陶瓷考古 通讯

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A *luohan* from Yixian in the Hermitage Museum: Some Parallels in Material Usage with the Longquanwu and Liuliqu kilns near Beijing

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Abstract

A body sample from a life-sized lead-glazed Chinese *luohan* figure from the State Hermitage Museum in Saint Petersburg, Russia was analysed by SEM and EDS techniques. The results were compared with analyses of clays and *sancai* shards from the Liuliqu kiln near Beijing and also the Guantai kiln in southern Hebei. The Hermitage *luohan* sample was also compared with a previous analysis of a comparable glazed *luohan* figure from the musée Guimet in Paris. All these large glazed figures (ten are known) are believed to have been found in mountain caves in the Yixian region of northern Hebei province in 1912, and TL mid-dates of AD 1200-1210 ± 200 years have been proposed for three examples.

The Hermitage *louhan* body- material proved closely similar in composition and microstructure to clays and shards from the modern Liuliqu kiln, but not to those from the Guantai kiln. The Hermitage *luohan* also showed a composition close to one other *luohan*, now in Paris. The Liuliqu kiln is 1.6km south from the Liao-to-Jin Longquanwu kiln-site, and published compositions of Liao-to-Jin Longquanwu whitewares, blackwares and *sancai/liuli* wares also show the same unusual features of the high-alkali levels combined with high-alumina levels found in the *luohan* analysis and in the raw samples of Liuliqu clay. The results of these analyses may throw important new light on the nature of the clay employed to make the Yixian Luohans. The Liuliqu clay is a chloritoid schist and its important feature is a fine-grained matrix largely composed of both potassium mica (muscovite) and sodium mica (paragonite). These minerals account for the elevated alkali contents found in analysis, and their thermal breakdown during firing results in the highly expanded microstructure observed for the Hermitage *luohan* body. An 8 km-wide band of chloritoid schist that extends for 50 km southwest from exposures in the Longquanwu area is the only known match across the region.

Introduction

In 1912 a group of life-sized glazed ceramic sculptures of *luohan* was discovered in limestone caves in a mountainous region of Yixian in Hebei province. Soon after their discovery the figures reached the international market and nine are now in major public museums in Canada, the USA, Russia, France, and the UK, while one is in the Sezon Museum of Modern Art, a private museum in Japan. The seated figures are about one metre tall and weigh more than 120 kg each, with another 100 kg for their separate stands. Three have replacement heads (those in museums in Toronto, Boston and Karuizawa) while the Hermitage example survives as an armless torso.

TL mid-dates of AD 1200-1210 ± 200 years have been proposed for three of the Yixian *luohan* and suggestions for possible sites of manufacture have included the Guantai kilns in southern Hebei province and the Western Hills region of Beijing, either at the Longquanwu kilns, or at nearby Liuliqu, where a glazed-tile factory still operates[1]. Both Longquanwu and Liuliqu are small villages under the jurisdiction of the Mentougou district, a much larger administrative unit of the Beijing Municipality. The problem of whether the glazed *luohan* were made for their mountain-cave site or were moved there for safety at a time of conflict has also been the subject of art-historical research[2].



Figure 1 Three examples of the Yixian luohan
Left the torso presently in the State Hermitage Museum, Saint Petersburg, Russia, Ht. 54 cm,© The State Hermitage Museum ; (centre) in The British Museum, London, Ht. 123 cm including stand, ©The Trustees of the British Museum; and (right) in the Penn Museum USA, Ht. 120.6 cm including stand, Penn Museum Object #C66A,B, Courtesy of the Penn Museum.

In terms of scientific investigation, body analyses have been published of one of the Yixian *luohan* – now in the Guimet in Paris although no kiln-site was matched to the composition established[3]. Now, thanks to the generosity of the State Hermitage Museum in Saint Petersburg, Russia a further sample from one of the ten surviving Yixian *luohan* has been made available for study, at the Research Laboratory for Archaeology and the History of Art at Oxford University. The 'Hermitage *luohan*' consists of the

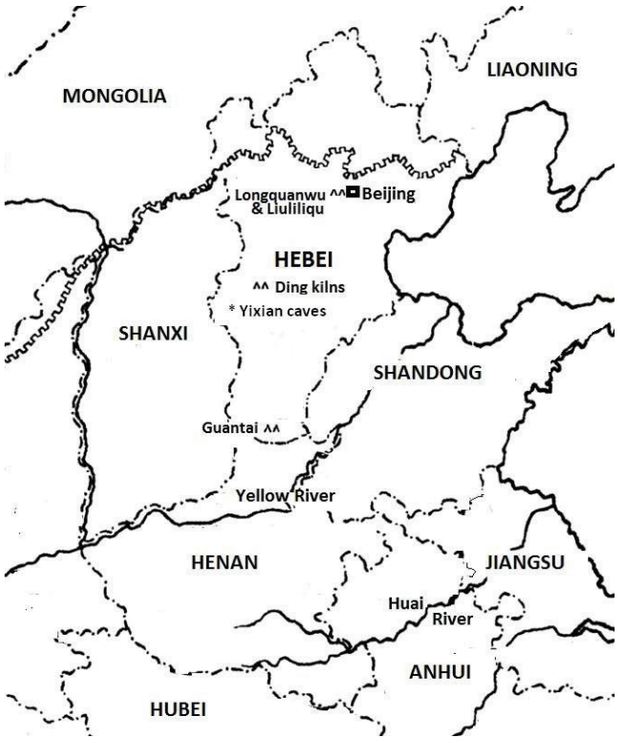

Figure 2 Map showing the relationship of the Longquanwu, Liuliqu , Ding and Guantai kilns, and the Yixian caves.

head and torso of the original figure (see Fig. 1, left). It was found in this state in China and sold to the German collector Harry Fuld in 1912. In 1937 the Fuld collection in Frankfurt (the property of a Jewish collector) was confiscated by the Nazi authorities and the *luohan* torso was ultimately sold by auction to the Berlin Museum. The gallery displaying it was destroyed in the wartime bombing of Berlin in 1944 and the piece was believed lost. In 2001 its surviving remains were discovered in a storage room in the Oriental Department at the Hermitage Museum by Dr Maria Menshikova and during conservation and restoration in 2015 a small unglazed sample was taken from the *luohan*'s interior for more detailed examination and analysis[4].

Comparative study

In the present work, the Hermitage *luohan* sample was compared with raw and fired materials from two of the proposed production-sites for the figures – Guantai in the south of Hebei province, and the Western Hills region of Beijing, and also with the *luohan* body-analysis made earlier in Paris. The Longquanwu kilns closed towards the end of the Jin dynasty (AD 1115–1234) so the Western Hills samples used for comparison came from the nearby Liuliqu kiln located in the Mentougou district in the western suburbs of Beijing. The Mentougou District museum records that in AD 1263 the Yuan government set up the office Liuliju (Bureau of Liuli Architectural Ceramics) at Liuliqu to produce glazed tilework and the kiln is still producing lead-glazed architectural ceramics and sculptures today. (See Fig. 2 for the relationship of these kiln sites with the Yixian (Yizhou) caves.) The Liuliqu kiln was visited in 2012, when some raw clay was collected, while the Guantai samples were collected in 2009 with the permission of the Palace Museum, Beijing. All the samples were studied at the RLAHA Oxford, using both Optical Microscopy and Scanning Electron Microscope techniques, particularly EDS and backscattered imaging (Table 1).

Results

The sample taken from the Hermitage *luohan* proved on analysis to be similar in its body composition to another *luohan* considered to be from the same original group and now in the musée Guimet in Paris. The Hermitage sample also proved similar in both its composition and microstructure to the raw clay sample from the modern Liuliqu works. The chemical compositions of the *luohan* and the modern Liuliqu clay also proved remarkably close to published analyses of whitewares, blackwares and *sancai*/

	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	Total
***luohan* bodies**									
Average Hermitage body	56.3	33.4	2.0	1.0	2.3	0.3	1.9	2.3	99.6
Average musée Guimet body	51.2	38.1	0.5	1.3	1.3	0.4	2.3	4.0	99.2
Longquanwu bodies (Liao/Jin)									
Average LQW Liao whiteware body	53.6	38.3	0.3	1.4	0.8	0.2	1.4	3.4	99.3
Average LQW Liao blackware body	53.8	37.0	0.9	1.4	1.0	0.15	1.6	3.4	99.2
Average LQW Liao *sancai* body	57.8	32.5	1.6	1.2	0.6	0.2	1.8	3.5	99.3
Modern Liuliqu material									
Modern raw clay	52.6	39.7	n.d	n.d.	n.d.	n.d.	3.5	4.3	100.00
Materials from the Guantai kilns									
Jin dynasty *sancai* body from Guantai	62.2	30.3	3.4	1.5	n.d.	n.d.	1.8	0.8	100.0
Raw clay from the Guantai site	57.2	36.6	1.8	2.1	n.d.	n.d.	2.1	0.4	100.0

Table 1 Compositions of fired ceramics and raw clay samples (n.d. = 'not determined'). The Oxford analyses are normalised, while other analyses are from Bouquillon et al[3], Chen et al [5].

luili wares from the Longquanwu kilns, sited 1.6km north from the Liuliqu tile factory, and manufactured during the Liao-Jin period and currently on permanent display at the Mentougou District Museum[5]. However, analysis showed that the samples from the Guantai kiln site were different from all of the above in both their compositions and in their microstructures, particularly in their sodium oxide contents, which are consistently low in all published analyses of the Guantai material[6]. Thus we can say that the best body-match so far found for the Yixian *luohan* is clay from the Western Hills region in Mentougou and that a similar material was also used for the Liao/Jin ceramics at Longquanwu.

The Western Hills clay

The Western Hills clay proved to be an exceptional raw-material, apparently without parallels at other north Chinese kiln sites. Bulk analysis showed a low-silica, high-alumina clay, superficially similar to other north Chinese clays but with the presence of some 4-5 wt. % of sodium oxide and 3-4 wt. % of potassium oxide (see Table 1).

Such high alkali levels in Chinese ceramic bodies are usually associated with large amounts of powdered igneous rock, but no evidence for ground rock could be seen in the SEM images and EDA-results. Most unusually the alkalis seem bonded in a very stable manner as Na and K cations to the clay or clay-mica components of the raw material. Another unusual feature of the *luohan*'s body is its highly expanded microtexture (see left SEM image, Fig. 3). This suggests a significant late release of volatiles as the clay-mica minerals decomposed. Therefore, compositionally and texturally, the raw materials used for the Hermitage *luohan* body differ significantly from typical north Chinese sedimentary high-alumina clays. Small dark crystals dispersed in the main matrix of the Western Hills samples may provide an explanation for this difference. These are of the iron-alumina-silica material chloritoid and their occurrence identifies these materials as metamorphic rocks, rather than the expected north Chinese high-alumina sedimentary clays. In geological nomenclature these are chloritoid schists, which can exhibit a range of compositions,

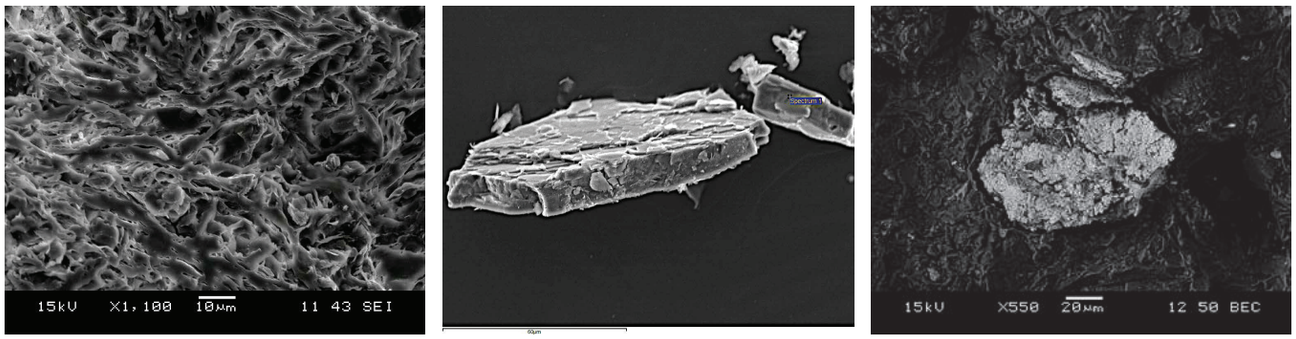

Figure 3 Backscattered SEM images
Left microstrure of the Hermitage *luohan*, centre chloritoid crystal from the Liluiqu clay, and right, chloritoid crystal in the Hermitage *luohan* sample.

including some with only incipient chloritoid. Their important common feature is a fine-grained matrix largely composed of both potassium mica (muscovite) and sodium mica (paragonite). The matrix minerals account for the elevated alkali content, and their thermal breakdown during firing results in the highly expanded microstructure observed for the Hermitage *luohan* body (Fig.3, left). An 8 km-wide band of chloritoid schist that extends for 50 km southwest from exposures in the Longquanwu area is the only known match across the region[7].

This unusual, but very versatile, Western Hills raw material seems to have been suitable for making high-fired Liao/Jin glazed whitewares and blackwares, and low-fired *sancai* wares at Longquanwu, and also architectural ceramics at Liuliqu – largely by choosing lighter-firing clays for whitewares, adjusting the degrees of grinding used for the raw clays, and by varying the kilns' firing temperatures. With regards to the Longquanwu kiln, the ability to make such a range of high-quality ceramics in the Western Hills region of Beijing may have owed much to the enforced re-settlement of Ding ware potters who brought their skills to this area in the Liao dynasty[8]. The Ding kilns in Quyang county Hebei province were the most advanced in China, and the world, at that time. They specialised in high quality whitewares, but also made small amounts of blackware and *sancai* ware, although with rather different body-materials from those used at Longquanwu[9].

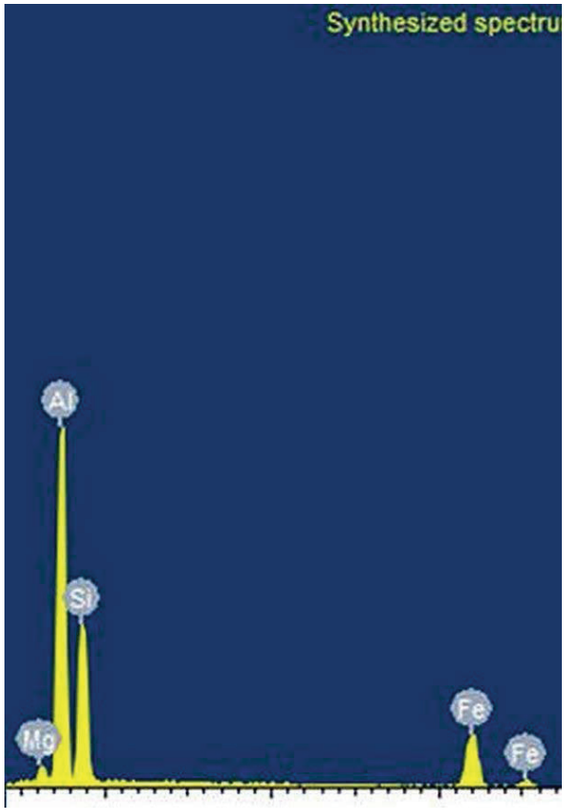

Figure 4 The ED spectra analysed in the Liuliqu clay (see centre, Fig 3).

Manufacture

Carbonised remains of a wooden armature were found in the Hermitage figure during restoration, and the oxidized relicts of what appeared to be iron rods are evident inside the Yixian *luohan* figure in the collection of the Royal Ontario Museum, Toronto[10]. Armatures made from various materials are the usual aids to the manufacture of both unfired-clay and dry-lacquer figures in China[11] although such armatures may present problems in drying and firing if left in situ in sculptures intended for the kiln. However recent conservation work on some unglazed Tang funerary figures in Amsterdam showed the use of fired-in iron supports, and the authors cite other examples of this practice in China[12]. The Yixian *luohan* figures are exceptionally well modelled, particularly in their hands, heads and features, so this apparent use of a making method more often employed by sculptors of unfired-clay and dry-lacquer figures may suggest the involvement of such specialists in the creation of the *luohan* group.

Non-plastic 'fillers'

Large-scale ceramic figures usually need a good proportion of non-plastic material in the clay-mix. This assists in the drying of thick sections, and also helps to avoid cracks in drying and firing by limiting uneven shrinkages. Such non-plastic materials may take the form of coarsely ground raw clay, pre-fired and crushed clay ('grog'), or the separate addition of an aplastic material such as crushed igneous rock. Study of the microstructure of the Hermitage *luohan* suggests a use of the first method, where the partial crushing of the dry shaley clay has left a good proportion of unground clay in the prepared body. This resisted plasticising by water and allowed the coarser clay-fraction to act as its own 'filler' (Fig. 5).

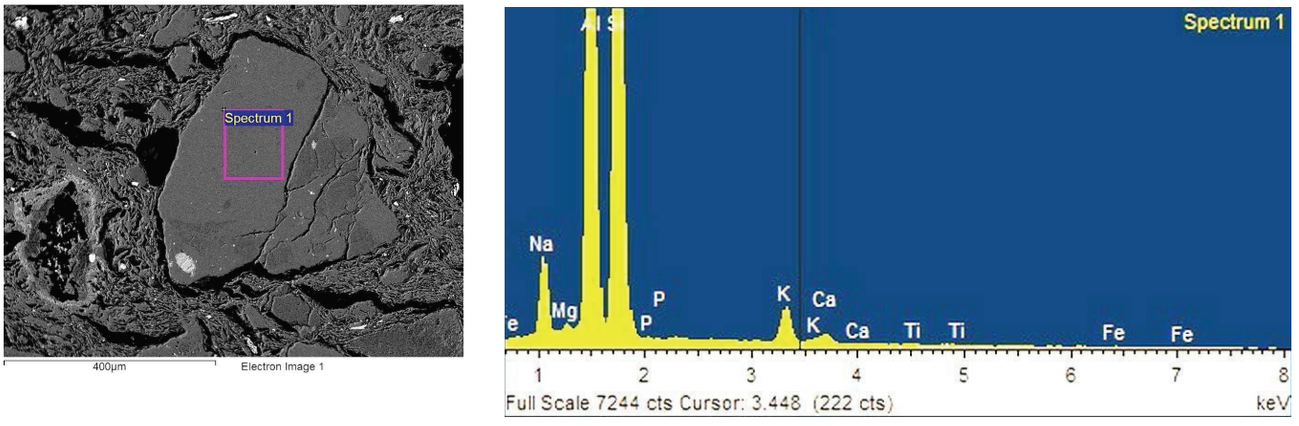

Figure 5 (Left) SEM images of the Hermitage *luohan* body show much unmixed clay of the same composition as the bulk matrix, probably used as an inert 'filler' to limit and control shrinkage in making and drying.
(Right) SEM analysis confirms that the inclusions are AlSiNa-K, i.e. clay with the same composition as the bulk matrix

Firing

With the likely presence of considerable organic material in the raw clay (1.5-3.5 wt. % carbon was found in the Liuliqu clay) a preliminary biscuit-firing would have probably been necessary for the *luohan* figures, as the carbon component of the clay tends to burn away at the same temperature as *sancai* glazes are maturing (ca. 800-900°C), and lead glazes can be

damaged by localised reducing atmospheres. From notes taken by Eileen Hsiang-ling Hsu in October 2009 at the modern Liuliqu kiln site, a biscuit firing for architectural ceramics to between 980°C and 1010°C was typical, while the second lead-glaze firing was taken to a slightly lower temperature, 960°C - 990°C[13].

Conclusion

Although we cannot be certain that the Yixian *luohan* were made near Beijing, at kilns in the Western Hills region, it does appear that they were made from a clay body closely similar to that used in this area from the Liao dynasty onwards, and still used there today. The two *luohan* figures so far analysed have shown this unusual clay composition. This is a low-iron, high-alumina clay material with a high natural percentage of alkaline oxides from the abundance of potassium and sodium micas in the raw material. The results of the analyses at the RLAHA Oxford therefore throw important new light on the nature of the clay employed to make the Yixian *luohan*, and also on some of the practical aspects of manufacture that may have arisen from the use of this very unusual metamorphosed clay-like rock.

In addition, the recorded presence of oxidised or carbonised armatures within two of the *luohan* so far examined implies making-methods similar to those used by contemporary unfired-clay or dry-lacquer sculptors – which may have some bearing on the outstanding sculptural qualities of the Yixian *luohan* figures. It might also be suspected that the high level of ceramic expertise that developed in the Mentougou region of Beijing may have owed much to the forced relocation there of potters from the Ding ware kilns during the Liao dynasty.

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俄罗斯圣彼得堡国家遗产博物馆藏中国易县出土三彩罗汉像的科学分析
——兼谈北京龙泉务窑和琉璃渠窑制胎原料选择方面的共同点

摘　要：本文使用扫描电子显微镜及外接能谱分析了一件三彩罗汉像的胎体样品。该罗汉像有真人大小，现由俄罗斯圣彼得堡国家遗产博物馆收藏。类似的大型三彩塑像（目前已知共有十件）据称是 1912 年在中国河北省北部易县境内一座山洞里发现的。对其中三件的热释光测年平均结果表明其烧造年代为公元 1200±200 年。本文还对比分析了北京琉璃渠窑以及河北观台磁州窑现代制瓷粘土和三彩残片样品。同时还和以前分析过的巴黎吉美博物馆藏的一件类似的三彩罗汉像进行了比较。

遗产博物馆三彩罗汉的胎体无论是化学组成还是显微结构都与北京琉璃渠窑现代制胎粘土和三彩残片的比较接近，但与观台磁州窑的样品有所差异。同时该样品与吉美博物馆的罗汉样品的化学组成也类似。琉璃渠窑位于辽金时期的龙泉务窑窑址南约 1.6 公里 (1 英里)。发表的龙泉务窑窑址出土白瓷、黑釉瓷以及三彩 (琉璃器）的胎体化学组成数据也和这件罗汉像以及琉璃渠窑样品比较接近，特征都是含有较高的三氧化二铝和碱金属氧化物。

本次分析使得我们对琉璃渠窑陶瓷生产所用制胎粘土的特征有了重要的全新的认识。分析结果表明这类粘土是一类绿泥片岩的风化产物，主要由白云母（钾云母）和钠云母组成的细小的结晶组织基体。大量的云母类矿物是胎体中碱性氧化物含量偏高的原因；同时这类矿物在烧造过程中的受热分解导致在显微观察中发现的胎体出现大的膨胀现象。目前已知的龙泉窑附近这类原料唯一产地是该窑址西南面的一条宽 8 公里绵延 50 公里的绿泥片岩带。

关键词：圣彼得堡国立遗产博物馆，三彩罗汉像，制胎粘土，琉璃渠窑，龙泉务窑，绿泥片岩

（崔剑锋译）