses, meteor, comet, guest star, sunspot, aurora, motion of planets and so forth. Table 1 shows the representative Korean astronomical heritage.

Korea also has a long history of constellation maps. Most notable one is the stone star chart, Cheonsangyeolchabunyajido (天象列次分野之圖), which was carved upon a stone slab in A.D. 1395, the early Joseon dynasty. The map contains 1,467 stars with various sizes and individual stars are engraved in such a way that its area is linearly proportional to the visual magnitude (Yang 2009; Park 1998). According to the description of the star chart, the chart based on an astronomical chart from Goguryeo (37B.C.~A.D.688) that had been sunk in the river in Pyeongyang (平壤) during the war. Park (1998) statistically analyzed the position of stars and found that the epochs of the stars are mixed around first and fourteenth centuries. Most stars with declination lower than 50 degrees are represent the night sky of the first century, the era of Goguryeo, while stars

located higher than 50 degrees are positioned to represent the epoch close to the fourteenth century, the era of early Joseon dynasty.

Prior to the Joseon dynasty, many constellations remain in tombs. Nine Goryeo (高麗) tombs and twenty four Goguryeo (高句麗) tombs have star paintings on the walls and ceilings (Park & Yang 2009; Park 2008). Goguryeo tombs have various astronomical paintings such as the Sun, the Moon, stars, and constellations (Kim 1996; Yang & Park 2003; Park & Yang 2009). In particular, two of Goguryeo tombs and one Goryeo tomb seem to have paintings of the whole oriental 28 constellations.

In prehistoric period, some astronomical signs are discovered in Korean dolmens. Dolmens are representative megalithic monuments of Korean Bronze age and they are scattered around the Korean peninsula. Although dolmens are abundant in Asia, Europe, and North Africa, Korea has the greatest number in the world. While dolmens are studied in the viewpoint of archaeology, there have been few researches about dolmens in the viewpoint of astronomy. Meanwhile, European and north-Korean scholars reported that dolmens have astronomical signs. Recently it also reported that some dolmens in southern Korea have astronomical meanings.

In this paper, I will introduce the Korean mural star paintings and astronomical aspect of Korean dolmens. I found some star-like patterns of cup-marks in dolmens such as Big Dipper, Sagittarius, Pleiades, Corona Borealis and so forth. The results will be published in somewhere.

Table 1 Representative Korean astronomical heritage (Park 2008)

Dates	Period	Astronomical Heritage
30CB.C.~ A.D.2C	Stone, Bronze & Iron Ages	Petroglyphs Directions and constellations of dolmens
24CB.C. ~ 2CB.C.	Dangun Joseon, Gija Joseon & Wiman Joseon	12 records on astronomical phenomena Chamseongdan obs. in Mt. Mari, Gangwhado
57B.C. ~ A.D. 935 37B.C. ~ A.D. 668 18B.C. ~ A.D. 660 A.D. 689 ~ 926	Silla (新羅) Goguryeo (高句麗) Baekje (百濟) Balhae (渤海)	Over 240 astronomical records in Samguksagi 25 Goguryeo tombs with star paintings Cheomseongdae obs. in Gyeongju Relics such as sundial and 12 zodiacal statues
AD. 918 ~ 1392	Goryeo (高麗)	Over 5,000 astronomical records in Goryeosa Cheomseongdang obs. in Gaeseong 9 Goryeo tombs with star paintings
A.D. 1392 ~ 1910	Joseon (朝鮮)	Over 20,000 astronomical records in history books Relics such as armillary sphere, celestial spheres, etc Sundials and clepsydrae and astronomical clocks Astronomy books Stone star chart, the Cheonsangyeolchabunyajido

II. Prehistoric star markings

Dolmens are most typical megalithic monuments of Korea's prehistoric period. It is known that Dolmen is the representative tomb of Korea Bronze age, and human bones and burial accessories were discovered in an underground burial chamber. Although Korea has a largest number of dolmens in the world, there are few researchers on the dolmens in the viewpoint of astronomy. Astronomical researches on the dolmens are generally focused on the direction of chambers and pattern of constellation-like cup-marks which are carved on the cover stone of dolmens.

Meanwhile, there are various studies for astronomical aspects on dolmens in Europe. One of the nineteenth-century accounts of the Panorama Stones on Ilkley Moor by Nathan Heywood proposed that simple cup-marks represent the fixed stars, and the concentric circle means the planets, with the rings intended to give the appearance of motion (Hadingham 1975). Brown (1921) reported constellations such as Ursa Major, Ursa Minor, Corona Borealis, and Hercules from the cup-marks at the Sin Hinny and Rothiemay stones in England. Schönfeld (1921) found astronomical signs from Scandinavian cup-marks such as the Ursa Major, Bootes, Gemini, Leo, Lynx, Orion, Virgo, and the Milky Way. Most of these astronomical patterns were identified through eye-fitting method. It has been known that the entrance of a lot of chambers in European dolmens are oriented to the direction of sunrise, the South-East (Hoskin 1997; Belmonte 1998).

In northern Korea, it is reported that several dolmens have astronomical marks. There are about 200 dolmens with cup-marks and 18 of them have pattern of constellation-like cup-marks such as Ursa Major, Ursa Minor, Corona Borealis, Draco, Virgo, Cepheus, and so forth (Kim 1996; Lee 1996; 朝鮮技術發展史 1996). Most well-known dolmens with constellation-like cup-marks are located in Wonwha-ri, Pyeongwon (平原) and Jiseok-ri, Hamju (咸州). Cup-marks in the two dolmens are identified with several constellations around circumpolar circle. Figure 1 shows the drawings of two dolmens and cup-marks on the dolmens depict several constellations. Fig. 1(a) is the Wonwha-ri dolmen and 1(b) is the Jiseok-ri dolmen. On the other hand, Kim (1996a) estimated the epoch of dolmens based on precession of the stars compare to the center of dolmens which is considered to be the north pole of their own period. Table 2 shows list of dolmens with constellation-like cup-marks and estimated epoch of the dolmens in northern Korea.

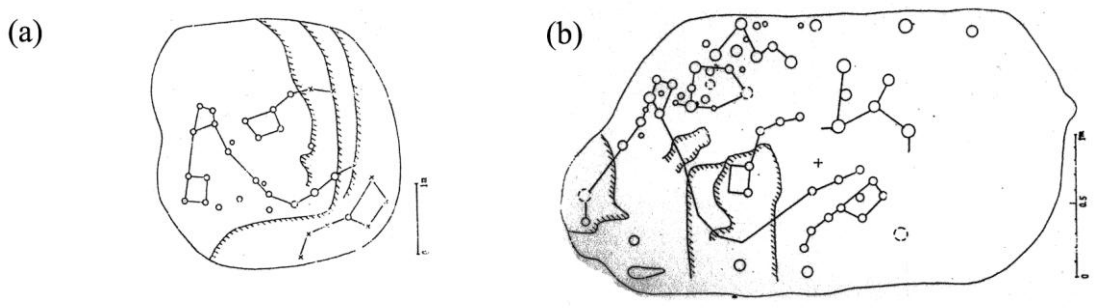

Fig. 1 Dolmens with cup-marks depicting constellations in northern Korea. (a) Wonhwa-ri dolmen in Pyeongwon-gun and (b) Jiseok-ri dolmen in Hamju-gun (朝鮮技術發展史 Ⅰ 1996).

Table 2. Dolmens with constellation-like cup-marks in northern Korea (Kim 1996a; Yang 2004)

Dolmen	No. of cup-mark	Identified constellations	Estimated epoch
Jiseok	58	Ursa Major, Ursa Minor, Draco, Cassiopeia, Cepheus	~3000 B.C.
Ryongdeok 10	68	Ursa Major, Ursa Minor, Corona Borealis, Cepheus	2879 ± 215 B.C
Sangwon 703	5	Corona Borealis	2703 B.C.
Euncheon 11	63	Gemini, Auriga, Aries, Taurus, Pleiades*	2603 B.C.
Sangwon 26	27	Bootes, Corona Borealis, Ursa Major, Virgo, Leo	2503 B.C.
Anak 2	64	Lyra, Pegasus, Aries, Taurus	2503 B.C
Sangwon 19	30	Sagittarius	2503 B.C
Sinyang 1	14	Taurus	2503 B.C
Wonhwha	26	Ursa Minor, Draco, Ursa Major (?)	~2500 B.C.
Euncheon 24	43	Draco, Ursa Major, Corona Borealis	2203 B.C.
Sinyang 3	16	Virgo	2203 B.C.
Gangdong 1	13	Ursa Major, Draco	2083 B.C.
Sangweon 2	71	Ursa Major, Virgo, Draco	2083 B.C.
Eunryul 3	6	Corona Borealis	2003 B.C.
Euncheon 3	28	Ursa Major, Ursa Minor, Draco	1947 ± 215 B.C.
Maengsan 1	28	Auriga	1803 B.C.
Gangdong 1	13	Cepheus	1703 B.C.
Euncheon 1	134	Aquila, Lyra, Draco, Ursa Minor, Gemini, Orion	1203 B.C.

In southern Korea, Lee (1975) first suggested that small holes on a stone plate which was discovered near Ahdeugi dolmen at Cheongwon can represent stars. However, he did not identify the holes with constellations. The stone plate has 65 holes with various sizes. Park et al (2001) analyzed the holes in the stone plate and identified some holes with parts of constellation of Big Dipper, Ursa Minor, Ursa Major, Draco and Cassiopeia using quantitative analysis. Figure 2 shows the holes (cup-marks) and patterns of constellation. The constellations in Fig. 2 are mirror images.

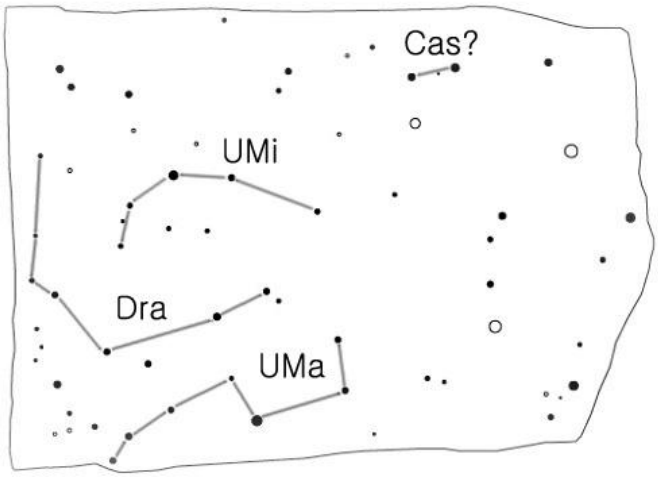

Fig. 2 The schematic figure of stone plate that was discovered underground near the Ahdeugi dolmen. Some holes have been identified with Ursa Major, Ursa Minor, Draco, and Cassiopeia using quantitative analysis (Park et al. 2001). This figure is a mirror image.

Recently Yang et al (2010) investigated Korean dolmens in the viewpoint of astronomy though most of dolmens had been investigated in geographical investigations in Korea. Yang et al searched all literatures related with dolmen in the library of Seoul National University and found total of about 300 dolmens with cup-marks from 202 regions and 7 menhirs, 24 natural rocks, 6 stone monuments, and 2 stone plates with cup-marks.

In order to investigate the astronomical direction in Korean dolmens, they examined the direction of cover stones and cup-marks. In some European dolmens, South-East direction of entrance of chamber is known to be an astronomical direction in the period of megalithic culture. However, it is difficult to confirm the direction of chambers in Korean dolmens because most chambers are being buried underground under a huge cover stone. Meanwhile most cover stones of dolmens have a long- axis and the direction of cover stone seems to be related to the direction of buried chamber. Thus, they examined the direction of cover stones instead of the direction of chambers.

Yang et al (2010) have carried out 27 times of field surveys during two years. They examined direction of cup-marks of 120 dolmens and direction of long-axis of 135 dolmens from the surveyed dolmens. Figure 3 shows the numbers and distribution of Korean dolmens with cup-marks. Particularly, they investigated dolmens in Haman (咸安) and Gyeongju-Angang (慶州-安江) regions because they are high density regions of dolmens and most of their dolmens have cup-marks. They found special dolmens that have concentric ring-shaped grooves or that have a few hundred cup-marks all over the stone in Haman. A few dolmens have 29 cup-marks, forming a shape of "⊕". This pattern of cup-marks is interpreted as a symbol of 28 oriental constellations or the scene of a Yut game, which is a Korean traditional board game (Rhee 2003; Song 2003; Kim 2003).

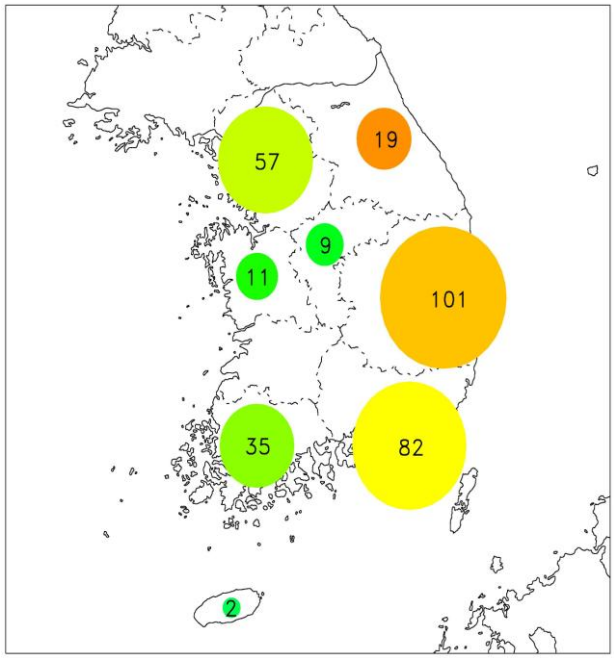

Fig. 3 The numbers and distribution of dolmens with cup-marks in Korea (Yang et al. 2010)

As a result, there are no conspicuous directions for the whole dolmens. In order to understand regional propensities of direction of long-axis of cover stones, Yang et al examined dolmens in two regions; Haman and Gyeongju-Angang. The two regions have abundant well-reserved dolmens. They found outstanding direction of long-axis of cover stone for each region. Dolmens in Haman have a notable direction of 160°, whereas the dolmens in Gyeongju-Angang have a 100° for their long axis of cover stone.

Thus, they investigate the relationship between the arrangement of dolmens and the configuration of ground for the dolmens in Haman. They surveyed the long-axis of cover stone of thirty-six dolmens. The location of dolmens can be grouped into three cases: located at the ridge of a mountain, located on the side of a river, and located between a ridge and a river. They investigated the arrangement of dolmens on those three cases of topography. From the analysis of location for the dolmens in Haman, they found that the direction of long-axis of dolmens located at the ridge is strongly related with the topographical direction; the cover stones are generally placed parallel with the ridge of mountains. They also found that the conspicuous direction of 160° for the long-axis of cover stones in Haman is caused by the configuration of ground around the dolmen.

On the other hand, they investigated the direction of cup-marks from the center of cover stone. They surveyed 120 dolmens with cup-marks and measured the direction of cup-marks for the 90 dolmens. Dolmens being moved from the original location or dolmens with cup-marks distributed evenly on the cover stone are excluded. The most conspicuous direction of cup-marks is 150°. This direction of cup-marks differs from that of the long-axis of cover stone. It is

sometimes difficult to determine one representative direction of cup-marks for a dolmen because dolmens have various numbers and patterns of cup-marks. Figure 4(a) shows the distribution of representative direction of cup-marks and figure 4(b) shows distribution of cup-marks by the weight value that evaluated by the concentration ratio and number of cup-marks.

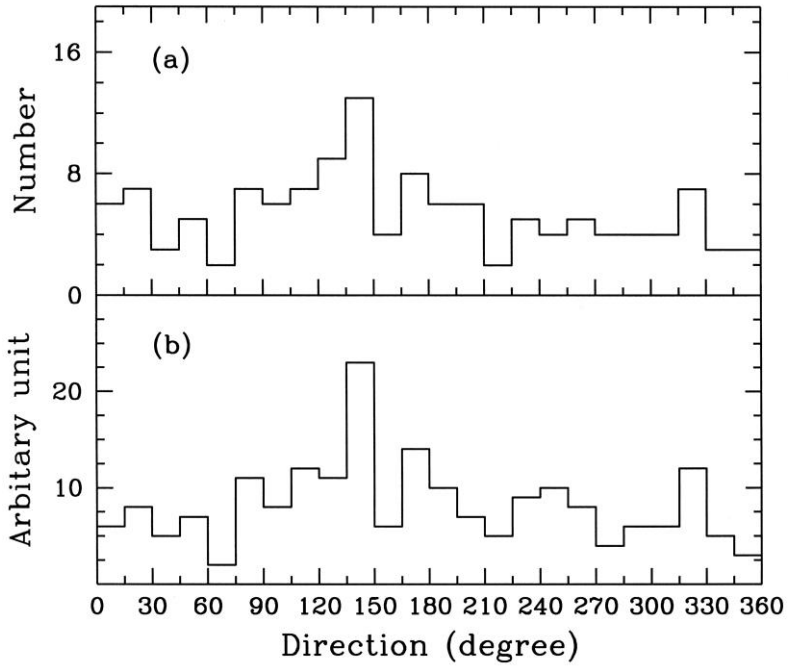

Fig. 4 Distributions of representative direction of cup-marks in Korean dolmens. (a) shows number distribution of dolmens by their each representative direction of cup-marks. (b) shows distribution of cup-marks by the weight value that is evaluated by the concentration ratio and number of cup-marks. (Yang 2004; Yang et al 2010)

III. Star paintings in Goguryeo and Goryeo tombs

It is well known that many Goguryeo (高句麗) tombs contain star paintings. From 1950s to 1990s several Japanese and north Korean scholars studied star paintings in Goguryeo tombs. Particularly north Korean Ree (1981a;1981b;1984) studied mural star paintings in Goguryeo tombs. Ree (1981a;1981b) identified mural star paintings on the ceiling with 28 oriental constellations in Deokwhari #2 (A.D. 5C) and Jinpari #4 (A.D. 6C) tombs. Recently Hirai (2003) tried to identify ceiling star paintings with modern constellations using numerical method for the Japanese Outsuka Decorated tomb (王塚裝飾古墳) and Jinpari #4 tomb of Goguryeo. Meanwhile, the earliest relic depicting the 28 oriental constellations is a lacquered box dating to the around B.C. 5C found in the Zeonghouyimu (曾侯乙墓) in Hubei (湖北).

South Korean scholars studied astronomical aspects in Goguryeo mural paintings after 1990s and found many constellations as well as the Sun, the Moon. Kim (1996, 1998) introduced north

Korean researches for the Goguryeo mural star paintings and tried to identify most star paintings with modern constellations. Recently Park & Yang (2009) also identified most star paintings with modern constellations and found some erroneous identification of Kim (1996)'s result. Park & Yang first suggest constellation system of Goguryeo tombs, which differ from the traditional oriental constellations system in terms of the location of constellations in East and West directions.

Oriental traditional astronomy has a different constellation system from modern one. Oriental constellation system is composed of 3 regions and 28 major constellations (3垣 28宿) and the 28 major constellations have been assigned the four cardinal directions. Each direction contains seven constellations and the each seven constellation generally have been described in four mythical oriental animals, a tiger, a dragon, a phoenix, and a tortoise twined by a snake. Meanwhile, using the Joseon astronomical book, Cheonmunryucho (天文類抄), Yang & Park (2003) reconstructed Korean animal sky map based on the four mythical animals and Ki-Rin (麒麟, oriental mythical giraffe) from Goguryeo mural paintings and 28 oriental major constellations in Cheonsangyeolchabunyajido (天象列次分野之圖).

Kim (1996) tried to identify star paintings in each direction with corresponding seven constellations. However, Park & Yang (2009) surveyed and compiled 684 stars in 25 Goguryeo tombs and found that the constellations corresponding oriental seven eastern major constellations were painted on the western wall and those of the seven western constellations were painted on the eastern wall. This Goguryeo constellation system made it possible for Sagittarius to be painted on the southern wall while Big Dipper appears in the north. This constellation system remained to be uniform for the all Goguryeo mural star paintings. Jinpari #4 tomb is famous for 136 stars painted with gold. Although North Korean Ree (1981b) and Kim (1996) identified the stars in Jinpari #4 with Big Dipper and 28 major constellations, Park & Yang (2009) confirmed only a few stars from several photographs and could identify Big Dipper and one major constellation, Bi-Su (畢宿). Jinpari # 4 has constellation paintings with mirror image thus Ree's identification showed a reverse allocated constellations. Kim (1996) fundamentally used Ree's reverse schematic identification but the direction of east and west is opposite to Lee's direction while the identification of stars is same with Ree's result. As shown in Deokwhari #2 and Jinpari #4 tombs, many stars were described by various sizes, showing the Korean tradition of indicating the brightness of the stars.

It is known that nine Goryeo (高麗) tombs depict star maps. Most star paintings in Goryeo tombs contain a few constellations such as Big Dipper, The Three stars and so forth. One of Goryeo tombs, which was constructed around 12C, was discovered in Seosamdong, Andong (安東). On the ceiling of the tomb, there are over 150 red circles depicting oriental 28 major constellations and Big Dipper. Most paintings in the tomb have not been identified with modern constellations but some of them well match with oriental 28 major constellations. The tomb also has paintings of four mythical animals inside of four mural walls. Figure 5 shows the depicting mural star paintings on the ceiling of Seosamdong tomb of Goryeo dynasty.

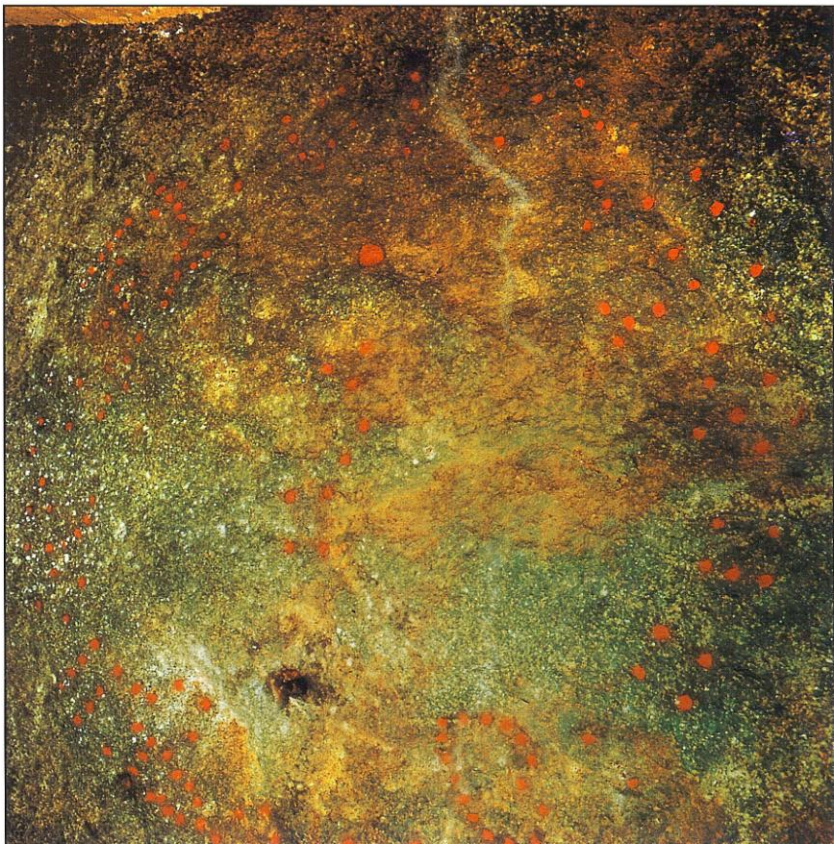

Fig. 5 Mural star paintings on the ceiling of Seosamdong tomb of Goryeo (高麗) dynasty

IV. Summary

Korea has a long history of star maps and a tradition of star paintings inside tombs from Goguryeo to Joseon dynasty. Many mural star paintings were reported and most star paintings in Goguryeo tombs were identified with oriental 28 major constellations as well as the Sun, the Moon and so forth. In particular, Deokwhari #2 and Jinpari #4 of Guguryeo tombs, which were constructed in late 5 century and early 6 century, have star paintings of the 28 oriental major constellations. Moreover, star paintings in both tombs have various sizes, showing the Korean tradition of indicating the brightness of the stars as the various size of stars in Cheonsangyeolchabunyajido (天象列次分野之圖) of Joseon dynasty. Kim (1996) compiled and identified Goguryeo mural star paintings with modern constellations based on the north Korean Ree(1981b)'s result. And recently Park & Yang (2009) also identified most star paintings in 25 Goguryeo tombs with modern constellations and found some erroneous identification of previous researches. Park & Yang (2009) also firstly suggest constellation system of Goguryeo tombs, which differ from the traditional oriental system in terms of the location of constellations in East and West directions.

Dolmens are representative tombs of the Bronze age in Korean peninsula. It was reported that many dolmens in European and northern Korea have astronomical aspects. Korea has the greatest

number of dolmens in the world. Recently Korean dolmens are being studied in the viewpoint of astronomy by Korean scholars. In southern Korea, Lee (1975) firstly suggested that small holes on a stone plate can represent stars. And Park et al (2001) analyzed the holes in the stone plate and identified some holes with parts of constellations of Big Dipper, Ursa Minor, Ursa Major, Draco and Cassiopeia using quantitative analysis. Recently Yang et al (2010) investigated Korean dolmens in the view point of astronomy though most of dolmens had been investigated in geographical investigations in Korea. In order to investigate the astronomical direction in Korean dolmens, they examined the direction of cover stone and cup-marks. Since for some European dolmens, South-East direction of entrance of chamber is known to be an astronomical direction in the period of megalithic culture. They have examined and analyzed the direction of long-axis of 135 dolmens out of 314 dolmens surveyed in total. Overall, there is no notable direction for the long-axis of cover stones in Korean dolmens. However, from the analysis of dolmens in Haman, they found that the long-axis direction of dolmens located at the ridge is generally placed parallel with ridge of mountains. They also have examined the direction of cup-marks carved on the cover stones of 100 dolmens and found that cup-marks in Korean dolmens were generally carved at the South-East direction on the cover stone regardless of the direction of long-axis of cover stone. The South-East direction of cup-marks is in accord with the direction of entrance of chambers in some European dolmens. This direction has known to be related with astronomy that is the direction of sunrise.

Now, it is reported that many patterns of cup-marks look like constellations in Goguryeo tombs. When we study the correlation between patterns of cup-marks and constellations in Goguryeo tombs, we can know more about the prehistoric astronomy in Korean peninsula.

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