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Upper Pleistocene human scapula from Salawusu, Inner Mongolia, China

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Abstract This article presents a fossil human scapula which was found *in situ* from the lower part of the Salawusu Formation in 1980 at the Salawusu site of Inner Mongolia,China. The stratum is dated from 70.9±6.2 ka BP to 124.9±15.8 ka BP by TL method. Dates from 44±7 ka BP to 63±3 ka BP, 61－68 ka BP and 35.34±2 ka BP are obtained for the lower part of this layer by ^{230}Th, IRSL and ^{14}C respectively. Based on the comparisons between this scapula and the scapulae of Neanderthals, Skhul/Qafzeh fossils, Eurasian Upper Paleolithic specimens and recent modern humans on the glenoid fossa, axillo-spinal angle, axillary border and other features, the present authors arrived at a preliminary conclusion that this Salawusu scapula is characterized by modern features of Upper Pleistocene humans mixed with a Neanderthal-like feature.

Keywords: Salawusu, upper Pleistocene, scapula, human fossil.

The fossil tooth found in Salawusu Valley, Inner Mongolia is the first Paleolithic human fossil found in China and even in East Asia[1, 2]. The Paleolithic artifacts recognized in Salawusu as well as those in Shuidonggou represent the earliest Paleolithic culture found and studied in China[3]. Salawusu site (37°10′59″N, 108°10′58″E) [4] (Fig. 1.) is located on the southeast of Ordos Plateau and presents the standard profile of late Pleistocene in northern China.

The earliest geological survey of Salawusu site was done by Pierre Teilhard de Chardin and Emile Licent from 1922 to 1923. They found the palaeolithic site and a human fossil tooth[2]. After that there were some human fossils found in this district[5－9].The studies on the rich human fossils in Salawusu will provide the basis illuminating the evolutionary status and phylogenetic relationship of Chinese late Pleistocene humans and in turn will make contribution to the theory of modern human origins.

However the study on human fossils from this site is not satisfactory because some of them are not clear enough in stratigraphy and dating. Dong *et al*. found 4 human fossils from the original Salawusu layers at the end of the 1970s and published an article later[10]. This greatly improved the study of Salawusu human fossils.

The scapula (No. s-11) studied here was found at the Milanggouwan of Salawusu in 1980. The locus yielding the scapula is 15 m above the riverbed and at the bottom of the Salawusu Formation. The geological section has been described by Dong *et al*.[10] The bottom of the Salawusu Formation, where many human fossils, Paleolithic artifacts,most animal fossils and some bony artifacts and carbon particles have been unearthed, belongs to the late Pleistocene[11].

Some researchers have done much work on the dating of the Late Pleistocene Salawusu site. The stratum of Salawusu Formation in which a large number of human fossils have been found is dated from 70.9±6.2 ka BP to 124.9±15.8 ka BP by TL method[12]. Dates from 44±7 ka BP to 63±3 ka BP[13], 35.34±2 ka BP[14] and 61－68 ka BP[15] are obtained for the lower part of this layer by ^{230}Th, IRSL and ^{14}C respectively. So this scapula is earlier than the Upper Cave Man and belongs to the early or middle part of late Pleistocene.

Complete fossil human scapula is seldom seen because of the fragile supraspinatus and infraspinatus surfaces.There is no comparable specimens in China except the late Pleistocene scapulae recently found in Tianyuan Cave[16]. The detailed study about Chinese fossil human scapula has not been done yet.

The s-11 scapula is light brown in colour and fossilized. It preserves the most part of right scapula.The lateral and medial border of this scapula is nearly complete except for a little break near the superior and inferior angle. The acromion does not exist and the hind part of the coracoid process preserves. The remained scapular spine is about 81 mm long excluding the broken medial part of it. Nearly all the supraspinous fossa disappears and infraspinous fossa mostly preserves.The glenoid fossa is nearly intact except a bit break at its inferior border (Fig. 2). The scapula from Salawusu is

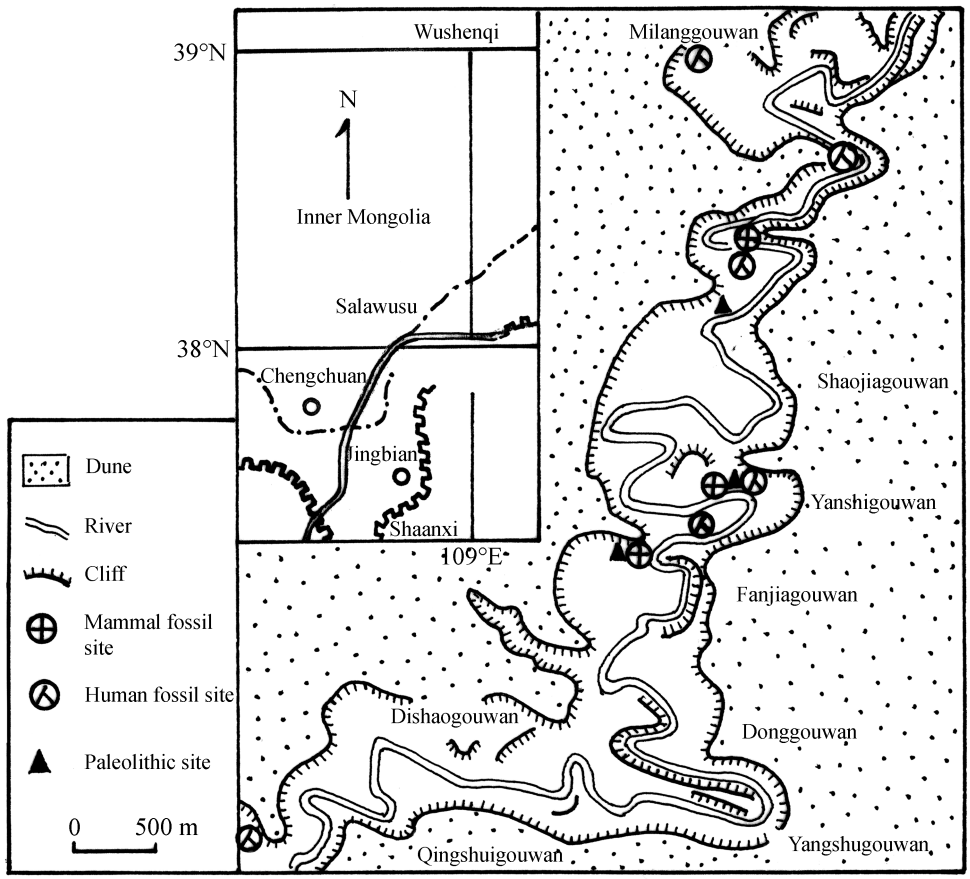

Fig. 1. The location of Salawusu site (after refs. [10, 11]).

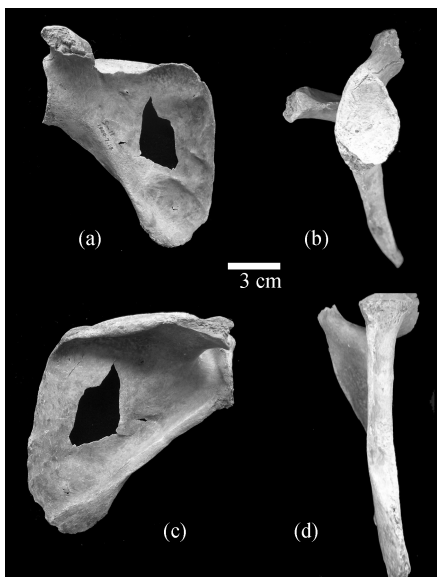

Fig. 2. Fossil human scapula from Salawusu site. (a) Frontal view; (b) lateral view: glenoid fossa; (c) occipital view; (d) lateral view: the axillary border.

more complete and could offer detailed information for study and comparison with other specimens.

This scapula is small and its dimension is similar to that of modern female. It is estimated that this scapula should represent an individual older than 17 according to the condition of its epiphyses.

1 Morphological length

The morphological length of this scapula is estimated to be 88 mm though the spine has a little break at its medial end. This length is well within the variation range of modern humans and shorter than most of the comparative specimens shown in Table 1.

The average morphological length of Chinese modern women is longer than that of Japanese ones. The s-11 is much shorter than Minatogawa I (male) in the morphological length. Currently, it is no way to do the comparison of morphological length between Salawusu and Minatogawa females because there is no Minatogawa female scapula whose morphological length right for this measurement.

The sex difference of both Chinese and Japanese modern humans in the morphological length is about 9

Table 1 Morphological length of scapula (mm)

	Morphological length of scapula	*N*	Sex
Salawusu s-11[a)]	88	1	female
Shanidar 1,2,3,4[17]	110－116	4	male
La Ferrassie [17]	121.5	1	male
Krapina 125,127,130,132[17]	100－115	4	?
Dolni Vestonic 13,14,15,16[18]	92－108	4	male
Minatogawa I[19]	100	1	male
Neolithic Japanese[19]	98.8	4	male
Neolithic Japanese[19]	93.8	5	female
Modern humans[17]	83.9－102.9	22	
Modern Chinese[20]	103.2	326	male
Modern Chinese[20]	94.29	264	female
Modern Japanese[19]	98.8±5.53	30	male
Modern Japanese[19]	89.9±4.17	20	female

a) From the present authors.

mm in average and that of Neolithic Japanese is 5 mm. Because the sample size of the Neolithic specimens in our data bank is too small, we deduce the female morphological length of Neanderthals and Eurasian Upper Paleolithic humans from their male counterpart on the supposition that the sex differences in them are similar to those in modern humans rather than those in Japanese Neolithic populations. In this way the tentative result is that the morphological length of Salawusu female scapula is similar to that of Eurasian upper Paleolithic female and shorter than that of Neanderthal female.

The infraspinatus fossa is 102 mm in height and the ratio of it to the morphological length expressed as a percentage is 113. This is close to the corresponding value of modern humans (112±1.1, $N = 31$)[17] and lower than that of the La Ferrassie 1[17].

In sum, the Salawusu s-11 is similar to that of different groups of early and late modern humans and different from that of Neanderthals in the morphological length of the scapula.

2 Axillary border

The infraglenoid tubercle of Salawusu scapula is prominent. It is wide on the top and gradually becomes narrower downward to continue with the dorsal crest.

Many researches have been done on the shape of the axillary border of the late Paleolithic human scapula[19,21]. The crests and sulci along the axillary border of scapulae in different human populations have different characters. Majority of the axillary borders of Neanderthal scapulae show a dorsal sulcus,most of the Upper Paleolithic individuals are of bisulcate pattern, and the recent humans have a predominance of the ventral sulcus pattern[21].

Salawusu scapula shows the ventral sulcus pattern similar to most recent humans.

Minatogawa shows bisulcate pattern which is obvious in the male individual MI specimen and not distinct in the female individual MIII. This is the typical transitional pattern between Neanderthals and modern humans[19]. The axillary border of Salawusu s-11 scapula with ventral sulcus pattern just like the late moderns does not show the similar pattern of Minatogawa scapula.

The morphology of the axillary border seems to be related to the robusticity of the individuals. According to Trinkaus' opinion, the dorsal sulcus pattern in the axillary border of Neandertal scapula implies a pronounced development of M. Teres minor acting as a lateral rotator of the humerus[21]. The enlargement of this muscle among the Neandertals appears to have counteracted the medial rotation associated with humeral adduction when the upper arm of Neanderthals move down forcely. It is important for developed M.Teres minor to keep the Neandertal humerus adducting precisely and shoulders moving around stably. Salawusu scapula is different from that of Neandertals in this aspect. Perhaps it is unlikely that the Salawusu Man adducted their arm so strongly and frequently as Neanderthals, so that the M.Teres Minor is not necessary to develop for keeping the balance and stability of the shoulder joint.

3 Axillo-spinal angle of scapula

The axillo-spinal angle of Neanderthals is large and the axillo-spinal angles of the Skhul as well as the modern Chinese are smaller (Table 2). The s-11 axillo-spinal angle is about 50°.After considering the sex differece we prefer to think that the axillo-spinal angle of s-11 scapula is much smaller than that of Neanderthals and close to the angles in modern humans and the Skhuls specimens.

Neanderthals have larger axillo-spinal angle than modern humans, indicating that the shoulder musculature of Neanderthals is more hyperplastic than modern humans[17]. Axillo-spinal angle of Salawusu is close to that of early modern humans and that of modern humans which are different from the Neandertals.

4 Glenoid fossa

The glenoid fossa of this scapula is rather complete

Table 2 Axillo-spinal angles of scapula (°)

	Axillo-spinal angles of scapula	SD	*N*	Sex
Salawusu s-11[a)]	50		1	female
Shanidar 1[17]	67		1	male
Shanidar 3[17]	60		1	male
Tabun C1[17]	55		1	male?
European Neanderthals[17]	56.7	1.5	6	
Skhul 4[17]	52		1	male
Skhul 5[17]	51		1	male
Modern humans[17]	40.5－47.8		16	
Modern Chinese[20]	52.28		244	male
Modern Chinese[20]	50.65		206	female
Modern Chinese[22]	51.33	0.24	337	male
Modern Chinese[22]	50.03	0.28	163	female

a) From the present authors.

with a little damage at the caudo-dorsal part. Neither a distinct caudo-ventral bulge nor a corresponding notch in the upper or middle part of the ventral margin can be seen. Its morphology is different from that of most moderns observed but its contour is similar to that of Neanderthals in spite of being less robust.

The height of glenoid fossa of this Salawususs scapula is different from the heights of the Qafzeh early modern humans and European early Upper Paleolithic humans and has no significant difference from those in the female Neanderthals, European late Upper Paleolithic humans, Japanese late Paleolithic humans, Japanese Neolithic humans and different groups of modern humans shown in Table 3.

The comparison of glenoid fossa breadth is shown in Table 4. The glenoid fossa breadth is different from the breadths of the female European early Upper Paleolithic humans, European late Upper Paleolithic humans and most groups of modern humans. The Salawusu scapula has a much narrower glenoid fossa than most of the modern humans and European Upper Paleolithic humans and this breadth is lower than the average value of Chinese female modern humans reported by the Physical Survey Groups of Chinese Society for Anatomical Science for nearly 10 standard deviations.

The height-breadth index (Table 5) of Salawusu glenoid fossa shows the most remarkable feature of Salawusu' scapula. The indices of 3 groups of Japanese are smaller than most European Upper Paleolithic populations (except Obercassel)and modern Chinese and are similar to those of Neanderthals. This value of Salawusu is similar to the values of Neanderthals and 3 groups of Japanese including Minatogawa, Neolithic and modern Japanese and different from early or late

Table 3 Glenoid fossa height (mm)

	Glenoid fossa height	SD	*N*	Sex
Salawusu s-11[a)]	33		1	female
Neanderthals[23]	32.7－42.5		7	male
	30.5－33.1		2	female
Qafzeh 8[23]	40.4		1	male
Qafzeh 9[23]	36		1	female
European Early U.P.[23]	29.5－42.3		17	male
	33.2－38		6	female
European Late U.P.[23]	35.0－39.5		10	male
	32.0－34.0		8	female
Minatogawa I[19]	38		1	male
Minatogawa III[19]	33		1	female
Neolithic Japanese[19]	37.3	1.80	13	male
	31.6	2.94	15	female
Modern humans[24]b)]	33.9	3.1	99	
Modern Chinese[20]	33.7		384	male
	33.48		308	female
Modern Chinese[22]	37.84	0.16	328	male
	33.64	0.2	159	female
Modern Chinese[a)]	34.6	1.7	65	
Modern Japanese[19]	35.1	1.80	30	male
	31.6	2.28	20	female

a) From the present authors; b) Euroamerican and Amerindian.

Table 4 Glenoid fossa breadth (mm)

	Glenoid fossa breadth	SD	*N*	Sex
Salawusu s-11[a)]	22.3		1	female
Neanderthals[23]	21.8－30		8	male
	21－21.6		2	female
European Early U.P.[23]	21－29		17	male
	22.6－27		6	female
European Late U.P.[23]	24.2－28.9		8	male
	21.7－25.3		8	female
Minatogawa I[19]	26		1	male
Minatogawa III[19]	22		1	female
Neolithic Japanese[19]	26.2	1.34	12	male
	21.9	2.19	16	female
Modern humans[24] b)]	24.9	2.2	99	
Modern Chinese[20]	26.83		384	male
	23.65		308	female
Modern Chinese[22]	27.6	0.12	328	male
	23.75	0.14	159	female
Modern Chinese[a)]	25.3	1.4	65	
Modern Japanese[19]	24.8	1.61	30	male
	21.1	1.21	20	female

a) From the present authors; b) Euroamerican and Amerindian.

modern humans besides modern Chinese. This index of the Salawusu specimen is lower than that of modern Chinese reported by Physical Survey Groups of Chinese Society for Anatomical Sciences for at least 6 standard deviations.The difference might imply that Salawusu, Neanderthals and 3 groups of Japanese are

Table 5 Height - breadth index of glenoid fossa

	Indices (X or R)	SD	N	Sex
Salawusu s-11[a)]	67.5		1	female
Neanderthals [24]	67.5	4.0	6	male
	65.4		2	female
Dolni Vestonic[18]	70.5－75.3		5	male
	84.3		1	female
Taforalt[25]	81(72.5－88.6)		24	male
Predmosti[23]	72.7	3.5	6	male
	71.1－77.1		4	female
Obercassel[25]	64		1	male
Minatogawa I[19]	68.4		1	male
Minatogawa III[19]	66.7		1	female
Neolithic Japanese [19]	70.5	1.87	11	male
	69.3	4.2	15	female
Modern humans[24] [b)]	73.1	3.4	46	male
	73.8	3.7	50	female
Modern Chinese[20]	74.41	0.6	84	male
	72.81	0.64	58	female
Modern Chinese[22]	72.56	0.36	337	male
	70.06	0.41	163	female
Modern Chinese [a)]	73.3	2.5	65	
Modern Japanese [19]	70.7	2.89	30	male
	67.1	4.85	20	female

a) From the present authors; b) Euroamerican and Amerindian.

more similar than modern Chinese in function or heredity in this respect. It is also possible that this is only a occasional affair of individual deviation which needs further samples to check.

The Neanderthals have longer, narrower and shallower glenoid fossa than modern humans. This difference in morphology implies difference in the habitual degrees of dorso-ventral gleno-humeral movement between Neanderthals and modern humans. This in turn may be related to the contrast in tool use, especially with respect to throwing and projectile use as indicated by some researchers' work[24]. The similarity between Salawusu and Neanderthal scapulae in this aspect may suggest that Salawusu population often have this same degree of dorso-ventral gleno-humeral movement as Neandertals or may reflect the gene flow between Salawusu population and Neanderthals.

The glenoid fossa of Salawusu scapula is different from that newly found from Tianyuan Cave near Zhoukoudian site in the morphology. However the shape of axillary border of scapula from both sites is similar to that of modern humans.

Minatogawa III scapula is the most similar specimen to Salawusu's among the other Eurasian Upper Paleolithic specimens . This could be seen from the height, breadth, and the index of the glenoid fossa as well as the morphological length.Bisulcate pattern is shown in Minatogawa, but absent in Salawusu.

In sum, the Salawusu scapula is not strong and with many modern features. However it has Neanderthal character in the height-breadth index of glenoid fossa. Judging from the stratigraphic position and morphology, Salawusu human scapula belongs to upper Pleistocene humans of China.

The current information is limited. However it deserves to be further discussed since this scapula has the characters of both the modern and the Neanderthal features. Exploring the exact age of other Salawusu human fossils and integrating the morphological information of other human fossils will contribute more to the phylogenic position of Salawusu fossil humans in the course of human evolution and the relationship with other fossil populations.

Considering that some Neanderthal characters such as occipital bunning and the antero-lateral surface of the frontal process of the zygomatic bone facing more laterally appear on fewer Chinese Pleistocene human skulls and Shuidonggou culture was influenced by distinct Mousterian, Wu[26] has pointed out that on both physical character and ancient culture, the influence from the West can be found on the Chinese late *Homo sapiens*. The relatively narrow glenoid fossa in Salawusu scapula may be the similar phenomenon which will add new evidence to the hypothesis of "Continuity with hybridization" for human evolution of China. The distance between the site yielding the Salawusu scapula and Shuidonggou site is less than 250 km. To consider both sites jointly gives people much food for thought.

5 Conclusion

Different scapular characters of recent humans, European Paleolithic humans, early modern humans and Neanderthals are mixed in Salawusu scapula. The Salawusu scapula is similar to early moderns and recent moderns and different from Neanderthals in morphological length, axillo-spinal angle and shape of the axillary border. However Salawusu scapula is similar to Neanderthals' and different from the most of the early modern and later modern groups except the Japanese in the breadth and height-breadth index of glenoid fossa.

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