earnings home to their families in the villages, but none return to learn the potter's craft.

Conclusion

We hope that these observations of traditional potters and pot-making techniques in Bannu District have revealed the potential for further systematic study there, as well as showing the diversity of techniques and technology used by potters in this small area. Sadly, there can be little doubt that the future of the Bannu potters is rather bleak. External and internal pressures, outlined above, have caused numerous families to abandon the making of pots, or to specialise in producing a restricted range of types of ceramic (notably *thaibi*, the much-in-demand cooking trays for flat breads). A few have responded to new opportunities by making different types of ceramics, such as the yogurt-processing pots used by Afghan refugees, or by moving their workshops to villages which have lost their own potters. All these aspects highlight the need for further work in this area, both to document more fully the surviving traditions, and their social contexts, as well as to investigate the socio-economic dynamics underlying innovations in pottery production.

As a postscript: there was an intention that, some 10 years on (i.e. in December 2001), we would revisit the villages and potters observed in this brief initial study to find out how they had fared in the intervening interval, how many were still in business and what range of wares they were producing. This was not to be, because events following the 11th September 2001 atrocities in the USA, which have reverberated throughout the region ever since, have made it impossible for us to undertake any kind of field work in Bannu District.

Acknowledgements

We would like to thank the many potters in Bannu who admitted us into their workshops, provided hospitality and information, and permitted photographs to be taken; Mr M. Naeem for practical assistance; and Dr Michela Spataro and Caroline Cartwright for encouraging us to resurrect our long-abandoned field notes and photographs, and to prepare our observations for publication.

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WHAT'S IN A FORMING TECHNIQUE? AN INVESTIGATION INTO WHEEL-THROWING AND WHEEL-COILING IN BRONZE AGE CRETE

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Introduction

Clay vessels can be made with a wide variety of individual techniques or combinations of two or more techniques. The most common ways of making pots are wheel-throwing, coiling, slab-building and mould-making (Rice 1987). While most techniques are classified by archaeologists as either wheelmade or handmade, there is at least one set of techniques, called wheel-coiling, that combines the two at different stages of the manufacturing process. It is this technique, and its relationship with wheel-throwing, that is the primary interest of this paper.

The forming techniques

Wheel-throwing can be defined as a technique that uses the potter's wheel as its only means to create the vessel shape. Depending on a vessel's height, shape and the particular stage of the forming process, speeds can be as low as 40 rpm or as high as 130 rpm. This contrasts with wheel-coiling which uses the potter's wheel merely to facilitate the joining, thinning or smoothing of a pre-shape that was built using the coiling technique. As rotation can be utilised at different stages of the wheel-coiling process (Courty & Roux 1995; Roux & Courty 1998; then still called wheel-shaping), speeds can vary depending on its application and overlap with those recorded for wheel-throwing (Figure 1).

At first glance, the end-products of the two techniques look the same. They both display the existence of rilling around the interior and/or exterior, concentric striations on the base and compression ripples around the neck. On closer inspection, minor differences emerge: for example, the rilling is continuous for wheel-throwing, but discontinuous for wheel-coiling (Courty & Roux 1995; Roux & Courty 1998). It is mainly by using X-radiography to reveal the internal structure and physical characteristics of the clay matrix that wheel-throwing and wheel-coiling can be clearly

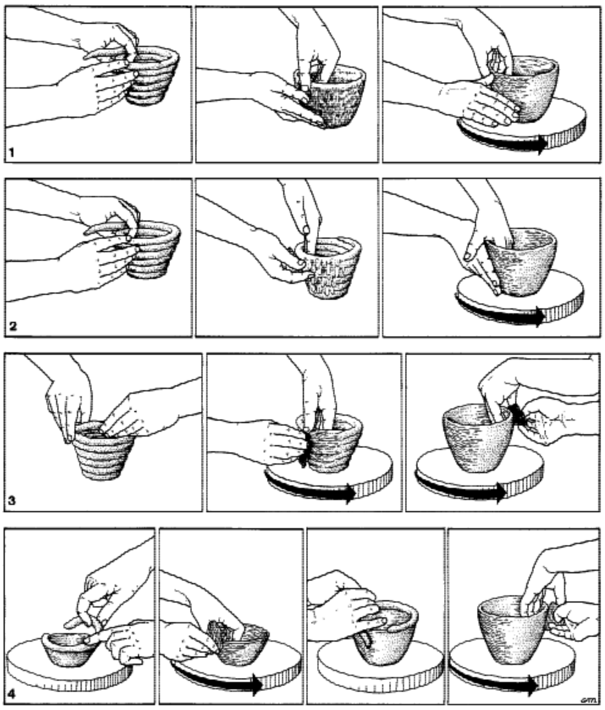

Figure 1: Manufacture of pots according to four different wheel-coiling methods (reproduced from Roux & Courty 1998: fig. 1; with permission from author).

distinguished (Berg 2008, 2009). In particular, as a consequence of pulling the vessel upwards during manufacture, the X-ray fingerprint for wheel-throwing is characterised by a *diagonal* alignment of voids and fissures. In contrast, wheel-coiling can be identified by the combination of macroscopic features from wheel-throwing (i.e. rilling or ripples on the interior and/or exterior surface, compression marks around the neck) with the X-ray fingerprint (i.e. *horizontal* alignment of voids and fissures) from coil-made vessels (Figure 2).

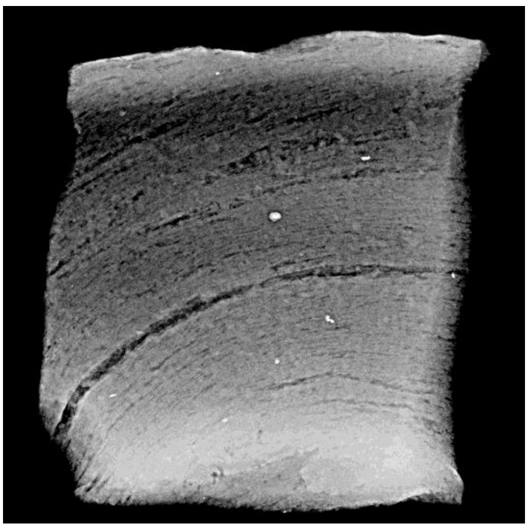

Figure 2a: Enhanced radiograph of Late Minoan II wheel-coiled saucer from Knossos showing the characteristic horizontal coil seams and horizontal voids. Towards the rim, the voids become more diagonal indicating that the very last coil was attached to the vessel and then pulled up on the wheel as if wheel-thrown (Berg 2009: catalogue no. 92).

Figure 2b: Outside view of same saucer.

How easily we pottery specialists can be misled by the expertise of ancient potters who used the wheel-coiling technique is demonstrated in Table 1. Having inspected pottery macroscopically two months prior to X-radiography analysis, I was able to compare my original conclusions – as well as those recorded by the original pottery specialist– with those based on the analysis of the X-radiographs. The results show clearly that a) pottery specialists do not necessary agree with one another about the type of technique used when inspecting a vessels visually, and b) all of them can be misled by the expertise of ancient potters especially in relation to wheel-thrown vs. wheel-coiled (Berg 2009).

Why forming technique is important

But why, one may ask, is it so important for us to know the difference between those two techniques? After all, both utilise the potter's wheel to a lesser or larger degree and indicate the acquisition of a new and different set of motor skills that required a long and dedicated apprenticeship. The answer is that the two techniques indicate different degrees of the utilisation of the potter's wheel. Wheel-coiling – because it requires the construction of a coiled shape first – is an intermediate stage between handmade and wheel-thrown pots. Not surprisingly, it also occupies an intermediate skill level between the two techniques. Due to the need for constructing coils first, it only marginally speeds up the production process when compared to exclusively handmade vessels. Roux (2003: 18; Roux & Court 1998:750) estimates that wheel-coiling speeds up production by 25%. However, wheel-coiling has two major advantages that may explain its continuing popularity. First, it resembles the wheel-throwing technique - a potentially valuable cultural commodity - visually. An example of its value is the use of the potter's wheel in Phylakopi, Melos, where copies of Cretan vessels signalled the introduction of a new imported drinking and feasting tradition (Berg 2007). Second, wheel-coiling allows potters to build vessels up in stages and can thus be adapted to a variety of manufacturing settings and equipment types – as is explored in the following section.

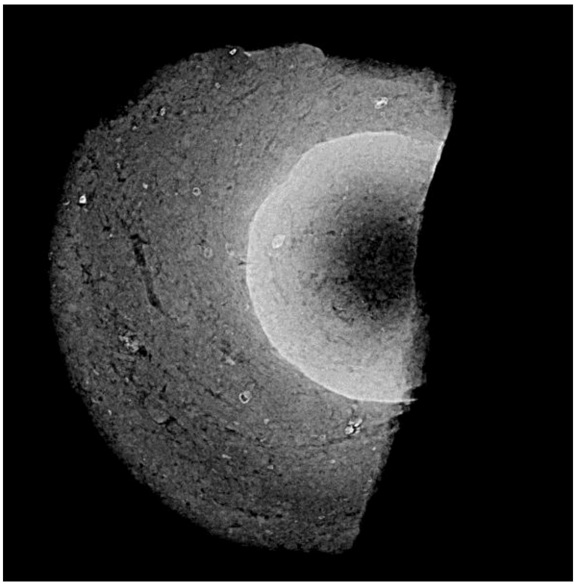

Figure 2c: Enhanced radiograph of a Middle Minoan IIB conical cup showing a diagonal alignment of voids characteristic of the wheel-throwing technique (Berg 2009: catalogue no 51).

Figure 2d: Outside view of same conical cup.

The potter's wheel in Bronze Age Crete

A case study from Bronze Age Crete demonstrates that the development of wheel-coiling may have been an ingenious solution to the limitations imposed on potters by the potter's wheel that was available during the Bronze Age (for full details of this study, see Berg 2009).

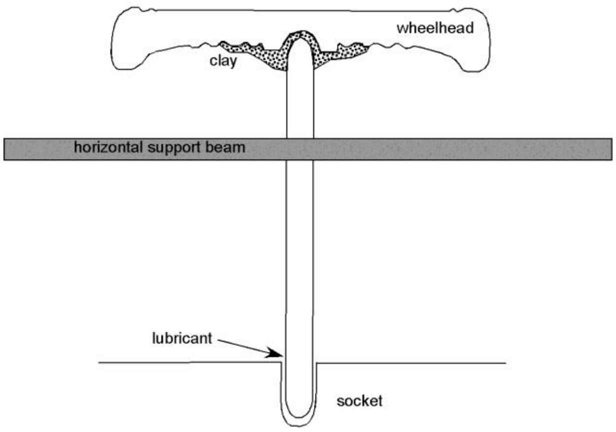

Figure 3: Reconstruction of Minoan potter's wheel with clay wheel head (after Evely 1988, 2000; Morrison & Park 2007/8; http://www.spiritofgreece.gr/).

The first appearance of the potter's wheel on Crete can be dated to the MM I-II period. Evely (1988, 2000) has identified several dozens of wheelheads as well as other parts of potter's wheels. Wheelheads are made of fired clay. They are large (25-75 cm in diameter) but their low weight (4-10 kg) makes it unlikely that they were able to store the momentum in the same way as heavy stone wheels (normally above 20kg; heavy ones may be up to 40kg in weight). Evely's comprehensive catalogue of potter's wheel devices and workshop settings (Evely 2000), as well as recent experimental work on Crete has clarified the potter's wheel design (Figure 3) and capabilities. We now reconstruct the wheel's axle to have been located in a shallow socket on the ground. A horizontal support half-way or two-thirds up the axle must have existed to give core stability to the device. Throwing experiments by two groups of scholars (Don Evely and Vasilis Politakis at Knossos, Jerolyn Morrison and Doug Park at Mochlos) have shown that the wheel could be used by the potter him/herself or with the help of an assistant to aid rotation of the wheel. The vessels that have been produced by the Mochlos team were small simple bowls and cups. Results from the Knossos experiments indicated that "speeds sufficient to permit throwing, centering, raising and shaping and finally turning were all readily possible for small and medium-sized pots. But this toil was always easier with the assistance of the second pair of hands. Larger vessels, or those made from heavier clays, were better produced by coils and always needed the second person, and at times a considerable output of energy" (Evely, in: http://www.spiritofgreece.gr/; see also Evely, Politakis, Morrison & Doug 2008; Morrison & Park 2007-2008).

If the Cretan potter's wheel could not maintain the momentum for long enough for large pots to be wheel-thrown, then wheel-coiling – a technique that did not require continuous high speeds, and which could produce a pot step-by-step by building it up from coils first which were then 'thrown' – offered a simple way to overcome these wheel technology limitations. Cretan potters were thus able to produce pots of almost any size, ranging from the very small cup to the 70 cm large storage jar by using either wheel-throwing (small vessels only) or wheel-coiling (any size). To the uninitiated eye, the latter pots would give the appearance of having been wheel-thrown in one piece, when in fact they are based on the coiling technique with rotation applied at different moments during the manufacturing sequence. These conclusions are fully and unanimously supported by the evidence from my own X-radiography project of Cretan vessels as well as an analysis of published pottery assemblages from Crete (Berg 2009). Without exception, all findings indicate that wheel-throwing was reserved for small vessels while wheel-coiling was used for all vessel sizes.

Catalogue No.	**Technique based on X-radiography**	**Technique based on visual inspection by author**	**Technique given in original publication**
15	Coiled (and wheel-shaped)	Uncertain	Wheelmade
17	Drawn, coiled (and wheel-shaped	Handmade and wheel-shaped	Wheelmade
57	Coiled	Coiled?	Wheelmade
63	Moulded or pinched (and wheel-shaped)	Moulded and wheel-shaped	Wheelmade
71	Coiled (and wheel-shaped)	Coiled and wheel-shaped	Wheelmade

Table 1: Comparative identification of primary forming techniques by X-radiography and visual inspection.

Thus, the invention of the wheel-coiling technique in Bronze Age Crete and its continued use over many centuries should be considered a clever solution to a technological problem rather than as an indicator of semi-competence whereby wheel-throwing is seen as the pinnacle of achievement. With potting having been a specialist production activity since at least the Early Bronze Age, this ingenious technique pays tribute to the skill and experience of the potters.

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