Archaeometry **52**, 6 (2010) 1057–1078 doi: 10.1111/j.1475-4754.2010.00517.x

INTERPRETING THE SOCIAL MEANING OF DIFFERENT SHAPES OF HOUSE STRUCTURES BY EXAMINING THE FLOW OF RESOURCES: A CASE STUDY OF SAQACENGALJ AT THE SOUTHERN TIP OF TAIWAN*

MAA-LING CHEN, YI-LIN CHEN and HAI-LING LEE

Department of Anthropology, National Taiwan University, Taipei, 10617 Taiwan, Republic of China

Social differentiation is characterized by differences in social status and wealth, which are established and maintained by controlling and constraining the labour and flow of resources. This would affect the development of various aspects of a settlement in establishing hierarchical relationships. This study focuses on identifying the variations in the distribution of certain resources, such as imported goods, that help interpret the social meaning, particularly with regard to social status and wealth, of house structures having different shapes in an ethnic settlement in Taiwan. A petrographic study and residue analysis of the pottery along with spatial examination of the material remains were conducted to achieve the goal.

KEYWORDS: CERAMIC, PETROGRAPHIC STUDY, RESIDUE ANALYSIS, SOCIAL DIFFERENTIATION, TAIWAN, PAI-WAN

INTRODUCTION

One of the lines of evidence that can be used to detect social differentiation is the diversity in power for accessing various resources. The exchange of goods, especially of prestige goods, and the power to manipulate the exchange network reflect social status and maintain social distinction. Therefore, examining and comparing the number of prestige goods that different houses possess is a method that can be used to detect variations in the social status of households in a society.

Saqacengalj is located in Mu-dan County in the Ping-tung District at the southern tip of Taiwan. It is the oldest abandoned settlement of Kau-shi, a Pai-wan Group (specifically, the Southern Pai-wan Group) of the Taiwan indigenous populations. Previous studies have shown that the house structures at Saqacengalj have a highly repetitive patterned distribution and that certain sizes of house are highly clustered within a certain range, with only a few of other size falling outside this range. These patterns have been argued to reflect the strong and intense social constraints on and regulations of the appearances and sizes of the houses and settlements. The house structures at the sites have both vertical and horizontal rectangular shapes,[1] and the sizes of the latter are larger than average.

Petrographic and residue analyses were conducted to identify the provenance and the function of the pottery found at the site. These analyses were performed in collaboration with an examination of the spatial distribution of the other material remains to detect the distributional pattern of imported goods within house structures of different shapes. By an examination of the distri-

[1]The vertical rectangular shape refers to the depth of a unit being longer than its length, while the horizontal rectangular shape refers to the length of a unit being longer than its depth.

*Received 15 June 2009; accepted 12 October 2009

bution of the number and types of imported or prestige goods in the house structures, it is hoped that the different shapes of the house structures might be interpreted to support the argument that social differentiation is based on house patterns and size. It is also hoped that the relationship among the patterns of house structures, the material remains and the social–cultural contexts that produced them may be better understood and reconstructed in the future.

RESEARCH THEME

Social differentiation is examined by looking at the differences in social status and wealth, which are mainly established through the power and rights of access to resources, as well as through the manipulation of exchange networks for certain resources (Trubitt 2000). Through these mechanisms, certain economic power legitimizes the translation of financial control to sociopolitical control (Costin and Hagstrum 1995), allowing for the maintenance of the status quo and/or further distinction. Tentatively, material culture is employed in these social processes. Therefore, archaeologists have been generally looking for material evidence that suggests differences in the control of labour and resources as indicators of social differentiation and social control, which can be used to identify complexity. Therefore, variations in the distribution of exchanged goods, especially of prestige goods, have been regarded as one of the significant visible indicators (other than mortuary treatment, residential and public architecture, the existence of monumental constructions and craft specialization) for the detection of these processes and for the formation of materialization and symbolization in social differentiation.

The Kau-shi people were called the Kus-kus and belonged to the Parilarilao/Paliljalijau of Southern Pai-wan[2] (Utsushi *et al.* 1988; Chiang 2002). Saqacengalj was the first settlement established by the ancestors of the Kau-shi people when they migrated to the Hen-chun region at the southern tip of Taiwan. According to their oral history, the Kau-shi people moved and established new settlements five times after they departed from Saqacengalj and before settling in the current village. This process is said to have covered a period of 500–600 years. Aumargan and Cacenvakan are the two other settlements that the Kau-shi established during their migration after they left Saqacengalj (Fig. 1).

The settlement configurations and house structures at Saqacengalj, Aumargan and Cacenvakan have been mapped (Fig. 2) and analysed, and the nature and characteristics of the settlements have been compared with each other and with those of other settlements. Saqacengalj, which literally means 'a tool for drilling slates', is located in the forested uplands at 120°51′25″E, 22°09′07″N. At an elevation of 250–300 m, the settlement is built on a flat slope and is oriented along an E–W ridge. The topography defines the main area of the settlement, which is about 140 m from east to west and 100 m from north to south, or an area about 14 000 m^2, including more than 10 terraces with over 83 slate architectural structures. Radiocarbon dating indicates that Saqacengalj's abandonment occurred about 350 years ago. The date of its establishment is not known, but could be much earlier.

The settlement at Saqacengalj is located on a gently sloping area in the mountain woodlands. There are stone–slate house structures (floor, walls, roof, poles and even internal structures) that are arranged in parallel to numerous slope terraces, that stand adjacent to each other with a shared wall, and that are usually set against the slope facing the valley. The house structures have a foundation with an L-shaped cross-section formed by cutting into the terrace and building the rear

[2]The Pai-wan Group is a hierarchical society subdivided by anthropologists into Northern, Southern, Eastern and Western groups.

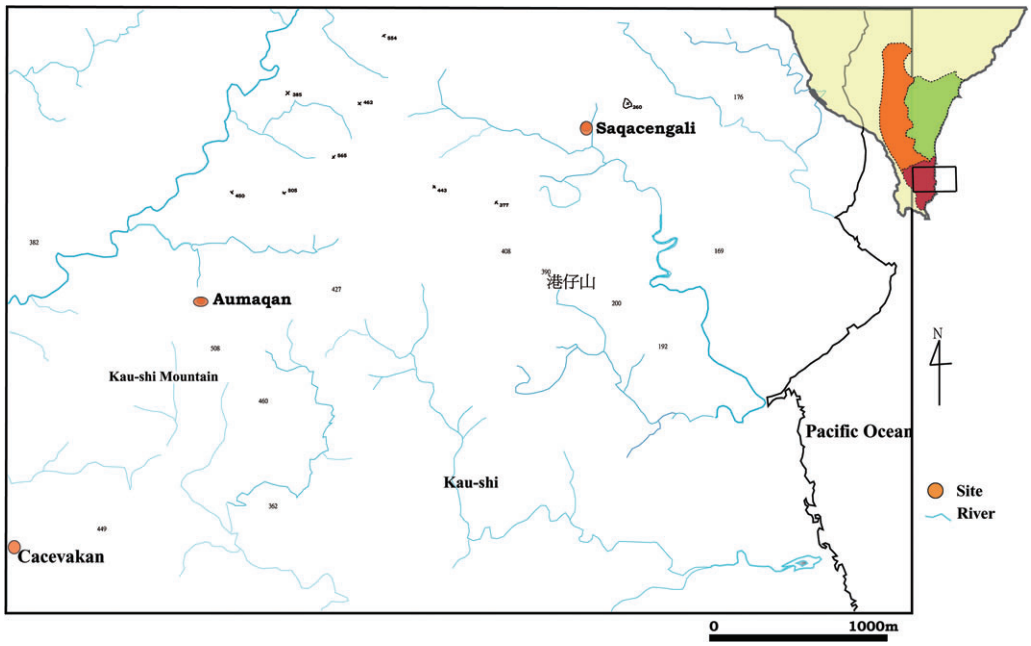

Figure 1 *The locations of the study area and the sites.*

and side walls against the excavated portions. Every house structure at these sites is independent of other house structures, with no pathway connecting any one house to the others.

The house structures at the site (Saqacengalj) have a vertical rectangular shape rather than a horizontal rectangular shape. Besides the house structures *per se*, there are other kinds of slate structures, such as front yards, ditches and platforms. In front of most house structures, there is a rectangular platform, varying in size, which is formed from slate slabs. While some house structures have individual platforms, some structures that are adjacent to one another share a platform that stretches from one end of the first unit to the other end of the second unit, without any clear dividing feature. Analysis shows that there is a high percentage of house structures at the settlement that have a platform attached. Some slates appear to have been assembled purposely into various features at various locations inside the house structures. Some of the paired structures that share a side wall and platform have small rectangular features located in the left part of the left unit and in the right part of the right unit (Fig. 3).

The settlement configurations at Aumargan and Cacenvakan share the same characteristics as those at Saqacengalj presented above. In general, the house structures have vertical rectangular shapes, a front yard and an attached platform, and a pair of house structures share a platform, with a feature inside each structure arranged in the left/right correspondent pattern (see Tables 1 and 2). In other words, these patterns are a common feature that the three sites share, and they may indicate a spatial arrangement rather than a sampling error.

If the topography of a settlement, typically a gentle slope with several terraces, is the primary determining factor for architectural design, it is more rational for residential units to be designed with 'horizontal rectangular' shapes in order to obtain more household space (such as in the Northern Pai-wan, as shown in Table 1), since the depth of the terrace is limited. Conversely, the

Figure 2 *The configuration of the settlement and the distribution of the seven structures with horizontal rectangular shapes at Saqacengalj (the units marked with horizontal lines are horizontal rectangular in shape).*

primary shape of the structural units at these three settlements is vertical rectangular. Moreover, the terraces even provide space for bigger front yards and platforms to be built, restricting the size of the houses. The terraces of the Northern Pai-wan settlements are steeper and deeper compared to the ones at the studied sites, and the minimum, maximum and average depths of the house structures at Northern Pai-wan are all larger. The platforms attached to the front yards at the Northern Pai-wan settlements were used to identify the status of the chief or the elites.

These differences in settlement characteristics between the Northern Pai-wan and Kau-shi are the result of different ideas about what the settlement and the house structure should be like (Chen 2010). While one group recognized that having a front yard and a platform attached to the house structure was ideal, the other group either had a different viewpoint or was constrained to having a big front yard and a platform attached to the house structure, and used this to express certain social meanings, such as status. What, then, were the social systems of the Kau-shi people?

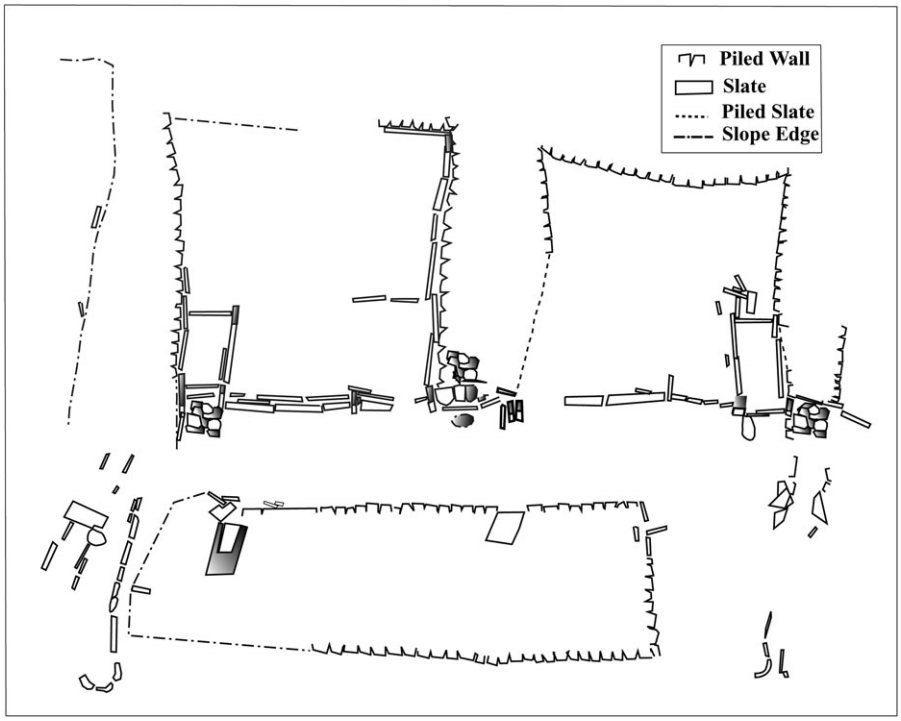

Figure 3 *A pair of house structures, with internal features located in the left/right corresponding pattern.*

Table 1 *Distribution of the different house shapes at the three sites*

Site	*House shape*							
	Vertical rectangular		*Horizontal rectangular*		*Square*		*Platform*	
Saqacengalj	73/83	88%	7/83	8.4%	3/83	3.6%	64/83	77%
Cacenvakan	7/15	47%	3/15	20%	5/15	33%	14/15	93%
Aumargan	35/50	70%	12/50	24%	4/50	8%	32/64	65%
Lai-yi (Northern Pai-wan)	23/215	10.7%	181/215	84.2%	11/215	5.1%	6/24	25%

Ethnographic and historic sources (mainly recorded in the Japanese occupation period) have recorded that Pai-wan was traditionally a ranked society that practiced primogeniture, in which the eldest child in the family, whether male or female, inherited the name and property of the family. Land ownership and economic development were closely tied to these social structures, and they shaped the method of use, distribution and extension of lands in and around the settlements. The settlement patterns and configurations, therefore, were shaped by these cultural and social aspects. In addition, the oral history of the Kau-shi group also characterizes Saqacengalj as a stratified society when the residents of Saqacengalj moved out of the settlement (Chen 2008).

Ching-yi Li (1994), Chun-min Huang (1982) and Sheng-fa Hsu (1996) studied the spatial construction and patterned arrangement of the Pai-wan settlements and how social stratification

Table 2 *The distributions of 'Platform', 'Pair of houses that share a platform' and 'Pair of houses that share a platform with structures in a left/right pattern' at the three sites*

Site/structure	*Platform*	*Pair of houses that share a platform*	*Pair of houses that share a platform with structures in a left/right pattern*
Saqacengalj	64/83, 77%	13 pairs, 41%	9/13, 69%
Cacenvakan	14/15, 93%	5 pairs, 71%	5/5, 100%
Aumargan	32/64, 65%	10 pairs, 63%	3/10, 30%
Lai-yi (Northern Pai-wan)	6/24, 25%		

is reflected in the diversity of architectural patterns and functions (particularly the size of houses and the degree of complexity of the interior spatial arrangements to distinguish between the elites and commoners). However, their sampling of the settlement sites failed to consider a representative cross-section of the households in the community, missing many of the subtle variations in settlement organization. The emphasis on elite households rather than on the more comprehensive settlement patterns made it difficult to understand the larger patterns of social rank and status in the community, as well as the material reflected in the household architecture and settlement organization. Moreover, some characteristics of the settlement at the studied site varied from these previous understandings. Can we take the oral history of Kau-shi and the general literature of Pai-wan as references for the social system at Saqacengalj and the early Kau-shi period?

Based on the effects of system integration, a high degree of either political or economic integration indicates that strong centralizing and coordinating controls and constraints regulated the flow of resources (Johnson 1980). The integration of the functions of social control and centralization of power to regulate and coordinate households, and the idea of how a house should appear and what its size should be, is a result of a negotiation based not only on the available natural resources but also on social rules, constraints and control of the flow of resources (land, materials etc.). Therefore, it is expected that the degrees of centralization and constraint regulating the flow of resources (especially land, manpower and construction materials for the house structures) in a settlement would affect the size distribution of the house structures and the distribution of certain materials.

An examination of the size distribution of the house structures at Saqacengalj shows that 93% of 83 houses were smaller than 30 m^2 in size, and that among them, 63% of the houses were between 10 and 20 m^2. Of the remaining 7%, one house is larger than 40 m^2, while another is much larger than the others, being in excess of 70 m^2. Corroborated by the highly repetitive patterned distribution of the characteristics of the house structures, this could be argued as an indicator that the inhabitants of the site had particularly consistent rules about how their houses should be built, and how certain social controls and constraints shaped the construction of the houses and limited the people's choice, if only to make the pattern consistent. Most of the inhabitants had limited resources and were only allowed to build houses up to a certain size limit. By contrast, certain people could build houses that had the size they preferred, in order to show their status and wealth.

Seven house structures at Saqacengalj are horizontal rectangular in shape and larger than the average size (Fig. 2). Two of them in particular are larger than the rest, thus showing their uniqueness compared with the others. Could this variation in the house layout at the Saqacengalj

settlement, as well as at other Kau-shi settlements, have significant social meaning? Could it be also linked to control of the flow of labour and resources, as well as being an indicator of social differentiation? Additional work on the ethnographic and historical literature may further illuminate this archaeologically encoded variation, especially work on the Pai-wan regarding the nature of their social stratification, the composition of corporate households, and the control of land ownership by the chief and the elites prior to and since the Japanese occupation period. Furthermore, can an analysis of other material culture patterns reveal more about the social and economic structures at Saqacengalj?

The primary goal of this study is to examine the pattern of spatial distribution of the materials unearthed from the house structures, which are of two shape types, to detect the differentiation in resource accessibility, especially in the exchange and acquisition of prestige goods, of the households at Sacaqengalj. Three methods are used for this study. The first and second use compositional analysis through petrographic study and residue analysis on the pottery in order to identify the sources and possible usage and function of the ceramic assemblages from the different house structures. The third compares and corroborates the structural features and material remains unearthed from the house structures to identify the possible meaning of the different shapes of the structures. To achieve this goal, house structures of different shapes were sampled and excavated in a way that allowed for further detailed spatial analysis.[3] The analyses of material remains were focused on a comparison of artefacts from the structures of different shapes to detect any differentiation in the accessibility of resources for the households. In this study, two units, 0S1 (vertical rectangular in shape) and 0S6 (horizontal rectangular in shape), at Saqacengalj were studied (Fig. 2).

CERAMIC ANALYSIS AND RESULTS

Classification and sampling

The potsherds from the two structural units (mainly from the front section in unit 0S1 and from the rear section in unit 0S6; see Fig. 4) were classified into several individual pots according to their interior and exterior colours, texture, manufacturing techniques and form, and re-fitted for further analysis. Unit 0S1 has five pot groups (P1, P2, P3, P4 and P5), with some potsherds that could not be assembled into any pot, while 0S6 has four pot groups (P1, P2, P3 and P4). The sherds were sampled from these individual pots for compositional study and residue analysis. Two samples from each pot group were selected, except for P2 of 0S1, while only one sample from P4 of 0S6 was selected, because the former was under reconstruction and the latter only had a few sherds in the pot. Two samples were also selected from the sherds that could not be assigned to any pot. A total of 17 sherds were sampled. (For data on the sherd samples, see Appendices A and B.)

Ceramic compositional study

Petrographic and mineralogical analysis was conducted for a ceramic compositional study. The mineralogical analysis shows that although the pots differ in appearance from each other, the compositions of the mineral assemblages are almost the same. The mineral assemblages of all paste samples contain mainly quartz, which is close to 20% in the clay matrix for all the samples, and less than 1% of some trace minerals (Table 3).

[3]The location, depth, orientation and angle of incline of provenance of every single material unearthed was recorded.

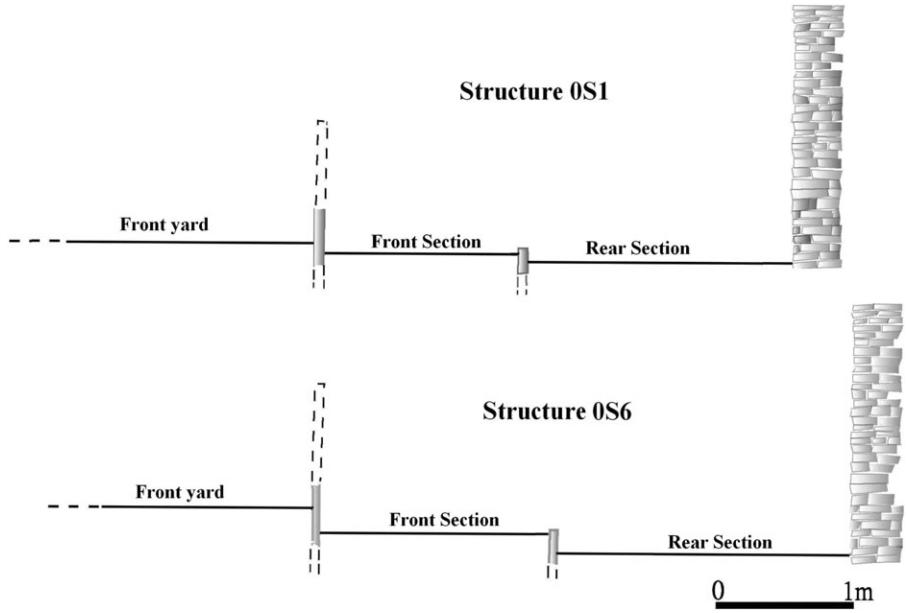

Figure 4 *The structure of the floors in the two studied units.*

The grain-size distribution of the inclusions, with corroboration from mineral composition, further indicates the source location of raw materials, the washing selection process, and the mixing and blending processes of the paste. Therefore, further analysis was carried out focusing on the attributes of the quartz inclusions, in order to examine in detail the properties of the composition of the samples. These results are shown in Table 3.

An examination of the grain sizes of the quartz was conducted using IPwin4[4] software. Since the software can analyse very fine grains, this examination included grains that would not otherwise be included in the petrographic analysis using visual inspection under a microscope. The grain sizes were further classified into sand-scale (>0.0625 mm^2), powder-scale (0.0625 mm^2 to 0.004 mm^2) and clay-scale categories (<0.004 mm^2) to make the data compatible with that of others (see Table 4). The result shows that most of the grain sizes of the quartz are grouped in the clay-scale region for all the paste samples. Observed under a microscope, the grain surfaces have neither sharp angles nor cleavage planes, which would result from the grinding process. Because of the combination of the mineral composition and the size distribution of the quartz grains, the results indicated that the paste samples did not contain artificial tempers and that they all came directly from the clay sources. Moreover, the high similarity in mineral composition implies that the raw clay material might have come from the same location or the same region.

The average and standard deviation of the grain sizes in the paste of the pottery groups varied (although most of them belong to the clay-scale category). A *t*-test (with $\alpha = 0.05$) was conducted on the samples in the same pot group to examine the variability of the average grain size. The results are presented in Table 5, which shows that in the average grain size of the samples from 0S1P1, 0S1P3, 0S1P4 and 0S6P3, there is no significant difference between two samples from

[4]The full name of the software package is 'Image-Pro Plus 4.1 for Windows, a product of Mediacybernetics'. More information is available from www.mediacy.com.

Table 3 *The properties of quartz in each sample (modified from Chen 2007, table 4-1-2)*

Sample ID		*Characteristics of quartz grain*			
		Grain size (mm²)		*Grain density (%)*	
Sample number	*Pot group*	*Average (granular group*)*	*Standard deviation*	*Average†*	*Standard deviation*
KS-01	0S1P1	0.0004821 (clay)	0.0001167	19.83	1.37
KS-02		0.0004787 (clay)	0.0000365	20.69	0.77
KS-03	0S1P5	0.0001308 (clay)	0.0000329	19.04	2.88
KS-04		0.0001752 (clay)	0.0000415	16.09	2.01
KS-05	0S1P3	0.0000877 (clay)	0.0000251	13.90	0.97
KS-06		0.0001804 (clay)	0.0001434	16.58	4.54
KS-07	0S1P4	0.0003109 (clay)	0.0001395	17.18	3.03
KS-08		0.0004373 (clay)	0.0002157	20.18	3.76
KS-09	0S1P?	0.0002026 (clay)	0.0000307	17.74	1.19
KS-10	0S1P?	0.0001553 (clay)	0.0000209	16.20	1.64
KS-11	0S6P1	0.0003581 (clay)	0.0001730	24.99	4.85
KS-12		0.0001917 (clay)	0.0000899	21.14	3.61
KS-13	0S6P2	0.0003304 (clay)	0.0000965	17.68	1.72
KS-14		0.0002301 (clay)	0.0001053	20.40	3.81
KS-15	0S6P3	0.0001595 (clay)	0.0000200	22.70	1.14
KS-16		0.0001528 (clay)	0.0000195	21.94	0.44
KS-17	0S6P4	0.0001620 (clay)	0.0000383	17.19	2.52

*Sand-scale (>0.0625 mm²), powder-scale (0.0625 mm² to 0.004 mm²) and clay-scale (<0.004 mm²).

†The values come from the average of five measurements of different spots on the same potsherd sample.

the same individual pot. On the other hand, there are significant differences among the samples from the rest of the pots. Sixty per cent of the total pots from unit 0S1 and 33% from unit 0S6 contained paste inclusions that are more homogenous in grain size. The paste of these pots might have gone through more intense washing selection processes when the potter prepared the materials.

Further analyses were carried out on the amount of polycrystalline quartz, the percentage of wavy extinction of monocrystalline quartz and the degree of roundness of the quartz. Polycrystalline quartz derives from a volcanic process that assembles monocrystalline quartz into polycrystalline quartz. Wavy extinction is the characteristic of a partial deformation of quartz under the action of stress. The source location of the minerals may be indicated by these two characteristics of quartz crystal, and the history of transportation and sedimentation of the mineral source can be determined from the roundness of the quartz crystal. The longer the process of transportation and the longer the duration of the mineral sedimentation, the higher is the degree of roundness of the crystal. Since the gangue in the southern Taiwan area is made up of a majority of metamorphic and igneous rocks, the quartz in the sedimentary rocks is mainly polycrystalline and undulatory. The crystalline quartz in this area is characterized by short streams that are angular and with a lower degree of roundness, as the grains do not go through long processes of transportation and weathering. The results of the analyses of these three aspects are shown in Table 6.

The results show that the amount of the polycrystalline quartz ranges from 0 to 4 grains and that the percentage of wavy extinction also varies from 0 to 4. The roundness of the crystalline

Table 4 *The categorical distribution of the grain sizes of quartz (from Chen 2007, table 4-1-4)*

Sample ID		*Granular category*		
Sample number	*Pot group*	*Average grain number of sand-scale*	*Average grain number of powder-scale*	*Average grain number of clay-scale*
KS-01	0S1P1	0.2	38.2	1642.8
KS-02		0	44	1639.2
KS-03	0S1P5	1.2	22.8	5886.2
KS-04		0.6	31	3620.8
KS-05	0S1P3	1.2	10.2	6477.8
KS-06		1.4	10.8	5157.4
KS-07	0S1P4	2	22.8	2332.8
KS-08		1.6	22	2139.2
KS-09	0S1P?	0.2	30.6	3410.2
KS-10	0S1P?	0.2	26.6	4046.6
KS-11	0S6P1	2.4	21.4	3058.4
KS-12		1.6	19	4023.6
KS-13	0S6P2	0.6	37.4	2140.6
KS-14		0.4	34.4	3845.6
KS-15	0S6P3	0	34.8	5523
KS-16		0	35.6	5597.4
KS-17	0S6P4	0.6	16.2	4189

Table 5 *The results of the* t*-test on the grain size of paste samples (from Chen 2007, table 4-1-3)*

Pot group	P-*value*	*Evaluation*
0S1P1	0.052731	No significant difference
0S1P5	0.028684	Significant difference
0S1P3	0.116574	No significant difference
0S1P4	0.195399	No significant difference
0S6P1	0.004935	Significant difference
0S6P2	0.001146	Significant difference
0S6P3	0.298409	No significant difference

quartz is angular to semi-round. The low amount of polycrystalline quartz and the low percentage of wavy extinction do not match the characteristics of the quartz from sediments in Taiwan. On the other hand, the degree of roundness of the crystalline quartz shows a characteristic that is closer to the crystalline quartz of mainland China than that of Taiwan. Due to the characteristics of the geological setting in mainland China, the degree of roundness of the crystalline quartz is expected to be higher than that in Taiwan. Therefore, the results of the analyses of these three aspects strongly indicate that the source location of the raw material might not have been in Taiwan, but that it points to somewhere in mainland China. This interpretation, based on the petrographic analysis of paste, corresponds to the identification of the manufacturing provenance of pottery that was made on an identical style of pottery imported from mainland China through trade or exchange with the Han people (Chen 2008).

Table 6 *The results of the analyses of the three characteristic variables of quartz (from Chen 2007, table 4-1-5)*

Sample number	*Grain amount of monocrystalline quartz*	*Percentage of wavy extinction (50 samples)*	*Roundness*
KS-01	1	2	Semi-angular to semi-round
KS-02	0	0	Semi-angular to semi-round
KS-03	3	2	Semi-angular
KS-04	2	2	Semi-angular
KS-05	2	0	Angular to semi-angular
KS-06	1	0	Angular to semi-angular
KS-07	0	0	Semi-angular
KS-08	1	2	Semi-angular
KS-09	2	0	Semi-angular
KS-10	0	0	Semi-angular
KS-11	4	0	Angular to semi-angular
KS-12	3	2	Semi-angular
KS-13	2	2	Angular to semi-angular
KS-14	1	2	Angular to semi-angular
KS-15	1	4	Angular to semi-angular
KS-16	0	0	Angular to semi-angular
KS-17	0	2	Angular to semi-angular

According to the combined results of the various analyses and the interpretation of the geological information, the compositions of potsherds from 0S1 and 0S6 at Saqacengalj are highly similar and homogeneous. The raw materials may have come from a single area, with a high possibility of their source being located somewhere in mainland China and not in Taiwan. However, the variation in grain size of the inclusions in the paste of the individual pots may indicate that some samples of clay were washed more efficiently than others during processing. In addition, the variation in grain size of the inclusions in the paste among the pot groups implies that although the paste material was collected from the same area or sediments of the same stream, the location might vary. The coarse-grained material may be from upstream, and the finer-grain material may have been collected from downstream.

Residue analysis of ceramics

The samples that were used in the petrographic study were also used for residue analysis to detect the possible usage of the pots. About 100 mg of powder was taken from each potsherd sample to conduct the analysis, which was focused on detecting organic compounds. The results are shown in Tables 7 and 8 and in Appendix C.

Bisphenol A, di-2-ethylhexyl phthalate, erucylamide and bis-octylphenyl-amine were found in most of the samples. Bisphenol A and di-2-ethylhexyl phthalate are generally used in flame retardants and plastic softeners. Therefore, the samples may have been contaminated by the equipment. Erucylamide is a derivative of erucic acid, which is mostly used as a lubricant for metals in manufacturing. It comes from the seeds of the Brassicaceae, such as rape flowers (*B. napus*), mustard (B. *juncea*), and the Tropaeolaceae, and from fats of marine animals. 4,4′-Butylidenebis is a new product used for food packaging materials. Therefore, where samples contain this substance, it may have been obtained from deposited food packs recently left at the

Table 7 *The results of the GC/MS analysis (the percentage of the six major compounds in the sample; Lee 2008, table 4)*

Sample ID	*Pot group*	*Bisphenol A*	*Octyl-diphenylamine*	*1-Octadecene*	*Di-2-ethylhexyl phthalate*	*4,4′-Butylidenebis*	*Erucylamide*	*Bis-octylphenyl-amine*
KS1	0S1P1	4.30	1.48	–	7.32	–	–	15.82
KS2		2.55	1.43	–	16.56	–	**1.00**	16.62
KS3	0S1P5	7.67	**4.28**	–	11.89	–	–	35.34
KS4		4.78	2.46	5.85	7.72	7.50	2.34	54.74
KS5	0S1P3	9.02	–	10.05	4.81	17.87	8.93	17.79
KS6		8.11	–	10.95	3.70	12.99	3.13	2.45
KS7	0S1P4	2.58	–	**2.88**	**1.13**	11.86	1.28	–
KS8		9.61	–	8.21	6.04	**17.48**	4.94	6.20
KS9	0S1P?	8.11	–	8.90	4.21	11.78	4.04	9.35
KS10	0S1P?	8.10	–	7.78	2.41	9.42	4.09	**1.75**
KS11	0S6P1	5.11	–	5.67	**1.23**	13.92	3.73	**0.00**
KS12		1.98	3.60	–	9.79	–	1.63	**51.18**
KS12-1′*		6.33	–	7.49	6.50	**3.25**	–	–
KS12-2′*		9.23	–	0.00	13.40	–	–	–
KS12-3′*		**17.35**	–	4.57	20.82	–	–	–
KS13	0S6P2	6.69	–	11.90	2.98	15.90	3.16	7.08
KS14		7.81	**0.78**	9.01	3.79	12.02	3.18	9.43
KS15	0S6P3	–	–	–	–	–	–	–
KS16		0.41	1.18	6.03	3.79	12.71	1.47	8.41
KS17	0S6P4	–	1.48	–	**28.77**	–	**10.08**	**50.42**

*KS12-1′, KS12-2′ and KS12-3′ came from KS12, which was used for testing different solutions at different rates of chloroform and methanol.

Table 8 *The characteristics and the possible materials that each pot may have contained, from the results of residue analysis*

Sample ID	*Pot group*	*Pot characteristic*	*Pot form*	*Provenance*	*Compound:*	*1-Octadecene*	*Erucyl amide*	*Lauric acid*	*Octadecanoic acid*	*Methyl oleate*
					Possible sources:	*Alcohol*	*Brassicaceae and Tropaeolaceae*	*Coconut and palm*	*Animal and vegetable fats*	*Animal and plant fats*
KS1	0S1P1	Olive-green glaze	Jar	Fell down from the southern		–	–	–	–	–
KS2		Olive-green glaze	Jar	area of the front section		–	1.00	–	–	–
KS3	0S1P5	Slip	Base	Fell down from the northern		–	–	–	–	–
KS4				area of the front section or front yard		5.85	2.34	–	–	–
KS5	0S1P3	Plain	Base	Fell down from the northern		10.05	8.93	–	–	2.43
KS6				area of the front section or front yard		10.95	3.13	–	–	–
KS7	0S1P4	Slip	Jar	Fell down from the northern		2.88	1.28	–	–	–
KS8				area of the front section or front yard		8.21	4.94	–	–	–
KS9	0S1P?			Southern area of the front section		8.90	4.04	–	1.37	2.13
KS10	0S1P?					7.78	4.09	–	0.95	2.72
KS11	0S6P1	Dark-brown slip	Jar	Fell from the centre of the back section		5.67	3.73	–	–	–
KS12						–	1.63	1.43	–	–
KS12-1′						7.49	–	–	1.83	–
KS12-2′						–	–	–	5.90	–
KS12-3′						4.57	–	–		–
KS13	0S6P2	Olive-green glaze	Jar	On the floor of the central		11.90	3.16	–		–
KS14				area of the back section, or fell down on to that area before the structure fell		9.01	3.18	–	–	–
KS15	0S6P3	Red-brown slip	Jar	On the floor of the northern		–	–	–	–	–
KS16				area of the back section		6.03	1.47	–	0.51	–
KS17	0S6P4					–	10.08	–	–	–

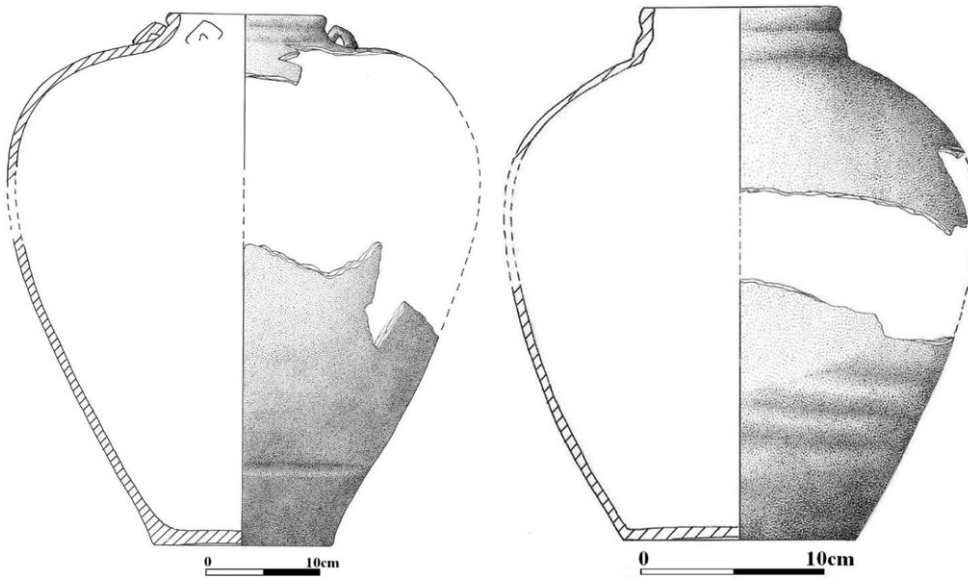

Figure 5 *Jar pots from unit 0S6.*

site. Bis-octylphenyl-amine is an element composed of a lubricant, and contamination may have come from the deposits after the site was formed. 1-Octadecene is a compound regarded as the 'background' of experiments (contamination of experiments). However, it might also come from deteriorated alcohol due to long-term storage. According to the ethnographies, most of the imported pots similar to these samples were used for containing alcoholic liquid and some of them were for ritual purposes. This might increase the possibility that the compound 1-octadecene comes from deteriorated alcohol; however, further verification still requires more samples and some advanced analysis. Some lipids were also found. Lauric acid usually comes from coconut oil or palm oil. Octandecanoic acid generally comes from animal or vegetable fats, while methyl oleate is contained in various fats.

The results of the residue analysis of the pottery samples show that all the pots retained certain organic compounds, indicating that they might have been used for containing certain organic materials. All the pots except for P1 of 0S1 and P4 of 0S6 may possibly have contained materials such as alcohol, rape flowers or leaf mustard. P1 and two individual samples from 0S1, together with P1 and P3 from 0S6, may have also been used to store meat or vegetables. P1 of 0S6 may have also contained coconut or palm plant food. However, due to the shapes of the pots (P1 and P4 of 0S1 and P1, P2, and P3 of 0S6 are all jars with small mouths; see Fig. 5), and since no evidence of burning was observed on the pots, these results reveal that the individual pots may have been used repeatedly for storing liquid or food, but not for cooking purposes. The variation in the amount and type of compounds contained in the same samples of the same pot group may be due to the uneven interpenetration of compounds into the pores.

THE SPATIAL DISTRIBUTION OF UNEARTHED ARTEFACTS IN DIFFERENT STRUCTURE UNITS

Aside from pottery, there are some objects, such as bronzes, iron artefacts and beads (the material of which is still unknown), that were unearthed from the studied structure units (see Fig. 6). The

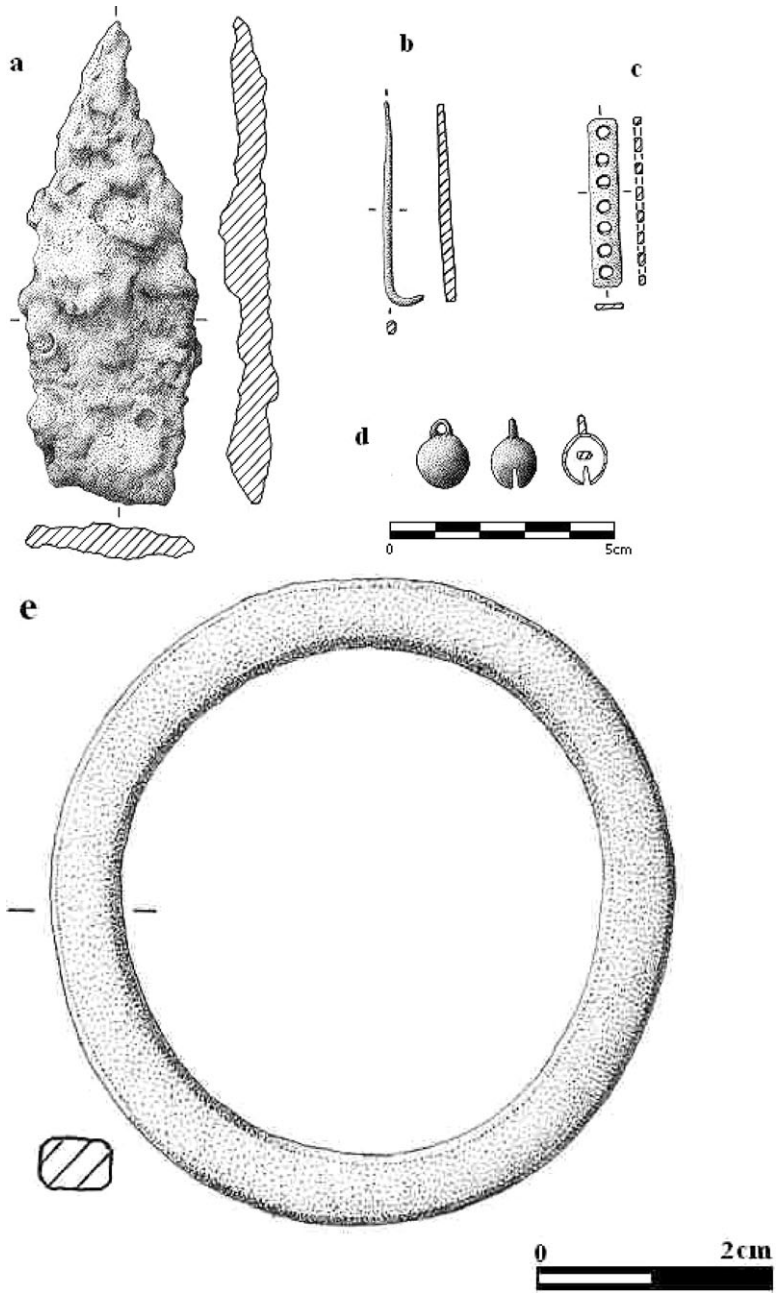

Figure 6 *Various metal artefacts unearthed at Saqacengalj. (a) Iron tool; (b) iron needle; (c) bronze plate with holes; (d) bronze bells; (e) bronze brace.*

Table 9 *Artefacts unearthed from the units*

Bronze			*Iron*			*Other*		
Type\unit	*0S1*	*0S6*	*Type\unit*	*0S1*	*0S6*	*Type\unit*	*0S1*	*0S6*
Buckle hook	1		Point	2	3	Bead	–	18
Needle with hook	1		Knife		1			
Square plate with single hole	2		Pan plate		6			
Plates	2		Plate		13			
Plates with hook	1		Waste	5061.5 g				
Rectangular plate with holes	–	12						
Bell	–	4						
Brace	–	4						

type and amount of these materials were analysed to examine the variation in the spatial distribution between the two structure units. The results are presented in Table 9, which shows that unit 0S1 has six types and a total of nine pieces of material goods, while 0S6 has eight types and a total of 61 pieces of material goods.

So far, the ethnographical and ethno-historic studies, as well as the oral histories of the ethnic groups, do not provide the data to inform us about the local (referring to Taiwan) manufacturers of bronze and iron artefacts in the aboriginal groups. Although certain evidence has been found at prehistoric sites to indicate the local manufacturing of iron, there are only records that show the technologies and the maintenance and repair of iron tools and artefacts within the ethnic groups, aside from trading bronze and iron with the Han and other people. Therefore, the bronze and iron have been regarded as imported, and bronze was even considered a prestige good by the Taiwanese ethnic groups. Although the material from which the beads unearthed at Saqacengalj were made is still unknown, the beads have been regarded as valued goods within the ethnic groups. Although the values of some of the artefacts are still uncertain, the artefacts themselves may indicate the power to regulate and coordinate trade and the flow of resources, especially of imported goods. Therefore, the distribution of these materials can be used to evaluate the variation in wealth or accessibility to special resources between two structure units.

SYNTHESIS AND DISCUSSION

The number of types and pieces of materials, such as pottery, bronze, iron and beads, in the two structure units were relatively different. The spatial distributions of these materials in the two units also varied. The formation processes of these two structure units have been studied, and the material remains used in the study have been identified as having been found *in situ* (Du 2006; Tsai 2007). According to the results presented above, all the pottery may have been imported through trade with the Han people, and these pottery artefacts may have been used as storage vessels for containing similar foods. However, the pottery in unit 0S1 was originally left in the front section, with an oven structure nearby. On the other hand, the pottery in unit 0S6 was in the rear section (Fig. 4), without any sign of nearby ovens or any other identifiable feature (this may be due to their being badly damaged). In any event, wherever they were found, no evidence for burning has been observed on any sherd remains. The bronze in both units and the beads in 0S6 were all left in the northeastern corner of the front section. The iron

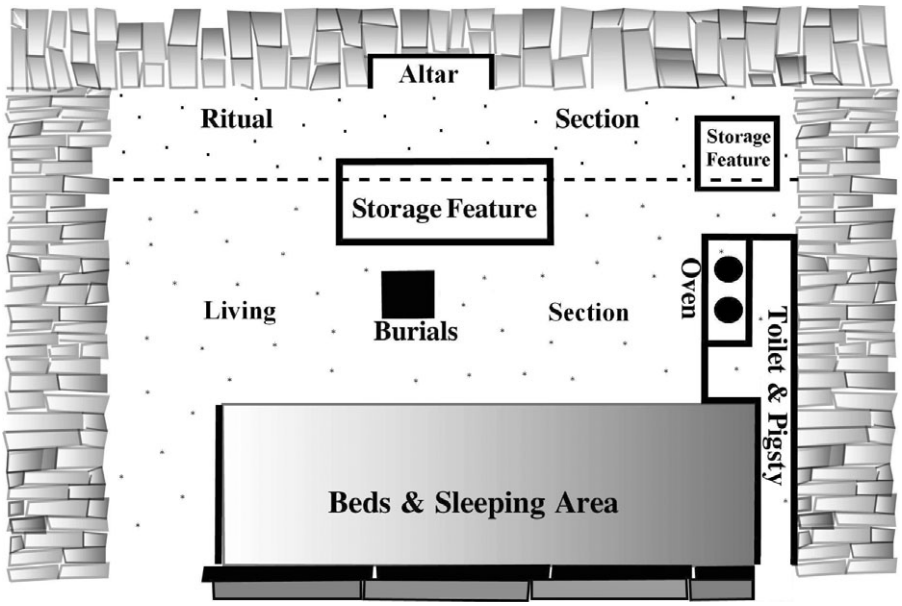

Figure 7 *The domestic spatial pattern of house structures in the Northern Pai-wan settlement (modified from Chiang and Li 1995).*

goods in both units were left in the rear sections. Almost all the materials unearthed from the two units might have been imported goods, and some of them might even have been prestige goods. The types and amounts of these materials were different in the two structure units, which may imply that the power and right of accessibility to imported resources or prestige goods was different.

The study of the usage of domestic space in a Northern Pai-wan settlement presents a pattern in which the domestic space inside a house was divided into mundane and sacred sections, with no dividers on the floor (Chiang and Li 1995). The front three-quarters of the house was the mundane area, and was furnished with beds for sleeping, an oven for cooking and a toilet. An area for pigs and storage features were also included. The rear section was the sacred area, with an altar for worship and containers for storage (Fig. 7). The floors at Saqacengalj were structured differently from those in the Northern Pai-wan settlements. They were even more restricted in order to separate the front and rear sections through the use of different floor levels (Fig. 4). Two oven structures were identified in unit 0S1: one was located in the front section, with certain associated items of pottery, and the other was in the rear section, with many iron slags unearthed. However, no oven feature was identified in unit 0S6. No altar feature was found in either unit. Although bronze ornaments from both units and beads from 0S6 were found, and suspected bed features were found in the sections where personal and sleeping spaces can be expected to be located if the Northern Pai-wan settlement pattern is considered, the pattern of the domestic space of the Northern Pai-wan settlements cannot be completely related to this site. Whether the front and rear sections of the studied structure units correspond to the mundane and sacred sections as seen in the division of the Northern Pai-wan settlement units is still undetermined.

Both studied structure units had metal ornaments left in the sleeping areas and storage vessels, possibly for containing similar foods. Some vessels were left in the front section, with an oven

nearby, while the others were in the rear section, where no other obviously identifiable features existed. This may indicate the presence of ceramic vessels in unit 0S1, although the storage types were more related to mundane purposes. The ceramic vessels in unit 0S6 were also for storage; however, if they were related to ritual purposes, there are still no available data by which this can be determined. There is another oven located in the rear section of unit 0S1, and it was associated with some pieces of iron tools and certain amount of iron slag. The oven structure is too incomplete to determine if it was related to the iron slag, and if it was used for repairing or maintaining iron tools. In any case, based on the features and materials that remained in the two structure units, the two units were both for domestic usage, but the activities and daily tasks carried out there and the spatial arrangement in the two units varied to some extent.

CONCLUSIONS

The petrographic study on mineral assemblages and their properties in the pottery corresponds to the results of stylistic examination of the pottery discovered in the two structure units 0S1 and 0S6 at Saqacengalj. This pottery may have been imported from mainland China through trading activities with the Han people. Residue analysis of the pottery items in relation to their shapes and spatial distributions indicates that the pottery may have been used for storing foods such as alcohol, rape flowers or leaf mustard, meat or vegetables, and coconut or palm plant food. However, the pot vessels in unit 0S1 may have been used more for food preparation activities in areas with nearby ovens, while those in unit 0S6 may have been used for storage purposes in non-cooking areas. The material unearthed from, and features identified in, the units show that the spatial pattern and the activities undertaken in the two units with different shapes are somewhat different. The front half of the front section may have been used for sleeping and personal space in both units, but there were diverse uses for the other sections. The imported goods in the two units vary in frequency of type and amount. Unit 0S1 has a vertical rectangular shape, while unit 0S6 has a horizontal rectangular shape. The various lines of evidence may illustrate that the daily tasks carried out in the different shapes of the structure units were not all the same, and the right or power to access imported or prestige goods may differ between the two structure units. This evidence may indicate that the social meaning of the two different shapes of the structures differed between the settlements, and mainly indicated social status or wealth.

In order to confirm the results obtained in this study and to interpret their social meaning, more data from the other structure units that have different shapes—especially data related to the identification of social differentiation at the site—are needed for further studies. Nevertheless, the initial results presented here suggest that different powers and rights of access to imported or prestige goods may have existed for groups in the two different shapes of house structure. This would further support the argument that social differentiation was practised at Saqacengalj, as evidenced by the pattern of the house sizes and corroborated by oral history. Overall, the results presented in this study show that the approach of using petrographic and residue analysis on materials to identify and examine the distribution of imported or prestige goods in different-shaped houses is worth further consideration in detecting social differentiation at the studied site.

ACKNOWLEDGEMENTS

The authors are grateful to Dr Jei-shoung Kou, in the Department of Chemistry, and to Dr Wu-shan Chen, in the Department of Geology, National Taiwan University, for kindly offering

the use of the chemical and petrographic laboratories, and for assistance in conducting the petrographic and residue analyses. The Study Center of Austronesian Cultures and Chiang Ching-kuo Foundation, are also thanked for offering the grants to make the research possible.

REFERENCES

Chen, Maa-ling, 2008, Settlement patterns at Saqacengalj, a slate house settlement in southern Taiwan, *Asian Perspectives*, **47**(2), 210–41.

Chen, Maa-ling, 2010, Interpreting the social differentiation by examining the house and settlement pattern and the flow of resources: a case study of Pai-wan slate house settlements in southern Taiwan (submitted for publication).

Chen, Yi-lin, 2007, *Revealing the social ranking encoded in the material culture: a case study on the ceramics from Saqacengalj, a Pai-wan abandoned settlement, Taiwan*, Unpublished bachelor thesis, Department of Anthropology, National Taiwan University, Taipei (in Mandarin). [陳以琳, 2007,《排灣族社會透過物質文化所展現的階序關係—以屏東縣牡丹鄉排灣族 Saqacengalj 舊社的陶器分析研究為例》, 國立臺灣大學人類學學士論文]

Chiang, Bien (ed.), 2002, *An investigatory report on aboriginal tradition, volume 5: Pai-wan Group*, Ethnology Institute of Academia Sinica, Taipei, Taiwan (in Mandarin). [蔣斌主編, 2002, 《番族慣習調查報告書 第五卷 排灣族》, 台灣總督府臨時台灣舊貫調查會原著, 中央研究院民族學研究所 。]

Chiang, Bien, and Li, Ching-yi, 1995, The spatial organization and meaning of household of the Pai-wan Group, in *Space, power, and society* (ed. Yin-kuai Hong), 167–212, Ethnology Institute of Academia Sinica, Taipei, Taiwan (in Mandarin). [蔣斌 李靜怡, 1995, 《排灣族家屋的空間結構與意義》, 黃應貴 編, 《空間、力與社會》, 中央研究院民族學研究所, 167–212.]

Costin, C. L., and Hagstrum, M. B., 1995, Standardization, labor investment, skill, and the organization of ceramic production in late prehistoric Highland Peru, *American Antiquity*, **60**(4), 619–39.

Du, Mei-huei, 2006, *A study on the site formation process: a case study of Saqacengalj, an abandoned Pai-wan settlement*, *Taiwan*, Unpublished thesis, Department of Anthropology, National Taiwan University, Taipei (in Mandarin). [杜美慧, 2006, 《遺址形成過程與廢棄現象之探究 — 以排灣族舊社 Saqacengalj 遺址為例》, 國立臺灣大學人類學研究所碩士論文。]

Hsu, Sheng-fa, 1996, *An initial study on traditional household decoration of the Northern Pai-wan*, Unpublished thesis, Department of Architecture, University of Chen-koun, Tai-nan (in Mandarin). [許勝發, 1996, 《傳統排灣族群北部式家屋裝飾初步研究》, 成功大學建築所碩士論文 。]

Huang, Chun-min, 1982, *A study on the change in house structure of the Northern Pai-wan*, Unpublished thesis, Department of Architecture, University of Chen-kou, Tai-nan (in Mandarin). [黃俊銘, 1982, 《排灣族北部型住屋變遷之研究》, 成功大學建築所碩士論文 。]

Johnson, A. G., 1980, Rank-size convexity and system integration: a review from archaeology, *Economic Geography*, **56**(3), 234–47.

Lee, Hai-lin, 2008, *Residue analysis: a case study on ceramics from Saqacengalj, an abandoned Pai-wan settlement, Taiwan*, Unpublished bachelor thesis, Department of Anthropology, National Taiwan University, Taipei (in Mandarin). [李慧琳, 2008,《殘留物分析的研究—以屏東縣牡丹鄉排灣族 Saqacengalj 舊社的陶器分析為例》, 國立臺灣大學人類學學士論文 。]

Li, Ching-yi, 1994, *The reconstruction and interpretation of the house structure of Lai-yi abandoned settlement, Pai-wan Group*, Unpublished thesis, Department of Architecture, University of Tou-hai, Tai-chun (in Mandarin). [李靜怡, 1994,《排灣族舊來義社住屋的復原與詮釋》, 東海大學建築所碩士論文 。]

Trubitt, M. B., 2000, Mound building and prestige goods exchange: changing strategies in the Cahokia Chiefdom, *American Antiquity*, **65**(4), 669–90.

Tsai, Pei-ying, 2007, *Spatial analysis and architectural structures: a case study at Saqacengalj, an abandoned Pai-wan settlement, Taiwan*, Unpublished thesis, Department of Anthropology, National Taiwan University, Taipei (in Mandarin). [蔡佩穎, 2007, 《空間分析與房舍結構—以屏東縣牡丹鄉排灣族 Saqacengalj 舊社遺址為例》, 國立臺灣大學人類學研究所碩士論文。]

Utsushi, K. N., Miyamoto, N., and Mabuchi, T., 1988, *The classification of Taiwan aborigines*, transl. Li-yu Huang, Unpublished, Ethnology Institute of Academia Sinica, Taipei, Taiwan (in Mandarin). [移川子之藏、宮本延人、馬淵東一等著, 黃麗雲 譯, 1988, 《台灣高砂族系統所屬之研究》, 台北: 中央研究院民族學研究所[未出版] 。]

APPENDIX A

Information concerning potsherd samples in this study

Sample ID	*Unit*	*Pot group*	*Length (cm)*	*Width (cm)*	*Size (cm^2)*	*Thickness (cm)*	*Weight (g)*	*Colour*	*Colour of Paste*	*Colour (inner)*	*Forming*	*Shaping*	*Shaping (inner)*	*Decoration*	*Decoration (inner)*
KS-01	0S1	0S1P1	4.83	3.52	17.00	0.51	13.5	2.5Y 3/3	5YR 5/3	5YR 4/2	Wheel	Smooth	None	Glazed	Slipped
KS-02	0S1	0S1P1	4.54	2.55	11.58	??	9.0	2.5Y 3/2	10YR 7/3	10YR 5/2	Wheel	Smooth	Smooth	Half-glazed	None
KS-03	0S1	0S1P5	3.63	3.17	11.51	0.67	9.5	2.5Y 7/4	2.5Y 7/4	10YR 6/4	Wheel	None	None	Half-glazed	None
KS-04	0S1	0S1P5	3.30	2.56	8.42	0.57	7.0	2.5Y 3/1	2.5Y 7/3	10YR 6/4	Wheel	Smooth	None	None	None
KS-05	0S1	0S1P3	5.03	3.01	15.14	0.43	9.5	7.5YR 5/3–5/4	10YR 6/3	10YR 5/4	Wheel	None	None	None	None
KS-06	0S1	0S1P3	3.89	2.98	11.59	0.47	12.0	10YR 5/3	10YR 6/3	10YR 5/3	Wheel	Smooth	Smooth	None	None
KS-07	0S1	0S1P4	3.92	2.21	8.66	0.92	13.5	10YR 4/3	10YR 6/3 and 10YR 4/1	7.5YR 6/4	Wheel	Smooth	None	None	None
KS-08	0S1	0S1P4	4.07	2.58	10.50	0.67	13.5	10YR 5/4	Interior 10YR 6/3; exterior GLEY1 5/10Y	10YR 6/4	Wheel	Smooth	None	Slipped	None
KS-09	0S1	0S1P?	3.82	2.85	10.89	0.68	17.0	10YR 5/2–5/3	10YR 5/1–4/1	10YR 5/3 and 10YR 5/1	Wheel	None	None	None	None
KS-10	0S1	0S1P?	3.62	3.16	11.44	0.47	10.5	10YR 6/3–5/3	2.5Y 6/3 and 10YR 5/1	10YR 4/2	Wheel	Smooth	Smooth	None	None
KS-11	0S6	0S6P1	4.10	2.57	10.54	0.85	13.0	2.5Y 5/3	2.5Y 6/4	2.5Y 6/3 and GLEY1 6/N	–	Smooth	None	Slipped	None
KS-12	0S6	0S6P1	3.80	3.66	13.91	0.87	22.0	10YR 4/1	2.5Y 7/4 and 10YR 6/1	10YR 6/3	–	Smooth	None	Slipped	None
KS-13	0S6	0S6P2	3.34	2.77	9.25	0.56	9.0	2.5Y 4/4	10YR 6/3	10YR 4/1	Wheel	Smooth	Smooth	Glazed	Slipped
KS-14	0S6	0S6P2	2.95	2.08	6.14	0.47	6.0	2.5Y 6/4	10YR 6/3	10YR 4/1	Wheel	Smooth	Smooth	Glazed	Glazed
KS-15	0S6	0S6P3	6.25	5.6	35.00	0.61	49.5	2.5Y 4/4	2.5Y 7/4	7.5YR 5/4	Wheel	Smooth	Smooth	Glazed	Glazed
KS-16	0S6	0S6P3	5.23	2.21	11.56	0.60	13.5	2.5Y 4/3	10YR 6/3	10YR 5/4	Wheel	Smooth	Smooth	Glazed	Glazed
KS-17	0S6	0S6P4	2.92	2.69	7.85	??	7.5	2.5Y 6/2	2.5Y 6/1	2.5Y 6/1	–	Smooth	None	None	None

APPENDIX B

Attributes of samples for residue analysis (from Lee 2008)

Sample ID	*Unit*	*Pottery*	*Power amount (mg)*	*Extracting amount (mg)*
KS1	0S1	0S1P1	101.7	55.3*
KS2	0S1	0S1P1	101.2	2.2
KS3	0S1	0S1P5	100.3	1.8
KS4	0S1	0S1P5	100.3	3.2
KS5	0S1	0S1P3	103.8	1.9
KS6	0S1	0S1P3	101.0	0.5
KS7	0S1	0S1P4	101.0	1.2
KS8	0S1	0S1P4	100.5	1.8
KS9	0S1	0S1P?	100.9	0.7
KS10	0S1	0S1P?	100.3	0.4
KS11	0S6	0S6P1	101.7	1.1
KS12	0S6	0S1P1	100.3	2.7
KS13	0S6	0S6P2	99.7	0.9
KS14	0S6	0S1P2	101.6	2.2
KS15†	0S6	0S6P3	–	–
KS16	0S6	0S1P3	100.4	1.0
KS17	0S6	0S6P6	101.5	0.5

*The weights were measured within a day after extraction, but they were greatly reduced after settling for 2 days at room temperature due to the evaporation of gas: the final weights should be less than 1.5 mg.

†Sample KS15 had completely worn out in the thin-sectioning process and is therefore not included in the analysis.

APPENDIX C

The result of the GC/MS analysis for sample SK1 (from Lee 2008)