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Technological choices and lithic production in the Indus period: Case studies from Sindh (Pakistan)

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Abstract

The Indus Civilisation flourished in part of the Indian Subcontinent during the Bronze Age. It was a complex urban civilisation, with a writing system, still undeciphered. It is also famous for its sophisticated handicrafts, painted pottery, stoneware, steatite and semiprecious beads, faience and metalwork, which were traded to long distances across the Persian Gulf and the Arabian Sea. Nevertheless chipped stone technology and flint artefacts production still represented important aspects of the economic system, especially in connection with specialised craft productions, which led to an intensive exploitation of the flint raw material sources of the Rohri Hills, in Upper Sindh. Here thousands of flint mines were exploited for a mass production of blades and bladelets, which were later transformed into sophisticated micro-drill points in the craft activity areas of the cities, where they are found in association with semiprecious stone bead making workshops.

This paper analyses the complexity of the lithic production of the Indus Civilisation. It describes the technology and methods of production of such blades, according to the evidence collected during several years of research carried out in the Rohri Hills. Here, besides the mines, a good number of flint knapping workshops were excavated by the Italo-Pakistani expedition. The analytical study of the lithic assemblages recovered from these excavations and the experimental reproduction of the debitage sequence, favoured the reconstruction of the techniques and the methods of the Indus flint working.

Keywords: Pakistan, Upper Sindh, Indus Civilisation, Flint sources, Bronze Age flint mining, Flint knapping workshops, Lithic technology, Blade production.

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Introduction

Until the end of the 1980s, very little was known of the Bronze Age chipped stone assemblages of Sindh. The first summary report written by Cleland (1987) gives an immediate idea of the scarcity of data available at that time for the entire Indus Valley and its surrounding regions, regarding the Amri, Kot Diji and Mature Indus cultures, which developed in the territory during the Chalcolithic and Bronze Age, roughly from 3500 to 2000 cal. BC years (Possehl 1988). Furthermore if we consider the number of artefacts from the Bronze Age sites analysed by this author (Cleland 1987), we can notice that, although Sindh represents one of the Indus Valley regions very rich in settlements of this age, the chipped stone assemblages he considered come from only four sites: Amri, Kot Diji, Allahdino and Mohenjo-daro (Cleland 1987: tables 1 and 2). Nevertheless, the technological and typological characteristics of the chipped stone assemblages of these periods were defined for the first time in this paper.

In 1984 J. M. Kenoyer wrote a comprehensive report of the chipped stone assemblages from the excavations carried out by J. Dales in 1964-65 at Mohenjo-daro, the largest Indus urban settlement of Sindh. In his preface he points out the limits of his analysis, due to the very restricted number of chipped stone tools available for his study - only 115 items - because '*in the course of these massive excavations only the most complete and unique examples of stone tools were collected and recorded*' (Kenoyer 1984: 117). His report represents a first attempt to a techno-typological and functional analysis of a Mature Indus chipped stone assemblage, whose laminar characteristics can be easily recognised both in the core types and unretouched by-products.

This paper follows another contribution by B. Allchin (1979), who, apart from considering the chipped stone assemblages from the old excavations at Mohenjo-daro, gives a first comprehensive account of the Holocene blade assemblages from Sindh (Allchin 1979: fig. 2). Furthermore this paper provides some preliminary information of the lithic assemblages observed in a few 'working floors' in the Rohri Hills, near Sukkur (Upper Sindh), and other sites of different ages and cultures close to the Karachi Gulf, whose structural compositions were later compared in another paper by the same author (Allchin 1985: table 2).

Even though the first Indus flint workshops of the Rohri Hills were discovered in the 1880s (Biagi 1997), their chronology was discussed only some 50 years later by De Terra and Paterson (1939: 335). They '*found over 100 blade cores, mostly conical, flaked usually around a half to three quarters of the periphery*' at Rohri, along the northern edge of the Rohri Hills, which they correctly attributed to the Indus Valley Civilisation (De Terra and Paterson 1939: 336). Further researches around Rohri were carried out by members of the Cambridge Archaeological Mission in 1975. They led to the discovery of numerous Indus Civilisation flint working floors, mainly on the top of the limestone mesas of the Rohri Hills near Rohri (Allchin 1976: 477); whilst the first Indus flint mines were discovered in 1986 by Biagi and Cremaschi (1991) along the central-western terraces of the same hills, close to the Shrine of Shadee Shaheed.

Further investigations in the same area were resumed by the Ca' Foscari University, Venice (Italy) and Shah Abdul Latif University, Khairpur (Pakistan) between 1993 and 2002 (Biagi and Shaikh 1994). During the surveys conducted in those years hundreds of Indus mines and flint workshops were discovered (Biagi and Pessina 1994; Biagi et al 1995; 1997). In addition, excavation seasons were conducted both in the mining areas and flint workshops (Biagi and Pessina 1994; Negrino and Starnini 1995; 1996; Negrino et al 1996; Starnini and Biagi 2006).

Important advances in the study of the lithic tool-uses in the Indus urban centres were achieved in the 1980s, thanks to the research carried out at the so-called 'Moneer South East Area' of Mohenjo-Daro, in the framework of the Aachen-IsMEO Project (Bondioli et al 1984; Vidale 2000). The careful analyses of the artefacts clustered on the surface of several activity areas of the handicraft quarter of the city, revealed that the Rohri Hills flint and chert implements were still employed in large quantities by the Bronze Age artisans, especially for the manufacture of semi-precious stone and shell beads.

On the other hand, in the same years several French scholars centred their research mainly on the technological aspects of the flint industries (Anderson-Gerfaud et al 1989; Inizan and Lechevallier 1990; 1995; Inizan et al n.d.; Lechevallier 1978; 2003; Marcon and Lechevallier 2000; Pelegrin 1994), reaching important conclusions about the technique

(The way flakes and blades were removed) and method (the organisation of the removal sequences) of flint knapping during the Chalcolithic and Bronze Ages of the Indus Valley. Their studies demonstrated that the use of copper tipped points in the blade debitage had been introduced since the Chalcolithic (Inizan et al 1994).

Finally, the discoveries recently made on the top of the limestone hills around Ongar, south of Hyderabad in southern Sindh (Biagi 2005), have shown that flint extractive structures and workshops attributable to the Mature Indus Civilisation, identical to those already known from the Rohri Hills, are present also in this region (Biagi 2006a: 190; 2007; Biagi and Franco 2008; Biagi and Starnini 2008). They indicate that, although the Rohri Hills were most probably acting as principal flint extractive centre, they are not the only mining areas, which were exploited during the Bronze Age, Indus Civilisation (see also Biagi and Nisbet 2010).

Despite the fact that the above-mentioned researches have proved that flint and chert exploitation, trade, transformation and use, undoubtedly played a significant role in the economy of the Indus Civilisation, both in the craft activities and in the strategy of raw material procurement, very few authors mention this aspect among those which are considered to be of crucial importance for the full understanding of the procurement system of the resources utilised and the craft production of the Indus economic system (Lahiri 1992: 48). Even though this subject has been almost neglected by most authors in their recent important syntheses on the Indus Civilisation (for example, see Gupta, 1996; Kenoyer, 1998: 43; Possehl 2003; Ratnagar 2004), the wide distribution radius of the Rohri Hills flint, which ranges at least from Harappa, in the north (Law et al 2002-2003: 11) to the mouth of the Hab River (Biagi 2004: 7), the Rahn-of-Kutch (Baloch 1973: 16; Biagi 2006a: 191) and Gujarat (Ajithprasad 2002; Bahn 1989: 223), in the south, clearly demonstrates the important role played by this resource in the economic strategy of the Bronze Age.

At present, the arid environmental conditions of the hills do not allow a thick vegetation to grow and the formation of a thick soil. This is why prehistoric flaking floors and chipping areas are still visible on the surface of the mesas, given that they have not been buried since their abandonment. Environmental studies demonstrated that these conditions were rather similar during the development of the Indus Civilisation (Biagi and Cremaschi 1988).

The Rohri Hills Flint Sources

The Rohri Hills consist of flat limestone terraces, which elongate for some 45 km east of the course of the Indus, between Rohri and the westernmost fringes of the Thar Desert, in Upper Sindh (Fig. 1). The Middle Eocene-Early Oligocene Brahui limestone formation of the Hills (Blandford 1880) is rich in stratified seams of flint nodules, which sometimes outcrop on the surface of the mesas (Fig. 2). The presence of this important stone resource undoubtedly attracted human groups since the Acheulian Palaeolithic (Biagi et al 1997), due to the scarcity of good raw material sources for stone-knapping in this part of the Indus Valley.

The flint from the Shadee Shaheed terraces, in the central-western part of the Hills, investigated by the Italo-Pakistani expedition, varies in colour from greyish-brown (10 YR5/2) to brown (10 YR5/3). The nodules are of irregular shape, sometimes in the form of empty cylinders (Fig. 3). A sample analysed in thin section at Ferrara University a few years ago (S. Bertola, unpublished report 1998) revealed that this flint is mainly composed of microcrystalline quartz and chalcedony (95%), containing a few Foraminifers (Nummulites and Textularides), isolated or aggregated calcite crystals, iron and manganese oxides and small, not silicified organic pellets. The fine, homogeneous texture, mineralogical composition, high degree of crystallization of the quartz, and the absence of cracks or micro-fractures in the nodules, make this flint ideal for knapping.

The surveys carried out by members of the Italo-Pakistani Joint Rohri Hills Project, led to the discovery of hundreds of flint mines surrounded by workshops, resulting from the knapping of the raw material on the spot, which were later recorded and mapped (Fig. 4).

It was observed that, on the Rohri Hills, flint extraction occurred as “opencut mining”, according to the terminology suggested by G. Weisgerber (2008: fig. 1), in irregular open pits or trenches (Fober & Weisgerber 1999), excavated in the limestone deposit probably with the use of a bar, a method still nowadays in use the same area by Balochi limestone quarriers (Starnini and Biagi 2006).

Fig. 1. Landscape view of Upper Sindh, with the Rohri Hills in the background (photograph by E. Starnini).

Fig. 2. Large flint nodules embedded in the limestone formation of the Rohri Hills (photograph by P. Biagi).

Fig. 3. Flint nodule found in situ in the Indus mine floor of Site 862 (photograph by P. Biagi).

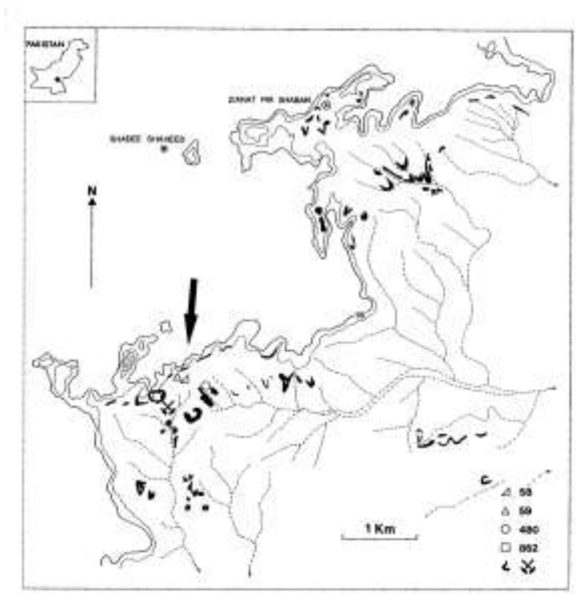

Fig. 4. Location of the Rohri Hills, south to the shrine of Shadee Shaheed, with the location of the sites mentioned in the text. The black spots correspond to the main flint mining areas recorded during the surveys (after Starnini and Biagi 2006: fig. 1).

During the 1990s, few test-trenches were opened within the mines and some workshops excavated, among which are Sites 58 and 59 (Biagi and Pessina 1994), 480 (Negrino and Starnini 1995), 862 and its adjacent Workshop 1 (Negrino et al 1996) and Site ZPS3 (Negrino and Starnini 1996). Of particular importance is Site 862, an open-air mine, with associated workshops (Fig. 5), which was excavated in four seasons between 1995 and 1998 (Starnini and Biagi 2006). This is the only flint extractive structure from which a radiocarbon date was obtained thanks to the recovery of a tiny charcoal piece of *Zyziphus nummilaria*. This provided a sample for radiocarbon dating that gave the result of 3870±70 BP, corresponding to 2460-2200 cal. BC at 1σ (GrA-3235: Biagi 1995: 81).

The Flint Knapping Workshops

The flint workshops, which were investigated and excavated during our researches, are often distributed along the edges of the mesas, sometimes in thick clusters (see also Figure 5). They are characterised by dense concentrations of knapping by-products, flakes and debitage wastes (Fig. 6), among which the exhausted cores were often left (Biagi and Pessina 1994). They lay on top of the limestone surface of the terraces; the thickness of the archaeological deposit depends from the intensity and duration of the chipping activity.

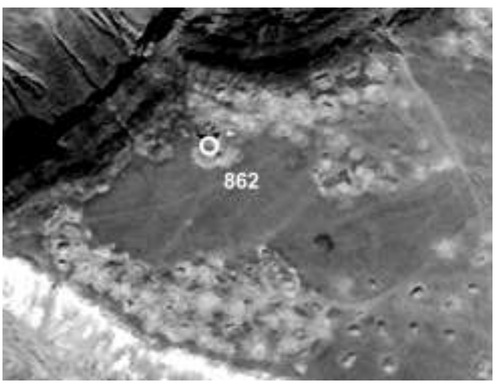

Fig. 5. A satellite view of the group of flint quarries in which Site 862 is located (white circle).

The average dimension of the recorded workshops ranges between 15 and 150 m^2. The amount of flint artefacts collected varies from more than 7,000 pieces from Site 58, to some 10,000 from the only 2 m^2 excavated at Site 59 (Biagi and Pessina 1994), 35,283 pieces at Site 480 (Negrino and Starnini 1995) and 51,378 at Site 862, of which 27,015 pieces belong to its Workshop 1 (Negrino and Starnini 1996; Biagi et al 1997).

This enormous quantity of flint artefacts was collected both by hand and dry sieving at 2 mm. This method favoured the recovery of the small chips and fragments resulting from the debitage. Thus a detailed typo-metrical and technological analysis was possible to perform in addition to the refitting and spatial distribution analyses of the flint artefacts within the workshops, and the reconstruction of the complete reduction sequence or *chaîne opératoire* from core preparation to blade and bladelet production (Negrino and Starnini 1996; Briois et al 2006).

Technology and Methods of Knapping

Following the proposal by J. Tixier (1967), we distinguish the technique of flake/blade removal from the method of debitage, which analyses the organization of the reduction sequence.

The study of the artefacts collected from the flint workshops revealed the existence of at least two different production technologies. The first, related to the debitage of blades from subconical and prismatic cores, the second to the debitage of bladelets from bullet cores (Figure 7). According to the evidence obtained from the excavations, it was possible to reconstruct the complete *chaîne opératoire* of the Indus blade production, starting from the extraction of the flint nodules to the method of blade detachment. The techno-typological analysis of the flint artefacts from the blade workshops was coupled with the experimental reproduction of the laminar debitage (Briois et al 2006). It was made according to the archaeological evidence, aimed at testing the validity of the *chaîne opératoire* hypothetically reconstructed from the fieldwork data.

During our surveys and following the examination of museum collections (Biagi 1997), we noticed the presence of different types of blade products, which undoubtedly reflect at least two different production technologies, the first characterised by bigger-sized cores and regular blades (Fig. 7A), the second by small, bullet cores and narrow bladelets (Fig. 7B).

Following these observations some representative debitage workshops of both types were chosen for trial excavation, in order to collect enough data for the reconstruction of the two *chaînes opératoires* and later compare them. The first of these two technologies (Fig. 7A) is represented at Sites 480 (Negrino and Starnini 1995) and 58 (Biagi and Pessina 1994), both in the Shadee Shaheed Hills. Here flint blades of an average length of 95 mm were struck from subpyramidal and subconical cores. Suitable pieces of flint nodules, extracted from the neighbouring mining areas, were roughly shaped into pre-cores and further reshaped by removing transversal and longitudinal flakes. According to the archaeological evidence, the cores were prepared following the crested blade method, and a flat striking platform was obtained by detaching a large flake. The platform itself was kept plain during the entire debitage sequence by removing core tablets. It was calculated that some 20 regular blades might have been produced from each of these cores.

The workshop yielded very few complete blades, given that most of them had undoubtedly been exported from the production areas.

Nevertheless, a great number of blade fragments were collected and among them proximal fragments prevail, allowing the detailed reconstruction of the *chaîne opératoire*, or reduction sequence (Briois et al 2006: fig. 3).

The second case regards the production of narrow, regular bladelets of an average length of 45 mm (Fig. 7B) struck from bullet cores (Fig. 8), characterised by a flat striking platform, without any evident trace of progressive rejuvenation. As in the first case, complete bladelets are under-represented in the assemblage, for being exported from the production areas. Blade butts are always flat, and the bulbs sometimes show small, parasite flakes.

Furthermore, thanks to the observations made at Site ZPS3, a small workshop near the tomb of Ziarāt Pir Shābān, it was possible to achieve more information for a better understanding of the peculiar *chaîne opératoire* for the pressure method of debitage.

Fig. 6. An example of a large flint knapping workshop on the top of the Rohri Hills (photograph by P. Biagi).

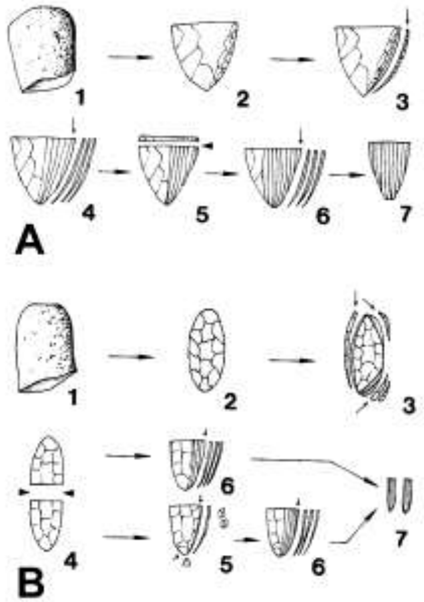

Fig. 7. A) Schematic reconstruction of the two *chaîne opératoires* for blade production: 1) flint nodule; 2) pre-core; 3) detachment of the crested blade; 4) blade detachment by indirect percussion; 5) rejuvenation of the core platform; 6) blade detachment by indirect percussion with soft hammer and copper tipped punch; 7) exhausted core; B) Schematic reconstruction of the *chaîne opératoire* for bladelets: 1) flint nodule; 2) almond-shaped, bifacial pre-form; 3) detachment of crested blades; 4) splitting the perform into two pre-cores; 5) eventual adjustment of the pre-core with further detachments of blades and flakes; 6) pressure bladelet debitage by copper tipped punch; 7) exhausted bullet core (modified after Briois et al 2006: fig. 3).

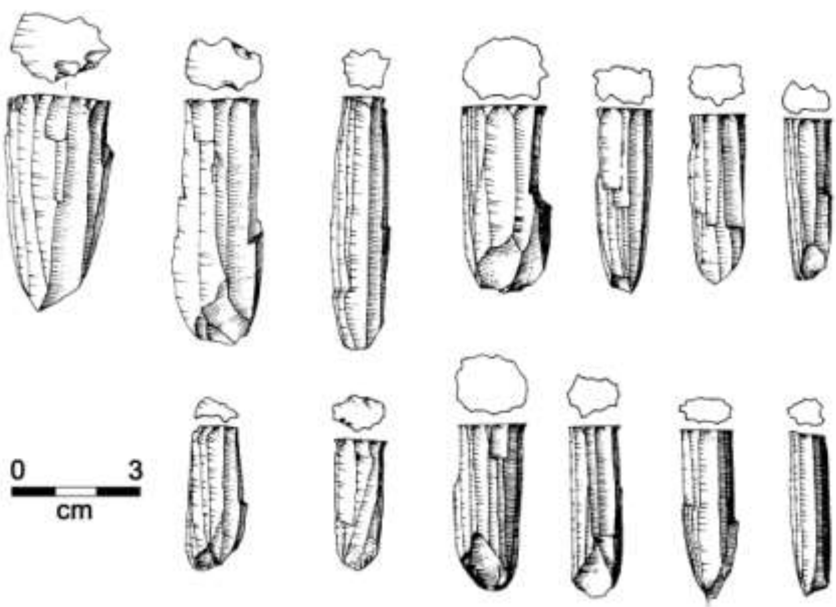

Fig. 8. Typical bullet cores from the excavations of Workshop 1 at Site 862 on the Rohri Hills (drawings by G. Almerigogna).

In fact, ZPS3 was recognised to represent the very initial stage of the operative chain for the production of bladelets, struck from bullet cores. More precisely, at this site oval pre-forms were shaped into almond pre-cores with crested edges by bifacial flaking; they were later split into two ready-to strike, flat-platformed cores by only one, skilled, hard-hammer hit (Negrino and Starnini 1996).

Given the importance of a skilled experimental knapping experience to understand the flint knapping techniques utilised by the Indus artisans, a campaign of experimental tests was performed at the Anthropological Research Centre of the University of Toulouse with the help of F. Briois (et al 2006).

The experiment involved the reproduction of the blade technology observed at Site 480, with the indirect percussion technique, employing a pointed punch made of pure industrial copper (Fig. 9). The same debitage accidents noticed in the archaeological record occurred during the experimental debitage. In particular, the blades often broke accidentally, showing a tongue fracture, which especially occurred at the proximal end. This could explain the high number of proximal edges collected in a very restricted area of Workshop 480, possibly indicating the precise location of the flaking zone (Negrino and Starnini 1995: 72, fig. 21).

The second experimental knapping test concerned the pressure bladelet debitage from bullet cores, which characterise Workshop 1 at Site 862 as well as other sites. In this case an antler-hafted punch with a smaller copper-tip, 12 cm long, was employed for the experiment. The copper point, with a rounded, ogival tip, 5 mm in diameter, was made of pure, industrial copper. The detachment of the bladelets was made freehand. The only equipment consisted of a wooden grooved support to hold the core with the help of a small leather piece (Pelegrin 1988).

After removing the crested blade, several bladelets were struck from the core by this pressure technique, simply pressing, by hand, the copper-tipped punch on the platform with an angle of 90°. Along the edges of the core platform, we noticed the formation of small scars due to the contact with the wooden support. The experimental bladelets (Fig. 10) obtained with this technique are identical to those recovered from Sites 59 and 862 (Biagi and Pessina 1994; Negrino et al 1996).

Fig. 9. Experimental replica of a blade core, struck by indirect percussion and a copper tipped punch, made by F. Briois (photograph by E. Starnini).

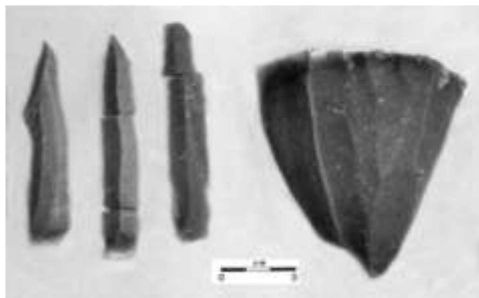

Fig. 10. Experimental replica of a pressure-debitage core and its bladelets by-products, detached with a copper tipped punch, made by F. Briois (photograph by E. Starnini).

Discussion

Mining areas and flint knapping workshops are the most important components of a lithic production system. In this respect, the Rohri Hills extractive and productive complexes, undoubtedly offer an exceptional chance to shed light on this aspect of the Indus Civilisation. Furthermore it is well known the importance of studying the mines and production ateliers to understand the context of procurement, exchange and social organisation of a cultural system (Ericson 1984; Purdy 1984).

Despite the fact that pressure debitage is known in South Asia from the 7th millennium cal. BC, as far as we know it is only from the beginning of the 3rd millennium cal. BC that a new technical advance can be recognised in the flint knapping technique employed for the production of regular blades and bladelets. The experimental tests demonstrated that the innovation consisted in the introduction of metal points for pressing. As shown by the researches carried out in the Rohri Hills, the increase in the production of blanks and the introduction of the copper-tipped punches, seem to imply the existence of skilled specialists, as already suggested by the French scholars (Anderson-Gerfaud et al 1989: 443).

Other aspects, which are still to be clarified, regard the organisation of the production. Did the people who mined flint and the flint knappers live in neighbouring settlements? Was the production of blades on the Hills an all-year-round or a seasonal activity? And, finally, which was the distribution radius of the flint blades towards the Indus cities and handicraft centres?

These aspects are to be investigated at least at three levels:

- At a micro-regional scale, i.e. identifying the possible settlements at the foothills involved in the exploitation of the flint outcrops,

- At a macro-regional scale, studying the diffusion of the Rohri Hills workshop products at longer distances (see above), either in the form of semi-finished raw material items or blades ready for use.

- And taking into consideration the (complementary?) role played by other important raw material sources of chippable siliceous rocks exploited in Chalcolithic and Bronze age times recently discovered in Lower Sindh, among which are Ongar and Jhimpir (Biagi 2011: 524).

These two latter aspects, however, can be clarified only after a detailed study of the flint assemblages collected from old and recent excavations is carried out at several urban centres of the Indus Civilisation. The very few published detailed analyses of flint assemblages from the urban centres have demonstrated that the flint blades were undoubtedly employed in the pottery workshops (Anderson-Gerfaud et al 1989), in the semiprecious stone beads manufacture, for which they were turned into very small drill points for piercing beads (Bondioli et al 1984: 24; Bulgarelli 1986; Pracchia et al 1985) and in shell working (Vidale 2000: 72).

Demand can essentially be viewed as a function of three variables: 1) the number and frequency of activities requiring stone tools, 2) stone tool production techniques and, 3) stone tool efficiency (Luedtke 1984). Hence, to fully understand and quantify the scale of demand for lithic material in the Indus Civilisation a future research objective will be to better understand the many socio-economic activities in which stone tools were involved and functioned.

It is regrettable that these extraction sites and impressive workshops, which are monuments of unique importance for the understanding of the Indus Civilisation economic system, are systematically destroyed for industrial purposes since the last 50 years (Dar 1991; Biagi and Nisbet 2011). It is even more regrettable that their devastation is still currently under way and no attention has ever been paid for their preservation by both local and national authorities (Biagi 2006b; 2007).

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