'05

古陶瓷科学技术 6

2005年国际讨论会论文集

（ISAC'05）

郭景坤 主编

上海科学技术文献出版社

·上 海·

编辑委员会

前　言

由中国科学院批准，并得到中国国家自然科学基金委员会、上海市科学技术委员会的支持和赞助，由中国科学院上海硅酸盐研究所和上海古陶瓷科学技术研究会主办的2005年古陶瓷科学技术国际讨论会将于2005年11月1日至11月4日在中国上海，中国科学院上海学术活动中心召开。

自1982年召开的第一届中国古陶瓷科学技术国际讨论会至今，古陶瓷科学技术国际讨论会已经是第八届了，其中七届会议由中国科学院上海硅酸盐研究所主办与承办。在这七届中共编辑出版了中、英文版论文集十一册，是我们中国科学院一个系列性国际会议的成果，讨论会为世界范围古陶瓷科学技术、考古、古陶瓷贸易、工艺、美术、测试分析方法及其他等各个方面的研究工作的最新成就提供了讨论和交流的论坛。

本届会议收到来自澳大利亚、中国、印度、日本、俄罗斯、新加坡、韩国、英国、美国、乌兹别克斯坦和香港等国家和地区的学者同行提供的81篇论文。为了便于交流讨论，本届会议在会前正式出版了附有详细英文摘要及少数中、英文全文的中、英文混合版论文集。提交本届会议的论文涉及到如下的研究内容：

1.研究范围包括陶器、原始瓷、瓷器等的科学技术、工艺、原料、测试方法、窑炉、考古、仿制、修复及其他方面的内容。

2.研究对象除中国古陶瓷外，还有俄罗斯滨海州等地区、中亚（突厥）、乌兹别克斯坦、朝鲜、日本、印度、泰国、印度尼西亚、东南亚（唐代沉船）等地区发现的古陶瓷。

3.本届会议论文中俄罗斯学者提交的论文主要是研究在俄罗斯东北部滨海州地区出土的古陶瓷。青花瓷和乳浊、分相釉的研究论文占本论文集论文总数20%。“支持向量机算法”有关论文，首次有稍多的研究篇幅。

在本届会议论文中，中国科学院上海硅酸盐研究所提交的论文数量达到论文总数的27%，上海大学论文数量占10%，上海古陶瓷科学技术研究会会员提交论文数量是历届之最，达到论文总数43%，国外提交论文达到总数20%。

为了更好的交流和讨论，我们衷心希望本论文集为本届会议的召开和成功作出贡献。同时也希望能为未能参加本届会议的各国古陶瓷研究工作者提供有关古陶瓷科学技术和古陶瓷考古研究的最新信息。

本论文集本着兼容并蓄的原则，对各家观点基本上按原论述发表，我们编辑委员会只对个别的词句、英文摘要和个别文章作了稍多的修改及版面的编排。

由于时间的限制，对于超过截稿期而未能纳入本论文集的论文的作者，表示十分的歉意。

最后，借此机会向支持和资助会议及出版本论文集的单位和个人表示衷心的感谢，也向参加审稿、翻译、校对和出版的所有工作人员表示衷心的感谢。

2005年古陶瓷科学技术国际讨论会主席

中国科学院院士

上海古陶瓷科学技术研究会顾问

2005年5月

PREFACE

As an international forum for the exchange of scientific and technological findings in the field of ancient ceramics, the 2005 International Symposium on Ancient Ceramics —— Its Scientific and Technological Insights (ISAC'05) will be held from November 1 to November 4, 2005 at Convention Center of Chinese Academy of Sciences, Shanghai, China. This Symposium was approved by the Ministry of Science and Technology and is sponsored by the Shanghai Institute of Ceramics, Chinese Academy of Sciences (SICCAS), and the Shanghai Research Society of Science and Technology of Ancient Ceramics (SRSSTAC) under the auspices of the National Natural Science Foundation of China and the Shanghai Science and Technology Committee.

Eight International Symposia on the Science and Technology of Ancient Ceramics have been convened as an international symposium series since the convening of the first symposium in 1982, seven of which were sponsored and undertaken by SICCAS. A total of 11 proceedings in Chinese or English were edited and published. All these symposia have been proved to be effective forums for the worldwide discussion and exchange of the latest research findings in different fields of ancient ceramics including scientific and technological research, archaeology, trade, art and crafts, dating and measuring methods and others.

There are 81 papers submitted to this Symposium by scientists and experts from different countries and areas, including Australia, China, Japan, Russia, Singapore, South Korea, United Kingdom, United States, Uzbekistan, and Hong Kong. For the convenience of exchange and discussion, the Chinese—English proceedings including original texts with detailed English or Chinese abstracts were regularly published before the Symposium. The papers submitted to the Symposium deal with the following research topics:

1. The research fields cover science and technology of pottery, proto-porcelain and porcelain, processing, raw materials, measuring methods, kilns, archaeology, imitation and restoration technology.
2. Besides ancient Chinese ceramics, the objects of study include ancient ceramics from Russian Primorye region, Middle-Asia (Turkey), Uzbekistan, Korea, Japan, India, Thailand, Indonesia, and Southeast Asia (wrecked ship of the Tang dynasty).
3. Papers submitted by Russian scholars mainly focus on the ancient ceramics unearthed from the Primorye region in the Northeast of Russia. Up to 20% of the papers relate to the blue-and-white porcelains, opaque glazes and phase-separated glazes. Comparatively more papers with regard to "Support Vector Machine" are included in the Proceedings for the first time.

27% of the papers were submitted from the Shanghai Institute of Ceramics, and 10% were from the Shanghai University. Up to 43% of the papers were from the members of the Shanghai Research Society of Science and Technology of Ancient Ceramics, being the highest number so far submitted. While 20% of the papers were from abroad.

It is sincerely hoped that this proceedings could promote academic exchange and discussion among

colleagues so as to make contribution to the convening of this Symposium and the achievement of its success. It is also hoped that for colleagues of different countries and areas who could not attend this meeting, the proceedings could provide information concerning the latest advances in fields of science and technology as well as archaeology of ancient ceramics.

For the sake of incorporating papers of diverse points of view of different schools, all papers published in the proceedings are their original texts. The editorial work has been confined to the lay-out of figures and articles and to abridgement of individual words and sentences in the texts and English abstracts.

Owing to the limitation of time, a few overdue papers can not be included in the proceedings. We would like to express our deep regret for this.

Finally as the Chairman of ISAC'05, I wish to take this opportunity to express my hearty thanks to all the organizations and individuals who have contributed funds and given support to the Symposium and the publication of this proceedings. Thanks are also due to all who have participated in review, translation, collation, edit and publication.

Prof. Guo Jingkun
Chairman of ISAC'05
Member, Chinese Academy of Sciences
Counsellor of SRSSTAC
June, 2005

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跨湖桥遗址陶器的研究*

Study on Pottery Excavated at Kuahuqiao Site

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Abstract

The Kuahujiao site is a newly-discovered site of Neolithic cultures at the middle and the lower reaches of the Changjiang River. It is located at Xiaoshan District, Hangzhou of Zhejiang Province. The site was unearthed three times from 1990 to 2002. According to the ^{14}C data of the pottery specimens measured by the laboratory of the related college of Bejing University, the date was 8000 to 7000 years ago. A large number of pottery wares were excavated.

The sherds excavated from different cultural layers and different search pits were considered when the pottery specimens were chosen. In addition, four kinds of typical decorative pottery sherds were selected for study. They are black pottery with bright surface, pottery with red coat, decorative pottery with small clay spots and the red painted pottery. Their chemical compositions, microstructures, firing temperatures and some physical properties have been measured. Their raw materials, manufacturing process and the forming methods for the decorative pottery have been discussed.

Four conclusions drawn are as follows.

1.The sherds unearthed at Kuahujiao site are basically charcoal-contained pottery. They were manufactured by consciously mixing the ashes of the stems and leaves which burnt in advance into clay composed of muscovite, quartz and feldspar, adding appropriate water into them and stirring them, forming various kinds of green bodies out of the mixture and firing them.

These pottery wares contained many ashes of plants. Therefore their organic matter and charcoal increase correspondingly. Their losses on ignition are large.

2.Raw materials for pottery wares of the Kuahujiao site did not vary clearly. The firing process for near a thousand years did not vary clearly either.

3.The black pottery with bright surface was not made by "clay glaze". Pottery with red coat was formed by giving the surface of a body a coat of slurry whose grains were very small in size and contained higher content of Fe_2O_3, and then fired. Decorative pottery with small clay spots was manufactured by drawing a lot of small spots of clay containing less content of Fe_2O_3 and firing the drawn green body. The painted pottery might be formed by painting the surface with some materials

* 国家自然科学基金项目（项目编号 40343021）；中国科学院上海硅酸盐研究所知识创新项目（项目编号 SCX 200415）；上海古陶瓷科学技术研究会科学基金项目

or ground red mineral slurry containing higher content of Fe_2O_3. After firing, the red patterns dependent on iron oxide play an important role in decoration.

4.The black pottery with bright surface, decorative pottery and painted pottery all occurred very early.

长江下游地区一个新的新石器时代文化遗址——跨湖桥遗址位于浙江省杭州市的萧山区。1990年进行第一次发掘，2001年5~7月进行第二次发掘，2002年10月~12月进行第三次发掘。根据北京大学文博学院实验室对标本进行的^{14}C测定数据，年代定为距今8000~7000年间。从时间来看，跨湖桥遗址的最早期要超过著名的河姆渡遗址。跨湖桥遗址的3次发掘，特别是第二、三次发掘，出土了大量陶器。出土的陶片基本为泥质夹炭陶，部分陶片还含砂粒或蚌屑。夹砂的陶片是部分釜、甑类炊器的碎片[1]。

陶器的主要器形为釜、圈足盘、罐、钵以及甑等。纹饰有彩绘、镂孔、戳印、拍印、刻划、泥点等多种。陶器大多器壁匀薄，造型规正，修整仔细。成型主要是手工制作，已用慢轮修整。

从已修复的150余件陶器复原器来看，器物形态及其组合跟河姆渡和罗家角等附近地区发现的早期文化遗址的陶器不同，那就体现了跨湖桥文化遗址的独立性。联系其陶器延续近千年的历史，为我们研究古陶器工艺发展提供了难得的机会。

跨湖桥遗址有一层文化层由于出土陶片少未能提供陶片标本外，其余各文化层均提供了较多的陶片标本。为此，对浙江省文物考古所，特别是蒋乐平先生对我们这一工作的支持，表示衷心感谢。

为了对跨湖桥遗址陶器的烧制工艺及其近千年的发展过程有一个较全面的了解，我们选择了不同文化层并照顾到不同探方的陶片标本。另外还考虑到跨湖桥遗址出土陶器中有装饰陶器，我们挑选了4种典型的装饰陶片，即黑光陶、红色陶衣陶、属于厚彩的泥点纹装饰陶和属于薄彩的红色彩绘陶进行研究。对这些陶片进行了化学组成、显微结构、烧成温度和某些物理性能的测定。从原料、烧成工艺以及装饰陶形成的方法等方面进行探讨分析。

从跨湖桥遗址陶器和装饰陶的出现，反映出当时人类除了考虑实用性外已开始在生活中追求美学，从中我们多少可以领略到长江下游地区七八千年前文明起源的一些情况。

一、化学组成

用EDAX公司生产的Eagle III型能量色散X射线荧光能谱仪，分析了这些陶器，包括黑光陶和红衣陶的表面和内部以及白色泥点纹装饰陶的泥点和陶胎表面，彩绘陶的红色彩绘和陶胎的化学组成。也分析了当地取的4种土即湖Ⅴ层土、原始生土、8A层土和湖Ⅳ层土的化学组成。测试结果分别列在表1，表2中。这里需要说明的是表1编号一栏中X代表萧山，K代表跨湖桥遗址，T代表陶器。因此XKT就是萧山跨湖桥遗址陶器。下文各表表示同样意思。用多元统计分析的对应分析对表1数据进行处理，得到图1跨湖桥遗址陶器的化学组成因子载荷图[2]。从图1来看，跨湖桥遗址陶器的分布没有随时间的推移按不同时期产生有规律性的分布。分布是比较分散，相互交叉。也就是说，各文化层陶器的化学组成没有明显的差别。表2是跨湖桥遗址黑光陶和装饰陶的化学组成。图2是跨湖桥遗址黑光陶和装饰陶。

我们选择的跨湖桥遗址陶器样品基本上都是夹炭陶，大多数均是夹炭黑陶，也有少数陶

器是外表面带红色的夹炭红陶或夹炭灰红陶。肉眼可以从陶片的断面上看到炭粒的分布情况。我们在各个文化层中选取一个编号的陶片做烧失试验，数据列在表3跨湖桥遗址陶器烧失量中。从表3中可以看到样品的烧失情况。一般来说跨湖桥遗址陶器的烧失量是比较大的，最高的可达14.7%，最低的也有6.9%。

表 1　跨湖桥遗址陶器和有关黏土的化学组成

Table 1 Chemical compositions of pottery and the related clays from Kuahujiao site

序号	时期	编号	化学组成（wt%）										
			SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	MnO	P_2O_5	总量
1		湖Ⅴ层土	64.06	20.49	6.76	0.60	0.55	3.24	3.92	0.39	0.03	0.02	100.06
2		原始生土	77.04	14.67	4.04	0.75	0.26	1.19	1.84	0.20	0.03	0.04	100.06
3		8A层土	69.63	13.67	6.85	0.44	5.86	1.33	1.99	0.24	0.13	0.99	101.13
4		湖Ⅳ层土	72.96	14.64	5.34	0.60	2.54	1.49	2.06	0.38	0.07	0.48	100.56
5		XKT(4)-1	64.16	23.25	5.20	0.60	1.27	1.84	2.33	1.35	0.02	0.30	100.32
6		XKT(4)-2	71.02	19.10	4.40	0.55	0.74	1.05	2.02	1.11	0.03	0.10	100.12
7		XKT(4)-3	64.49	23.41	5.16	0.64	0.49	1.43	3.31	1.07	0.03	0.12	100.15
8		XKT(4)-4	69.52	20.64	3.71	0.62	1.16	1.63	2.00	0.73	0.01	0.07	100.09
9		XKT(5A)-1	69.33	20.43	3.81	0.58	1.21	0.74	2.65	1.25	0.01	0.43	100.44
10		XKT(5A)-2	67.86	21.91	3.50	0.57	0.79	1.52	2.61	1.23	0.02	0.07	100.08
11		XKT(5A)-4	65.04	22.43	6.00	0.51	1.83	1.39	1.77	1.03	0.01	0.38	100.39
12		XKT(5A)-5	67.97	20.40	6.09	0.55	0.91	1.15	2.09	0.82	0.02	0.14	100.14
13		XKT(6A)-1	70.87	19.28	3.30	0.44	0.94	1.92	2.24	1.01	0.05	0.14	100.19
14		XKT(6A)-2	67.50	22.55	3.00	0.62	1.37	1.36	2.45	1.16	0.01	0.28	100.30
15	晚期	XKT(6A)-3	68.85	20.05	4.69	0.58	1.67	1.10	2.40	0.66	0.04	0.41	100.45
16		XKT(6A)-4	68.45	21.57	3.51	0.64	1.29	1.06	2.69	0.79	0.02	0.13	100.15
17		XKT(6A)4-1	67.70	20.80	4.35	0.58	1.32	1.52	2.63	1.09	0.02	0.14	100.15
18		XKT(6A)-5	68.19	20.94	3.87	0.54	1.46	1.43	2.83	0.74	0.03	0.25	100.28
19		XKT(7A)-1	69.56	20.30	2.87	0.68	1.54	1.05	2.78	1.20	0.02	0.15	100.15
20		XKT(7A)-2	67.88	20.95	4.10	0.55	1.25	1.57	2.52	1.19	0.01	0.10	100.12
21		XKT(7A)-3	68.40	20.42	4.56	0.62	1.26	1.12	2.22	1.40	0.02	0.25	100.27
22		XKT(7A)-3-1	67.72	21.13	4.70	0.63	1.16	1.15	2.22	1.29	0.02	0.23	100.25
23		XKT(7A)-4	61.99	23.26	8.22	0.56	1.65	1.37	1.98	0.98	0.03	0.63	100.67
24		XKT(7A)-5	67.40	21.48	4.26	0.63	1.63	1.17	2.55	0.87	0.01	0.60	100.60
25		XKT(8B)-1	67.46	21.51	3.98	0.50	1.24	1.75	2.60	0.96	0.02	0.09	100.11
26		XKT(8B)-2	69.64	19.26	3.89	0.57	0.94	1.78	2.36	1.57	0.02	0.05	100.08
27		XKT(8A)-5	64.49	22.86	5.39	0.63	1.41	1.68	2.42	1.13	0.01	0.13	100.15
28		XKT(9A)-1	69.36	20.79	2.97	0.56	1.58	1.21	2.30	1.24	0.02	0.16	100.19
29		XKT(9A)-2	68.36	19.93	3.42	0.60	1.63	2.14	2.62	1.30	0.03	0.14	100.17
30		XKT(9A)-3	68.90	21.13	3.20	0.66	1.08	1.86	2.33	0.84	0.01	0.14	100.15
31	中期	XKT(9A)-4	66.21	18.33	5.92	0.56	2.93	0.90	3.49	1.65	0.02	0.31	100.32
32		XKT(9A)-5	69.04	20.21	4.28	0.62	1.39	1.51	2.17	0.79	0.02	0.17	100.20
33		XKT(9B)-6	68.17	21.93	3.72	0.61	1.14	1.47	2.38	0.57	0.02	0.10	100.11
34		XKT(9B)-7	66.38	18.50	4.96	0.54	1.90	4.40	2.73	0.59	0.06	0.23	100.29
35		XKT(9B)-8	65.71	22.10	4.98	0.53	1.20	2.00	2.73	0.75	0.01	0.14	100.15
36		XKT(9C)-9	59.96	24.19	6.69	1.43	1.04	2.32	3.28	1.10	0.04	0.03	100.08
37		XKT(9C)-10	64.62	23.34	5.09	0.65	1.24	1.84	2.45	0.76	0.01	0.11	100.11
38		XKT(湖Ⅰ)-1	69.51	21.54	2.36	0.54	1.02	1.34	2.52	1.17	0.01	0.05	100.06
39		XKT(湖Ⅰ)-2	66.74	22.59	3.91	0.59	1.63	1.26	2.37	0.92	0.02	0.35	100.38
40		XKT(湖Ⅰ)-3	63.18	20.78	6.22	1.11	2.12	2.85	2.64	1.10	0.07	0.10	100.17
41	早期	XKT(湖Ⅲ)-1	64.77	24.01	3.80	0.62	1.41	1.59	2.67	1.13	0.02	0.13	100.15
42		XKT(湖Ⅲ)-2	68.89	20.65	4.24	0.51	0.95	1.44	2.10	1.24	0.02	0.05	100.09
43		XKT(湖Ⅳ)-1	72.16	19.28	2.19	0.64	0.99	1.26	2.30	1.19	0.01	0.06	100.08
44		XKT(湖Ⅳ)-2	72.19	19.15	3.35	0.64	1.09	0.81	2.18	0.59	0.01	0.16	100.17

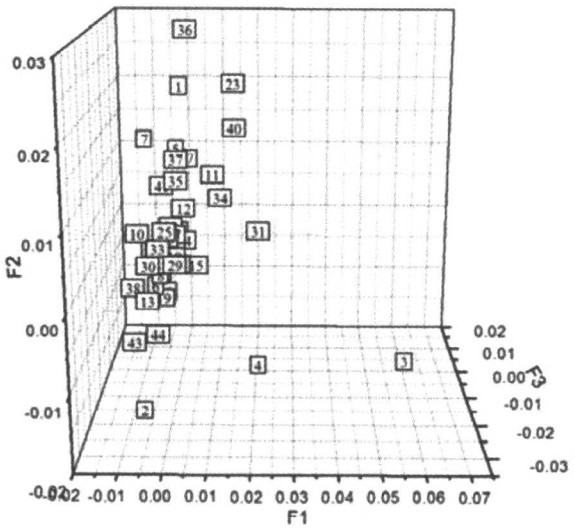

图 1 跨湖桥遗址陶器的化学组成因子载荷图

Fig.1 Factor loading diagram of the chemical composition of pottery from Kuahujiao site

表 2 跨湖桥遗址黑光陶和装饰陶的化学组成

Table 2 Chemical compositions of black pottery with bright surface and decorative pottery

品名	测量部位	化学组成（wt%）									
		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	MnO	P_2O_5
黑光陶	光亮表层	68.62	19.54	5.22	0.68	1.23	1.47	2.32	0.92	0.02	0.18
	陶内部	65.66	21.35	7.05	0.47	1.41	0.03	1.68	0.30	0.02	0.40
红衣陶	红色表层	72.78	17.01	4.66	0.77	1.03	1.10	2.13	0.53	0.01	0.10
	陶内部	66.98	22.37	3.54	0.52	1.59	1.82	2.56	0.63	0.03	0.46
泥点纹装饰陶	泥点	79.86	13.13	2.40	0.48	0.46	0.70	2.26	0.70	0.01	0.05
	陶器	69.42	19.85	3.88	0.67	1.02	2.49	2.15	0.53	0.03	0.07
彩绘陶	红色彩绘	68.76	21.42	3.52	0.66	0.67	1.58	2.16	1.05	0.13	0.03
	陶器	70.21	21.38	2.88	0.53	0.54	1.38	2.20	0.83	0.03	0.02

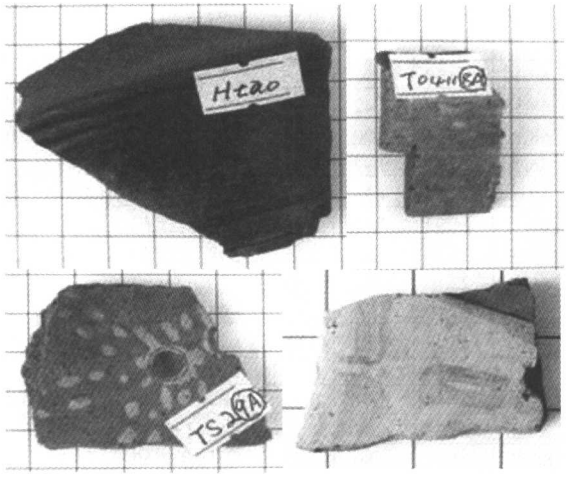

图 2 跨湖桥遗址黑光陶和装饰陶

Fig. 2 Black pottery with bright surface and decorated pottery from Kuahujiao site