Excavations at Emeelt Tolgoi Site: The third Report on Joint Mongolian-Japanese Excavations in Outer Mongolia

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3 The Strontium analysis on the human skeletal remains from the Emeelt Tolgoi Site and Bor Ovoo Site in Bayanhongor, Mongolia

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Introduction

Ericson (1985) first demonstrated that the strontium (hereafter Sr) isotope analyses in human bones and teeth could be used to study aspects of ancient human behavior based on geological and physiological principal. This analysis is based on the Sr isotope (hereafter $^{87}Sr/^{86}Sr$) ratios in soil, groundwater, vegetation, and fauna largely reflect underlying $^{87}Sr/^{86}Sr$ bedrock values. The $^{87}Sr/^{86}Sr$ ratios change little as they pass from weathering rocks, through soil and water, into food chain (Slovak and Paytan, 2011). Humans that eat animals and plants and drink water in the food chain acquire the $^{87}Sr/^{86}Sr$ ratio of local. Although human bone remodels continuously, tooth enamel is not reformed after being formed as infancy and childhood (Hillson 1996). The $^{87}Sr/^{86}Sr$ ratio in tooth enamel reflects childhood diet and the geology of the place where one has been brought up. Conversely, $^{87}Sr/^{86}Sr$ values in bone will reflect adult diet and adult local (Ericson, 1985). Recently, many archaeologists have used $^{87}Sr/^{86}Sr$ signatures in human enamel and bone apatite to reconstruct ancient mobility patterns and to distinguish between individuals of local and non-local origins at archaeological sites (e.g. Bently et al. 2004; Bently 2006; Slovak and Paytan, 2011).

Most previous studies of Sr isotope analysis in archaeology have been performed using thermal ionization mass spectrometry (TIMS) which is applicable for solution of entire teeth. The third molar have used for these analyses, because there is little influence on morphological researches. However, third molar is generally most variable tooth in terms of their development, formed from 7 years old to 16 years old (Hillson 1996). Automatically, analyses of $^{87}Sr/^{86}Sr$ ratio are limited to this age stage. Although there is an advantage of third molars form after the period of weaning, these analyses cannot clarify about $^{87}Sr/^{86}Sr$ ratio in one's infancy and childhood. The advent of laser-ablation multi-collector inductively coupled plasma mass spectrometry (LA-MC-ICP-MS) enable us measure Sr isotope ratio with less damage to the samples than TIMS (Porhaska et al. 2002; Horstwood et al. 2008). Kyushu University Advanced Asian Archaeological Research Center established a method to measure $^{87}Sr/^{86}Sr$ ratio almost nondestructively using LA-MC-ICP-MS. Due to the character of less damage, it is possible to analyze for any tooth type, not only the third molar. Particularly, due to the analysis of the Sr value of the incisor, it enable to investigate the Sr value of their geological habitat at the age of 0-4. It means that it was possible to more directly reflect the Sr isotope ratio of the place of birth or person's childhood geological habitat than those from the third molar. While LA-MC-ICP-MS based enamel $^{87}Sr/^{86}Sr$ values were said to be less precise than the corresponding TIMS values, Slovak and Paytan (2011) argue that LA-MC-ICP-MS is sufficiently accurate to investigate their geographic origins and their mobility if the geologic units are considerably variable from one another.

Our researches have tried to explore rules of group composition who shared same graveyard at Bronze age in Mongolia using LA-MC-ICP-MS. We have shown that two persons who were buried in Khyar Kharaach site were very different in $^{87}Sr/^{86}Sr$ values (Yonemoto et al., 2017). Moreover, the two human remains who have different $^{87}Sr/^{86}Sr$ values were buried in different burial types and had different facial traits (Okazaki and Yonemoto, 2017: Miyamoto , 2017). We found that among the persons who were buried in Khyar Kharaach site, there were persons who may have been grew in different place. We have also discussed that there is a difference in $^{87}Sr/^{86}Sr$ ratio between Tevsh No.1 and Tevsh No.3 (Yonemoto et al., 2016). Thereafter, the number of analysis cases increased (Yonemoto at al., 2017). It was found that the $^{87}Sr/^{86}Sr$ ratios of these two individuals in Tevsh site differ, but both showed relatively high $^{87}Sr/^{86}Sr$ in the whole of analyzed Mongolian data. Based on this result, it follows that Tevsh No.1 and No.3 may have grown up in similar areas, but much work remains to be done in order to understand their origin.

There were still few analysis examples, and further analysis is necessary to clarify group composition of population of Mongolian Bronze Age. In this article, we investigate $^{87}Sr/^{86}Sr$ values of human skeletal remains from Emeelt Tolgoi Site and from Bor Ovoo Site in Bayanhongor, Mongolia.

Materials and Method

For this study, we used samples of two individuals from the Emeelt Tolgoi Site and of two individuals from the Bor Ovoo Site. Also, we used a sample of individual from burial No.37 of the Egin Gol-2015 Site excavated by the Mongolian research team. Table 5-1 shows the details of individuals analyzed in this year. As comparative data, the samples from Tevsh Sites, Chandman Khar Sites (Yonemoto et al., 2016), Khyar Kharaarch Sites, Ulaan Boom Sites, Khushuut 1 and 2 sites, Houvsgol Sites (years excavated were 2006 and 2007) and Zuun Bel Sites (Yonemoto et al., 2017) were used (Table 5-1, 5-2).

The morphological analysis on the human skeletal remains from Emeelt Tolgoi Site is reported by Okazaki et al. in this book. The biological sex in Burial No.40 individual (ET40) is male and estimated age is twenties. The biological sex in Burial No.44 individual (ET44) is female and estimated age range from forties to fifty. The radiocarbon ages on the human skeletal remains from this site is reported by Yoneda et al. in this book. ET40 and ET44 were excavated in same graveyard and they were buried in same type of grave. Because these two are different sex, we cannot simply compare physical traits.

The morphological analysis on the human skeletal remains from Bor Ovoo Site was reported by Okazaki and Yonemoto (2017) and the radiocarbon ages was reported by Yoneda et al. (2017). The biological sex in Burial No.2 individual (BO2) was unknown and age ranged the first half of thirties. The biological sex in Burial No.8 individual (BO8) was unknown and age ranged from the late teens to twenties. Because the preservation of these two were not good, the details of their traits were also unknown. The Egin Gol-2015 Site is reported by Mongolian research team. The biological sex in this individual (EG37) is female and estimated age range from twenties to forties.

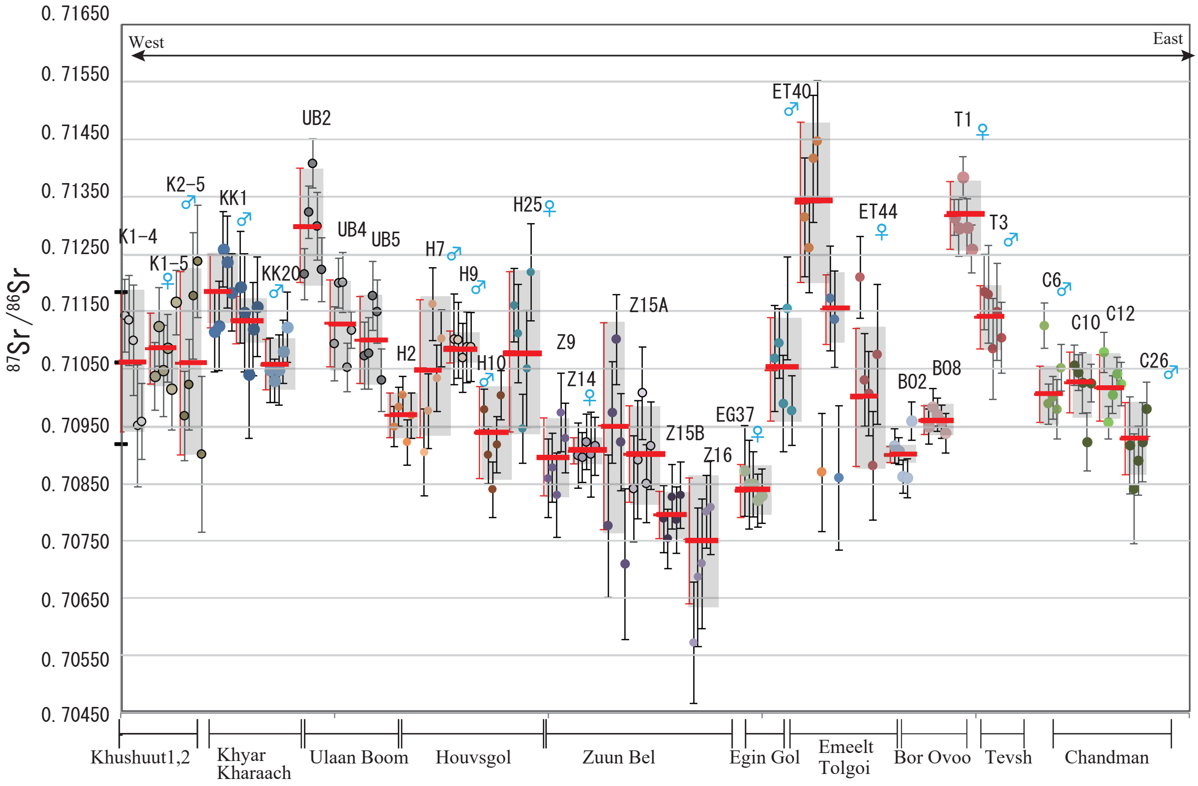
The teeth analyzed were left upper first incisor and left lower first premolar of ET40 and right upper first incisor of ET44. The odontogenesis age of the analysis point on ET40 was regarded as 2-6 years old. Since there were two parts analyzed in left lower first premolar of ET40, the odontogenesis age range of the analysis point was wide. The odontogenesis age of the analysis point on ET44 was regarded as 2-4 years old (Hillson 1996). The teeth analyzed were left upper first incisor of BO2 and right lower first molar of BO8. The odontogenesis age of the analysis point on BO2 was regarded as 2-4 years old and the odontogenesis age of the analysis point on BO8 was regarded as 11-12 years old (Hillson 1996). The teeth analyzed were right lower canine of EG37 and the odontogenesis age of the analysis point on this is regarded as 3-5 years old.

We used LA-MC-ICP-MS (Thermo Fisher Scientific, Neptune Plus) combined with LA system (Photon Machine, Analyte G2 Excimer laser) installed at Kyushu University, Japan. First, the state of analysis part was observed using an optical microscope in order to avoid weathered portion. The surface of teeth was polished from 3mm to 7mm using dental engine to make flat plane in order to obtain the stability of the signal. Second, isotopic analyses were performed using LA-MC- ICP-MS. Isotopic ratios were calculated based on data correction protocols described by Horstwood et al. (2008). In this paper, we analyzed not only $^{87}Sr/^{86}Sr$ ratios but also $^{43}Ca/^{88}Sr$ ratios. By checking $^{43}Ca/^{88}Sr$ ratios, content of Sr was estimated. Because main ingredient of teeth is apatite (Ca_5 $(PO_4)_3$ (F, Cl, $OH)_2$), the concentration of Ca is approximately constant. Finally, the analysis traces were observed using scanning electron microscope (SEM, Keyence VHX-D500). The analysis carried out for each tooth more than five lines which were used to calculate weighted means of $^{87}Sr/^{86}Sr$ ratios to check deviation of the obtained date. Weighted means of $^{87}Sr/^{86}Sr$ ratios were also used calculate probability density to reveal the cluster of these values

Results

The results and weighted mean are presented in Table 5-1 and 2, Figure 86 and figure 87 show $^{87}Sr/^{86}Sr$ ratios and $^{43}Ca/^{88}Sr$ ratios, respectively.

The $^{87}Sr/^{86}Sr$ ratios in LUI^1 of ET40 was 0.71049 ± 0.0009, in LLP_1 upper part of ET40 is 0.71340 ± 0.0014 and in LLP_1 lower part is 0.71153 ± 0.00061. There were two outliners in this individual. As figure 87 shows, the $^{87}Sr/^{86}Sr$ ratios of the ET40 varied relatively large. The $^{87}Sr/^{86}Sr$ ratios in RUI^1 of ET44 was 0.71000 ± 0.0012. There was an outliner in ET44. The $^{87}Sr/^{86}Sr$ ratios of the ET44 also varied relatively large. As shown in Figure 87, there was not difference in $^{87}Sr/^{86}Sr$ values between ET40 and ET44, although the $^{87}Sr/^{86}Sr$ ratios of these two individuals extremely had big unevenness. In the case of the ET40 and ET44, the variations and values of $^{43}Ca/^{88}Sr$ ratios for each analysis points were large (Fig.87). Particularly, the differences between types of teeth were large, but in one type of teeth the variation of $^{43}Ca/^{88}Sr$ ratios was



The numbers in these circles indicate the analysis No in table1.
Red Bold bar indicate the weighted average Sr ratio of each skeleton.
Each fill box with ash color indicate StdErr (2σ).

Fig.86 Diagram of $^{87}Sr/^{86}Sr$ ratio

relatively small. It means that Sr concentration was low. Hence, it is thought that the variation of $^{87}Sr/^{86}Sr$ ratios in ET40 and ET44 had some influenced by Sr concentration.

On the other hand, the $^{87}Sr/^{86}Sr$ ratios of Bor Ovoo were relatively in union (Fig.86). The $^{87}Sr/^{86}Sr$ ratios in LUI[1] of BO2 was 0.70900 ± 0.00046. There was not outliner in this individual. The $^{87}Sr/^{86}Sr$ ratios in RLM$_3$ of BO8 was 0.70960 ± 0.00014. There was not outliner in this individual. As shown in figure.2, the variations and values of $^{43}Ca/^{88}Sr$ ratios for each analysis points were relatively small except for an analysis point in BO2. The $^{87}Sr/^{86}Sr$ ratios of EG37 also were relatively in union (Fig.86). The $^{87}Sr/^{86}Sr$ ratios in RLC of EG37 was 0.70837 ± 0.00025. There was not outliner in this individual. The variations and values of $^{43}Ca/^{88}Sr$ ratios for each analysis points were relatively large (Fig.87).

Figure 88 demonstrates these $^{87}Sr/^{86}Sr$ values of all samples with probability density distribution. The values were arranged based on the location of sites from west to east. The calculated age by probability density distribution were 0.709186 ± 0.0000, 0.710617 ± 0.0001 and 0.71184 ± 0.0002. The obtained data means that there were three clusters based on three peak point in the $^{87}Sr/^{86}Sr$ ratios of all Mongolian samples in this study. The $^{87}Sr/^{86}Sr$ ratio of ET40 fluctuated from 0.710617 to 0.71184. The $^{87}Sr/^{86}Sr$ ratio of ET44 fluctuated from 0.709186 to 0.710617. On the other hand, the $^{87}Sr/^{86}Sr$ ratios of BO2 and BO8 both clustered around 0.709186. The $^{87}Sr/^{86}Sr$ ratios of EG37 also clustered around 0.709186.

The clusters having lowest point (i.e. 0.709186 ± 0.0000) were as follows; all samples excavated from Zuun Bel, C26 (i.e. Chandman burial no.26), H2 (i.e. Houvsgol2006 burial No.2), H10 (i.e. Houvsgol 2007 burial no.10), BO2, BO8 and EG37. The $^{87}Sr/^{86}Sr$ ratios of every individuals from Zuun Bel sites did not have the clear difference. What should be noted was that every individual from Zuun Bel sites and EG37 clustered around the lowest point and show lower values than that.

The clusters having highest point (i.e. 0.71184 ± 0.0002) were as follows; KK1, T1 (Tevsh burial No.1), UB2 (Ulaan Boom No.2), probably T3 (Tevsh burial No.3) and premolar of ET40. Other samples were belonged to middle cluster (i.e. 0.710617 ± 0.0001).

Discussions

These results of our experiments indicate that the dispersions in $^{87}Sr/^{86}Sr$ ratios of ET40 and ET44 are large. Their both $^{87}Sr/^{86}Sr$ ratios is hardly difference. Although we cannot compare their physical traits due

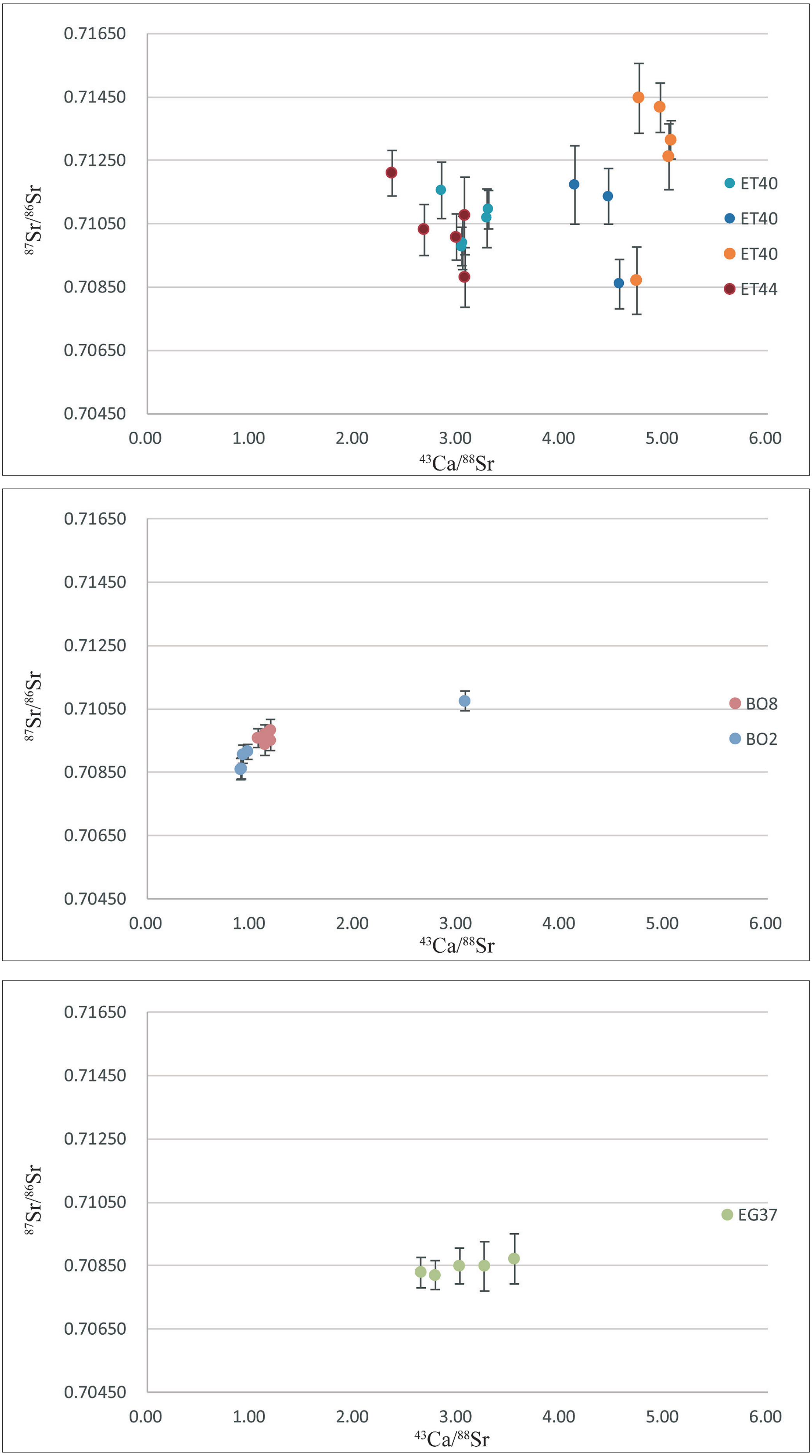


Fig.87 Diagrams of $^{43}Ca/^{88}Sr$ ratio vs $^{87}Sr/^{86}Sr$ ratio of each site

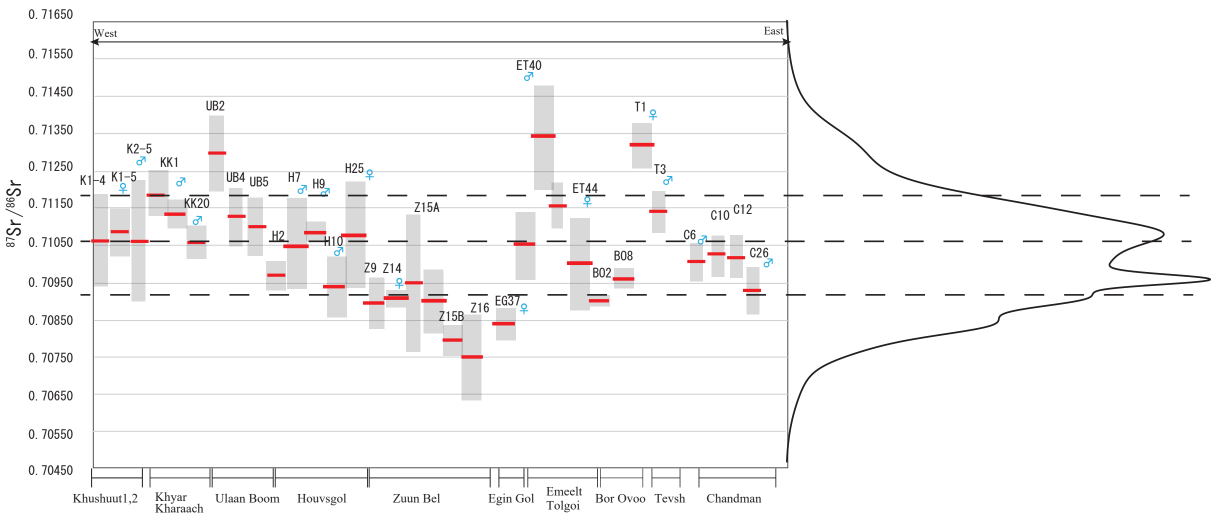


Fig.88 Diagram of ^{87}Sr/^{86}Sr ratio with probaility density

to different in sex, two human remains were basically same in burial styles. These burial styles same that of KK20. Moreover, ET 40 male were similar to KK 20 male in nasal root. Facial flatness and burial style of ET40 suggested the possibility of some influence from the west side. While ^{87}Sr/^{86}Sr ratios of ET40 and ET44 overlap with the value of KK 20, the dispersions are larger than KK20. It is the location of Emeelt Tolgoi Site to be important for interpret this result. In this area, geology with different types of rocks is distributed in narrow areas. It is therefore possible that the inhomogeneity of the ^{87}Sr/^{86}Sr value indicates not the magnitude of their travel distance, but the geological features of the place they grew up. We interpret the result as generally same in childhood habitat between ET40 and ET44. Probably, they were brought up near the place where their graves were made. Therefore, ET40 male and ET44 female who adopted the burial style influenced by west side may not be directly come from the west side.

As figure 88 shows, the ^{87}Sr/^{86}Sr ratios of three individuals from Bor Ovoo Site and Egin Gol Site are low. These low values are rare in Mongolia and are mainly found from ZuunBel Site. The specificity of the ^{87}Sr/^{86}Sr ratios of ZuunBel Site might result from Permian granite (Yonemoto et al., 2017). The location of Egin Gol Sites is close to ZuunBel Site (Fig.89). Although these sites are difference in the results of radiocarbon ages (Table5), the specificity of the ^{87}Sr/^{86}Sr ratios of ZuunBel and Egin Gol may come from Permian granite located on these sites (Fig.89). Also, the ^{87}Sr/^{86}Sr ratios of H2 and H10 in Houvsgol Sites cluster around the lowest point. Because Houvsgol Site is near to ZuunBel Site, the ^{87}Sr/^{86}Sr ratios of H2 and H10 may be affected by the human mobility from Permian granite in Northern Mongolia around ZuunBel Site and Egin Gol Site. However, it should be noted that there were greatly difference in period between Houvsgol site and Egin Gol Site, and ZuunBel Site (Table.5).

More noteworthy is the fact that the ^{87}Sr/^{86}Sr ratios of two individuals from Bor Ovoo Site were low (Fig.88). In respect of Bor Ovoo, it may be difficult to think that it was affected by human mobility from Permian granite in Northern Mongolia around ZuunBel Site, because the distance between the sites is too far. Permian granit also is slightly distributed in this Bor Ovoo area. Therefore, the low ^{87}Sr/^{86}Sr ratios of Bor Ovoo may related not to the fact that the population moved from Northern Mongolia but to the fact that Permian granite is distributed in this area. Moreover, BO2 was round grave with a burial pit and consist of a stone mound (Miyamoto et al., 2017). BO8 was figured grave with a burial pit (Miyamoto et al., 2017). Although these burial types are different, the ^{87}Sr/^{86}Sr ratios of two individuals were similar. From the result obtained in the ^{87}Sr/^{86}Sr ratios, we suggested that persons who were buried in Bor Ovoo Site, at least BO2 and BO8, may have been grew in similar place near burial site.

Here we have three types of the ^{87}Sr/^{86}Sr results in one graveyard: The first is that people who grew up in different areas are buried in different types of burial in the same graveyard, such as Khyar Kharaach Site (Miyamoto et al., 2017). The second is that person who grew up in a similar area were buried in different types of burials in the same graveyard, such as Bor Ovoo (Miyamoto et al., 2017). Viewed in the light of adopted burial types, we see a difference between first and second. For example the khereksurs is said to be

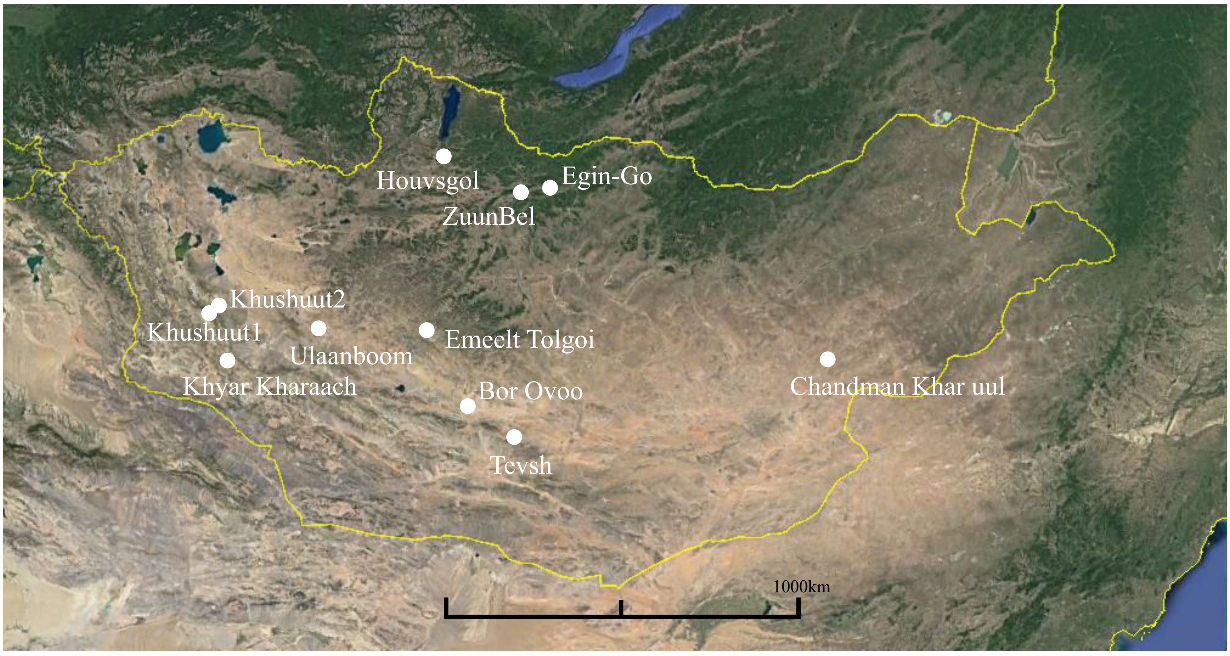


Fig.89 The locations of each site (Google earth)

the grave system which was particularly strongly affected by the west. In addition, the facial traits will be related to the person's origin. The burial type and facial traits in kk20 were in fluenced by the westside. The difference between first and second is whether it has some elements affected by the westside. There are many cases that people who clustered around middle point (0.710617±0.0001) have elements affected by the west.The third is that person who grew up in similar areas are buried in the same type of burial in the same graveyard, such as Emeelt Tolgoi and Tevsh Site (Miyamoto and Amgalantgus, 2016).

Moreover, except for the first case, in many cases of Mongolia, the geology of the grave site and the $^{87}Sr/^{86}Sr$ ratios can be explained without inconsistency. It is worth noting that many of them may be not moving longitudinally across Mongolia, namely we may reasonable conclude that there is no clear difference between the burial area and the area where individuals might have been grow up. One interpretation would be that the range of movement does not exceed the minimum range required for their lives, and that the extent of marriage was also basically limited. However, since people who grew up in different areas may form a group that shares the same graveyard as Khyar Kharaach, it can be said that there were various exceptions regarding the group composition principle in the cemetery.

Much work remains to be done in order to understand the group composition principle in the cemetery. Detailed studies should be made on the correlation among the $^{87}Sr/^{86}Sr$ ratios, burial types and anthropological traits.

Conclusions

We investigated the possibility of mobility and their origin in individuals who were buried in Bor Ovoo Sites and Emeelt Tolgoi Site using the $^{87}Sr/^{86}Sr$ ratios to research rules of group composition who shared same graveyard. The strontium isotopes result indicated that there is not differences in $^{87}Sr/^{86}Sr$ ratios between BO2 and BO8 and between ET40 and ET44. The results suggested that the geographic origins are each similar between BO2 and BO8 and between ET40 and ET44 who were buried in the same sites.

Table 5-1 Characters, $^{87}Sr/^{86}Sr$ ratio and $^{43}Ca/^{88}Sr$ ratio of human skeletal remains who were analyzed in this study.

Sitename	Burial No.	Individual skeleton No.	sex	age	Teeth type	Age estimated by Analysis point	Analysis No.	$^{87}Sr/^{86}Sr$	StdErr (2σ)	$^{43}Ca/^{88}Sr$	Weighted mean	SD	MSWD	Calibrated ^{14}C age (*Yoneda 2016, **Yoneda 2017, ***published in this book by Yoneda)
Emeelt Tolgoi	M40	ET40	Male	Young adult	LUI^1	2-4years old	1	0.7107	0.0009	3.2875	0.71049	0.0009	3.9	1266BC-1125BC***
							2	0.7109	0.0006	3.3025				
							3	0.7099	0.0008	3.0489				
							4	0.7116	0.0009	2.8438				
							5	0.7098	0.0006	3.0434				
					LLP_1 upper part	3-5years old	6	0.7131	0.0010	5.0661	0.7134	0.0014	3.4	
							7	0.7126	0.0008	5.0464				
							8	0.7142	0.0011	4.9620				
							9	0.7145	0.0011	4.7605				
							10	0.7087	0.0010	4.7382 *				
					LLP_1 lower part	5-6years old	11	0.7117	0.0009	4.1359	0.71153	0.00061	0.34	
							12	0.7114	0.0008	4.4635				
							13	0.7086	0.0013	4.5670 *				
	M44	ET44	Female?	Middle adult	RUI^1	2-4years old	1	0.7121	0.0007	2.3685 *	0.71	0.0012	2.8	1289BC-1112BC***
							2	0.7103	0.0008	2.6810				
							3	0.7101	0.0007	2.9906				
							4	0.7088	0.0009	3.0718				
							5	0.7107	0.0012	3.0693				
Bor-Ovoo	No.2	BO2	unknowen	Young adult	LUI^1	2-4years old	1	0.7092	0.0003	0.9682	0.709	0.00046	6.6	1316-1207BC**
							2	0.7091	0.0002	0.9216				
							3	0.7086	0.0003	0.9092				
							4	0.7086	0.0003	0.9028				
							5	0.7096	0.0003	0.9102				
	No.8	Bo8	unknowen	Juvenile	RLM_3	11-12years old	1	0.7095	0.0003	1.1905	0.7096	0.00014	1.19	1112-974BC**
							2	0.7098	0.0003	1.1895				
							3	0.7097	0.0003	1.1370				
							4	0.7096	0.0003	1.0660				
							5	0.7094	0.0003	1.1356				
Egin Gol-2015	No.37	EG37	Female	Young adult	RLC	3-5years old	1	0.7087	0.0008	3.5485	0.70837	0.00025	0.42	1216BC-1056BC***
							2	0.7085	0.0008	3.2589				
							3	0.7085	0.0006	3.0199				
							4	0.7082	0.0005	2.7832				
							5	0.7083	0.0005	2.6440				
Khyar Kharaach	No.1	KK1	Male	Middle adult	RLC	3-5years old	1	0.7111	0.0007	3.6125	0.71185	0.00063	3.3	1265BC-1108BC**
							2	0.7112	0.0008	3.2325				
							3	0.7126	0.0007	2.7859				
							4	0.7124	0.0008	2.7095				
							5	0.7118	0.0007	2.3282				
					RLI_1	1-4years old	6	0.7119	0.0010	4.7216	0.71135	0.00041	1.2	
							7	0.7115	0.0010	4.9333				
							8	0.7104	0.0011	4.7812				
							9	0.7112	0.0008	4.6864				
							10	0.7116	0.0009	4.3105				
	No.20	KK20	Male	Middle adult	RLI_2	1-4years old	1	0.7105	0.0006	2.5225	0.71057	0.00044	1.9	1306BC-1054BC**
							2	0.7103	0.0004	2.3801				
							3	0.7105	0.0006	2.4643				
							4	0.7108	0.0005	2.5467				
							5	0.7112	0.0006	2.7684				
Tevsh Uul	No.1	T1	Female	Middle adult	LLI_1	1-4years old	1	0.7131	0.0003	2.5910	0.71295	0.00040	1.5	901BC-812BC*
							2	0.7130	0.0005	2.8070				
							3	0.7138	0.0004	3.0216 *				
							4	0.7130	0.0005	3.0495				
							5	0.7126	0.0004	2.9097				
	No.3	T3	Male	Middle adult	LLI_1	1-4years old	1	0.7118	0.0007	4.0891	0.71140	0.00055	1.4	1392BC-1264BC*
							2	0.7118	0.0009	4.1888				
							3	0.7109	0.0009	4.2074				
							4	0.7115	0.0008	4.2166				
							5	0.7110	0.0006	4.1657				
Chandman	No.6	C6	Male	Middle adult	RUI^1	2-4years old	1	0.7113	0.0004	1.9792 *	0.71006	0.00049	2.4	406BC-367BC**
							2	0.7099	0.0004	1.9360				
							3	0.7100	0.0004	1.9327				
							4	0.7098	0.0005	1.9634				
							5	0.7105	0.0004	1.9116				
	No.10	C10			RUI^2	3-5years old	1	0.7106	0.0003	2.3285	0.71026	0.00053	5.2	51BC-52AD**
							2	0.7104	0.0003	2.2943				
							3	0.7103	0.0005	2.1983				
							4	0.7092	0.0005	2.2809				
							5	0.7102	0.0003	2.2327				
	No.12	C12			RUI^1	2-4years old	1	0.7108	0.0003	1.6230	0.71017	0.00058	8.6	-
							2	0.7096	0.0003	1.5867				
							3	0.7101	0.0003	1.5853				
							4	0.7104	0.0003	1.4713				
							5	0.7102	0.0004	1.6025				
	No.26	C26	Male	Young adult	RUI^1	2-4years old	1	0.7092	0.0008	2.4779	0.70928	0.00063	2.4	1493AD-1603AD**
							2	0.7084	0.0010	2.6863				
							3	0.7089	0.0006	2.7062				
							4	0.7092	0.0007	2.6572				
							5	0.7098	0.0005	2.5649				
Ulaan Boom	No.2	UB2			RUi^1	Birth-6month	1	0.7122	0.0004	4.3489	0.71300	0.00100	12	1266BC-1113BC**
							2	0.7132	0.0005	4.1848				
							3	0.7141	0.0004	4.2149				
							4	0.7130	0.0006	4.0884				
							5	0.7122	0.0006	4.1764				
	No.4	UB4			RUI^1	2-4years old	1	0.7109	0.0006	4.0048	0.71129	0.00076	8.2	1216BC-1052BC**
							2	0.7120	0.0004	3.9451				
							3	0.7120	0.0005	4.4232				
							4	0.7105	0.0004	2.1567				
							5	0.7112	0.0003	2.2738				
	No.5	UB5			LLI_1	1-4years old	1	0.7107	0.0006	3.6504	0.71100	0.00076	4.5	1133BC-976BC**
							2	0.7108	0.0006	3.8396				
							3	0.7118	0.0006	3.7979				
							4	0.7115	0.0006	3.6112				
							5	0.7103	0.0005	3.7092				

* indicate the outlier value

Table 5-2 Characters, $^{87}Sr/^{86}Sr$ ratio and $^{43}Ca/^{88}Sr$ ratio of human skeletal remains who were analyzed in this study.

Sitename	Burial No.	Individual skeleton No.	sex	age	Teeth type	Age estimated by Analysis point	Analysis No.	$^{87}Sr/^{86}Sr$	StdErr (2σ)	$^{43}Ca/^{88}Sr$	Weighted mean	SD	MSWD	Calibrated ^{14}C age (*Yoneda 2016, **unpublished data by Yoneda, HH is published in this book by Yoneda)
Khushuut1	No.4	K1-4			LLi_2	Birth-6month	1	0.7114	0.0006	2.1269	0.71060	0.00120	6.1	1214BC(92.7%)1041BC**
							2	0.7113	0.0008	2.7455				
							3	0.7110	0.0010	2.7415				
							4	0.7095	0.0011	2.9653				
							5	0.7096	0.0007	1.9671				
	No.5	K1-5	Female	Young adult	RLI_2	1-4years old	1	0.7104	0.0006	2.5735	0.71085	0.00062	3.4	1390BC(93.5%)1259BC**
							2	0.7112	0.0007	2.4092				
							3	0.7105	0.0008	2.3149				
							4	0.7109	0.0006	2.0136				
							5	0.7101	0.0007	1.9548				
							6	0.7117	0.0006	2.1673				
Khushuut2	No.5	K2-5	Male	Middle adult	LLI_2	1-5years old	1	0.7097	0.0008	3.5620	0.71060	0.00160	7.3	1386BC(85.5%)1251BC**
							2	0.7102	0.0008	3.4618				
							3	0.7118	0.0011	3.5490				
							4	0.7124	0.0010	4.0245				
							5	0.7090	0.0014	4.0962				
Houvsgoll2006	No.2	H2	Unknown	Child	LLI_2	1-4years old	1	0.7095	0.0004	2.0268	0.70969	0.00039	3.1	1010BC(95.4%)901BC**
							2	0.7098	0.0003	1.9021				
							3	0.7100	0.0003	1.9846				
							4	0.7092	0.0004	2.1759				
							5	0.7097	0.0004	2.2802				
	No.7	H7	Male	Old adult	RLI_2	1-4years old	1	0.7090	0.0008	2.9995	0.71050	0.00120	9.4	1126BC(95.4%)978BC**
							2	0.7098	0.0007	3.0027				
							3	0.7116	0.0006	3.0192				
							4	0.7103	0.0006	2.9961				
							5	0.7110	0.0005	2.9429				
Houvsgol2007	No.9	H9	Male	Young adult	LUI^2	3-5years old	1	0.7110	0.0008	3.0219	0.71088	0.00028	0.16	1262BC(95.4%)1122BC**
							2	0.7110	0.0007	2.7540				
							3	0.7107	0.0006	2.6365				
							4	0.7109	0.0006	2.5443				
							5	0.7109	0.0006	2.4784				
	No.10	H10	Male	Middle adult	RUI^2	3-5years old	1	0.7098	0.0004	2.2415	0.70939	0.00080	8.6	1316BC(73.7%)1213BC**
							2	0.7090	0.0005	2.4409				
							3	0.7084	0.0005	2.3815				
							4	0.7092	0.0005	2.4460				
							5	0.7100	0.0004	2.2480				
	No.25	H25	Female	Old adult	RLI_2	1-4years old	1	0.7116	0.0006	2.7547	0.71080	0.00140	9.4	1291BC(94.1%)1127BC**
							2	0.7111	0.0009	2.8698				
							3	0.7095	0.0006	3.1033				
							4	0.7105	0.0010	3.1293				
							5	0.7122	0.0008	3.0333				
Zuun Bel	No.9	Z9			RLI_2	1-4years old	1	0.7086	0.0007	2.0003	0.70896	0.00068	2.8	-
							2	0.7088	0.0006	2.2422				
							3	0.7083	0.0007	2.2697				
							4	0.7097	0.0007	2.1301				
							5	0.7093	0.0006	2.1364				
	No.14	Z14	Female	Young adult	LUI^1	2-4years old	1	0.7090	0.0006	1.6317	0.70907	0.00023	0.23	-
							2	0.7090	0.0004	1.6379				
							3	0.7092	0.0005	1.6641				
							4	0.7090	0.0007	1.6742				
							5	0.7092	0.0005	1.5636				
	No.15A	Z15A			RUc	Birth-9month old	1	0.7078	0.0012	2.6653	0.70950	0.00180	9.2	1299AD(75.0%)1370AD**
							2	0.7097	0.0009	2.7130				
							3	0.7110	0.0008	2.7104				
							4	0.7092	0.0008	2.7314				
							5	0.7071	0.0013	2.7695				
					LLM_1	1-3years old	6	0.7084	0.0009	2.7224	0.70901	0.00084	2.8	
							7	0.7089	0.0010	2.5930				
							8	0.7101	0.0008	2.4129				
							9	0.7085	0.0007	2.3844				
							10	0.7092	0.0008	2.3609				
	No.15B	Z15B	Unknown	Child	LUI^1	1-4years old	1	0.7079	0.0006	2.7036	0.70795	0.00041	1.3	1340AD(57.7%)1397AD**
							2	0.7075	0.0005	2.6803				
							3	0.7083	0.0006	2.6915				
							4	0.7079	0.0006	2.6353				
							5	0.7083	0.0006	2.6593				
	No.16	Z16			RUC	2-4years old	1	0.7057	0.0011	2.5101	0.70750	0.00110	4.3	-
							2	0.7069	0.0012	2.5673				
							3	0.7071	0.0011	2.2701				
							4	0.7080	0.0006	1.7373				
							5	0.7081	0.0008	1.9093				

* indicate the outlier value