DESIGNS AND PRODUCTION TECHNOLOGY OF SICKLE ELEMENTS IN LATE NEOLITHIC WADI ZIQLAB, NORTHERN JORDAN

S. KADOWAKI

Abstract : *This paper examines sickle elements from Late Neolithic agricultural settlements in the southern Levant with a particular focus on the tool morphology and the production technology. The results of the examination suggest that two Late Neolithic farmsteads in Wadi Ziqlab share greater morphological similarity of sickle elements than do other sites of the same cultural group (the Wadi Rabah culture) in other regions. However, the technological analyses of sickle elements suggest that the two farmsteads in Wadi Ziqlab had different patterns in some technological practices during the production processes, including the blank production, the extent of retouch, backing technique, and possibly the sequence of retouching processes.*

Based on these results, the subsequent discussion aims at explaining the standardized design of sickle elements and their varied production technology observed in Wadi Ziqlab, particularly focusing on several factors, including chronology, geography, the mechanical functions of sickle elements, and the mechanical logistics of production technology. After examining these factors, I will briefly discuss social contexts that may have been related to the production practices of sickle elements.

Résumé : *Cette étude examine les éléments de faucille des établissements agricoles du Néolithique Récent dans le Sud du Levant ; l'attention se porte plus particulièrement sur la morphologie des outils et la technologie de production. Les résultats de l'analyse suggèrent que les deux établissements du Wadi Ziqlab présentent une plus grande similarité morphologique des éléments de faucille que ne le font dans les autres régions les sites de même culture (Wadi Rabah). Les analyses technologiques des éléments de faucille suggèrent pourtant que les deux fermes du Wadi Ziqlab usaient de modes différents dans leurs technologies que ce soient celle de la production et de la sélection du support (éclats* vs *lames), l'étendue de la retouche et la retouche (denticulation, dos, troncature).*

En se fondant sur ces résultats, la discussion cherche à comprendre comment s'est effectuée à la fois la standardisation des éléments de faucille et la variation dans les techniques de production observée sur les sites du Wadi Ziqlab. Plusieurs facteurs sont pris en compte : chronologie, géographie, fonctions mécaniques des éléments de faucilles, et logiques mécaniques des technologies de production. Après l'examen de ces facteurs, une brève discussion porte sur les contextes sociaux qui peuvent avoir exercé une influence sur les mécanismes de production d'éléments de faucille.

Key-Words : *Late Neolithic, Wadi Ziqlab, Sickle elements, Production technology.*
Mots Clefs : *Néolithique Récent, Wadi Ziqlab, Éléments de faucille, Technologie de production.*

Sickle elements usually form a distinctive tool category in many Neolithic lithic assemblages because of their standardized morphologies and distinct use-traces, *i.e.*, macroscopic sheens on their edges. These noticeable characteristics of sickle elements have long attracted archaeologists' attentions, resulting in numerous studies of morphologies and use-traces.

Manuscrit reçu le 19 janvier 2005, accepté le 16 juin 2005

These traits of sickle elements were analyzed to investigate various culture-historical and anthropological questions, including chronological and geographic distributions[1], hafting methods[2], mechanical functions[3], and tool designs[4].

In comparison to the morphologies and use-traces of sickle elements, the production technology of sickle elements appears to have had only an auxiliary position in the study despite its close relationship with economic and social contexts. This paucity of attention to the production technology may be partly because many sickle elements, particularly those of the Pre-Pottery Neolithic, were used with little modification of their blanks, which were simply snapped or segmented before use[5], and because archaeologists have usually examined the technology of blank production as a separate subject[6]. However, some types of sickle elements in the Late Neolithic southern Levant are usually manufactured into highly standardized shapes through a variety of retouching processes, including the denticulation of cutting edges and the modification of blanks by invasive flaking, backing, and truncation[7]. Although these retouching processes can be performed in a short period, they may leave various morphological traces that can be examined to detect patterns in the production technology of sickle elements.

In order to approach the technological practices involved in the production of sickle elements, this paper examines the morphological traits and production technology of sickle elements from Late Neolithic settlements in Wadi Ziqlab, northern Jordan (fig. 1). The technological analyses in this study are based on an assumption that lithic technology and, more specifically, the practices of lithic tool production are intertwined with both social and ecological contexts. In other words, the manufacture of lithic tools is structured under various social and ecological conditions. This perspective towards technology derives from a series of analytical concepts used in two major kinds of approaches to lithic technology : the *chaîne opératoire* and the technological organization. The principal premise of the *chaîne opératoire* approach is that technology is a representation of socially shared knowledge materialized through people's actions[8]. Technology is thus regarded as "a social construct"[9]. On the other hand, the technological organization approach tends to focus on mechanical functions of technology to explain artefacts in terms of their various performance characteristics[10] or in terms of economic factors, including efficiency, risk reduction, and versatility[11].

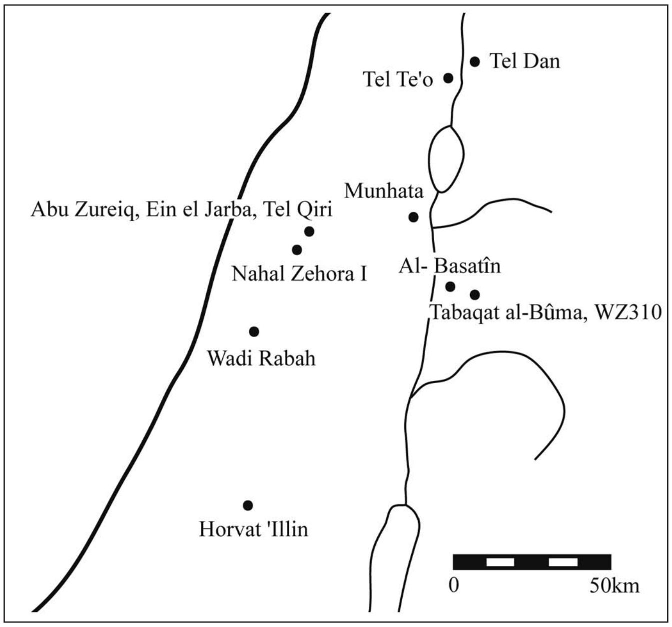

Fig. 1 : *Late Neolithic sites mentioned in the text.*

The two analytical approaches are underpinned by different theoretical roots, and many lithic studies deal with them separately[12]. Nonetheless, both approaches similarly examine technological behaviours and people's decisions during artefacts' life-histories, *i.e.,* processes from the acquisition of raw materials through tool production, use, and maintenance, to the point at which they are discarded[13]. Such analytical methods are also employed in this paper to investigate technological practices during the production of sickle elements.

Based on the examination of technological practices, this study aims at providing insights into how the design and the

1. BURIAN and FRIEDMAN, 1979 ; GOPHER, 1989 ; ROSEN, 1997.
2. CAUVIN, 1983 ; FUJII, 1983 ; NISHIAKI, 2000, 2001 ; OLSZEWSKI, 1994.
3. ANDERSON, 1994 ; QUINTERO *et al.*, 1997 ; UNGER-HAMILTON, 1988, 1989.
4. PEROS, 2000 ; SIGGERS, 1997 ; UNGER-HAMILTON, 1988.
5. NISHIAKI, 2000.
6. QUINTERO and WILKE, 1995 ; WILKE and QUINTERO, 1994.
7. BARKAI and GOPHER, 1999 ; GOPHER, 1989 ; ROSEN, 1997.
8. EDMONDS, 1990 ; LEMONNIER, 1986 ; PELEGRIN, 1990 ; SELLET, 1993 ; STARK (ed.), 1998.
9. LEMONNIER (ed.), 1993.
10. SKIBO and SCHIFFER, 2001.
11. BAMFORTH, 1986 ; BLEED, 1986 ; HAYDEN *et al.*, 1996 ; NELSON, 1991 ; ODELL (ed.), 1996 ; SIGGERS, 1997.
12. BAR-YOSEF *et al.*, 1992 ; BLEED, 2001 ; HENRY and ODELL, 1989 ; NISHIAKI, 2000 ; ODELL, 1996 ; SELLET, 1993.
13. BLEED, 2001 ; NISHIAKI, 2000 ; SELLET, 1993.

production technology of sickle elements were related to various factors, including chronology, geography, mechanical functions of sickle elements, and social contexts of Late Neolithic settlements in Wadi Ziqlab. Before presenting the results of analyses, the following will briefly present the cultural-history and general socio-economy of Late Neolithic settlements in Wadi Ziqlab in order to present general backgrounds of the sickle elements analyzed in this study.

LATE NEOLITHIC FARMSTEADS IN WADI ZIQLAB

The Late Neolithic settlements in Wadi Ziqlab appear to have consisted of small farmsteads or hamlets at dispersed locations with agriculture and livestock[14]. In such general socio-economic settings, sickle elements are likely to have played a significant role in agricultural practices. This idea may be supported by the high proportions of sickle elements among formal tool types in many Late Neolithic lithic assemblages[15]. Although sickle elements could have been used to harvest various plant materials[16], the high-power microscopic use-wear analysis of 30 sickle elements from a Neolithic farmstead in Wadi Ziqlab indicates that they were used "to harvest domesticated cereals… near their base with a sawing motion"[17].

The sickle elements analyzed in this study were obtained from excavated collections from Tabaqat al-Bûma and al-Basatîn, Late Neolithic agricultural settlements located only a few kilometres apart from each other in Wadi Ziqlab (fig. 1). The two sites also appear chronologically close to each other. A series of radiocarbon dates from Tabaqat al-Bûma range between 5 700 and 5 200 cal BC, while a radiocarbon date of the Neolithic contexts at al-Basatîn falls within this range. The chronological proximity between the two sites can be also supported by the great similarity of their material cultures, including lithic and pottery types[18].

These small settlements in Wadi Ziqlab were probably inhabited by agro-pastoralists that are directly or indirectly suggested by ecofacts and artefacts. For example, animal husbandry is clearly indicated by faunal remains that include sheep/goats, cattle, and swine[19]. Hunting may have been practiced occasionally as deer also contribute a significant portion in the recovered faunal remains ; however, its economic importance appears to have declined as suggested by the virtual absence of arrowheads in chipped-stone artefacts. Agriculture is likely to have been practiced as sickle elements characterize formal tool categories of chipped-stone artefacts[20]. In addition, the importance of agricultural products is also indirectly supported by various food-processing tools, such as large grinding querns and handstones[21].

In this way, the current archaeological evidence indicates that Tabaqat al-Bûma and al-Basatîn likely had similar functions as farmsteads. This idea can be also supported by their small settlement scales (smaller than 1 ha) and the small number of building remains. Although nearly ten rectilinear buildings were recovered at Tabaqat al-Bûma, stratigraphical analyses suggest that only some of the buildings were inhabited at a time, while open spaces or abandoned buildings were potential outdoor activity areas[22]. Probable outdoor activity areas were also discovered at al-Basatîn along with cobble-paved surfaces[23]. This small amount of building remains so far discovered at al-Basatîn might suggest its more ephemeral use, such as activity areas near agricultural fields or seasonal occupations ; however, similar kinds and range of activities were probably practiced at both sites as indicated by other material records, including subsistence data and various kinds of tools, including not only agricultural tools but also large food-processing tools.

These general characteristics in material culture, economy, and settlement scale at Tabaqat al-Bûma and al-Basatîn show affinity to the Wadi Rabah culture in the Neolithic Levant[24]. According to Gopher and Gophna[25], the Wadi Raba culture is a rather broadly defined cultural entity, including "normative" components, which are essentially found in the Jezreel Valley, and many "variants" distributed in other

14. BANNING, 2001 ; BANNING *et al.*, 1994, 2004 ; BANNING and SIGGERS, 1997 ; GOPHER, 1995 ; GOPHER and GOPHNA, 1993 ; KUIJT and CHESSON, 2002.

15. BANNING *et al.*, 1994 ; BANNING and SIGGERS, 1997 ; BARKAI and GOPHER, 1999 ; FINLAYSON *et al.*, 2003.

16. ANDERSON, 1994 ; UNGER-HAMILTON, 1989.

17. SIGGERS, 1997 : 175.

18. BANNING *et al.*, 1994 ; BANNING and SIGGERS, 1997 ; BANNING *et al.*, 2002, 2004.

19. BANNING *et al.*, 1994 ; BANNING and SIGGERS, 1997.

20. SIGGERS, 1997 ; BANNING and SIGGERS, 1997 ; BANNING *et al.*, 2004.

21. BANNING *et al.*, 1994 ; BANNING and SIGGERS, 1997 ; BANNING *et al.*, 2002, 2004.

22. BLACKHAM, 1997.

23. BANNING *et al.*, 2002, 2004.

24. GOPHER, 1995 ; GOPHER and GOPHNA, 1993.

25. GOPHER and GOPHNA, 1993.

regions. The material cultures at Tabaqat al-Bûma and al-Basatîn appear to represent a variant of the Wadi Raba culture at the eastern side of the Jordan Valley[26].

The following analysis will examine morphological and technological characteristics of sickle elements from Tabaqat al-Bûma and al-Basatîn. Morphological traits of sickle elements from these sites will be compared with those from other Wadi Rabah sites, while the technological analysis will compare the practices of sickle element production between these two sites.

MORPHOLOGICAL EXAMINATIONS OF SICKLE ELEMENTS FROM WADI RABAH SITES

Sickle elements from Wadi Rabah sites usually have a rectangular form with marginal, steep to semi-steep retouch at one side, and truncated or snapped ends (fig. 2). This general morphology can be subdivided according to Gopher's typology of sickle elements[27]. His Type C sickle elements are relatively thin and narrow with a trapezoidal cross-section formed by semi-abrupt backing retouch (fig. 2 : 1-8), while his Type D sickle elements are relatively thick and wide with a triangular cross-section formed by abrupt backing retouch (fig. 2 : 9-16). This typological scheme was employed by Barkai and Gopher to analyze sickle elements from Nahal Zehora I, and this analysis let them to point out that Type D sickle elements are characterized by coarse and semi-coarse denticulations on their cutting edge, while Type C sickle elements are dominated by fine denticulations and plain cutting edges[28]. In addition to these two types, Gopher originally defined Type E sickle elements, which are similar to Type C but tend to be longer and have plain or nibbled cutting edges instead of denticulations[29]. However, Type C and E sickle elements are grouped together in the analysis of Nahal Zehora I[30].

This typological scheme was employed for sickle elements from Tabaqat al-Bûma and al-Basatîn to be compared with other Wadi Rabah assemblages. The results suggest that the two sites in Wadi Ziqlab have higher proportions of Type D sickle elements than other three Wadi Rabah sites (fig. 3)[31]. As described above, Type D sickle elements are characterized by their thick, triangular cross-sections that are formed by abrupt backing retouch, and their cutting edges tend to be coarsely denticulated. Some of these detailed attributes were individually analyzed, and the results show that abrupt backing retouch appears to characterize the sickle elements from Tabaqat al-Bûma and al-Basatîn (fig. 4), conforming to the dominance of Type D sickle elements at these sites[32]. In addition, sickle elements from Wadi Ziqlab have higher occurrences of coarse and semi-coarse denticulations on their working edges than those from other Wadi Rabah sites (fig. 5)[33]. Interestingly, coarse or semi-coarse denticulations are frequently found on both Type C and D sickle elements in Wadi Ziqlab (*ca* 75 % of Type C and *ca* 65 % of Type D), while fine denticulations usually characterize Type C sickle elements in other Wadi Rabah sites as noted above.

In this way, sickle elements of Tabaqat al-Bûma and al-Basatîn appear to show greater morphological similarity in comparison to those from other Wadi Rabah sites. This morphological resemblance may not be surprising considering the chronological and geographical closeness between the two sites as explained earlier. Given this chronological and geographical proximity, it is likely that the formal similarity may not be a coincidence but a result of transmitted knowledge about the design of sickle elements.

However, this does not necessarily mean that inhabitants of the two sites also had the same technology of producing sickle elements because the same product design can be achieved through different manufacturing processes. Thus, to understand the technological knowledge, we need to investigate not only the morphologies of end-products but also the technological practices performed during the production of sickle elements. To this end, I will analyze technological practices of the sickle element production at Tabaqat al-Bûma and al-Basatîn, focusing on several key production activities, including raw material selection, blank production, and retouch.

26. BANNING *et al*., 1994 ; BANNING and SIGGERS, 1997 ; BANNING *et al*., 2002, 2004.
27. GOPHER, 1989.
28. BARKAI and GOPHER 1999.
29. GOPHER, 1989 : 95-108.
30. BARKAI and GOPHER, 1999 : 63.
31. Abu Zureiq : GARFINKEL and MATSKEVICH, 2002 ; Nahal Zehora I : BARKAI and GOPHER, 1999 ; Munhata : GOPHER, 1989.
32. *Ibid*.
33. Lower Horvat 'Illin : MARDER *et al*., 1995 ; Tell Qiri : BARUCH, 1987 ; Abu Zureiq : GARFINKEL and MATSKEVICH, 2002 ; Nahal Zehora I : BARKAI and GOPHER, 1999 ; Munhata : GOPHER, 1989.

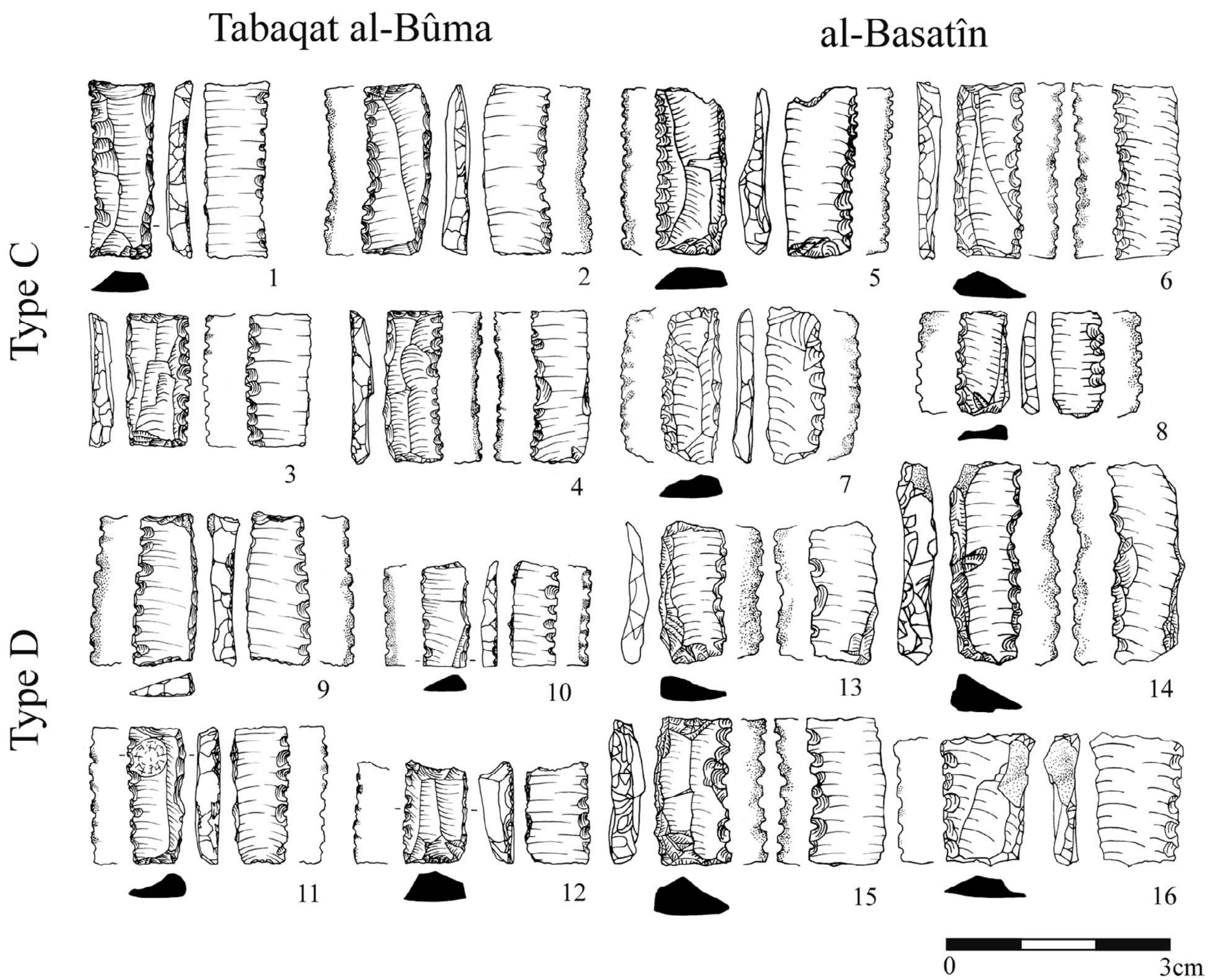

Fig. 2 : *Late Neolithic sickle elements from Wadi Ziqlab, northern Jordan : 1-8 : Type C ; 9-16 : Type D ; 1-4, 9-12 from Tabaqat al-Bûma ; 5-8, 13-16 from al-Basatîn.*

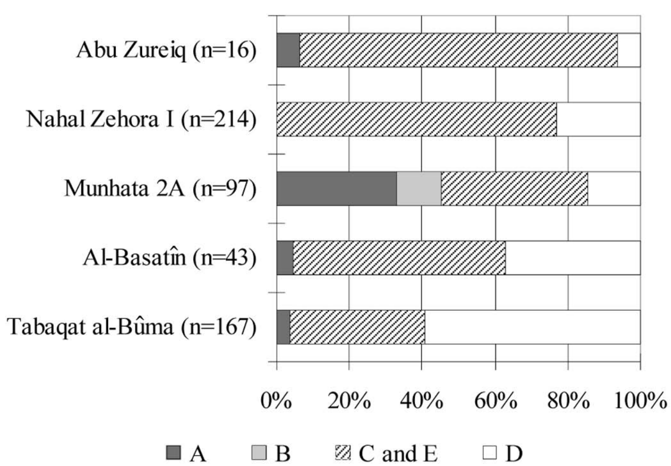

Fig. 3 : *Relative frequencies of Gopher's sickle-element types from Wadi Ziqlab and several Wadi Rabah sites.*

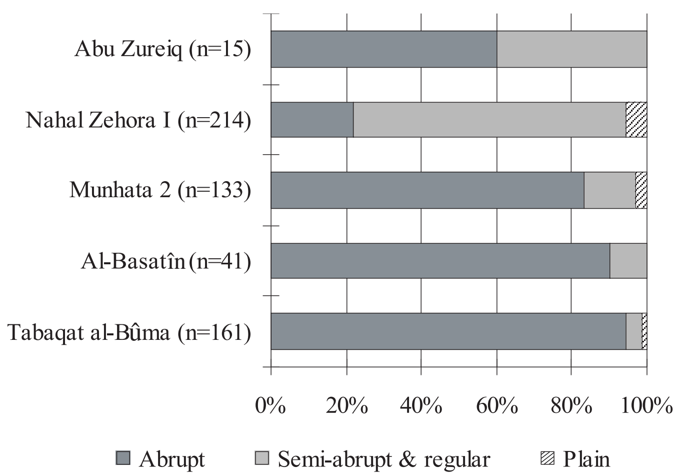

Fig. 4 : *Relative frequencies of retouch types at the hafted side of sickle elements from Wadi Ziqlab and several Wadi Rabah sites.*

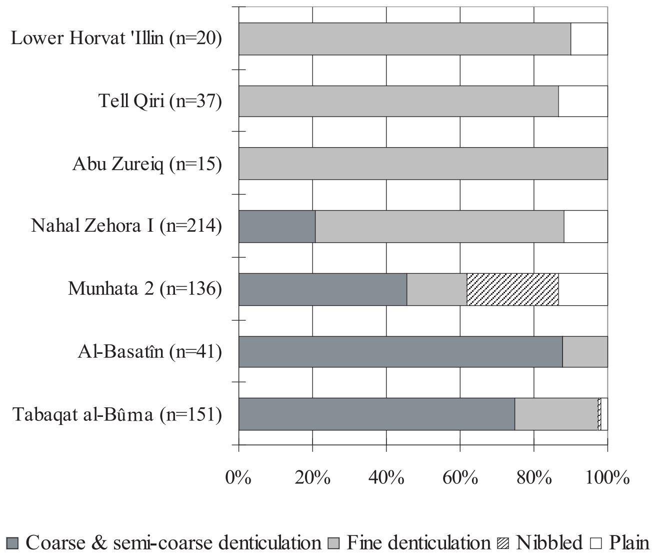

Fig. 5 : *Relative frequencies of working-edge morphologies observed on Type C, D, and E sickle elements from Wadi Ziqlab and several Wadi Rabah sites.*

PRODUCTION TECHNOLOGY OF SICKLE ELEMENTS AT TABAQAT AL-BÛMA AND AL-BASATÎN

RAW MATERIAL SELECTION

Tabaqat al-Bûma and al-Basatîn were compared in the colour and quality of raw materials used for sickle elements. Colours were classified by seven categories (light brown, medium brown, dark brown, light grey, medium grey, dark grey, and purple/pink), while qualities were classified into three grades (fine, medium, and coarse). As figure 6 shows, both colour and quality of raw materials used for sickle elements are quite similar at Tabaqat al-Bûma and al-Basatîn. Notably, fine-quality flint was most frequently chosen at both sites, accounting for more than 80 % of the tools. Moreover, at both sites, fine-grained flint is selected for sickle elements more frequently than for other major tool types, such as borers, scrapers, and retouched flakes, *ca* 50-70 % of which are made on fine-quality flint. These similar patterns in the use of raw material at the two sites may be partly explained by the easy access to high-quality flint sources from both sites[34].

34. BANNING *et al.*, 1994 : 161.

BLANK PRODUCTION AND SELECTION

In contrast to the similar preference of raw material quality, the blank morphology of sickle elements seems to differ between the two sites. As figure 7 shows, *ca* 60 % of sickle elements from al-Basatîn have been made on blades, while blades have been used for only *ca* 30 % of sickle elements from Tabaqat al-Bûma. In addition, over 30 % of sickle elements from Tabaqat al-Bûma do not allow the blank form to be identified because they have been intensively modified during the production processes. Assuming that sickle elements of indeterminate blank morphology are likely to have had irregular shapes that needed to be retouched into standardized rectangular forms, the high percentage of indeterminate blank forms at Tabaqat al-Bûma conforms to the frequent use of flakes for sickle elements at this site.

Despite the more frequent use of flakes at Tabaqat al-Bûma than at al-Basatîn, blades still appear to have been preferred to flakes for the production of sickle elements in comparison to other retouched tool types. Retouched flakes dominate the tool categories at both sites, while other major tool types, such as borers, scrapers, denticulates, and notches, are also largely made on flakes (*ca* 70-100 %). Given this frequent use of flakes for other tool types both at Tabaqat al-Bûma and al-Basatîn, the technology of blank production appears to differ between the two sites particularly in relation to the production of sickle elements rather than the production of other tool types.

RETOUCH

Cross-sectional morphology and backing technique

In order to examine the retouching technology employed in the production of sickle elements, cross-sectional morphologies and backing technique were analyzed. The cross-sectional morphology was classified into ten types, which are defined by the combinations of three attributes as seen in the figure 8[35] : the number of ridges on the dorsal surface (single or double), retouch angle (abrupt or semi-abrupt), and the extent of backing retouch (away-from-ridge or at-ridge). Backing retouch occurring “away from ridge” is marginal and indicates the less modification of blanks, while backing retouch located “at ridge” is more invasive and indicates the greater degree of blank modification.

35. BLACKHAM, 1997 : 160-163.

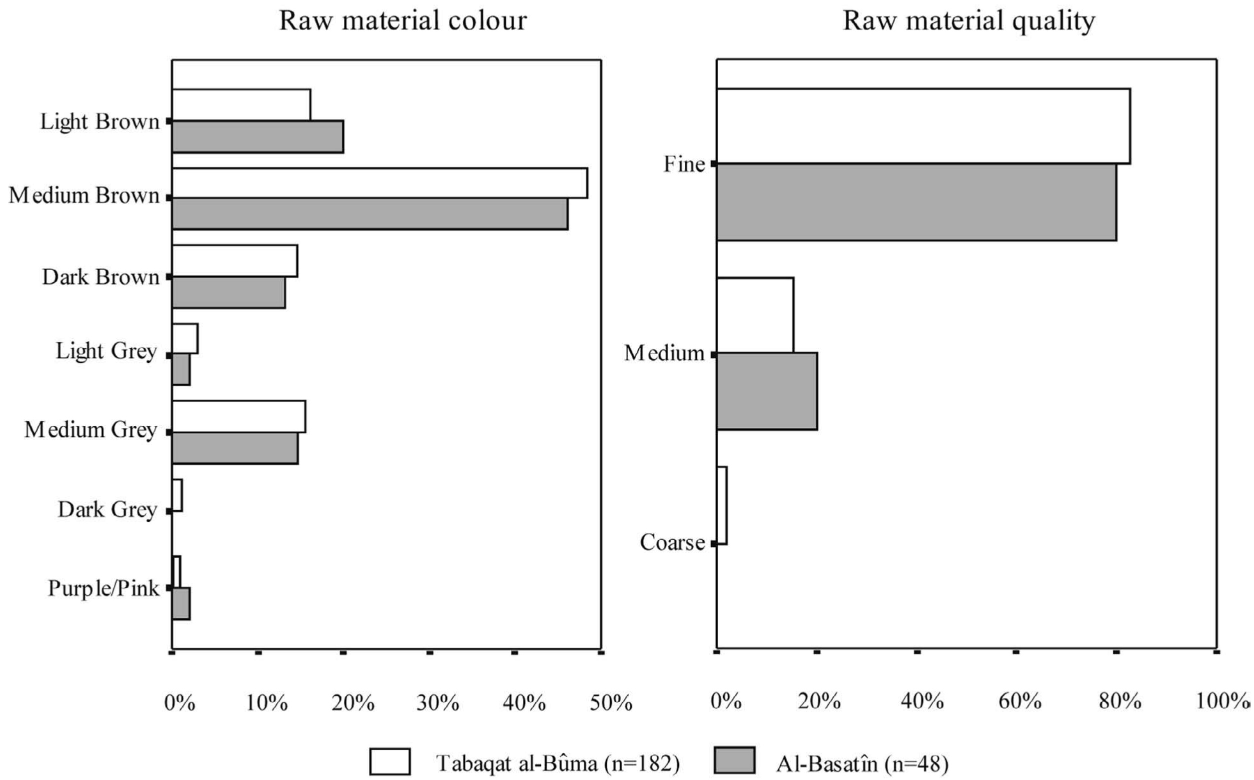

Fig. 6 : *Colour and quality of flint used for Neolithic sickle elements from Wadi Ziqlab.*

Figure 8 shows the occurrences of the ten types of cross-sectional forms at Tabaqat al-Bûma and al-Basatîn. While several types occur in clearly different proportions, two main patterns can be highlighted (table 1). First, the proportion of single-ridged sickle elements is significantly higher at Tabaqat al-Bûma than at al-Basatîn[36]. Second, backing retouch tends to be observed *at ridge* more frequently at Tabaqat al-Bûma, indicating that more extensive retouch was performed there[37]. Furthermore, these two patterns in cross-sectional forms seem to be related to blank morphologies. In fact, table 2 shows that single-ridged sickle elements have been largely made on flakes, while backing retouch occurring *at ridge* are more frequently observed on flakes than blades[38], indicating that flakes tend to have received the greater degree of modification than blades. Given this correlation between the cross-sectional morphology and the blank forms, the higher occurrences of single-ridged sickle elements and the backing retouch occurring *at ridge* at Tabaqat al-Bûma coincides with the fact that flakes have been more frequently used for the production of sickle elements there as described earlier.

In addition to the cross-sectional morphology, the technique of backing retouch was compared between the two sites (table 3). Three kinds of backing technique were identified ; two types were defined by the steepness of retouch (abrupt or semi-abrupt), while the other type (abrupt-and-crossed) was defined by abrupt retouch created by *bidirectional* (not bifacial) flaking from the dorsal and ventral surfaces as seen in figure 9 : 1. Table 3 shows that although abrupt retouch dominates at both sites, the proportion of abrupt-and-crossed backing is significantly higher at Tabaqat al-Bûma[39].

36. 1-tailed p of Fisher's exact test = 0.044.

37. The result of the difference-of-proportion test indicates that the proportion of retouch occurring *at ridge* differs significantly between Tabaqat al-Bûma and al-Basatîn (z-score = 1.645).

38. Fisher's exact test of the correlation between the blank forms (blades or flakes) and the number of ridge (single or double) resulted in 2-tailed p = 0.00, while the chi-square test of the correlation between the blank forms (blades or flakes) and the extent of retouch (no retouch, away-from-ridge, or at-ridge) resulted in the chi-square value = 19.9 and 2-tailed p = 0.00.

39. The result of the difference-of-proportion test indicates that the proportion of abrupt-and-crossed retouch differs significantly between Tabaqat al-Bûma and al-Basatîn (z-score = 2.22).

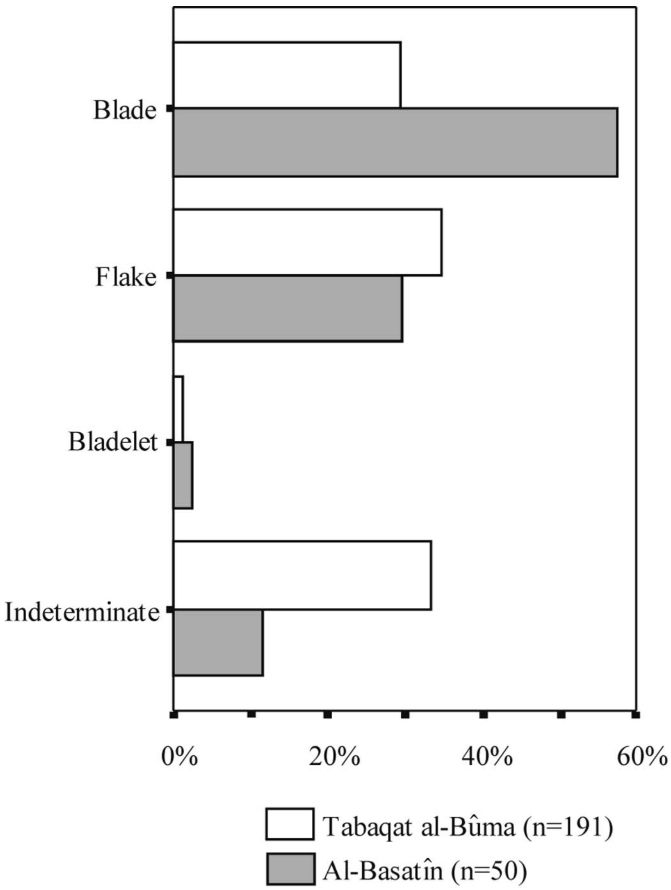

Fig. 7 : *Blank forms of Neolithic sickle elements from Wadi Ziqlab.*

Moreover, the abrupt-and-crossed backing technique seems to be correlated with the blank form and the extent of retouch as seen in table 3. In fact, the abrupt-and-crossed backing occurs more frequently on flakes than blades, and it also tends to occur at ridge, indicating the greater extent of retouch. Additionally, sickle elements with abrupt-and-crossed backing are significantly thicker than those with abrupt retouch[40], suggesting that the former technique was selected to modify relatively thick blanks. This correlation of the backing technique with the factors of the blank form and the extent of retouch is in accordance with the fact that sickle elements from Tabaqat al-Bûma are characterized by the higher occurrences of the abrupt-and-crossed backing technique, the more frequent use of flakes as blanks, and the greater extent of backing retouch than those from al-Basatîn.

40. 34. Abrupt-and-crossed (n=47) : Mean thickness = 6.2mm, s = 2.0 ; Abrupt (n=142) : Mean thickness = 5.3mm, s = 1.8 ; t value = 3.16 ; 2-tailed p = 0.002.

Denticulations on the cutting edge

Creating denticulations on the cutting edge should have been another important retouching process at Tabaqat al-Bûma and al-Basatîn because denticulations are observed on most sickle elements from both sites (fig. 5) ; however, the question is whether the denticulations were made during the production processes or the rejuvenation of cutting edges. The former possibility is indicated by the fact that no distinct sickle sheen or edge rounding can be observed on *ca* 30 % of the denticulated sickle elements from Tabaqat al-Bûma and al-Basatîn. This suggests that these sickle elements were already denticulated at the early stages of their use-lives. However, denticulations also seem to have been made during the edge maintenance as many sickle elements show polish removed at flake scars created by denticulations (for example, fig. 2 : 10 and 13).

In order to obtain further insights into the practices of creating denticulations, unfinished sickle elements were also examined. Their sample size is small (18 pieces from Tabaqat al-Bûma and 7 pieces from al-Basatîn), allowing no statistical verification to be made concerning the significance of the patterns observed in the practices of creating denticulations ; however, the unfinished sickle elements may still be worth being examined here because they clearly show another example of technological practices, where people's choices lead to the technological variability.

At Tabaqat al-Bûma, all of the unfinished products are abruptly backed or truncated without denticulations on their working edges (fig. 9), indicating that backing and truncation of blanks preceded the application of denticulations on the working edges. On the other hand, all seven pieces of unfinished sickle elements from al-Basatîn have denticulations on their working edges, and most of them are not yet backed or truncated (fig. 10). One broken piece with a denticulated edge appears to have been abandoned because of a failure of truncation retouch (fig. 10 : 1). This suggests that denticulations were usually made on the working edge before backing or truncation of blanks at al-Basatîn. Thus, the unfinished sickle elements indicate a contrast between the two sites in the sequence of retouching practices of sickle elements ; backing and truncation preceded denticulation at Tabaqat al-Bûma, while the reverse prevailed at al-Basatîn.

As pointed out earlier, this hypothesis will need to be verified with larger sample size, which may also allow us to examine how the sequence of retouching practices is related to other technological factors, including blank forms, cross-

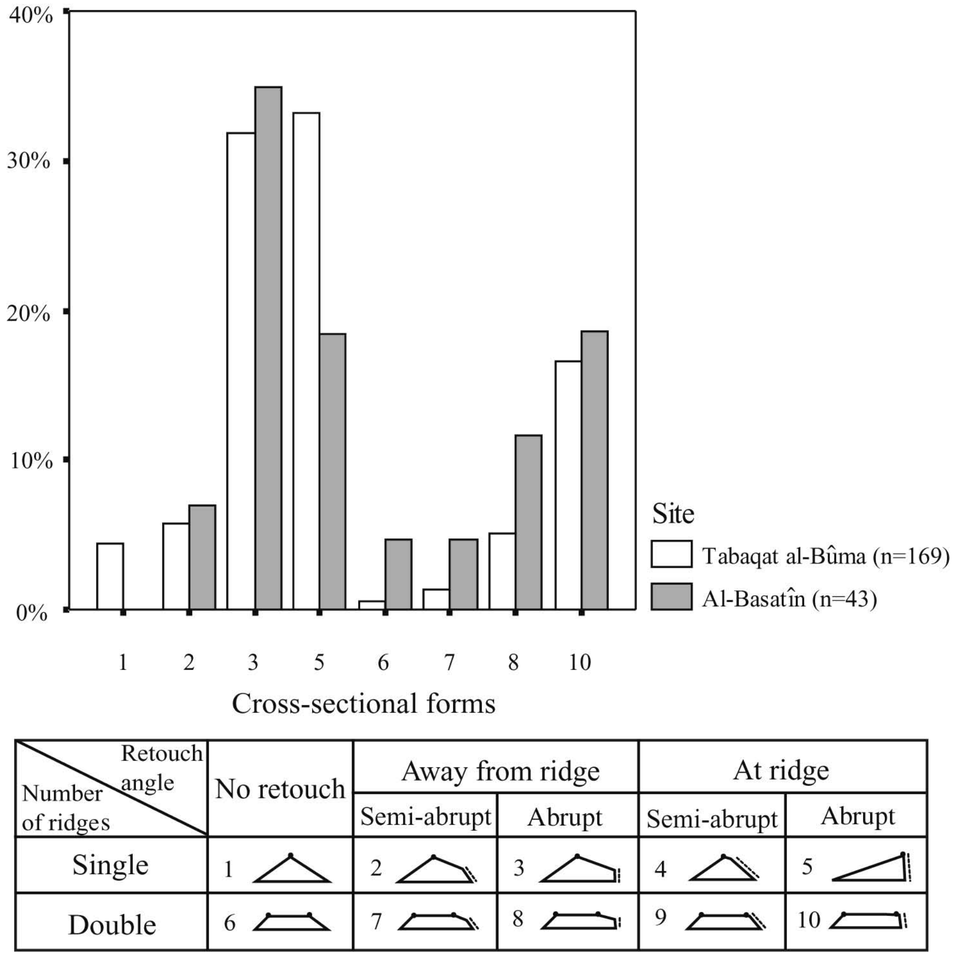

Fig. 8 : *Cross-sectional morphology of Neolithic sickle elements from Wadi Ziqlab. (Retouched areas are marked by dashed lines, while ridges are indicated by dots).*

Table 1 : *Number of ridges and the extent of retouch observed on Neolithic sickle elements from Wadi Ziqlab.*

		Tabaqat al-Bûma (n=169)	Al-Basatîn (n=43)
Number of ridges	Single	76%	60%
	Double	24%	40%
TOTAL		100%	100%
Extent of retouch	No retouch	5%	5%
	Away from ridge	44%	58%
	At ridge	51%	37%
TOTAL		100%	100%

sectional forms, and backing technique. Despite these remaining questions, the above observations still indicate that the sequence of retouching practices can provide another viewpoint towards the variability of lithic technological practices.

IMPLICATIONS OF SICKLE ELEMENTS IN LATE NEOLITHIC WADI ZIQLAB

The results of the above analyses indicate that some technological practices in the production processes of sickle elements probably differed between Tabaqat al-Bûma and al-Basatîn, while their final morphology was quite similar in

Table 2 : *Correlation between the blank forms and two attributes (the number of ridges and the extent of retouch) of Neolithic sickle elements from Wadi Ziqlab.*

	Number of ridges		**Extent of retouch**		
	Single (n=153)	Double (n=59)	No retouch (n=11)	Away from ridge (n=99)	At ridge (n=102)
Blade	30%	51%	55%	46%	25%
Flake	41%	15%	18%	20%	49%
Bladelet	1%	3%	9%	3%	0%
Indeterminate	28%	31%	18%	31%	27%
total	100%	100%	100%	100%	100%

Table 3 : *Correlation between backing retouch of sickle elements and other factors, including sites, blank forms, and the extent of retouch.*

Backing retouch	**Site**		**Blank form**		**Extent of retouch**	
	Tabaqat al-Bûma (n=170)	**Al-Basatîn (n=43)**	**Blade (n=76)**	**Flake (n=72)**	**Away from ridge (n=99)**	**At ridge (n=102)**
Abrupt	65%	74%	71%	49%	78%	61%
Abrupt and Crossed	25%	12%	9%	43%	10%	36%
Semi-Abrupt	6%	9%	11%	6%	12%	1%
Cortex	2%	0%	3%	1%	0%	2%
No retouch	2%	5%	7%	1%	0%	0%
total	100%	100%	100%	100%	100%	100%

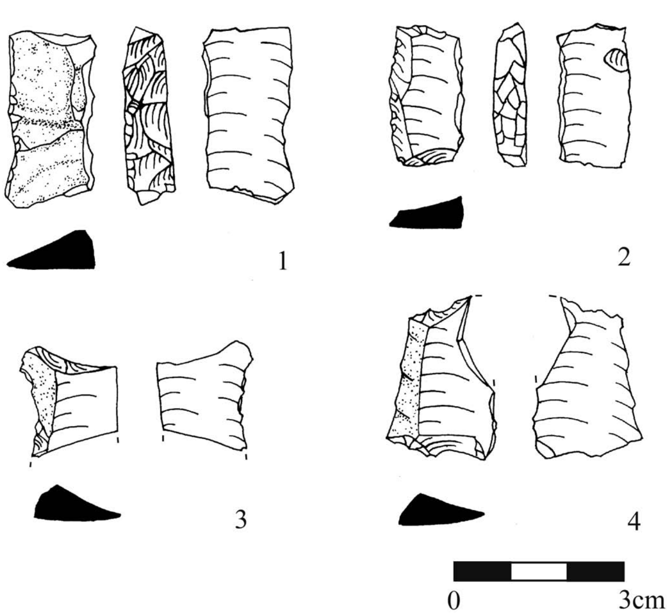

Fig. 9 : *Unfinished sickle elements from Tabaqat al-Bûma.*

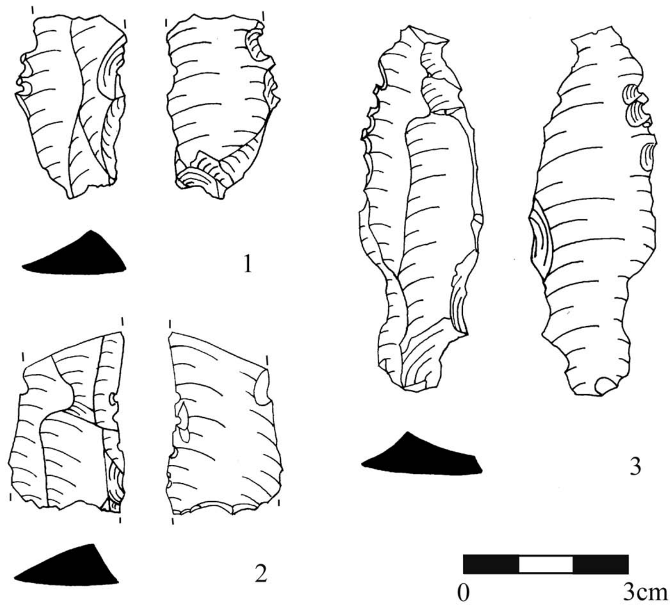

Fig. 10 : *Unfinished sickle elements from al-Basatîn.*

comparison to sickle elements from other Wadi Rabah sites. In other words, sickle elements from Tabaqat al-Bûma and al-Basatîn appear to have been manufactured according to a highly standardized design, which was achieved through various technological practices in the production processes, including the raw material selection, the blank production, and the blank modification. Although the variability of production technology also exists at each site, the results of the statistical tests show that the patterns observed in several production practices are significantly different between Tabaqat al-Bûma and al-Basatîn.

Based on these observations, the following discussion will aim at explaining the standardized design of sickle elements and their varied production technology in Wadi Ziqlab, particularly focusing on several factors, including chronology, geography, people's knowledge, the mechanical functions of sickle elements, and the mechanical logics of production technology. After examining these factors, I will briefly discuss social contexts that may have been related to the production of sickle elements in Wadi Ziqlab.

CHRONOLOGY, GEOGRAPHY, AND THE KNOWLEDGE ABOUT SICKLE ELEMENTS

As described earlier, a series of radiocarbon dates indicate that Tabaqat al-Bûma and al-Basatîn were probably occupied within the range of 5 700-5 200 cal BC. This chronological proximity between the two sites may partly explain the morphological similarity of their sickle elements, which are characterized by relatively high occurrences of Type D sickle elements, coarsely denticulated cutting edges, and abrupt backing technique. In fact, several researchers point out that coarsely denticulated sickle elements tended to appear early in the Late Neolithic period and were subsequently replaced by fine denticulations or plain edges at the end of the Late Neolithic and early in the Chalcolithic period[41]. According to this general trend from coarse to fine (or no) denticulation on the working edges, the dominance of coarsely denticulated sickle elements in Wadi Ziqlab may represent their earlier chronological positions than other Wadi Rabah sites. It is currently difficult to verify this hypothesis due to the lack of radiocarbon dates of Wadi Rabah sites that can be compared with Tabaqat al-Bûma and al-Basatîn ; nonetheless, deeply denticulated sickle elements have been found in a few sites, such as Tell Dan I layer XVI and Hagoshrim layer IV, which reportedly date to the early Wadi Rabah period[42].

On the other hand, the question is why the production technology of sickle elements appears to differ between Tabaqat al-Bûma and al-Basatîn despite their chronological proximity. One reason may be a subtle chronological difference between Tabaqat al-Bûma and al-Basatîn. While the Neolithic occupations at Tabaqat al-Bûma consist of several building phases within the range of 5 700-5 200 cal BC, the Neolithic occupations so far discovered at al-Basatîn are composed of less building remains, indicating its shorter occupational period[43]. This suggests that the production technology of sickle elements could have changed during the relatively long occupational period at Tabaqat al-Bûma (*ca* 500 years), and the production technology at al-Basatîn might resemble one of the temporal variations. This chronological question could be effectively investigated by analyzing sickle elements separately for each building phase at Tabaqat al-Bûma.

Although the chronological contexts may help us understand the morphological variations of sickle elements, geographical contexts also seem to explain the morphological variations of sickle elements. In fact, as described earlier, similar morphological traits are clustered in Wadi Ziqlab, such as at Tabaqat al-Bûma, al-Basatîn, and possibly another Late Neolithic site (WZ310)[44]. These sites are all located within a few kilometres range. In contrast, different morphological characteristics appear to be concentrated in another region, such as the Jezreel Valley, including Abu Zureiq, Nahal Zehora I, Tell Qiri, and probably 'Ein El Jarba[45], where most sickle elements are classified as Type C or E with finely denticulated (or plain) edges and less abrupt backing retouch. These observations indicate that the morphological variations of sickle elements can be understood as regional trends.

However, the question is whether these regional and chronological trends mean that people only knew the sickle-element designs of their region and time or that people made selections from a series of known designs. In fact, the regional and chronological variations of sickle-element morphologies are recognized as *proportional differences* of certain morpho-

41. Barkai and Gopher, 1999 ; Finlayson *et al.*, 2003 ; Garfinkel and Miller (eds), 2002 ; Gopher, 1989 ; Gopher and Gophna, 1993 ; Gopher and Rosen, 2001 ; Rosen, 1997 ; Wada, 2001.

42. Garfinkel and Matskevich, 2002 : 154 ; Gopher and Greenberg, 1996 : 73-74.

43. Banning, 2001 ; Banning *et al.*, 1994, 2002, 2004 ; Banning and Siggers, 1997 ; Blackham, 1997.

44. Banning *et al.*, 1996 : 44-46.

45. Kaplan, 1969 : 23-26.

logical attributes rather than as exclusive occurrences of different designs (figs 3-5). This suggests that people probably knew several different options for sickle-element designs and made choices according to some factors, including the mechanical goals to be achieved by sickle elements of selected designs. Thus, the standardized designs of sickle elements at Tabaqat al-Bûma and al-Basatîn are likely to have resulted from the similar patterns in people' choices of the designs.

Likewise, the technological difference between the two sites is also recognized as *proportional differences* in the occurrences of various technological practices rather than as their exclusive occurrences (figs 7 and 8, and tables 1-3), indicating that the inhabitants of the two sites probably knew the same range of technological options for the sickle-element production whether these sites were exactly contemporaneous or not. This leads us to questions what factors other than chronology and geography may have affected people's decisions when selecting the sickle-element designs and the production technology. To obtain some insights into this question, I will focus on two possible factors, *i.e.*, the mechanical functions and the social contexts of the tool production. The influence of mechanical factors will be examined first, and then I will discuss the social contexts that may have affected people's choices of the designs and the production technology of sickle elements.

DESIGN AND MECHANICAL FUNCTIONS

As described earlier, sickle elements constitute a major formal lithic tool type and were likely important cutting tools for agricultural practices in most Late Neolithic settlements[46]. Given this primary function, sickle elements' designs can be influenced by intended mechanical performance characteristics[47]. For example, the standardized morphology of sickle elements can facilitate their hafting and maintenance tasks[48], thus increasing the reliability and maintainability of sickles[49]. According to Bleed[50], an exploitation of resources that are predictably available in a limited period of time, such as migrant animals (or cultivated cereals in this case), is likely to lead people to design more reliable tools that are less likely to break. In fact, the morphological formality of sickle elements is distinct from other expedient flake tools, such as scrapers and retouched flakes, in the lithic assemblages of Tabaqat al-Bûma and al-Basatîn. The standardized morphology of sickle elements should secure their attachment to the haft. In addition, the uniformity of sickle elements is advantageous for the quick repair of broken sickles because it facilitates replacement of broken elements with new ones through quick adjustment of the size of new sickle elements by snapping[51].

However, these mechanical performance characteristics apply not only to sickle elements in Wadi Ziqlab but also those in other regions. To explain the sickle-element design specific to Wadi Ziqlab, a closer examination of performance characteristics would be necessary. As mentioned earlier, sickle elements from Wadi Ziqlab are characterized by higher occurrences of coarsely denticulated edges (fig. 5). Based on her cereal-harvesting experiments with sickle blades, Unger-Hamilton[52] reports that denticulations do not make edges sharper but extend the period of their utility. Siggers also suggests that denticulated edges do not cut as efficiently as unretouched ones when both types of edges are new, but denticulated sickle elements "work within acceptable levels of efficiency and maintain that efficiency for a far greater period of time" than unretouched edges[53]. He also points out that making denticulations is also a speedy way of resharpening edges, thus reducing the necessity of replacing dull sickle elements with new ones. In this way, denticulated edges may prolong the longevity of efficiency and enhance the maintainability of sickle elements.

Although these observations may partly explain the specific performance characteristics of denticulated sickle elements, the question remains why these particular performance characteristics were selected in Wadi Ziqlab. This may be related to differences in worked materials (*e.g.*, kinds and conditions) ; however, use-wear studies of sickle elements do not seem to support this idea[54], indicating the influence of cultural or social factors. Clarifying this problem will require further investigations about the relationships between mechanical performance characteristics and the sickle element designs.

46. BANNING *et al.*, 1994 ; BANNING and SIGGERS, 1997 ; BARKAI and GOPHER, 1999 ; FINLAYSON *et al.*, 2003 ; GOPHER, 1989, 1995.
47. SKIBO and SCHIFFER, 2001 : 143-146.
48. PEROS, 2000.
49. BLEED, 1986 ; SIGGERS, 1997.
50. BLEED, 1986 : 741.
51. PEROS, 2000.
52. UNGER-HAMILTON, 1988 : 183-184 and 1989 : 95.
53. SIGGERS, 1997 : 175.
54. SIGGERS, 1997 : 167-175 ; BARKAI and GOPHER, 1999 : 68.

PRODUCTION TECHNOLOGY AND MECHANICAL LOGICS

While the morphological traits of sickle elements can be explained by their mechanical functions, the production technology may be understood by the mechanical logics involved in the production processes. In order to manufacture sickle elements of intended designs, the production technology essentially needs to follow some mechanical logics. In the case of sickle elements in Wadi Ziqlab, their desired morphologies require several mechanical goals to be achieved in the production processes. As described earlier, sickle elements in Wadi Ziqlab usually have a rectangular form and a denticulated cutting edge within a certain range of size. In order to achieve these morphological traits, blanks are modified through various practices of production technology.

The comparative analyses of production technology at Tabaqat al-Bûma and al-Basatîn suggest that there are essentially two ways of achieving a rectangular shape of sickle elements ; one is using blades that require less extent of backing retouch, while the other is using flakes that need to be shaped into a rectangular form with a greater amount of modification. The former appears to have been more prevalent at al-Basatîn, while the latter was employed more often at Tabaqat al-Bûma. Although using blades that already have rectangular forms might appear more efficient than using flakes that require greater modification, the production of blades usually requires more skills and effort in the core reduction processes. These investments in the production of blades may be worthwhile when blades are intended to be made into various kinds of tools, such as in many Upper Palaeolithic industries, or to be traded for their specialized use, such as Canaanean blades[55] ; however, neither of these cases seem to apply to the lithic industries in Wadi Ziqlab, where most tools other than sickle elements are made on flakes, and no evidence indicates the trade of blades. Thus, it is difficult to decide whether using blades or flakes is a more efficient way of achieving a rectangular shape of sickle elements. Both ways appear to be equally effective as a way of achieving mechanical requirements for producing the sickle elements in Wadi Ziqlab.

Similarly, the observations of unfinished sickle elements suggested the different sequences of retouching practices of sickle elements ; backing and truncation preceded denticulation at Tabaqat al-Bûma, while the reverse prevailed at al-Basatîn. At present, it is difficult to differentiate between the two retouch sequences in terms of mechanical logics ; both ways seem similarly effective in creating rectangular forms and denticulations of sickle elements. However, the recovery of more unfinished sickle elements and their analyses in future may allow us to examine how the retouch sequences are related to other technological factors, such as blank forms and backing technique.

55. ROSEN, 1997 : 103-116.

SOCIAL CONTEXTS OF SICKLE ELEMENTS AND THEIR PRODUCTION PRACTICES IN WADI ZIQLAB

The above discussion examined how various mechanical factors can be related to the selections of the designs and the production technology of sickle elements ; however, the mechanical factors do not seem to explain some choices of designs and production methods. For example, although denticulated cutting edges may have some mechanical advantages, it is still unclear why they were more frequently selected in Wadi Ziqlab or in the early Wadi Rabah period than in the Jezreel Valley or in the later Wadi Rabah period. In addition, using flakes as a blank of sickle elements can be as effective as using blades in achieving mechanical requirements for producing sickle elements. Moreover, no difference can be seen between the different retouch sequences in terms of their mechanical advantages.

Now, the question is how we can explain these examples that do not seem to be explained only by mechanical principles. As described above, the chronological and geographical factors are not sufficient either because people appear to have known a range of optional designs and production technology of sickle elements beyond the temporal and spatial boundaries[56]. Therefore, the observed patterns in selecting certain designs and production technology may appear to reflect people's habits or their *arbitrary* selections[57], which leads us to consider social or cultural factors affecting people's technological choices.

As described earlier, the results of systematic regional surveys suggest that Late Neolithic settlements in Wadi Ziqlab consisted of small farmsteads or hamlets at dispersed locations. Since little is still known about the social organizations or ideological cultures of these rural agricultural communi-

56. See the preceding arguments based on the proportionally different occurrences of designs and production technology.

57. LEMONNIER, 1993 : 16-18.

ties, it is difficult to specify social or cultural factors affecting people's choices of the sickle-element designs and the production technology. However, the following will discuss possible social implications of sickle elements in order to develop the ongoing arguments about the settlement systems and social relations in Late Neolithic Wadi Ziqlab[58].

The primary question arises as to the social implications of highly similar sickle-element morphologies in Wadi Ziqlab. This similarity can indicate the frequent interactions among inhabitants in Wadi Ziqlab. Although the frequency of people's interaction does not always result in the material similarity[59], Neolithic farmsteads in Wadi Ziqlab may have regularly interacted with each other because of the easy access to neighbouring settlements and for the socioeconomic advantage. For the agriculturalists, who live in sparsely distributed small farmsteads, such as in Wadi Ziqlab, the maintenance of socioeconomic ties among settlements can be an important strategy to secure resource income in case of crop failure or to obtain necessary labour forces for multiple simultaneous tasks[60]. Banning points out that Late Neolithic pottery assemblages tend to include high proportions of small jars and bowls, which are suitable for preparing and serving food, and suggests that a "network of hospitability" had an important role in maintaining socioeconomic ties in the dispersed settlement system[61]. Although this idea needs to be tested by further examinations of pottery assemblages, I suggest that labour-sharing in agricultural tasks also help maintain reciprocal relations among community members.

According to some ethnographic studies of agrarian societies, community members from different households often collaborate to manage complex simultaneous tasks during the time of labour bottleneck, such as land clearance, planting, or harvesting[62]. One way to manage these occasions would be the use of efficient, well-designed tools, which are exemplified by the design investment in sickle elements as discussed above[63]. In addition to this mechanical solution, the labour collaboration would be another way to handle complex simultaneous tasks. Particularly, when this labour collaboration occurs in dispersed agricultural settlements, the travel distance to neighbours' lands conditions the distributional patterns of farmsteads[64]. As noted earlier, Tabaqat al-Bûma, al-Basatîn, and another possible Late Neolithic settlement (WZ310) in Wadi Ziqlab are located within a few kilometres' range. If their proximity represents the distributional pattern of Neolithic farmsteads in Wadi Ziqlab, it is possible that inhabitants visited neighbouring settlements in the occasions of labour bottleneck to accomplish complex tasks. Such reciprocal group works should have contributed to the enhancement of interactions among inhabitants of different farmsteads. In this way, the frequent interactions between farmsteads, particularly through the collaborative labour works involving the use of tools, can be a social factor that contributed to the dissemination of the similar choices of tool designs.

However, the above discussion leaves us with a question of why then the production technology of sickle elements statistically differed between Tabaqat al-Bûma and al-Basatîn despite their possible interactions. Although the two settlements may not have existed at exactly the same time and had no direct interactions, we may still question why the technological practices of sickle element-production were not inherited in the same way as the morphology of sickle elements.

To answer these questions, helpful may be our earlier observation that some technological options in the production processes are not likely critical in achieving morphological requirements of sickle elements. For example, it does not seem to matter in terms of mechanical logics whether people use flakes or blades as a blank of sickle elements. Likewise, denticulations can be equally created either before or after modifying the blanks by backing or truncating. These observations suggest that people may not have transmitted their choices of the production technology as clearly as the final morphology of sickle elements. People's low awareness of these technological choices may have let to their greater variability.

Another possible reason for the technological variability is that people may have selected the production technology according to their various knapping skills and the labour organizations of stone-tool production. For example, the different occurrences of blades as a blank of sickle elements at Tabaqat al-Bûma and al-Basatîn may reflect the inhabitants' different levels of skills of producing blades or the degree of specialization of the sickle-element production at each site.

As described earlier, the production technology of sickle elements at both sites appears distinct from other tool types because the production of sickle elements involves more frequent use of fine-grained flint, blades, and retouching technique than other tool types, such as borers, scrapers, and

58. BANNING, 2001 ; BANNING *et al*., 1994, 2002, 2004 ; BANNING and SIGGERS, 1997 ; BLACKHAM, 1997.
59. HODDER, 1979 : LEMONNIER, 1986.
60. BANNING, 1996, 2001.
61. BANNING, 2001 : 154.
62. STONE, 1993 ; WILK, 1984.
63. SIGGERS, 1997.
64. STONE, 1993 : 33.

retouched flakes. Despite these distinct production processes of sickle elements, it is still not clear whether their production was conducted by specialized people or shared by most members in a settlement. This issue can be effectively investigated through the spatial analyses of chipped-stone production activities to detect whether specialized workshops existed or not[65]. Once this problem is solved, we may clearly examine how the production technology is related the labour organizations of stone-tool production.

CONCLUSION

This study examined the morphology and the production technology of sickle elements from several Late Neolithic settlements in the southern Levant, particularly focusing on the similarity of designs and the variability of production technology observed at the two agricultural settlements in Wadi Ziqlab. The subsequent discussion aimed at explaining the results of the analyses by considering how observed patterns in the design and the production technology of sickle elements can be related to various factors, including chronology, geography, mechanical functions, and social contexts of Late Neolithic settlements in Wadi Ziqlab.

Some relations between these factors and sickle elements appear relatively clear. For example, the patterns observed in the morphological variations of sickle elements seem to reflect their chronological and geographical contexts. In addition, the standardized designs of sickle elements may be understood in terms of their intended mechanical advantages. However, a number of questions are remaining, particularly as to how the technological variability in the production of sickle elements are related to chronological positions, mechanical principles, and social contexts of the sickle-element production.

One way of examining these questions would be systematic experimental productions of sickle elements, which may allow us to objectively assess the mechanical requirements and the effectiveness of various technical solutions involved in the production processes. In addition, the spatial analyses of chipped-stone activities may help us obtain insights into the labour organizations in the stone-tool production activities, clarifying the social contexts of the sickle-element production. Thus, further investigations are necessary to better explain the variability of the production technology of sickle elements ; nonetheless, this paper hopefully showed that the analyses of the production technology and the morphology of sickle elements can provide essential archaeological records that can effectively guide our subsequent investigations of various archaeological and anthropological questions.

65. QUINTERO, 1998.

ACKNOWLEDGEMENTS

Research in Wadi Ziqlab has been supported by a host of individuals and funding from the Social Sciences and Humanities Research Council of Canada, the Department of Antiquities of Jordan, and the University of Toronto. I would like to thank E. Banning for his encouragement and support for this study and comments on the draft of this paper. I am also grateful for M. Chazan for his thoughtful feedback to this paper. I would like to extend my thanks to all the members of the Wadi Ziqlab project for their support in the field and the laboratory. Thanks are also due to R. Stebelski and J. Pfaff for their lithic illustrations. I am, however, responsible for the contents of this paper.

Seiji KADOWAKI
University of Toronto
Department of Anthropology
100 St. George Street
Toronto, Ontario M5S 3G3
Canada
seiji.kadowaki@utoronto.ca

BIBLIOGRAPHY

ANDERSON P.C.

1994 Reflections on the Significance of Two PPN Typological Classes in Light of Experimentation and Microwear Analysis : Flint “Sickles” and Obsidian “Çayönü Tools”. *In* : GEBEL H.G. and KOZLOWSKI S.K. (eds), *Neolithic Chipped Stone Industries of the Fertile Crescent* : 61-82. Berlin : ex oriente (*SENEPSE* 1).

BAMFORTH D.B.

1986 Technological efficiency and Tool curation. *American Antiquity* 51,1 : 38-50

BANNING E.B.

1996 Houses, Compounds and Mansions in the Prehistoric Near East. *In* : COUPLAND G. and BANNING E.B. (eds), *People Who Lived in Big Houses : Archaeological Perspectives on Large Domestic Structures* : 165-185. Madison Wisconsin : Prehistory Press (*Monographs in World Archaeology* 27).

2001 Settlement and Economy in Wadi Ziqlab during the Late Neolithic. *Studies in the History and Archaeology of Jordan* VII : 149-155. Amman : Department of Antiquities.

BANNING E.B. and SIGGERS J.

1997 Technological Strategies at a Late Neolithic Farmstead in Wadi Ziqlab, Jordan. *In* : GEBEL H.-G., KAFAFI Z. and ROL-

LEFSON G. (eds), *The Prehistory of Jordan* II. *Perspectives from 1997* : 319-331. Berlin : ex oriente.

BANNING E.B., GIBBS K., GREGG M., KADOWAKI S. and MAHER L.
2004 Excavations at a Late Neolithic site in Wadi Ziqlab, northern Jordan. *Antiquity* 78,302 : 764 (on the website).

BANNING E.B., GIBBS K., GREGG M., KADOWAKI S. and RHODES S.
2002 Excavations at al-Basatîn, Wadi Ziqlab, Jordan. *Neo-Lithics* 2/02 : 13-14.

BANNING E.B., RAHIMI D. and SIGGERS J.
1994 The Late Neolithic of the Southern Levant : Hiatus, Settlement Shift or Observer Bias ? The Perspective from Wadi Ziqlab. *Paléorient* 20,2 : 151-164.

BANNING E.B., RAHIMI D., SIGGERS J. and TA'ANI H.
1996 The 1992 Season of Excavations in Wadi Ziqlab, Jordan. *Annual of the Department of Antiquities of Jordan* 40 : 29-49.

BARKAI R. and GOPHER A.
1999 The Last Neolithic Flint Industry : A study of the technology, typology and social implications of the Lithic Assemblage from Nahal Zehora I, A Wadi Raba (Pottery Neolithic) Site in the Menashe Hills, Israel. *Journal of The Israel Prehistoric Society* 29 : 41-122.

BAR-YOSEF O., VANDERMEERSCH B., ARENSBURG B., BELFER-COHEN A., GOLDBERG P., LAVILLE H., MEIGNEN L., RAK Y., SPETH J.D., TCHERNOV E., TILLIER A.-M. and WEINER S.
1992 The Excavations in Kebara Cave, Mt. Carmel. *Current Anthropology* 33,5 : 497-550.

BARUCH U.
1987 The Early Bronze Age, Chalcolithic and Neolithic Periods. *In* : BEN-TOR A. and PORTUGALI Y. (eds), *Tell Qiri : A village in the Jezreel Valley*. Jerusalem : The Hebrew University of Jerusalem (*Qedem* 24).

BLACKHAM M.
1997 Changing Settlement at Tabaqat al-Bûma in Wadi Ziqlab, Jordan : a Stratigraphic Analysis. *In* : GEBEL H.-G., KAFAFI, Z. and ROLLEFSON G. (eds), *The Prehistory of Jordan* II. *Perspectives from 1997* : 345-360. Berlin : ex oriente.

BLEED P.
1986 Optimal design of Hunting Weapons : maintainability or reliability. *American Antiquity* 51,4 : 737-747.
2001 Trees or Chains, Links or Branches : Conceptual Alternatives for Consideration of Stone Tool Production and Other Sequential Activities. *Journal of Archaeological Method and Theory* 8, 1 : 101-127.

BURIAN F. and FRIEDMAN E.
1979 A Typology of Arrowheads and Sickle Blades and Its Chronological Implication. *Mitekufat Haeven* 16 : 1-16.

CAUVIN M.-C.
1983 Les faucilles préhistoriques du Proche-Orient : données morphologiques et fonctionnelles. *Paléorient* 9,1 : 63-79.

EDMONDS M.
1990 Description, Understanding and the *Chaîne Opératoire*. *Archaeological Review from Cambridge* 9,1 : 55-70.

FINLAYSON B., KUIJT I., ARPIN T., CHESSON M., DENNINS S., GOODALE N., KADOWAKI S., MAHER L., SMITH S., SCHURR M. and MCKAY J.
2003 Dhra' Excavation Project, 2002 Interim Report. *Levant* 35 : 1-38.

FUJII S.
1983 Classification of the Mounting Type of Sickle Blades. *Bulletin of the Ancient Orient Museum* 5 : 129-152 (In Japanese).

GARFINKEL Y. and MATSKEVICH Z.
2002 Abu Zureiq, a Wadi Rabah Site in the Jezreel Valley : Final Report of the 1962 Excavations. *Israel Exploration Journal* 52,2 : 129-166.

GARFINKEL Y. and MILLER M.A. (eds)
2002 *Sha'ar Hagolan 1 : Neolithic Art in Context*. Oxford : Oxbow Press.

GOPHER A.
1989 *The Flint Assemblages of Munhata - Final Report*. Paris : Association Paléorient. (*Cahiers du CRFJ* 4).
1995 Early Pottery-Bearing Groups in Israel. The Pottery Neolithic Period. *In* : LEVY T. (ed.), *The Archaeology of Society in the Holy Land* : 205-221. London and Washington : Leicester University Press.

GOPHER A. and GOPHNA R.
1993 Cultures of the Eighth and Seventh Millennia BP in the Southern Levant : A Review for the 1990s. *Journal of World Prehistory* 7,3 : 297-353.

GOPHER A. and GREENBERG R.
1996 The Pottery Neolithic Levels. *In* : BIRAN A., ILAN D. and GREENBERG R. (eds), *Dan I : A Chronicle of the Excavations, the Pottery Neolithic, the Early Bronze Age and the Middle Bronze Age Tombs* : 67-81. Jerusalem : Nelson Glueck School of Biblical Archaeology, Hebrew Union College – Jewish Institute of Religion.

GOPHER A. and ROSEN S.A.
2001 Lithics of Strata XIII-III, The Pre-Pottery Neolithic-Early Bronze Age. *In* : EISENBERG E., GOPHER A. and GREENBERG R. (eds), *Tel Te'o, A Neolithic, Chalcolithic, and Early Bronze Age Site in the Hula Valley* : 49-82. Jerusalem : Israel Antiquities Authority.

HAYDEN B., FRANCO N. and SPAFFORD J.
1996 Evaluating Lithic Strategies and Design Criteria. *In* : ODELL G. (ed.), *Stone Tools : Theoretical Insights into Human Prehistory* : 9-45. New York and London : Plenum Press.

HENRY D.O. and ODELL G.H.
1989 *Alternative Approaches to Lithic Analysis.* Washington, D. C. : American Anthropological Association (*Archaeological Papers of the American Anthropological Association* 1).

HODDER I.
1979 Economic and Social Stress and Material Culture Patterning. *American Antiquity* 44,3 : 446-454.

KAPLAN J.
1969 'Ein El Jarba : Chalcolithic Remains in the Plain of Esdraelon. *Bulletin of the American Schools of Oriental Research* 194 : 2-38.

KUIJT I. and CHESSON M.S.

2002 Excavations at 'Ain Waida', Jordan : New Insights into Pottery Neolithic Lifeways in the Southern Levant. *Paléorient* 28,2 : 109-122.

LEMONNIER P.

1986 The Study of Material Culture Today : Toward an Anthropology of Technical Systems. *Journal of Anthropological Archaeology* 5 : 147-186.

LEMONNIER P. (ed.)

1993 *Technological Choices : Transformation in material cultures since the Neolithic*. London and New York : Routledge.

MARDER O., BRAUN E. and MILEVSKI I.

1995 The Flint Assemblage of Lower Horvat 'Illin : Some technical and economic considerations. '*Atiqot* XXVII : 63-93.

NISHIAKI Y.

2000 *Lithic Technology of Neolithic Syria*. Oxford (*BAR Int. Ser.* 840).

2001 Hafting Systems of Sickle Elements from the Chalcolithic Levels of Telul eth-Thalathat II, Iraq. *In* : CANEVA I., LEMORINI C., ZAMPETTI D. and BIAGI P. (eds), *Beyond tools : Redefining the PPN Lithic Assemblages of the Levant* : 55-72. Berlin : ex oriente (*SENEPSE* 9).

NELSON M.C.

1991 The Study of Technological Organization. *In* : SCHIFFER M. (ed.), *Archaeological Method and Theory* 3 : 57-100. Tucson : The University of Arizona Press.

ODELL G.H. (ed.)

1996 *Stone Tools : Theoretical Insights into Human Prehistory*. New York and London : Plenum Press.

OLSZEWSKI D.I.

1994 The PPN Glossed Blades from 'Ain Ghazal, Jordan (1982-1985 and 1988-1989 seasons). *In* : GEBEL H.G. and KOZLOWSKI S.K. (eds), *Neolithic Chipped Stone Industries of the Fertile Crescent* : 467-478. Berlin : ex oriente (*SENEPSE* 1).

PELEGRIN J.

1990 Prehistoric Lithic Technology : Some Aspects of Research. *Archaeological Review from Cambridge* 9,1 : 116-125.

PEROS M.

2000 Sickle Blade Design and Hafting Strategies at Tabaqat al-Buma, a Late Neolithic Farmstead in Wadi Ziqlab, Northern Jordan. *Neo-Lithics* 2-3 : 2-4.

QUINTERO L.A.

1988 *Evolution of Lithic Economies in the Levantine Neolithic : Development and Demise of Naviform Core Technology*. Riverside : University of California, Unpublished Ph.D. dissertation.

QUINTERO L.A. and WILKE P.J.

1995 Evolution and Economic Significance of Naviform Core-and-Blade Technology in the Southern Levant. *Paléorient* 21,1 : 17-33.

QUINTERO L.A., WILKE P.J. and WAINES J.G.

1997 Pragmatic Studies of Near Eastern Neolithic Sickle Blades. *In* : GEBEL H.-G., KAFAFI Z. and ROLLEFSON G. (eds), *The Prehistory of Jordan* II. *Perspectives from 1997* : 263-286. Berlin : ex oriente (*SENEPSE* 4).

ROSEN S.

1997 *Lithics After the Stone Age : A Handbook of Stone Tools from the Levant*. Walnut Creek, London : Altamira Press.

SELLET F.

1993 Chaîne Opératoire ; The Concept and Its Applications. *Lithic Technology* 18, 1-2 : 106-112.

SIGGERS J.

1997 *The Lithic Assemblage from Tabaqat al-Bûma : A Late Neolithic Site in Wadi Ziqlab, Northern Jordan*. University of Toronto, Department of Anthropology, Unpublished Ph.D. dissertation.

SKIBO J. M. and SCHIFFER M.B.

2001 Understanding Artifact Variability and Change : A Behavioral Framework. *In* : SCHIFFER M.B. (ed.), *Anthropological Perspectives on Technology* : 139-149. Arizona : An Amerind Foundation Publication.

STARK M.T. (ed.)

1998 *The Archaeology of Social Boundaries*. Washington and London : Smithsonian Institution Press.

STONE G.D.

1993 Agrarian Settlement and the Spatial Disposition of Labor. *In* : HOLL A. and LEVY T. (eds), *Spatial Boundaries and Social Dynamics : Case Studies from Food-Producing Societies* : 25-38. Ann Arbor, Mi : International Monographs in Prehistory (*Ethnoarchaeological Series* 2).

UNGER-HAMILTON R.

1988 *Method in Microwear Analysis : Prehistoric Sickles and Other Stone Tools from Arjoune, Syria*. Oxford (*BAR Int. Ser.* 435).

1989 The Epi-Palaeolithic Southern Levant and the Origins of Cultivation. *Current Anthropology* 30,1 : 88-103.

WADA H.

2001 The Chipped Stone Tools. *In* : KAFAFI Z. A. (ed.), *Jebel Abu Thawwab (Er-Rumman), Central Jordan* : 117-154. Berlin : ex oriente.

WILK R.R.

1984 Households in Process : Agricultural Change and Domestic Transformation among the Kekchi Maya of Belize. *In* : NETTING R., WILK R. and ARNOULD E. (eds), *Households : Comparative and Historical Studies of the Domestic Group* : 217-244. Berkeley : University of California Press.

WILKE P.J. and QUINTERO L.A.

1994 Naviform Core-and-Blade Technology : Assemblage Character as Determined by Replicative Experiments. *In* : GEBEL H.G. and KOZLOWSKI S.K. (eds), *Neolithic Chipped Stone Industries of the Fertile Crescent* : 33-60. Berlin : ex oriente (*SENEPSE* 1).