

THE POTTERY TECHNOLOGY FROM BUKIT TENGGORAK,  
A 3000-5000 YEAR OLD SITE IN BORNEO, MALAYSIA

Pamela Vandiver\* and Stephen Chia\*\*

\*Conservation Analytical Laboratory, Smithsonian Institution,  
Washington, D.C., USA, PBV@CAL.SI.edu

\*\*Centre for Archaeological Research, Universiti Sains Malaysia,  
11800 P. Penang, Malaysia, arkeo@pc.jaring.my

INTRODUCTION

Bukit Tengkorak (Scull Hill) is a Neolithic period rock shelter complex and prehistoric pottery production site in southeastern Sabah, about 5 miles southwest of Semporna in Borneo, Malaysia at GPS N 4 7 20.08 and E 118 37 04.3. It was excavated for a 5-week season in 1995 and another in 1994 by a joint University of Science and Sabah Museum team under the direction of S. Chia. Two areas with volcanic outcrops about 10 meters apart were excavated. A total of 6 one-meter squares, three in each area, were excavated in 5 cm layers. The three rock shelter trenches, G17, G19 and J19, were excavated to the base of undisturbed cultural deposits, about one and one half meters deep. The main archaeological materials excavated from these squares comprised pottery sherds, stone tools, molluscs and fish and animal bones. Thick layers of ash, measuring 50 to 80 cm, were associated with the pottery sherds in the three rock shelter squares, suggesting that they could have been the remnant of an open pit kiln or pit kilns used for firing the pottery. In the lower outcrop, the three trenches R13, S37 and T38, were excavated near earlier archaeological excavation by Bellwood (1). Our excavation in this area revealed large deposits of clays not found elsewhere in this locale that were probably brought to the shelter to be used as raw material for making pottery. No food remains such as animal and fish bones or unworked shells were found in this area, leading credence to the interpretation of this as a craft working area for the production of pottery and stone and shell tools.

In total, the archaeological finds include a large number of chert and agate microliths and obsidian flakes and debitage (reported by Tykot and Chia elsewhere in this volume). Pottery sherds formed the main portion of the finds, with a total of about 5,000 pieces, followed by stone artifacts, with a total of 1,500 pieces. The large quantities of molluscs, weighing about 50 kgs, comprised mainly marine varieties while fish and animal bones added to a total of about 150 kg.

The radiocarbon dates place the site between 2000 and 5300 years ago. The date of 3300 B.C.E. means that this site has yielded some of the earliest pottery in island Southeast Asia and the Pacific regions, presumably in the Austronesian tradition--pottery that substantially predates the Lapita cultural complex which is documented at 1500-500 B.C.E. (2).

On or near the top of Bukit Tengkorak are three main rock shelters, the highest located about 600 feet above sea level. These shelters are formed by andesite boulders lying just below the summit of an eroded volcanic crater, a remnant of early Pleistocene age activity. Recent geomorphological studies conducted by the Malaysian State Geological Department confirmed that the crater remnant was once an island just of the coast. However, it is not yet known whether at the time of occupation between 5300 and 2000 years ago, the crater remnant was an island or near the end of a promontory of raised coral limestone and alluvium. Today it lies close to the Sulawesi Sea, separated only by a drained mangrove swamp about one km. wide. When the rock shelters were discovered, the floors were strewn with pottery sherds, bones and shell. The high densities reflect the washing or blowing out of soil matrix as well as recent disturbances. However, the very high density of marine shells and fish bones in the archaeological layers indicates that the inhabitants had easy access to the sea. Today, the many coral reefs with rich marine resources still provide an important means of livelihood for local fishermen as well as the sea nomads, the Bajau Laut.

The ecological, geomorphological and archaeological evidence thus far suggests that the site has been used in prehistoric times as a Neolithic pottery making site and stone tool producing site by marine-adapted people(s). It is the only candidate as a pottery producing site in Island Southeast Asia, and further excavation and analysis may determine whether it is a major one. Beyond the significance of this site as an early site with pottery or as a possible pottery production site loom larger questions requiring region-wide empirical data, as framed by H.E. Terrell, of whether the introduction of pottery implies one or more migrations of people(s), the introduction or importation of a technology, or the indigenous development of a technology and eventually an attendant, distinctive decorative style, called Lapita (3), or a combination of the above. Lapita style involves a handmade ware, low-fired, with a red-slipped surface that has a stamped or dentate pattern that is often post-fire infilled with a white material, often described as ground coral powder. Many of the more elaborate patterns are stylized faces or heads considered to be reminiscent of later Oceanic tattooing, bark cloth or wood decoration. This study is attempts to add one block of technical data on pottery production technology that is specific in time and space.

In Southwest Asia, similarities in Neolithic manufacturing technology, called sequential slab construction, underly fairly frequent and regional variation in decorative styles (4). Similarity of Neolithic pottery manufacturing technology from Egypt and Turkey to Pakistan from 7000 to 3000 B.C.E. imply interaction and long distance communication, as well as considerable temporal conservatism. The different Neolithic pottery fabrication tradition and resource base in northwest China has also been studied and characterized as a coil-based fabrication methodology involving small area paddle-and-anvil joint reinforcement, followed by surface scraping, as a sequence of steps with each step specific

to a range of drying of the clay body (5). As further studies of Southeast Asian and Oceanic pottery are conducted, a regional patterning of pottery fabrication technology may be found.

#### METHODOLOGY AND RESULTS

**Macroscopic Examination:** At Bukit Tengkorak only pottery sherds were excavated; no whole profiles or vessels. A few of the later sherds had punctate, probably Lapita decoration, but none were included in this study. All the pre- or early Lapita sherds were undecorated, gray to black to brownish red in surface color, usually with a black or dark grey core that is darker than the surfaces. No red slip or punctate decoration was observed on any of the early sherds, and no evidence of paddle-and-anvil forming or of scraping of the surfaces. Optical microscopy of ultrasonically cleaned edge fractures was carried out to detect evidence of manufacture. Only 19 possible diagonal, or bevel, joints were detected and 7 possible horizontal or butt joints were found in the 244 edges on 50 sherds. Pores are aligned parallel with the surfaces, as might be expected in a high pressure, evenly applied forming technique, such as throwing or mechanical press molding. As the macroscopic evidence for manufacture was meager, Xeroradiography was employed to record internal structure, especially to detect the porosity that is expected to occur at joints that are characteristic traits of various forming methods.

The firing temperature was expected to be low as the Mohs hardness of the sherds was measured in the range of 2-3. None of the sherds dissolved in boiling water; thus, they have been fired and have not rehydroxylated or re-weathered to clays, as occasionally occurs with low-fired ceramics maintained in moist or humid environments.

**Microscopic Analysis:** A subset of 50 sherds were grouped into 3 categories, using optical and petrographic microscopy to identify aplastic inclusions that ranged in volume fraction between 40 and 70 vol.% compared with the silt or clay fraction, thus many of these so-called ceramics are actually "rock-bodies". The three groups contain inclusions of (1) siliceous sand, (2) calcareous shell, coral or other marine organisms, usually as fragments, or (3) sand and shell together. There are black glassy inclusions of less than 1-5 vol% in the sherds containing siliceous sands. The clay sources and aplastic inclusions are of mixed volcanic and marine in origin.

Examples of the lowest fired pottery were analyzed by differential thermal analysis and x-ray diffraction for clay mineral type, and by scanning electron microscopy for particle size. The clay-type most resembles an illite with a typical particle size of 3-5 microns, a clay decomposition peak at 760°C and low-angle diffraction peaks at 8.2, 8.6 and 8.8. We did not have any raw clay or clay from the storage pit to test.

The firing temperature range for 9 samples, 3 from each group,

were determined by refiring from 600 to 1100°C in increments of 100°C using a firing profile of 5 min ramps followed by 10 minute soaks and then by using scanning electron microscopy of fresh fracture surfaces made parallel to the sherd surfaces to observe that degree of temperature at which changes in sintered microstructure signaled the original firing temperature had been exceeded during refiring. Viewed with scanning electron microscopy at areas of similar composition recorded using simultaneous energy dispersive x-ray analysis, it could be seen that seven samples were fired at 600 or perhaps as high as 700°C. One with only siliceous inclusions was fired to 700°C, and another with only siliceous inclusions and a red, harder surface was fired above 700°C, perhaps as high as 800°C.

Refiring of the sherds with calcareous inclusions to 800°C and above led to decomposition of the calcium carbonate, and in the 3-5 days following refiring, as the calcium oxide rehydrated and recarbonated, the sherd fragments broke-up into powder, thus demonstrating an upper practical limit to firing temperature of sherds with calcareous inclusions. Refiring each of the sherds to 1000°C and above led to a noticeable darkening of the oxidized red color and to cracking of the body, probably from differential thermal contraction of the various inclusions. At 700°C, the dark grey and black cores of all the 9 sherds became noticeably lighter in color and smaller in size, and by 800°C they were gone, leading to the conclusion that the original firings had been short, less than the 45 minutes our firing cycle took to equilibrate at 800°C. Using these results to generalize to the hardness and appearance of the rest of the sherd corpus, 42 were low fired at 600-700°C, 6 were medium fired near 700°C range, and 2 were high fired at about 800°C.

All 50 sherds were radiographed (Xerox Medical Systems 125, run in positive mode at 55-60 KV, 5 mA and 1 min with a 130 cm focal distance) with essentially the same results or pattern of forming. We found no patterns or pockets of porosity, no joints and only the presence of contrast from the coarse inclusions, as shown in Fig. 1. Note that the porosity, or white, areas, in the Bukit Tengkorak sherds has no preferential alignment. This differs from Chinese sherds from a Tang dynasty drainage tile from Xianyang, Jiangxi province, that used coil construction with superimposed bands of punctate decoration (Fig. 2a), and a Tang dynasty period Xi'an cup and bowl that were thrown on a wheel (Fig. 2b and c). The porosity developed by wheel throwing is usually diagonally aligned as in the fine textured small cup (Fig. 2c), unless the wheel is rotating very rapidly, as shown the bowl in Fig. 2b, in which case the porosity is more horizontally aligned.

Examination of the alignment of clay particles using scanning electron microscopy shows a patterned structure of pores aligned parallel to the surfaces (Fig. 3). This pattern is similar to that found in thrown and hydraulically mold pressed ware as well as vessels shaped by beating or paddle and anvil techniques.

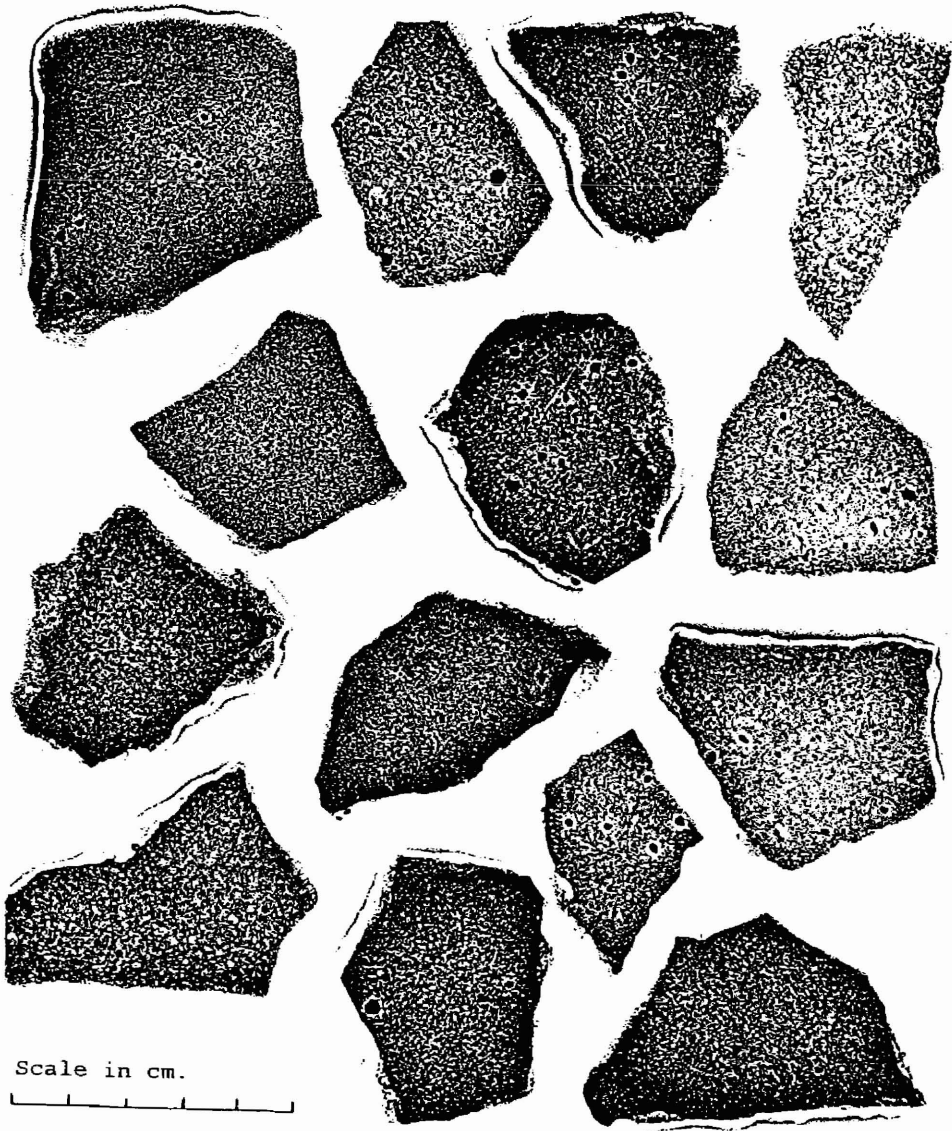
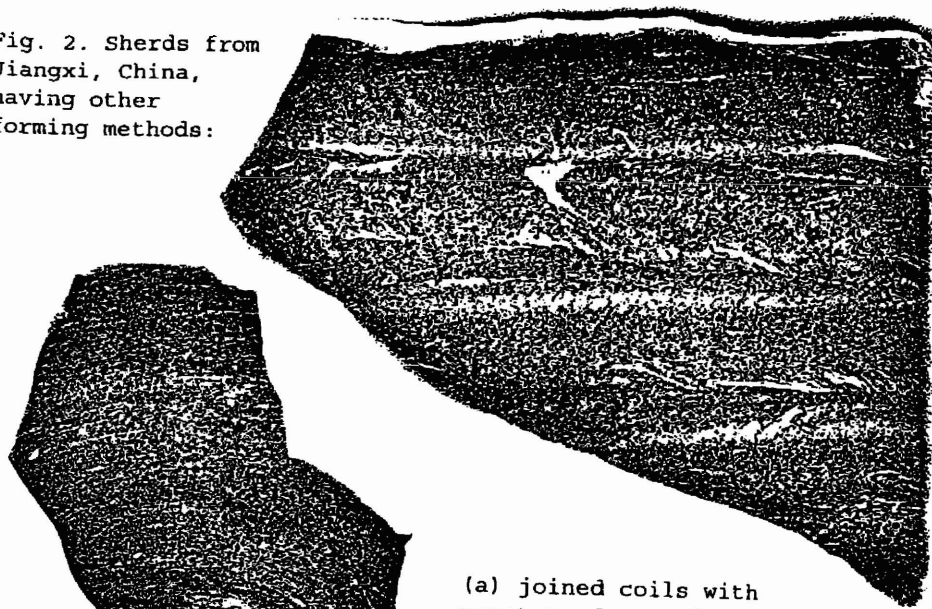
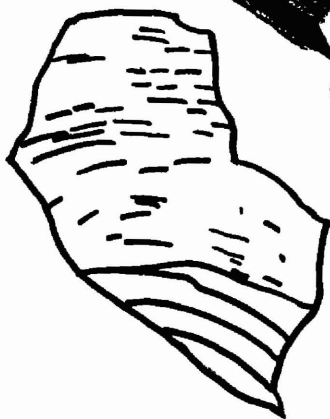


Fig. 1. Sherds from Bukit Tengkorak show even forming pressure and no joints. The homogeneous distribution of porosity is evidence for forming and finishing by beating from a single preformed lump of clay into which a single hole was made by hand or sticklike implement.

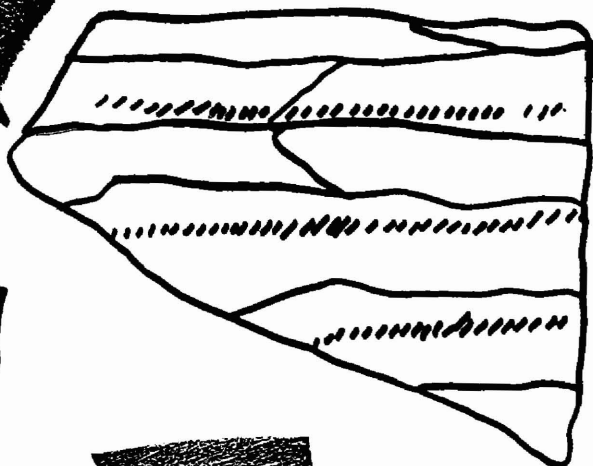
Fig. 2. Sherds from  
Jiangxi, China,  
having other  
forming methods:



(a) joined coils with  
punctate decoration in 3 bands



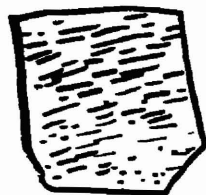
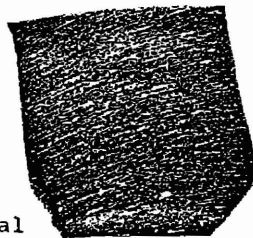
(b) thrown bowl with 3 trimmed  
facets and foot remnant



Scale in cm.



(c) thrown cup with diagonal  
alignment of porosity



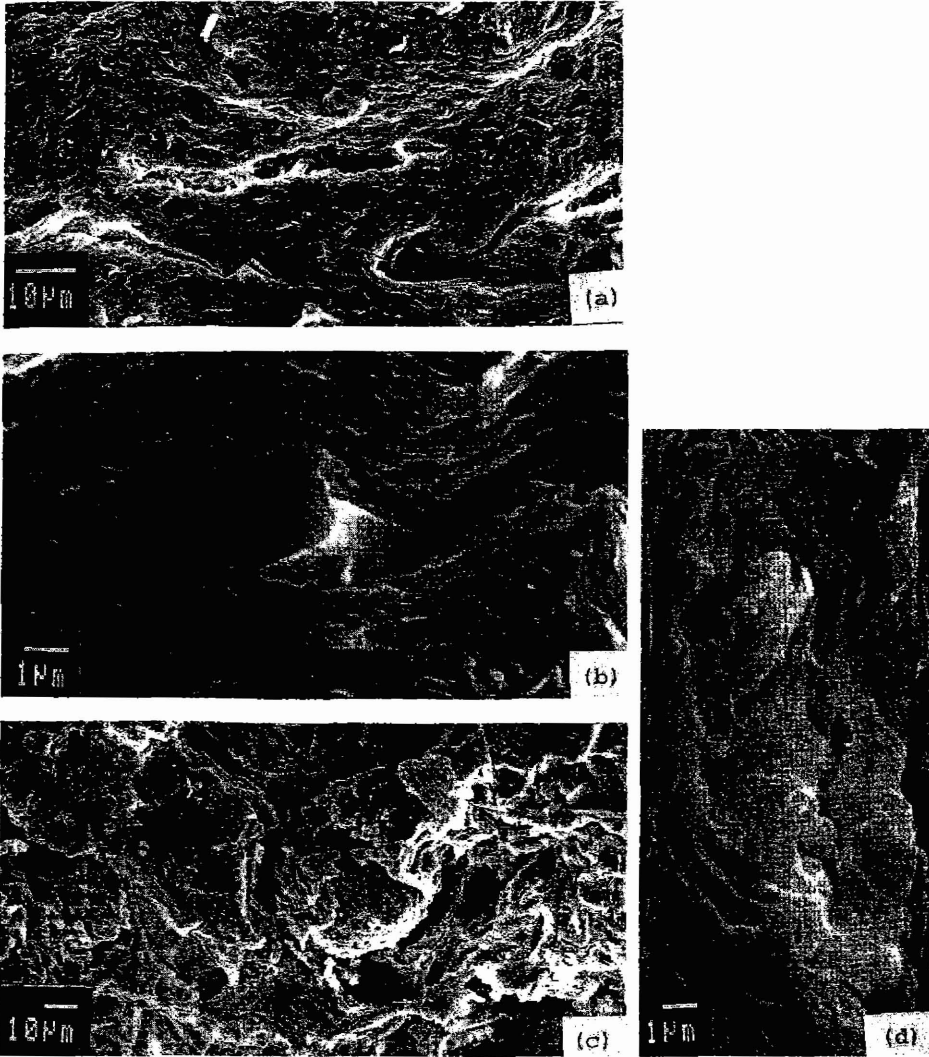


Fig. 3. SEM of fracture perpendicular to sherd surfaces shows clay platelets and porosity characteristically aligned parallel to one another and to the surfaces (a at 1100x), except where exceptionally well aligned platelets wrap around a quartz inclusion (b at 8000x); in fracture parallel to sherd surfaces the inclusions, pores and clay matrix align parallel to surfaces (c at 600x and d at 6000x). This typical pattern of alignment is surprisingly regular for handmade pottery and demonstrates force was applied perpendicular to the wall surfaces.

## DISCUSSION

Investigation of manufacturing technology using optical microscopy of edge fractures, surface morphology and sherd fracture shapes along with xeroradiography showed patterning in production that is similar to and indistinguishable from that found in modern wares made by village potters in northeast Thailand, studied and documented in the last three years by Louise Cort of the Freer and Sackler Galleries of Art and Leedam Lefferts of Drew University in collaboration with Vandiver (7). In addition, these two groups are similar to and essentially indistinguishable from the manufacturing tradition of wares made at the first millennium B.C. central Thai copper-producing sites of Nil Kham Haeng and Non Pa Wai that have been excavated by Vincent Pigott of MASCA and the University Museum at the University of Pennsylvania (7).

The hypothesis is set forth that a special and differentiable Neolithic and Bronze Age pottery manufacturing technology exists in Southeast Asia and Island Southeast Asia, and that it continues in some areas of Thailand today. Plotting its geographic and temporal distribution is fundamental to understanding the extent of interaction and communication and conservatism in technological and socio-cultural practice. Pottery from other well-dated, excavated sites is solicited for investigation in order to further the study of variation in Southeast Asian and Oceanic pottery fabrication in time and space.

## CONCLUSIONS

A range of illitic clay bodies with mainly siliceous and/or calcareous temper were fired for short periods of time, probably less than 45 minutes, to 600-700°C, rarely to 800°C. In other words, there was very little sintering and virtually no densification of the pottery during firing that might have obscured manufacturing joints or reduced porosity at joints.

The Bukit Tengkorak pottery was formed from a single lump, perhaps with a stick or hand placed into it, and then by using a transformational potting technology in which a preform or original lump was expanded using primarily beating or paddle-and-anvil methods that resulted in well-aligned clay particles, parallel to the surfaces. This is a transformational forming technology, rather than a constructivist one. It is more akin to producing a shape by throwing on a wheel than to constructing from the bottom to the top of a pot, as one would build a wall, a process more akin to architectural construction and to the sequential slab construction method found at Southwest Asian Neolithic sites (4). Rather than to cohere previous coils or slabs, as in the northwest Chinese case of Yangshao pottery manufacture(5), the Southeast Asian examples we have studied show that beating of clay into a vessel was the integral forming and shaping and finishing method.



#### ACKNOWLEDGMENTS

The authors would like to thank Prof. Zuraina Majid for her support of this work, the Centre for Archaeological Research of the Science University Malaysia and the Sabah Museum for their help, and Camie Campbell and Melanie Feather of the Conservation Analytical Laboratory of the Smithsonian Institution for help with the xeroradiography and x-ray diffraction.

#### REFERENCES

1. P. Bellwood and P. Koon, "Lapita colonists leave boats unburned? The question of Lapita Links with Southeast Asia," Antiquity 63 (1989) 613-622.
2. P.V. Kirch, The Lapita Peoples: Ancestors of the Oceanic World, Blackwell, 1997, esp. ch. 1, 3 and 5; and G. Irwin, The Prehistoric Exploration and Colonization of the Pacific, Cambridge Univ. Press, 1992, esp. ch. 3 and 5, and p. 32.
3. J.E. Terrell and R.L. Welsch, "Lapita and the Temporal Geography of Prehistory", ms. submitted to Antiquity, 1996, and J.E. Terrell, T.L. Hunt and C. Gosden, "The Dimensions of Social Life in the Pacific," ms. accepted in Current Anthropology.
4. P. Vandiver, "Sequential Slab Construction: Conservative Southwest Asiatic Ceramic Tradition, ca. 7000-3000 B.C.," Paleorient, vol. 13/2, 1987, pp. 9-35, and P. Vandiver, "The Production Technology of Early Pottery at Mehrgarh", in Mehrgarh: Field Reports 1974-1985 from Neolithic Times to the Indus Civilization, ed C. Jarrige, J.-F. Jarrige, R.H. Meadow and G. Quivron, Dept. of Culture and Tourism, Govt. of Sindh, Pakistan and French Ministry of Foreign Affairs, pp. 648-661.
5. P. Vandiver, "The Implications of Variation in Ceramic Technology: The Forming of Neolithic Storage Jars in China and the Near East," Archeomaterials, vol. 2/2, Spring 1988, p. 139-174.
6. P.B. Vandiver and C.S. Tumosa, "Xeroradiographic Imaging", in Am. Jour. of Archaeol., 99 (1995) 121-124.
7. Publication forthcoming.