The Archaeological Record of the Indus (Harappan) Lithic Production:

The Excavation of RH862 Flint Mine and Flint Knapping Workshops on the Rohri Hills

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The Archaeological Record of the Indus (Harappan) Lithic Production: The Excavation of RH862 Flint Mine and Flint Knapping Workshops on the Rohri Hills (Upper Sindh, Pakistan)

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The formal structure of artifact assemblages together with the between element of contextual relationship should and do present a systematic and understandable picture of *the total extinct* cultural system
(Binford, 1962: 218-219)

Keywords
Indus Valley, Indus Civilisation, Upper Sindh, Flint mines, Chipped stone technology, Blade debitage.

Abstract
Despite more than twenty-five years of intensive research on the exploitation of the lithic raw material sources, and the typological characteristics of the Indus (Harappan) chipped stone assemblages by the Italian Archaeological Mission in Sindh, this topic is still neglected in both the recent literature and the general syntheses on the Indus Civilization. Although much work is undoubtedly still to be made, this paper shows how our knowledge has greatly improved mainly thanks to the systematic excavation of flint mining sites and knapping workshops on the Rohri Hills, focussing in particular on Site RH862.
Site RH862 is located along the central-western fringes of the Rohri Hills, a series of limestone terraces (or mesas) that extend along the eastern side the Indus Valley in Upper Sindh. This paper is a synthesis of the results and data collected during four fieldwork seasons and excavations by the "Joint Rohri Hills Project" in the above flint mine

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and its related knapping workshops. The Rohri Hills limestone deposits are very rich in flint nodules, which have been exploited since Acheulian Palaeolithic times. They represent one of the most important raw material sources of the Indus Valley in Indus Civilisation times, during which flint was intensively exploited, and hundreds of mining pits and trenches were opened mainly along the western fringes of the hills.
They demonstrate the important role still played by flint in the Mature Indus period. This material was mainly employed for the manufacture of regular blades and bladelets, which were later distributed and utilised for different handicrafts in the urban centres of the Indus Valley.
Site RH862 produced evidence of a mining episode radiocarbon-dated to the second half of the III millennium BC. It is surrounded by flint knapping workshops for the production of bladelets detached from bullet cores. The excavations carried out at Site RH862 were an extraordinary opportunity for the reconstruction of the mining techniques, and the definition of the complete chaine operatoire, from the flint nodules extraction to the blade production during the Mature Indus period.

1. Preface

This paper considers one aspect of the research conducted by the Italian Archaeological Mission in Sindh, more specifically the discovery of the Indus flint mines of the III millennium BC in the Rohri Hills, and the excavations carried out at flint mine RH862. These are just some of the activities of the Mission between 1996 and 2002, given that many others dealt with other topics and territories of Lower Sindh, the Indus delta and the coastal area in the province of Las Bela in Balochistan.

The results so far obtained, which led to many significant changes in the prehistory of the above regions (Biagi 2011a), can be summarised as follows:

1) the establishment of a preliminary sequence for the Palaeolithic period of Sindh (Negrino and Kazi 1996; Biagi 2008c),
2) the definition of the characteristics of the south-easternmost Middle

Palaeolithic Levalloisian chipped stone assemblages (Fig. 1), which was possible mainly thanks to the discoveries made by Professor A.R. Khan at Ongar in the 1970's (Khan 1979a; Biagi 2007b; Biagi and Starnini 2011a),

3) the characterisation of the Mesolithic sites in the Thar Desert lake district (Figs. 2 and 3) following the discovery of the first Mesolithic assemblages with geometric trapezoidal microliths in Upper Sindh made in the 1990's on the sand dunes east of the caravan town of Thari (Biagi and Kazi 1995; Shar *et al*. 1997; Biagi and Veesar 1998-1999; Biagi 2001a, 2003-2004, 2008a),

4) the typological analysis and chronological periodisation of the Late (Upper) Palaeolithic and Mesolithic sites of Lower Sindh (Figs. 4 and 5) discovered by Professor A.R. Khan on the Mulri Hills (Zaidi *et al*. 1999) and other localities east and west of Karachi in the 1970's (Khan 1979b; Biagi 2003-2004, 2004a), and the preliminary establishment of a sequence for the Early Holocene assemblages in the above region,

5) the recovery of the first Final Palaeolithic chipped stone assemblages *in situ* (Fig. 6) on the top of the limestone terraces that extend south-west of the small town of Jhimpir in the Thatta district (Biagi 2011b),

6) the discovery, recording and mapping of the Indus flint mines on the hills of Ongar, Daphro and Bekhain, south of Kotri (Figs. 7-9) (Biagi 2006a, 2006b, 2008a; Biagi and Franco 2008), and other flint mines in the surroundings of Jhimpir (Biagi and Nisbet 2010),

7) the systematic radiocarbon dating of presently disappeared mangrove swamp environments exploited since the middle Holocene, thanks to the recovery of *Terebralia palustris* and *Telescopium telescopium* gastropods on the top of the limestone outcrops raising from the alluvial plain of the Indus delta (Blandford 1880; Lambrick 1986; Biagi 2010). This fact led to hypothesise that seafaring activities along the northern coasts of the Arabian Sea had already took place around the beginning of the seventh millennium BP (Biagi 2011a; Biagi *et al*. in press a), as already known from other regions of the Arabian Sea and the Persian (Arabian) Gulf (Cleuziou 2004; Biagi and Nisbet 2006; Biagi 2008d; Boivin and Fuller 2009),

8) the discovery and radiocarbon dating of many seventh and fifth millennium BP shell middens along the coast of Las Bela (Biagi 2004b, 2008d, 2011a; Biagi and Franco 2008; Biagi *et al*. in press a, in press

b), south of Gadani headland, which played an important role in prehistory because of the presence of liver-coloured jasper outcrops (Khan 1979b; Naseem *et al*. 1996-1997), which were exploited at least since the Mesolithic (Biagi 2004b: 13), and the presence of other shell middens on its top,
9) the definition of the typological characteristics of the Chalcolithic Amri Culture (Casal 1964) chipped stone assemblages (Lechevallier 1979), thanks to the analysis of the Tharro Hills lithic industries (Biagi 2005a, 2010),
10) the first traceological study ever made on any Chalcolithic and Bronze Age chipped stone industry of Sindh (Voytek 1994; Biagi 2010),
11) the first scientific pottery analysis of Bronze Age (Spataro 1998-1999), as well as of Buddhist (Biagi *et al*. 2002) and contemporary ceramic workshops of Sindh (Spataro 2005),
12) the first archaeobotanical study of prehistoric (Castelletti *et al*. 1994), historic (Madella 1997; Biagi and Nisbet 2009) and present-day ethnographic sites of Sindh (Nisbet 2010),
13) the first micromorphological analyses of soils from prehistoric sites of Upper Sindh (Biagi and Cremaschi 1988; Biagi *et al*. 1995, 1998-2000; Ottomano 1995; Ottomano and Biagi 1997),
14) the radiocarbon dating of a few famous historical sites of Sindh, among which are the Buddhist town of Seeraj (or Seeraj-ji-Takri or Shiraz) in the Rohri Hills (Jafri 1980; Verardi 1987; Biagi *et al*. 2002; Biagi 2004c) - totally destroyed by the opening of a new illegal limestone quarry in the early 2000's - Aror (Pithawala 1978; Ottomano and Biagi 1997) and Ranikot Fort (Hasan 2006; Biagi and Nisbet 2009) (Figs. 10 and 11).
15) the flint knapping experimental tests (Figs. 12 and 13) performed at the Anthropological Research Centre of the University of Toulouse (France) in cooperation with François Briois (Briois *et al*. 2006) aimed at the reproduction of a) the blade technology observed at the workshop Site RH480 (Negrino and Starnini 1995) with the indirect percussion technique and with a wooden hafted copper-pointed flaker, employed as a punch; b) the pressure bladelet debitage from bullet cores (Inizan *et al*. 1992: 63; 1995: 77) characteristic, among others, of Workshop 1 at Site RH862, employing for the experiment a 12 cm long copper-

tipped and antler-hafted punch. The experimental bladelets obtained with this technique are identical to those from Sites RH59 and RH862 (Biagi and Pessina 1994; Negrino *et al*. 1996).
16) Last, but not least, the discovery of extensive flint mining areas and thousands of flint knapping workshops on the Rohri Hills beyond the already well-known territory south of Rohri (Allchin 1976; 1979) (Figs. 14-17).

The study of the finds from the excavation of a few flint workshops, and the data recorded during the intensive surveys made on the Rohri Hills allowed us to define that at least two different blade productions have been developed during the Indus period. One is related to the production of regular blades with an average length of 95 mm, struck from subpyramidal and subconical cores, which are well represented from Site RH480 (Figs. 18 and 19) (Negrino and Starnini 1995) and RH58 (Biagi and Pessina 1994); the other to tiny, narrow bladelets of an average length of 45 mm, struck from bullet cores such as those from RH59 (Fig. 20) (Biagi and Pessina 1994) and RH862 (Negrino *et al*. 1996; Starnini and Biagi 2006). This paper will focus mainly on this latter topic.

2. The activities of the Italian Archaeological Mission of Ca' Foscari University, Venice

Despite more than twenty-five years of intensive research carried out by the Italian Archaeological Expedition in Sindh on the chipped stone assemblages and lithic production of the Indus (Harappan) Civilization, and more than twenty-five papers published in English on various international journals, monographs, proceedings of international round tables and conferences (Biagi 1994a, 1995, 1997a, 1997b, 2001b, 2005a, 2005b, 2006b, 2007a, 2008a, 2011b; Biagi and Cremaschi, 1990, 1991; Biagi and Nisbet 2010; Biagi and Pessina 1994; Biagi and Shaikh 1994, 1998-99; Biagi and Starnini 2008, 2011a; Biagi *et al*. 1995, 1997; Briois *et al*. 2006; Maifreni 1995; Negrino and Starnini 1995; 1996; Negrino *et al*. 1996; Shaikh and Biagi 1997; Starnini and Biagi 2006) just a few years ago a long article discussing "*some aspects of the current research on craft production in the Harappan phase of* *the Indus tradition*" (Bhan *et al*. 2002: 221) dedicated only one page to the chipped stone assemblages, stating that "*the study of chipped stone or lithic industries of the Harappan phase is still in its infancy* " (Bhan *et al*. 2002: 231).

In effect, opposite to the great emphasis on the role played by metallurgy during the Indus age (Kenoyer and Miller 1999), the importance of the lithic tools production, typology and function has been often underestimated or almost neglected by most authors (Kenoyer 1991: 358; Inizan and Lechevallier 1997: 79), with the exception of just a few cases mainly linked with well-defined technological procedures (Pelegrin 1994) sometimes focussing on the function of very characteristic implements (Anderson-Gerfaud *et al*. 1989).

The present paper will show that, despite the fact that much work is undoubtedly still to be made, nevertheless these years witnessed a great improvement in the study of the chipped stone assemblages and lithic procurement of the Copper and Bronze ages in the lower Indus Valley, which were badly known until a few years ago (Gordon 1950; Hoffman and Cleland 1977; Allchin 1979; Kenoyer 1984; Bulgarelli 1986; Cleland 1987; Biagi 2005a); thus at present we can state that the infant has grown up and has become an adult.

During the fieldwork seasons carried out by the Italo-Pakistani team of the Joint Rohri Hill Project between 1993 and 1998 hundreds of flint mining complexes, including blade and bladelet workshops, were discovered on the limestone terraces, mainly those which face the Indus alluvial plain in the neighbourhood of the shrine of Shadee Shaheed, (Biagi and Pessina 1994; Biagi *et al*. 1995). The arid environmental conditions established since the beginning of the Holocene never favoured the growth of a thick vegetation cover on the hills, and the development of a thick soil; as a consequence prehistoric flaking floors and chipping areas are easily visible on the surfaces of the limestone mesas, given that they have never been buried since their discard (Fig. 21).

Impressive clusters of hundreds of open-air flint mines were discovered not only by intensive field surveys, but also thanks to series helium balloon photographs taken from different altitudes (Maifreni 1995), and the interpretation of satellite images (Figs. 22 and 23). A few workshops of different ages, with different characteristics and finds were excavated during the Project activities, namely Sites RH58, RH59 (Biagi and Pessina 1994), RH480 (Negrino and Starnini, 1995) and ZPS3 (Negrino and Starnini, 1996), all belonging to the Indus period, and ZPS1 (Figs. 24 and 25) (Biagi *et al*. 1996), ZPS2 (Biagi *et al*. 1998-2000) and ZPS4 (Shaikh and Biagi 1997) to be referred the first to the Acheulian, the other two to the Late (Upper) Palaeolithic. Site RH862, a flint mine-pit, was selected for more detailed investigations, which lasted four excavation seasons (Negrino and Starnini 1995; Negrino *et al*., 1996).

3. Excavations at Site RH862 on the Rohri Hills

Site RH862 is a flint quarry surrounded by a few knapping workshops located along the central-western fringes of the Rohri Hills in Upper Sindh (Pakistan) (Fig. 26). The hills consist of a dissected limestone plateau (mesa), which is part of the Upper Kirthar formation (Blandford 1880; Vredenburg 1909: pl. 12), attributed to the Middle Eocene/Early Oligocene period (Fig. 27). They elongate in north-south direction, and separate two very different landscapes, namely the fertile Indus Valley, in the west, the ancient course of the Hakra and the Thar Desert, in the east (see Flam 1999: fig. 7) (Fig. 28). Their northernmost edge is lapped by the course of the Indus River where, bending westwards, it flows across the gorge that opens between Rohri and Sukkur, inside which are a few islands the largest of which is Bukkur (Figs. 29 and 30). A few small limestone outcrops, on the top of which de Terra and Paterson (1939) recovered chipped stone artefacts, are still visible at Sukkur.

The hills are capped by a hard, highly fissured, yellowish limestone deposit, which is rich in flint nodules. Pale brown and variegated good quality flint occurs as nodules in seams, at various depths of the limestone formation (Fig. 31). The first report on the presence of flint artefacts on the hills was written by W.T. Blandford (1880: 20) who reported, "*Large quantities of flint cores have been found near Sukkur and Rohri, and there is a good collection in the Geological Museum, Calcutta*". At present this evidence, still partly available in the 1970's (Allchin 1976, 1979) and 1980's (Fig. 32), despite many claims by several archaeologists to the national and local authorities (Dar 1991; Allchin 1999; Biagi 2007a, 2008b) has sadly been totally destroyed by recent limestone quarrying (Figs. 33-36), and the expansion of the human settlements around the towns of Rohri and Sukkur (Biagi 1994b, 1997a).

The importance of the Rohri Hills as flint raw material sources since the Acheulian Early Palaeolithic (Biagi and Cremaschi 1988; Biagi *et al*. 1996; Negrino and Kazi 1996; Biagi 2008c), and also during Late (Upper) Palaeolithic times (Biagi *et al*. 1994, 1998-2000) is due to the fact that good quality siliceous rocks suitable for chipping are absent over quite large territories in the lower Indus Valley (Lahiri 1992: 21) with the exception of the Kirthar limestone hills south Kotri in Lower Sindh (Blandford 1880: 142). In this latter region the Ongar Hill (otherwise called Milestone 101) flint was exploited (Fig. 37) not only during the Palaeolithic, as reported by B. Allchin *et al*. (1978: 295; see also Khan 1979a; Biagi 2005b, 2007b; Biagi and Starnini 2011a; Biagi and Nisbet 2011), but also during the Indus Bronze Age (Biagi 2005b, 2006a; Biagi and Franco 2008; Biagi and Starnini 2008). Thanks to the information provided by W.T. Blandford (1880), other good quality flint outcrops and mining areas were discovered in 2010 (Fig. 38) along the limestone terraces that extend south-west of Jhimpir west of the present-day artificial Kalri Lake (Biagi 2011b; Biagi and Nisbet 2010).

The reported presence of rich, good quality sources led to a very extensive exploitation and trade of the Rohri Hills flint as (most probably) major raw material sources, especially during the entire Indus period, for the production, among others, of very specialised chipped stone tools, among which are long and regular blades, and micro-drills retouched from bladelets (Kenoyer and Vidale 1992) that were latter employed for piercing semiprecious stone beads by the craftsmen of the urban Indus centres (Tosi *et al*. 1984; Pracchia *et al*. 1985; Kenoyer 1986).

Recently, two absolute dates relating to surface exposure age have been obtained from two flint samples both collected in January 1999 from the hilltops (C. Baroni pers. comm., 2007). The two samples are a) one natural, unworked, aeolized (Figs. 39 and 40) flint piece (sample n. 990123.01) collected on the hills surface immediately to the south of Hoban Shah, and b) one small flint subconical blade core (Figs. 41 and

42) of Late (Upper) Palaeolithic typology (sample n. RH1288) collected not far from Site RH1288 (Biagi *et al*. 1994).

Terrestrial Cosmogenic Nuclides (TCNs) analyses (Gosse and Phillips 2001) have been performed by Dr. Naki Akçar at the Institut für Geologie of the Universität Bern (CH). The principle of this type of analysis, which was firstly applied to archaeology in the 1990's (Cerling and Craig 1994; Stuart 2001) is based on the evidence that every rock surface exposed to cosmic radiations produces nuclear reactions. In consequence of these reactions, unstable cosmogenic nuclides such as ^{10}Be, ^{14}C, ^{26}Al, and ^{36}Cl and stable cosmogenic nuclides such as ^{3}He and ^{21}Ne are produced in respective mineral lattices (Akçar *et al*. 2008). Stable and instable (radioactive) isotopes accumulate and remain entrapped in the mineral crystal lattices in the first 5 cm of the rock surface.
The measure of their quantity gives the exposure age of the rock surface.

According to the preliminary results, the calculated exposure ages of the two samples are both around 1.2 Myr (Fig. 43). The dates correspond to the time elapsed from the exposure of the two flint pieces on the surface of the mesas from which they have been collected. In particular, the date from the Palaeolithic core does not correspond to the age of its manufacture, rather to the age of the exposure of the flint nodule from which it was worked out. In fact the sample had to be completely powdered to extract enough material to be dated, and because the effects of the exposure penetrate up to 5 cm in depth, it is obvious that the measure obtained corresponds to the age of surface exposure of the original flint nodule. According to these preliminary results, flint nodules were outcropping from the surfaces of the Rohri Hills since 1.2 Myr and have been exploited and collected by humans since the Early Palaeolithic. It was only during the Indus period that intensive mining activity started to be performed to extract enough raw material for massive blade production, as testified the impressive quantity of flint knapping workshops recorded during the surveys of the Italian Mission (Biagi and Pessina1994).

The surveys carried out by members of the Joint Rohri Hills Project in the 1990's during eight fieldwork seasons (Biagi and Pessina 1994; Biagi *et al*. 1995) revealed an impressive number of flint exploitation areas and workshops still "*in situ*" and perfectly preserved along the central and south-western fringes of the hills.

Site RH862 is located 3.5 km south-southeast of the shrine of Shadee Shaheed (Fig. 44), where the first groups of Indus flint mines were discovered in February 1986 by Biagi and Cremaschi (1990, 1991). As reported in Biagi *et al.* (1997: 30) Site RH862 is part of an impressive, wide C-shaped group of features (mines, workshops and chipping floors), some 120 m in diameter, related to an Indus flint mining activity area (Fig. 26). From the surface Site RH862 was easy to recognise thanks to the presence of a wide, oval-shaped sand spot, corresponding to the lower-lying mining pit, partly surrounded by man-made heaps of limestone blocks, and two separate flint workshops (Workshops 1 and 3) resulting from two distinct chipping floors (Fig. 45).

The site was partly excavated between 1995 and 1998 (Biagi 1995; Negrino *et al*. 1996; Biagi *et al*. 1997) in the framework of the Joint Rohri Hills Project (Biagi and Shaikh 1994, 1998-1999; Shaikh and Biagi 1997), a research programme aimed at the study of the Rohri Hills flint exploitation and mining, carried out by Ca' Foscari University, Venice (I) and Shah Abdul Latif University, Khairpur (Sindh-PK).

The 1995 investigations began with the excavation of one debitage area (Workshop 1) closely connected with the flint mine (Negrino *et al*. 1996), where the production of narrow bladelets from bullet cores (Szymczak 2002) had taken place (Fig. 46). A test trench was then opened in the mine-pit in order to understand the mining techniques employed by the Indus workers (Figs. 47 and 48). During the second season it was possible to attribute the mine to the Mature Indus period thanks to the recovery a few ceramic fragments belonging to one single flat-bottomed vessel, and two tiny charcoal pieces of *Zizyphus* cf. *nummularia*, one of which was radiocarbon-dated to 3870±70 uncal BP (GrA-3235) (Biagi 1995, 2002). The two following seasons (1997 and 1998) were devoted to the excavation of the mine-pit and the interpretation of the way flint was exploited (Biagi 1998b, 1998c).

4. Mining techniques

The mining methods adopted at Site RH862, and in general at all the flint mining features recorded on the Rohri Hills during the above-mentioned surveys conducted during eight fieldwork seasons, were initially described as quarrying (Lech 1997: 614), resembling the pattern of the site of Aachen "Lousberg" in Germany (Weiner and Weisgerber 1980). In fact no evidence of underground shaft exploitation with galleries or deep shafts has been so far discovered, even though some features, occasionally encountered on the hills, characterised by small, well-defined sand spots, might eventually correspond to clusters of single pits.

According to the terminology recently suggested by G. Weisgerber (2008: fig. 1), flint extraction on the Rohri Hills should be better defined as "opencut mining", occurring in irregular open pits or trenches (Fober and Weisgerber 1999), excavated in the limestone deposit probably with the use of a bar, a method still nowadays in use the same area by Baloch limestone quarriers (Starnini and Biagi 2006).

In the case for Site RH862 the excavations have partly exposed a more or less continuous open mining space (Fig. 49). The excavation was carried out in correspondence of the mine front, clearly recognisable from the surface given that aeolian sand blown from the neighbouring Thar Desert dunes had been trapped inside the empty trenches left open by the Indus miners (Figs. 22 and 23). The presence of sand spots makes the recognition of every artificial pit or depression on the terraces very easy, especially with the aid of aerial (balloon) photographs (Fig. 50) (Maifreni 1995; Biagi 1996, 1998a).

Furthermore, in the undisturbed areas, the extractive empty features are always surrounded by the presence of materials resulting from the mining activity, *i.e*. by heaps of limestone rubble. These latter features are clearly visible from a given distance, even from the alluvial plain of the Indus, waving the flat profile of the limestone mesas.

The excavation of the mine revealed the composition of its fill. After the removal of the sandy layer, a stony level was encountered, composed of an admixture of reddish, sandy-clayey soil and limestone rubble (Fig. 48). Widening the ditch it was decided to remove part of the heaps of limestone boulders, which constituted the backfilling of the mine. This was made in order to understand whether such heaps hid either an old mine front or the mine bottom.

Following this excavation method it was possible to observe that, while in some cases the stone heaps covered part of the un-mined natural terrace, in others they were lying just at the bottom of the trench. Nevertheless, it is still to be clarified whether these untouched areas represent “islands” of the natural, limestone terrace left un-mined or are part of a continuous mine front whose complete edge is still to be defined.

As suggested by the presence of many fragments and crushed flint debris in the holes where the flint nodules were found still *in situ*, their extraction had to involve their breaking out of the limestone bedrock (Figs. 51 and 52). This pounding work was probably conducted with the aid of hammers or maces. So far, the mine-fill has not yielded any stone tool that might have been employed for this purpose. We know that antler tools, simple unhafted pebbles used as hammerstones, stone maces and flint picks were largely utilised for breaking the bedrock and extracting the raw material in the mining sites of Europe (see for instance Lech 1981: 43; Desloges 1986; Weiner 1997). Thus, chips and fragments of hammerstones are commonly found during the excavation of flint mining sites.

Despite the fact that quite a large area of mine RH862 has been carefully excavated during the last three seasons only a few, small hammerstones of flint pebbles have been recovered. They were probably employed in the flint-knapping performed inside the mining area, related to the decorticating and preparation of the pre-cores (Negrino *et al*. 1996: fig. 21.3), as the high number of refitting flakes found in the fill should testify (*ibid*.: fig. 18.2 and 3).

Thus, the absence of proper, complete and fragmented stone tools, led us to hypothesise the use of metal (and wood?) implements, as alternatives to the stone ones, for breaking the bedrock and extracting the flint nodules. In fact, up-to-now, we have never observed any evidence for wedge-holes, fire-settings or gad trace, although we have also to admit that no copper/metal implements have ever been found during either the excavations or the surveys. Their absence might derive from the recycling of the metal tools, leaving no traces in the archaeological record.

The natural characteristics of the local limestone formation, very fissured and weathered, facilitate its breakage with the use of a simple metal bar, acting as a lever, as the present Bugti and Shambani Balochi workers easily make quarrying the limestone for industrial purposes (Fig. 53). A similar pattern of stone mining has been reconstructed for a rock outcrop for polished axes (Pétrequin and Jeunesse 1995: 113). On the other hand, the metallurgy of the Bronze Age Indus Civilization was developed enough to favour the manufacture of proper tools for such an activity (Wheeler 1968: 74). However, some kind of hammers, possibly metal maces, were also employed in addition to other possible tools, as suggested by the presence of a certain amount of limestone flakes bearing clear traces of having been struck by hard hammering. At present we cannot exclude the utilisation of mining implements made of organic material such as wood, bone or antler, which have not been preserved or so far recovered. Nevertheless no organic material except for a very few pieces of charcoal was ever found either during the excavations of the workshops and the mines; this is the reason why we do not have any direct evidence for antler or wooden tools (Bostyn *et al*. 2007).

The extraction produced flint nodules, which seem to have been immediately tested and then utilised and processed in the ateliers (or workshops) scattered around the mining areas. Many flint nodules have been found still *in situ* inside the mine floor (Fig. 51). They are often irregular and of a small size, which might be the reason why they were left. The larger ones are always hollowed, but if properly split, they could provide enough raw material even for the preparation of large cores.

The preparation of the pre-core rough-outs was most probably performed inside the mine trench, or along its edge, as the many decorticating flakes, discarded pre-forms and typical crested blade-like flakes found inside the ditch fill should indicate.

The evidence to date available indicates that the flint nodules were extracted from the limestone deposits of the terrace thanks to open ditches or pit-systems, with an average extraction depth of some 1.5 m, down to a first flint seam. The extraction trenches exhibit more or less vertical walls, sometimes with niches at their bottom. The mine floor, exposed by the excavations, shows an irregular outline with steps and bulges, giving the impression of different episodes of exploitation (Figs. 48 and 49).

The excavation of Site RH862, which regarded two flint knapping workshops and 66 sqm of the mining pit, yielded a total number of 51,378 artefacts weighing 446 kg, some 12,000 of which (60 kg) from Workshop 1 (Negrino *et al*. 1996: 81).

5. Discussion

The excavations carried out at Site RH862 have provided us with a few preliminary results that are of fundamental importance for our better understanding of the exploitation of the flint resources of the Rohri Hills in Mature Indus times as one of the basic keys for the interpretation of the economy of the Bronze Age Indus society (Schild, 1997). They are:
1) the first AMS radiocarbon date of a flint mining pit in the region,
2) the models of exploitation of the flint seams which, according to the more recent results, seem to have been conducted in a rather random way most probably through the excavation of pits and/or trenches, even though traces of superficial mining are clearly visible along the edge of the terrace in form of long U-shaped incisions that cover the whole perimeter of the hill where Site RH862 is located. This evidence might indicate that the exploitation of the raw material resources started from the mine edge, following the buried seam of flint nodules, moving towards the interior of the terrace. Nevertheless, in the light of the new discoveries made in 1998, this interpretation is to be demonstrated through further excavations to be opened towards the western limit of the mesa,
3) the collection of information concerning the modes of utilisation of the flint resources, which regard mainly the operative chain followed for the production of parallel-sided blades and bladelets obtained from different types of subconical and bullet cores (Figs. 54 and 55), whose main stages have already been illustrated by Negrino *et al*. (1996: 100),
4) further consideration on the areas where the preliminary exploitation of the flint nodules took place, thanks to the recovery of masses of flint flakes inside the mine-pit, of almond-shaped pre-cores in the pit-fills as well as of three workshops around the edges of the mine-pit,

5) more data on the models of extraction of the flint nodules from the limestone floor reached by the Indus workers, even though no instrument related to the extractive processes has so far been recovered.

It has already been pointed out in several papers that the Rohri Hills acted as major flint sources (not exclusively) during Indus times (Allchin 1979; Negrino *et al*. 1996; Allchin R. and Allchin, B. 1997; Kenoyer 1998), and that flint artefacts from the hills were exported throughout a wide territory covered by the (Mature) Indus Civilisation down to the northern coast of the Arabian Sea in the south (Baloch 1973; Rao 1985), and as far as Harappa (Punjab), in the north (Law *et al*. 2002-2003: 14). In fact one of the characteristics of the Rohri Hills mining sites is the mass-production of blades and bladelets, which might improve not only our knowledge about the social organization of the Indus (Harappan) urban centres (Dhavalikar 2002), but also our better understanding of one factor never enough pointed out in the past, namely the trade and exchange patterns of this material, which took place at micro-regional and macro-regional scales during the flourishing and development of the Indus Civilisation.

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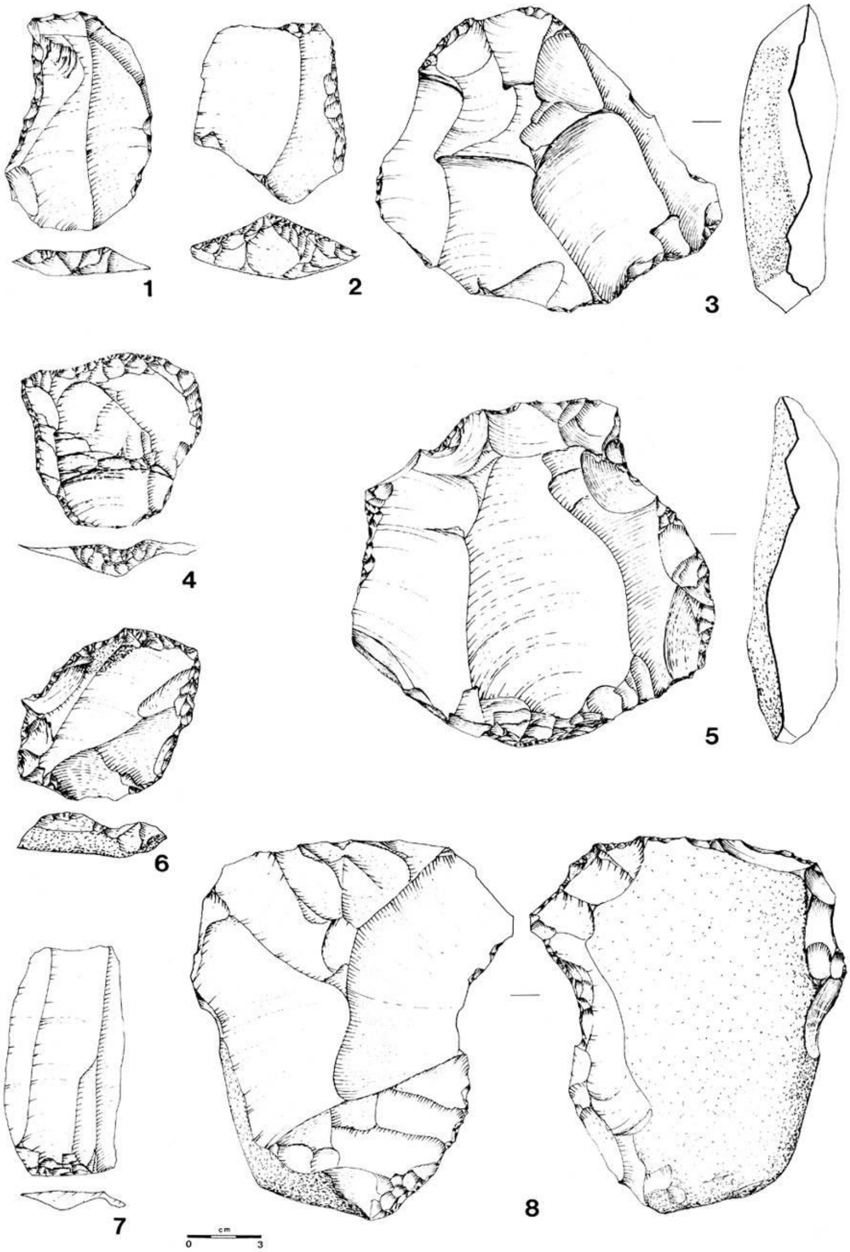


Fig. 1: Ongar. Middle Palaeolithic Mousterian Levalloisian artefacts from Prof. A. R. Khan's collection. Side scrapers (nn. 1, 2, 4 and 6), Levalloisian cores (nn. 3, 5 and 8), Levalloisian blade (n. 7).

Fig. 2: The Mesolithic site of Jamal Shah Sim 4 (JS4) in the Thar desert around Thari (from Biagi and Veesar, 1998-1999: Fig. 10)

Fig. 3: The sand dunes of Pir Nago in the Thar desert around Thari on the top of which is located a Mesolithic site (photograph P. Biagi)

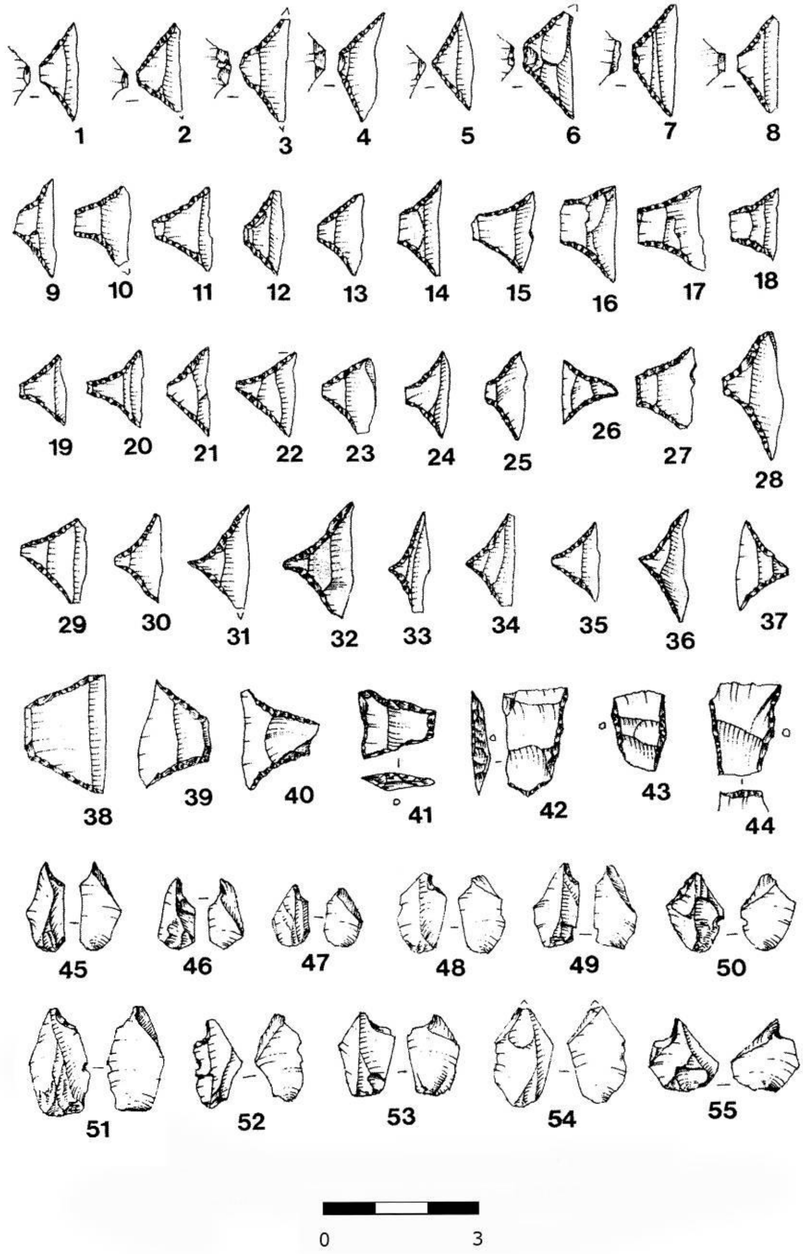


Fig. 4: Mulri Hills 12 (MH12). Trapezes (nn. 1-44) and microburins (nn. 45-55) from the Mesolithic site (from Biagi, 2003-2004: Fig. 10)

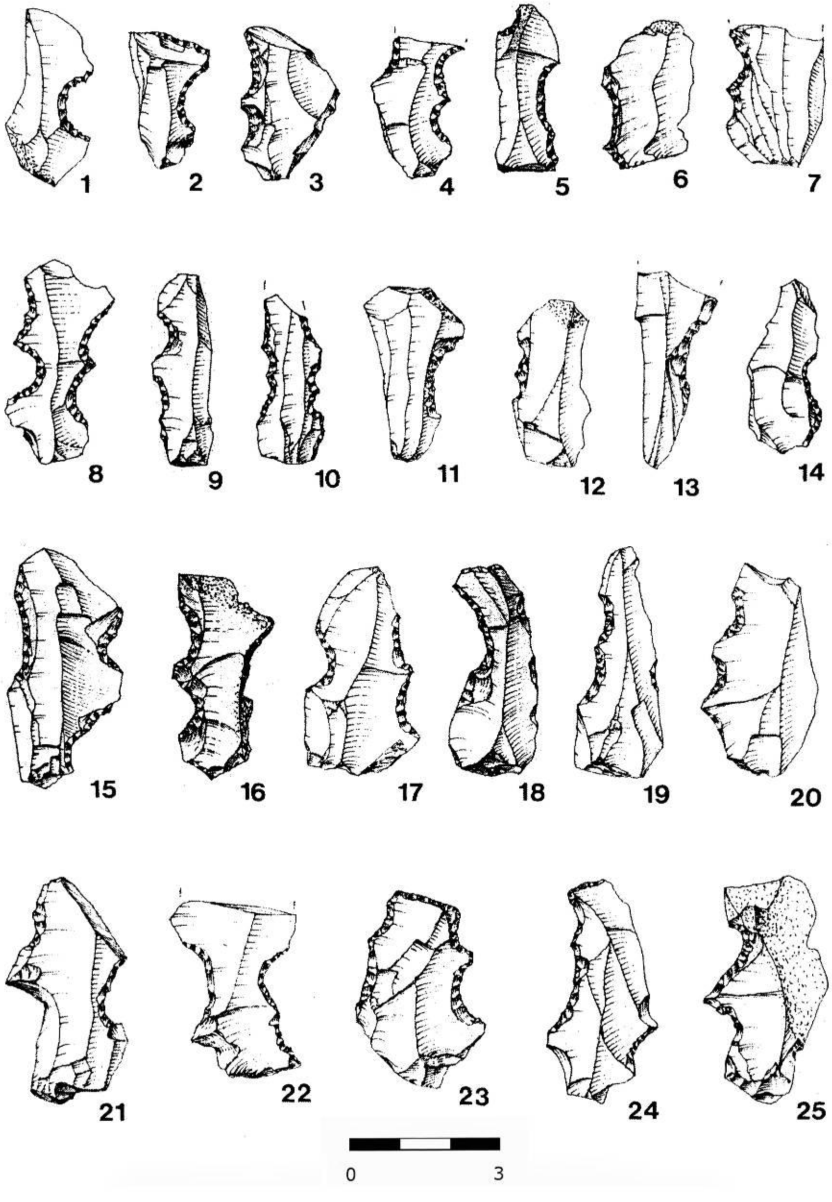


Fig. 5: Mulri Hills 12 (MH12). Notched blades (nn. 1-25) from the Mesolithic site (from Biagi, 2003-2004: Fig. 9)

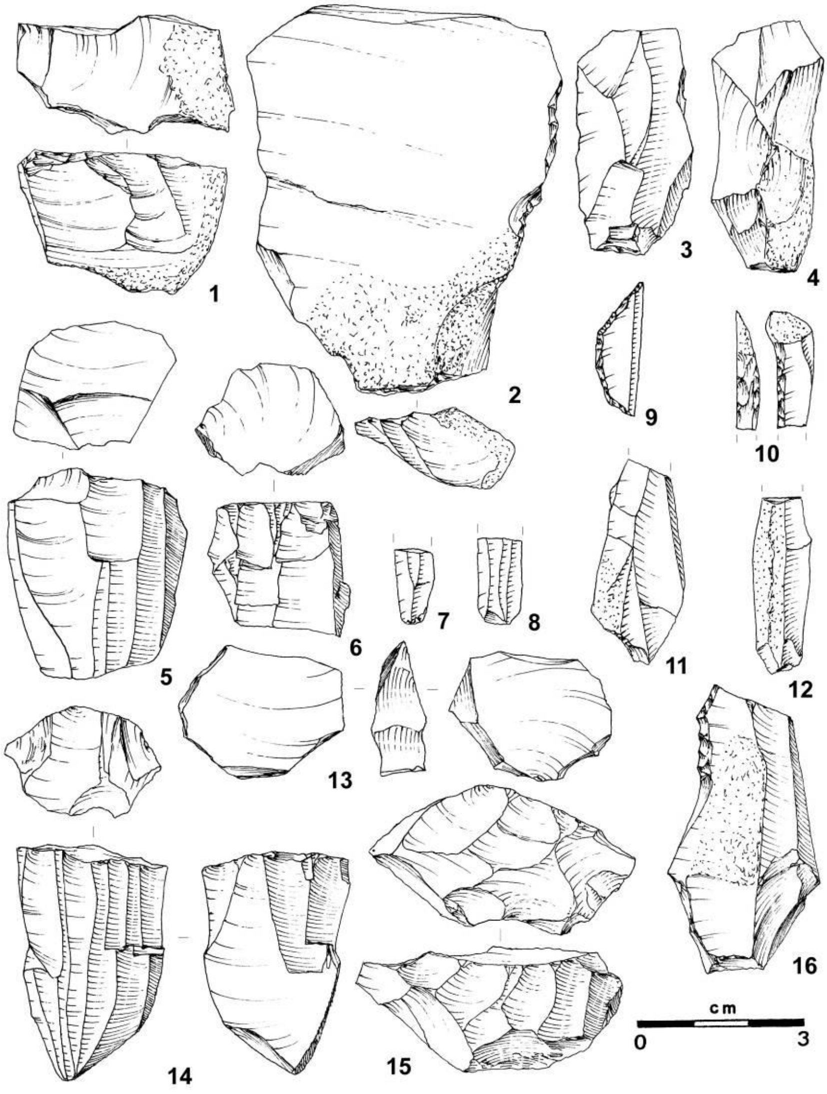


Fig. 6: Jhimpir. Palaeolithic cores (nn. 1, 5, 6, 14 and 15) and tools (nn. 2-4, 7-13 and 16) from different sites

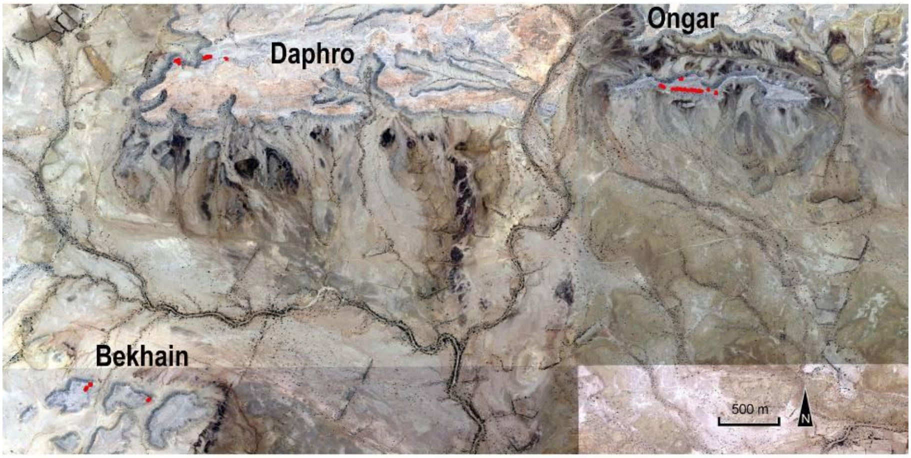


Fig. 7: Ongar, Daphro and Bekhain. Distribution map of the Indus flint mines on the hilltops (from Biagi and Starnini, 2008: Fig. 4)

Fig. 8: Daphro. Indus flint extractive trenches (from Biagi and Starnini, 2008: Fig. 7)

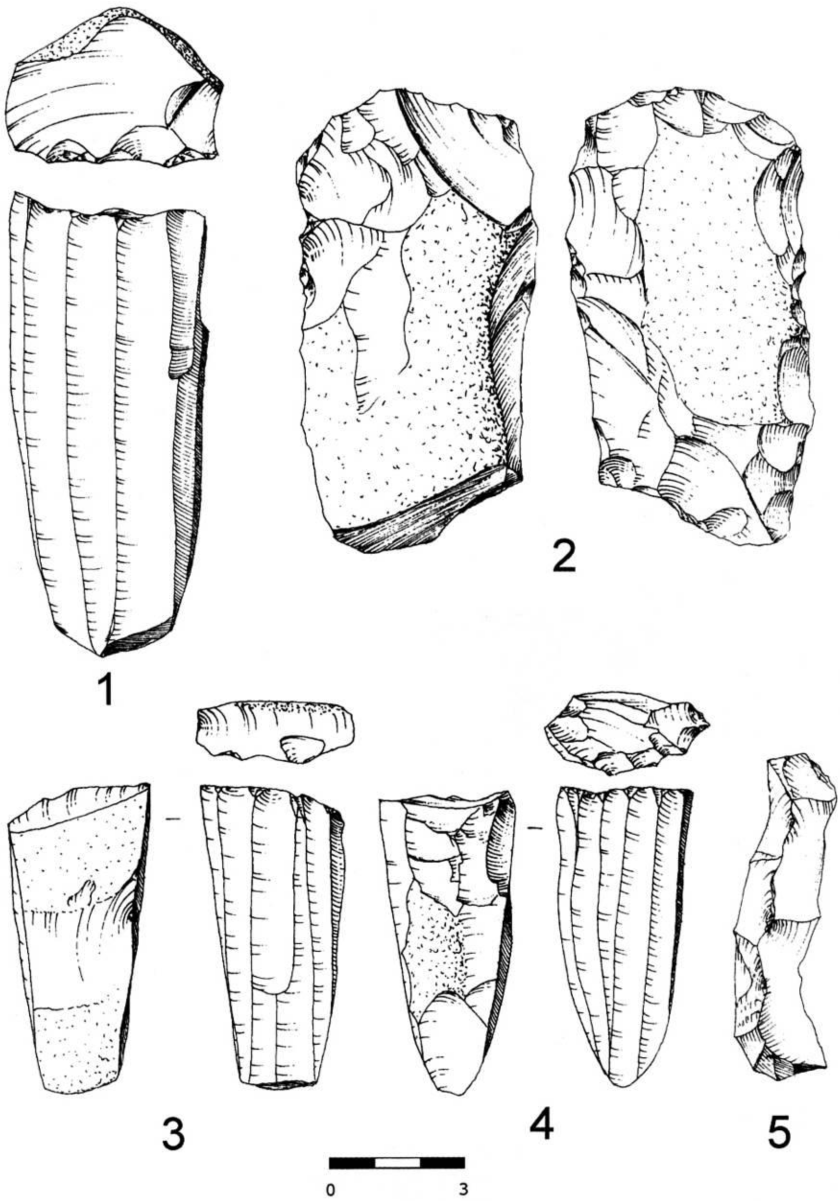


Fig. 9: Daphro. Subconical cores (nn. 1, 3 and 4), pre-core (n. 2) and crested blade (n. 5) from the Indus workshops (from Biagi and Starnini, 2008: Fig. 10)

Fig. 10: Ranikot Fort. A general view of Sann Gate and the bastions (photograph P. Biagi)

Fig. 11: Ranikot Fort. Sampling charcoals for radiocarbon dating from the collapsed pillar of Sann Gate (photograph P. Biagi)

Fig. 12: Experimental replica of a subconical blade core type RH480 by indirect percussion with a copper punch (photograph E. Starnini)

Fig. 13: Experimental replica of a bullet core by pressure flaking with a copper punch (photograph E. Starnini)

Fig. 14: Shadee Shaheed. The limestone mesas on the top of which the first Indus flint mines were discovered in 1986 (photograph P. Biagi)

Fig. 15: Shadee Shaheed. The clusters of Indus flint mines discovered in 1986 (photograph P. Biagi)

Fig. 16: Rohri Hills. Indus flint workshop in the central-western terraces (photograph P. Biagi)

Fig. 17: Rohri Hills. Large flint workshop in the central-western terraces (photograph P. Biagi)

Fig. 18: Rohri Hills. Balloon photograph of the Indus flint Workshop RH480 and its related sand spot (photograph A. Maifreni)

Fig. 19: Rohri Hills. Workshop RH480 before excavations (photograph P. Biagi)

Fig. 20: Rohri Hills. Excavations underway at the flint Workshop RH59 and its related mine-pit (photograph P. Biagi)

Fig. 21: Rohri Hills. The largest Indus flint workshop so far discovered destroyed at the beginning of the 2000's (photograph P. Biagi)

Fig. 22: Rohri Hills. Balloon photograph of a cluster of Indus flint mines and workshops (photograph A. Maifreni)

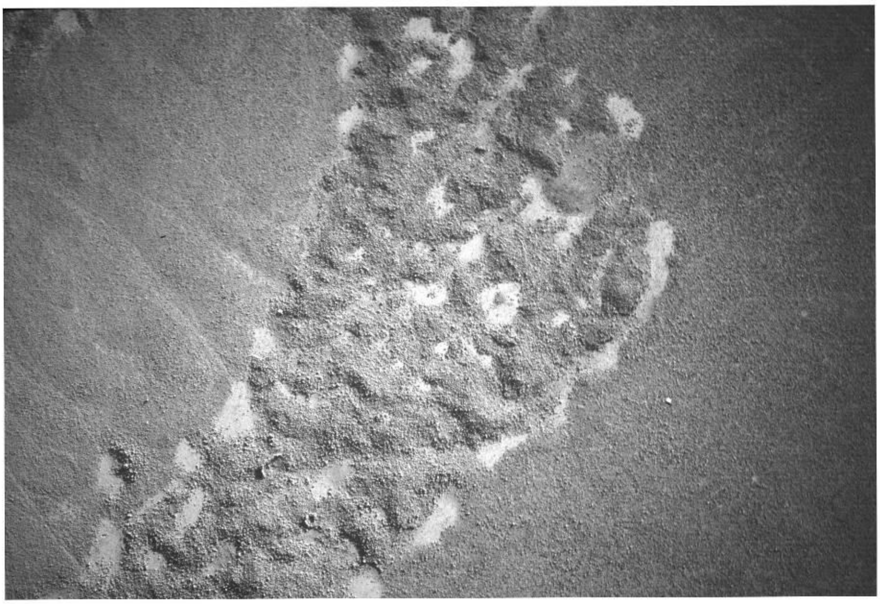


Fig. 23: Rohri Hills. Balloon photograph of a transect of the main Indus flint mining area discovered in 1992 (photograph A. Maifreni)

Fig. 24: Rohri Hills. Acheulian hand-axe on the surface of Ziarat Pir Shaban 1 (ZPS1) (photograph P. Biagi)

Fig. 25: Rohri Hills. Unfinished Acheulian hand-axe from Ziarat Pir Shaban (photograph P. Biagi)

Fig. 26: Rohri Hills. Satellite image with the location of Site RH862 surrounded by clusters of flint mines (1-4)

Fig. 27: The limestone terraces of the Rohri Hills from the Indus Valley (photograph E. Starnini)

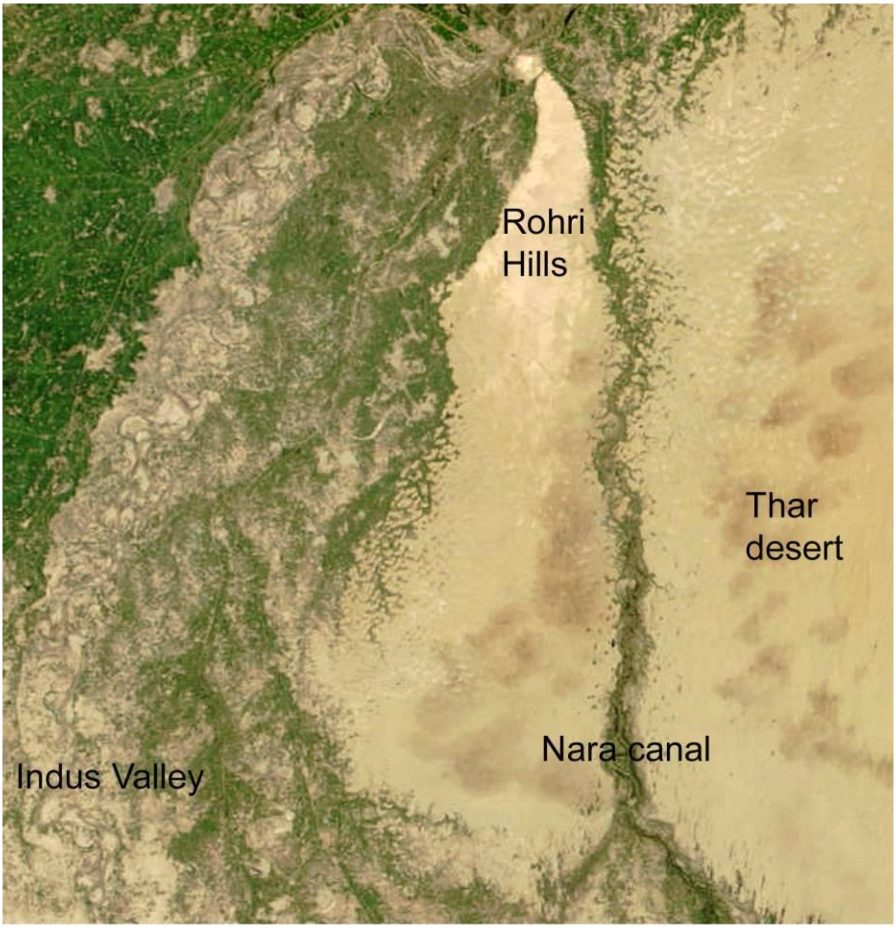


Fig. 28: Satellite image of the Rohri Hills between the Indus Valley, in the west, and the incision of the Nara canal, in the east

Fig. 29: The Indus River at Rohri with the Bukkur Island in the background (photograph P. Biagi)

Fig. 30: The Indus River as its flows between Rohri and Sukkur with the Landsdown Bridge in the background (photograph P. Biagi)

Fig. 31: Rohri Hills. Flint nodules outcropping from the limestone deposit (photograph P. Biagi)

Fig. 32: Rohri Hills. An Indus flint chipping floor on the terraces south of Rohri destroyed in the late 1980's (photograph P. Biagi)

Fig. 33: Rohri Hills. A limestone quarry opened in the late 1990's on the road to Sorah (photograph P. Biagi)

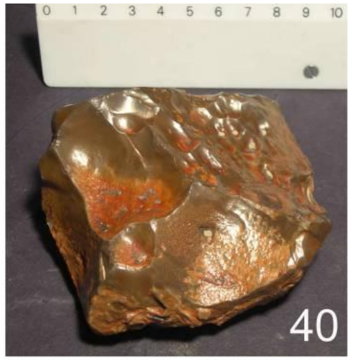
Fig. 34: Rohri Hills. Limestone quarrying underway along the fringes of the central terraces of the hills (photograph P. Biagi)

Fig. 35: Rohri Hills. Industrial limestone quarrying in the central region of the hills (photograph P. Biagi)

Fig. 36: Rohri Hills. A closer view of the quarry of fig. 35 (photograph P. Biagi)

Fig. 37: Ongar Hill. Flint nodules from the top of the limestone terrace (photograph P. Biagi)

Fig. 38: Jimpir. Flint nodules from the limestone terraces south-west of the town (photograph P. Biagi)



Figs. 39 and 40: Rohri Hills. Eolized, natural flint nodule from Hoban Shah submitted for TCNs analyses (sample 990123.01) (photographs C. Baroni)

Figs. 41 and 42: Rohri Hills. Late (Upper) Palaeolithic core from site RH1288 submitted for TCNs analyses (photographs C. Baroni)

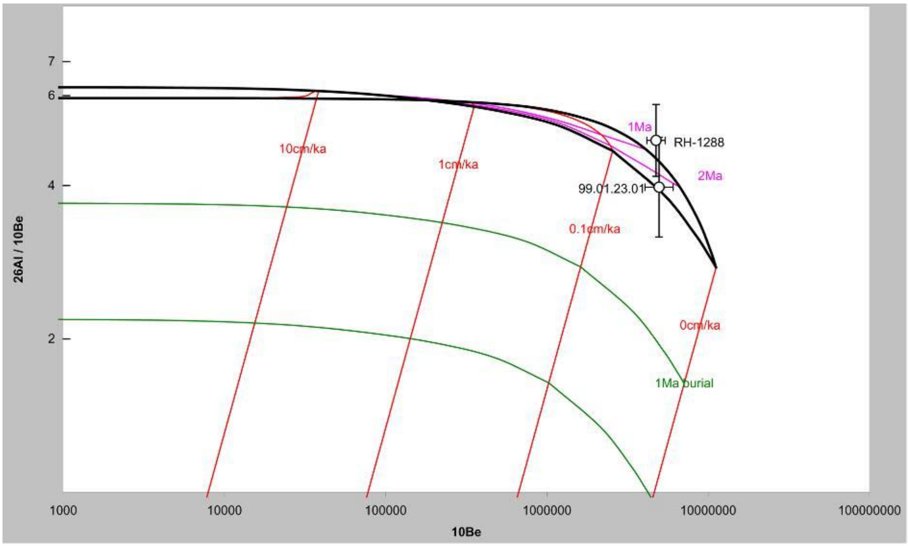


Fig. 43: Results of the TCNs analyses performed on two Rohri Hills samples. The surface exposure age is of some 1.2 Myr (courtesy of C. Baroni)

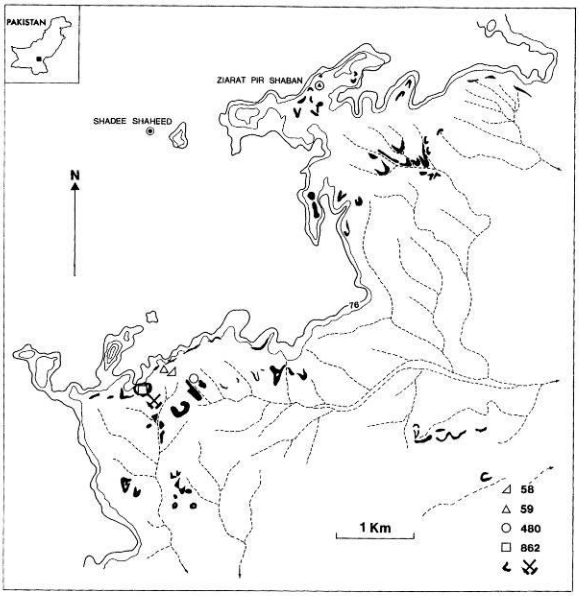


Fig. 44: Rohri Hills. Distribution map of the main Indus flint mine clusters with the location of the sites mentioned in the text

Fig. 45: Rohri Hills. The beginning of the second season of excavations at Indus flint mine RH862 (photograph P. Biagi)

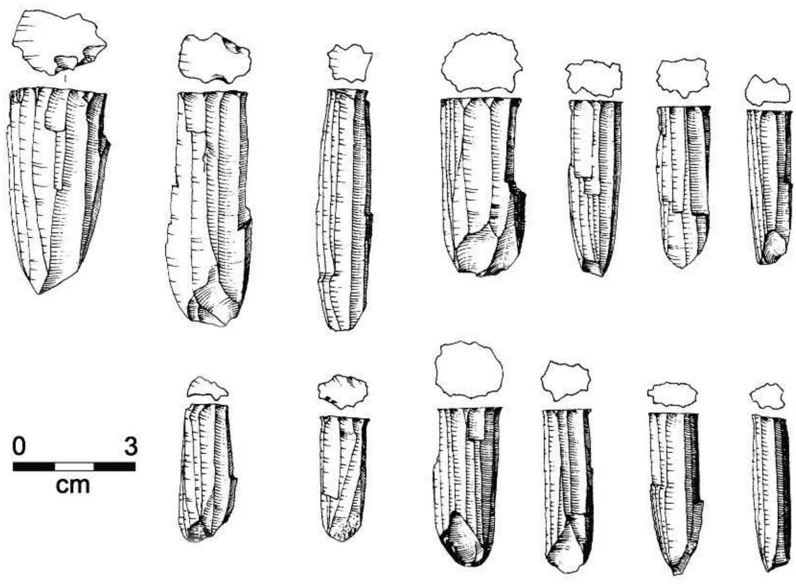


Fig. 46: Rohri Hills. Bullet cores from the flint workshop at Site RH862 (drawings G. Almerigogna)

Fig. 47: Rohri Hills. Excavations underway in the interior of flint mine-pit RH862 (photograph P. Biagi)

Fig. 48: Rohri Hills. Profile of flint mine RH862 at the end of excavations, with the surface of the mining floor in the foreground (photograph P. Biagi)

Fig. 49: Rohri Hills. The floor of flint mine RH862 with the flint nodules still *in situ* as they were left by the Indus miners (photograph P. Biagi)

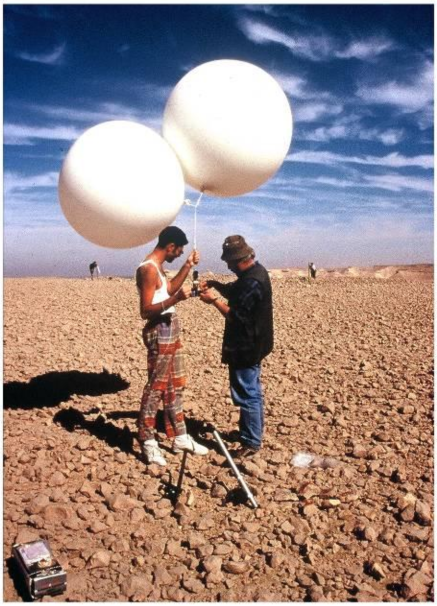


Fig. 50: Rohri Hills. Helium balloon device employed for taking aerial photographs in the early 1990's (photograph P. Biagi)

Fig. 51: Rohri Hills. Large, holed flint nodule found *in situ* in the floor of the Indus flint mine RH862 (photograph P. Biagi)

Fig. 52: Rohri Hills. Hole opened in the floor of flint mine RH862 to extract a flint nodule (photograph P. Biagi)

Fig. 53: Rohri Hills. Bugti Baloch worker dismantling the limestone terraces with a metal bar near site RH862 (photograph E. Starnini)

Fig. 54: Rohri Hills. Long bullet cores from the surroundings of Rohri, now in the collections of Birmingham University (photograph L. H. Barfield)

Fig. 55: Rohri Hills. Bullet cores from site RH862 (photograph P. Biagi)