

**Chert Mines and Chert Miners. The
Material Culture and Social
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Stone Workers, Artisans and Traders in
the Indus Valley (Sindh, Pakistan)**

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2018

Chert Mines and Chert Miners. The Material Culture and Social Organization of the Indus Chipped Stone Workers, Artisans and Traders in the Indus Valley (Sindh, Pakistan)

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Sindh (Pakistan) is very rich in lithic resources that were exploited in prehistory at least since the Acheulian Palaeolithic to the Bronze Age Indus Civilization. This activity left behind impressive archaeological evidence consisting of chert mines, chipping floors and blade/bladelet workshops, whose preservation is unfortunately challenged by present-day industrial works. The evidence is seriously risking of disappearing before it can be fully documented and understood by archaeologists. During the last twenty-seven years the explorations of the Italian Archaeological Expedition focused on three main chert sources: the Rohri Hills, Ongar, Daphro and Bekhain Hills, and Jhimpir. However, they are not the only ones known to date in Sindh that were intensively exploited during the development of the Indus Civilization. Although the economic importance of chert exploitation of the Indus Civilization has often been underestimated by most archaeologists, as it is evident reading the published narratives about its handicraft, trade and production, there is little doubt that this raw material played a fundamental role in the economy of the Indus cities, also as main alternative to metal for making well-defined tools for specific handicrafts. This paper summarizes the results of twenty-seven years of fieldwork carried out by the Italian Archaeological Expedition in Sindh in search for chert sources and documenting the Indus Civilization chert mining areas and workshops. It considers the available distribution of the chert outcrops, and the way they were exploited, the main characteristics of the lithic resources, their role in the economic system of the Indus world, the different stages of chipped stone tool production, and the available evidence for trade network throughout the territories covered by the Indus Civilization.

Keywords: Indus Civilization, Pakistan, Sindh, raw material sources, chert mines and workshops.

Introduction (P.B. and E.S.)

In 1984, Jonathan Mark Kenoyer wrote a first comprehensive report of the chipped stone assemblages from the excavations carried out in 1964-65 by G. F. Dales at Mohenjo-daro, the largest Indus urban settlement of Sindh (Kenoyer 1984). However, in his preface the same author pointed out the limits of his analysis, due to the very small number of chipped stone tools available at that time for his study – only 115 items from the whole excavations – 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 the first techno-typological and functional analysis of a Mature Indus Civilization chipped stone assemblage that represents an important period of the Bronze Age in the study region.

Indeed, until the end of the 1980s, very little was known of the Bronze Age chipped stone assemblages of Sindh and Pakistan in general, and the situation had not improved very much at the beginning of the 2000s ‘partly because of the emphasis given to other categories of objects made from bronze, semi-precious stone, shell etc.’ (Bhan *et al.* 2002). In 1987 J. H. Cleland

wrote the first summary report on this topic (Cleland 1987), in which he defined the technological and typological characteristics of the lithic assemblages of the Chalcolithic and Bronze Age of Sindh, dated from c. 3500 to c. 2500 cal. BC years (Possehl 1988).

Reading the paper we are immediately impressed by the scarcity of data available at that time for the entire Indus Valley and its neighbouring regions, and the very little importance that most Indus Civilization archaeologists ever paid to the lithic factor even recently (see for instance Ashtana 1993; Lahiri 1992; Possehl 2002; Ratnagar 2001, 2004a, 2004b; Wright 2010). Although Sindh represents indeed one of the regions with the highest density of Chalcolithic and Bronze Age settlements of the entire Indus Valley (Giosan *et al.* 2012: fig. 3a; Khan and Lemmen 2014: fig. 2), the chipped stone assemblages considered by J. H. Cleland for his study come from only four Sindhi sites: Amri (Casal 1964), Kot Diji (Khan 2002), Allahdino (Fairservis 1993) and Mohenjo-daro (Cleland 1987: tabs. 1 and 2; Hoffman and Cleland 1977), and Balakot in Las Bela (Balochistan) (Dales 1979; Shaffer 1986).

Important contributes on the chipped stone assemblages retrieved from the old excavations at Mohenjo-daro

were published also by B. Allchin. This author wrote the first important reports on the Holocene blade assemblages from Sindh (Allchin 1979: fig. 2; 1985) and provided us with some preliminary information on the Indus chert 'working floors' discovered near Rohri, at the northern edge of the Rohri Hills (Allchin 1976, 1999: 291; Allchin *et al.* 1978) (Figure 2, n. 6).

More recent work on the stone raw materials of the Indus Civilization by R. W. Law (2011) focused mainly on the characterization of geological samples, and provenance definition of all the stone/mineral artefacts. Also chert samples from four well-defined regions of the Rohri Hills were sampled. The above author pointed out the different appearance, colour and texture of the sources that were most probably exploited in different periods of development of the Indus Civilization (Law *et al.* 2002-2003).

A detailed analysis of the occurrences in numbers, percentages, tool types, technological and dimensional characteristics, use and exploitation of the chipped stone tools within the settlement sites are still missing. It is not surprising that most excavation reports systematically tell us just a few words on this topic. For example, the only information available from the recently excavated site of Farmana, in the upper Ghaggar Basin (India), is a short sentence where the authors report that 'all the stone blades at Farmana are made of fine chert [...] most probably brought from the Rohri Hills in Sindh of Pakistan. So far no evidence of the manufacture of these blades at Farmana has been found. It is quite likely that the people at Farmana traded finished products from some site near the source area in Sindh' (Osada and Uesugi 2008: 97-100).

Given the above premises, the scope of this paper is to present and discuss the impressive quantity of data collected by the Italian Archaeological Expedition after almost three decades of exploration of chert/flint sources and workshops in Sindh, and to reconsider the little information available from the excavated urban centres in an attempt to infer possible social organization of the operative chain connected to the exploitation of this resource that was of fundamental importance during the Indus period.

Prehistoric chert mines in Sindh (P.B. and E.S.)

Sindh is very rich in chert sources. Many of them outcrop from the limestone mesas that border the right, western side of the Indus Valley, at least from Ranikot, in the north (Blanford 1867), to Allahdino near Karachi, in the south (Fairservis 1993: 111). Although most of the sources have never been mentioned by most archaeologists, they are all described in the most important volume ever written on the geology of the country more than a century ago (Blanford 1880).

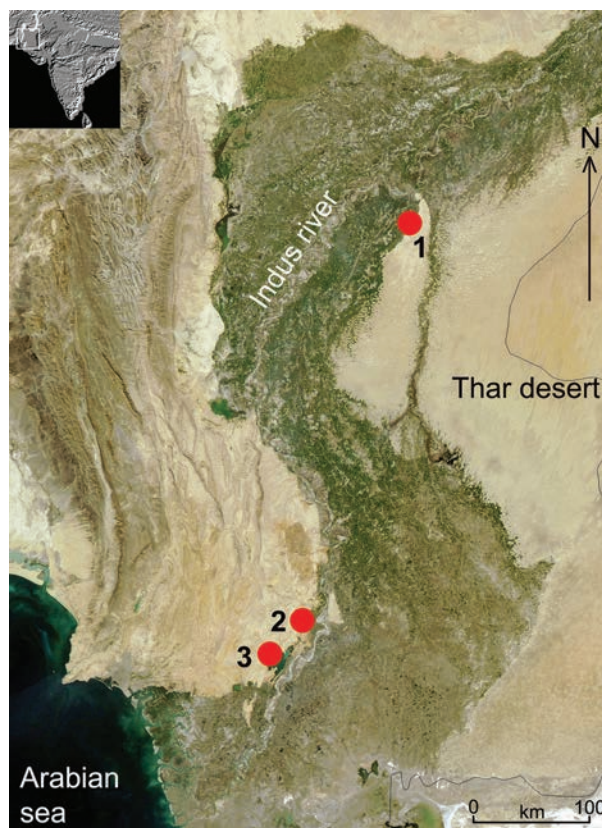


Figure 1. Location of the Indus Civilization chert mining sites mentioned in the text: Rohri Hills (1), Ongar, Daphro and Bekhain Hills (2), and Jhimpir (3) (drawing by P. Biagi).

W. T. Blanford accurately reports the occurrence of chert/flint artefacts, both cores and flakes, covering a large area of the terraces just south of Rohri (Blanford 1880: 103). The same he did at Ongar, from where he describes the discovery of flint from the Kirthar limestone beds that characterise the easternmost hill (Blanford 1880: 149). From Jhimpir he mentions the presence of flinty and cherty Kirthar limestone rocks near the village railway station (Blanford 1880: 152).

The above three regions were systematically surveyed by the Italian Archaeological Mission in Sindh. Reports on the different localities discovered by W. T. Blanford that were all revisited between 1986 and 2010, have already been published in several journals (for a summary, see Starnini and Biagi 2011).

The Rohri Hills (P.B. and E.S.)

The first reports of the presence of Indus Civilization chert workshops on the Rohri Hills, in Upper Sindh (Figure 1, n. 1), were published already in the late 1880s (Biagi 1997; Blanford 1880; Evans 1886), even though H. De Terra and T. T. Paterson discussed their chronology and cultural attribution only some sixty years later. These authors 'found over 100 blade cores, mostly

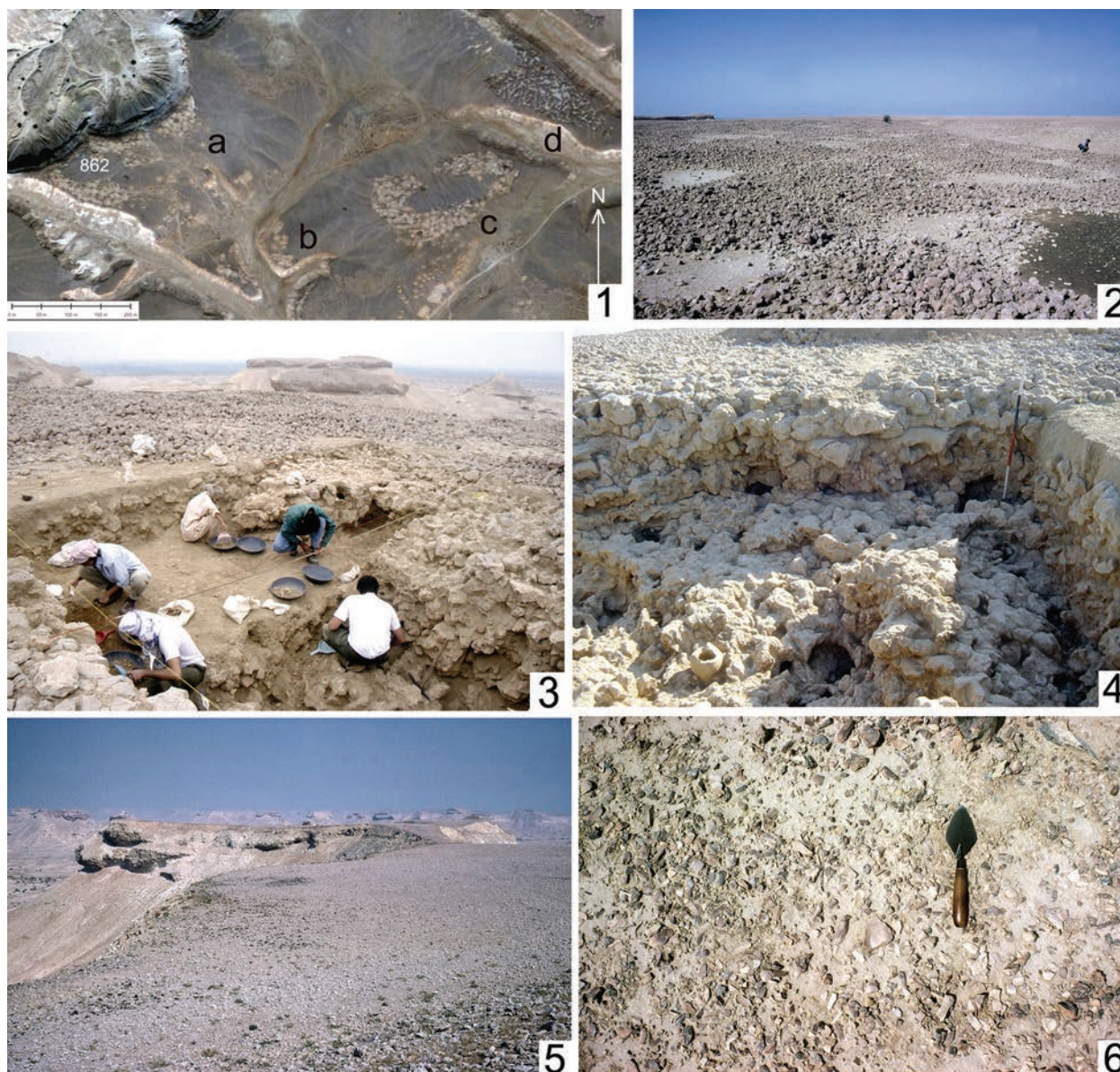


Figure 2. Rohri Hills: The main groups of mines and workshops so far discovered on a terrace some 130/135m high on the Rohri Hills roughly between 27°25'57"/27°25'39"N - 68°50'55"/68°51'26"E (a-c), and location of mine RH-862 (1), the edge of the terrace where mine RH-862 is located within a group of mining-pits and piles of limestone blocks (2), 1997 excavations underway at mine RH-862 (3), mine RH-862 wall and floor with extraction holes and nodules still *in situ* (4), small lithic workshops along the western terrace north of Shadee Shaheed (5), and the surface of a chert workshop on the terrace south of Rohri still *in situ* in 1986 (6) (photographs 3-6 by P. Biagi).

conical, flaked usually around a half to three quarters of the periphery' on the top of the limestone terraces located just south of Rohri, at the northernmost edge of the Rohri Hills, south of the course of the Indus, some of which they correctly attributed to the Indus Civilization (De Terra and Paterson 1939: 336). Further research on the hills was carried out by members of the Cambridge Archaeological Mission in 1975. Their surveys led to the discovery of many Indus Civilization chert working floors again located at the top of the northernmost limestone terraces, close to the city of Rohri (Allchin

1976: 477). Unfortunately, all the aforementioned sites were destroyed at the end of the 1980s by industrial limestone quarrying just after a short visit paid by one of the present authors (P. B.) to the sites (Figure 2, n. 6) (Biagi 2006).

The Rohri Hills elongate in a north-south direction between the course of the Indus and the cities of Sukkur and Rohri, in the north, and the westernmost fringes of the Thar Desert, in the south. They consist of Brahui formation fossiliferous limestone rocks attributed to

the Middle Eocene/Early Oligocene period, very rich in seams of good-quality chert (Blanford 1880: 103). The hills separate two very different environmental regions, the fertile Indus Valley, to the west, and the sandy Thar Desert, to the east. The eastern fringes are lapped by the Nara Canal, which flows inside the old bed of the Hakra-Ghaggar River (Wilhelmy 1966; Giosan *et al.* 2012). The hills consist of flat, slightly inclined limestone mesas, gently dipping to the east. They are dissected by erosion and deeply incised by old river courses (Biagi 2014; Biagi and Cremaschi 1988).

Indeed, the first clear evidence of Indus Civilization chert mining activity was discovered in February 1986 along the central-western terraces of the hills, east of the Shrine of Shadee Shaheed (Biagi and Cremaschi 1990, 1991). Therefore, all of the region was systematically surveyed by the Italo-Pakistani 'Rohri Hills Project' a few years later (Biagi and Shaikh 1994).

The Shadee Shaheed deposits contain nodular chert seams of uniform, greyish-brown (10 YR5/2) to brown (10YR5/3) colour. The nodules are often large, irregular, sometimes in the form of empty cylinders (Starnini and Biagi 2011: figs. 31 and 51). In some areas chert nodules are clearly visible along the profiles that open along the western edge of the Shadee Shaheed hills, where sometimes they lie overimposed in at least seven distinct seams (Biagi 2014).

The surveys of the Shadee Shaheed mesas were carried out mainly at the beginning of the 1990s. They led to the discovery of an impressive number of chert mines, workshops for the production of different types of blades and bladelets, chipping floors (Figure 2, n. 5; Figure 10, nn. 1 and 2) and decortication areas (Biagi and Pessina 1994; Biagi *et al.* 1995; Negrino and Starnini 1995, 1996). The mines are often characterized by large heaps of small limestone blocks arranged in oval, circular or semicircular structures around spots of sand that hide the opening of mining trenches and pits. These latter are sometimes surrounded by one or more knapping workshops easily recognizable due to the presence of blade-debitage waste, blade or bullet cores scattered all over their surface (see Negrino *et al.* 1996).

Along the western terraces of the Shadee Shaheed hills many extractive and manufacturing structures were recovered in a perfect state of preservation (Figure 2, nn. 1 and 2). They were often grouped in clusters of different shape and size (Biagi and Pessina 1994). This impressive mining complex is so far the largest ever recovered in the Indian Subcontinent. It is remarkable especially on the terraces between 27°25'57"/27°25'39"N-68°50'55"/68°51'26"E, where four main clusters of hundreds of features are still clearly visible (Figure 2, n. 1, a-d; see also Biagi and Starnini 2008: fig. 6). The above mining

area extends some 1.5km further east (Biagi and Pessina 1994: fig. 2).

Great differences between the aforementioned groups of structures can be noticed even from satellite and aerial photographs taken during the 1994 fieldwork season with the aid of a helium balloon (Maifreni 1995). The morphological differences noticed among the extractive areas perhaps indicate that mining activities were conducted according to different methods from those of the neighbouring groups of structures (see above and Figure 2, n. 1 a-c). This impression is reinforced by the discovery of more complex features, among which are stone platforms and walls (Biagi and Pessina 1994: figs. 2 and 4), and decortication areas represented by very small clusters of limestone flakes (Biagi *et al.* 1995: fig. 2).

The excavation of the Mature Indus mine RH-862, located close to the northern edge of one of the aforementioned clusters (Figure 2, n. 1), was carried out between 1995 and 1998 (Negrino and Starnini 1995; Negrino *et al.* 1996; Starnini and Biagi 2011). The mine was exploited during the Mature Indus Civilization. This fact is demonstrated by the characteristics of the material culture remains, and an AMS result obtained from a tiny fragment of *Zyziphus nummularia* charcoal recovered from the bottom of the limestone deposit at the southernmost edge of the mining trench (3870±70 BP: GrA-3235: Biagi 1995). The chert nodules were extracted from a seam discovered at c. 1.5m of depth, where the limestone layer becomes more compact and difficult to remove (Biagi *et al.* 1997; Starnini and Biagi 2006: 200).

The excavations carried out at RH-862 exposed part of a mining trench with a sinuous front and chert extractive niches at its bottom (Figure 2, nn. 3 and 4). The mine floor is characterized by an irregular surface with many holes into which the chert nodules were originally embedded. The Indus workers removed the limestone deposit as deep as to reach the uppermost chert seam. The limestone waste, derived from the excavation of the trench, was later dumped mainly in the back of the mine-trench itself in the form of large, subconical heaps of small limestone blocks. The extracted chert nodules were immediately tested or worked on site.

Part of another mine-front located at the back of the main one was brought to light during the 1997 fieldwork season. It shows that the mine had an irregular shape, and its front was not parallel to the edge of the terrace (Figure 2, n. 3). The excavation did not yield any evidence neither of tools employed for cracking the limestone and extracting the chert nodules, nor the existence of wedge-holes, fire setting or gad traces.

Given the occurrence of natural fissures in the limestone formation, and the recovery of cobbles with percussion marks, we can suggest that the limestone deposit embedding the flint nodules was fractured with the aid of (metal?) levers, though the excavation did not yield any clear evidence for mining tools. It is noteworthy to point out that this is the method still employed by the Balochi workers to mine the limestone exploited for road construction purposes.

The general impression is that the exploitation of the mine RH-862 was suddenly interrupted. As reported above the 1995-1998 excavations brought to light an intact mining floor in due course of exploitation, with some nodules ready to be extracted from their holes (Starnini and Biagi 2006: fig. 4). For unexpected reasons the exploitation was interrupted, and the workers never went back to the mine. Soon after the trench started to be refilled first with limestone blocks and mining debris, and later covered with sand blown from the neighbouring Thar Desert (Starnini and Biagi 2006: fig. 6). The AMS date 3870 ± 70 BP (GrA-3235) marks the end of the exploitation of RH-862 mine to a well-defined period of the Mature Indus Civilization.

A chert sample collected from mine RH-862 was analysed in thin section at Ferrara University (S. Bertola, unpublished report 1998). The results showed that the material consists mainly of microcrystalline quartz and chalcedony (95%). It contains 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 chert ideal for knapping (Biagi and Starnini 2008: 78).

The excavation carried out at only three knapping workshops, namely RH-58, RH-59 and RH-480, helped interpret the operative chain employed for the production of parallel-sided blades and bladelets performed at the above sites, core reduction, manufacturing technologies, and number of finished products obtained from each workshop, mainly hundreds of blades, bladelets, subconical and bullet cores (Biagi and Pessina 1994; Biagi *et al.* 1995; Negrino and Starnini 1995). The study of the chipped stone artefacts showed a great variability site by site, and the absence of specific retouched tools. Even the size of the above workshops varies, as the number of cores and debitage flakes, and the total weight of the chert pieces recovered from the different features, from 101.73 (RH-58) to 169.25kg (RH-480) (Biagi *et al.* 1995: 24).

The above workshops consist of very distinctive features characterised by dense scatters of chipped stone artefacts among which are clusters of different types

of subconical and bullet cores from which standardized series of blades and bladelets had been removed by pressure technique (Figure 3) (Briois *et al.* 2006; Inizan *et al.* 1994; Pelegrin 1988, 1994). The workshops are scattered around sub-rectangular or elliptic spaces from which the small limestone blocks that characterise the surface of the terraces had been accurately removed by Indus workers. The excavations, and the result obtained from the study of the chipped stone assemblages, have been of fundamental importance for the interpretation of the manufacturing processes of the chipped stone artefacts, and the definition of the quantity of final products obtained from each feature, always numbering several thousands (Negrino and Starnini 1995, 1996). This represents indeed the left evidence of a well specialised handicraft – that of the chipped stones – that was part of an operative chain for the manufacture of other products in the Indus centres, among which are semiprecious stone beads, bone and ivory, and pottery (Bondioli *et al.* 1984; Kenoyer 1986; Méry 1994; Méry *et al.* 2007; Pracchia *et al.* 1985). The chert blade mass production involved specialised, (itinerant?) artisans whose activity might have been seasonal, perhaps connected with the autumn-winter pastoral exploitation of the landscape.

More recently research has been focused on the southernmost fringes of the hills, where Indus chert workshops have been identified at Kandharki. They have been attributed to both the Kot Diji (Kandharki-I) and Mature Indus period (Kandharki-II and III) (Mallah 2010: 37). According to N. Shaikh *et al.* (2002-2003: 45), Kandharki-I is strictly connected with a ‘chert heating kiln’, although the authors do not provide us with any proof of the relations between the aforementioned structures, and the suggested kiln was not radiocarbon-dated. The Kandharki workshops are briefly described also by R. W. Law *et al.* (2002-2003: 9), although these authors did not report the presence of any kiln in the area. The material utilised by the Kandharki knappers consists of ‘light brown and gray cherts [that] tend to contain more inclusions and have a coarser texture than materials found further to the north’.

It is regrettable that the aforementioned authors did not provide us with any more detailed information about this very important region of the hills. Subconical, elongated blade cores, some 12cm long, were collected from Kandharki-I. A comparable core fragment comes from the site of Jamal Shah Sim (JS-5), in the Thar Desert, a few km southeast of Kandharki, where it was collected within a spot of chipped stone artefacts, mainly broken long blades, and potsherds typical of the Kot Diji aspect (Biagi and Veasar 1998-1999: fig. 16). Elongated subconical cores comparable to those from Kandharki are known also from the filling of mine RH-862 (Negrino *et al.* 1996: fig. 29, n. 1) as well as the Unnar (Nawab Punjabi) (Figure 10, n. 6). At

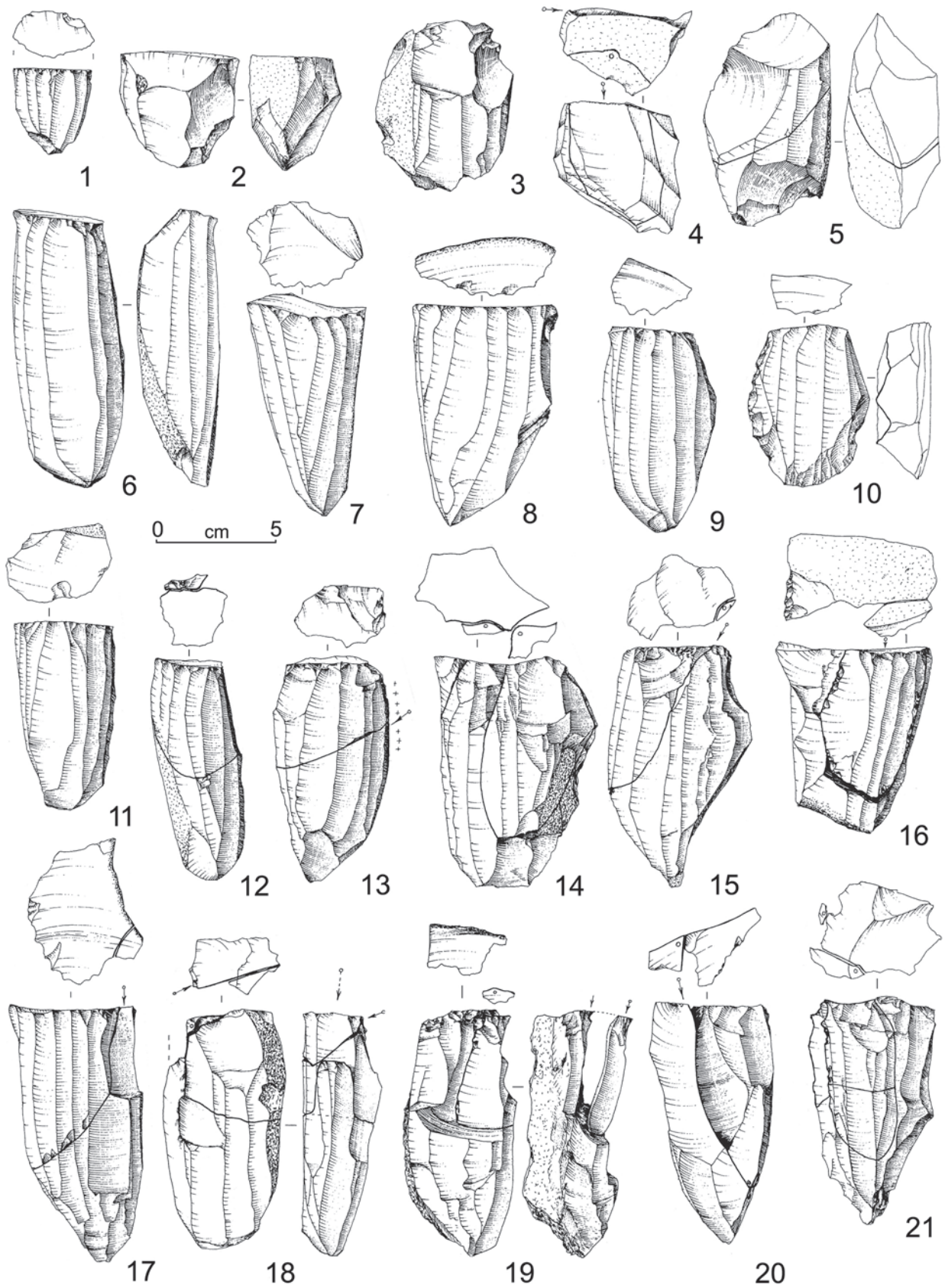


Figure 3. Rohri Hills: Cores, refitted cores, and core fragments from workshop RH-480 (from Negrino and Starnini 1995).

present this important site is unfortunately completely destroyed by limestone quarrying (material at Khairpur University Department of Archaeology).

The presence of rich, good quality chert sources led to an intensive and extensive exploitation and trade of the Rohri Hills chert, a very important raw material exploited during the entire Indus period. It was utilised by craftsmen of the urban Indus centres for the production of specialised implements. Among them are long, prismatic blades employed for pottery manufacture (see Nausharo: Méry 1994; Méry *et al.* 2007), and micro-drills (Kenoyer and Vidale 1992) for piercing semiprecious stone beads (see Mohenjo-daro: Kenoyer 1986; Pracchia *et al.* 1985; Tosi *et al.* 1984).

Ongar, Daphro and Bekhain (P.B. and E.S.)

Ongar is a hill located c. 25km south of Hyderabad, and 8km north of Jhirak, west of the national road to Karachi (Figure 1, n. 2). The lithic sites were discovered in 1959 (Fairservis 1975: 77) on a Kirthar limestone terrace already described in detail by W. D. Blanford (1880). Professor A. R. Khan of Karachi University visited the area in the summers of 1972 and 1973, when the limestone deposits of the hill, containing large chert nodules of light brownish grey colour (10YR6/2), were already exploited for industrial purposes. From Ongar and its surroundings, he collected an impressive number of Palaeolithic tools (Khan 1979). The easternmost horseshoe-shaped terrace was revisited by B. Allchin in 1975-76 (Allchin 1976). This author called it Milestone 101 following the indications of an officer of the Pakistan Archaeological Department (Allchin *et al.* 1978: 295).

Further investigations were carried out by one of the present authors (P.B.) between 2004 and 2008 (Biagi 2005; Biagi and Franco 2008). In contrast with the reports written by the aforementioned authors, the latest surveys demonstrated that the rich chert seams of Ongar, and those of the neighbouring Daphro and Bekhain Hills, were exploited also during the Indus period. Although already in 2004 most of the Ongar archaeological sites had been destroyed by contemporary limestone quarrying, just a few left intact areas were nevertheless discovered. In particular the narrow terrace that elongates between Ongar, in the east, and Daphro, in the west (25°09'36"N-68°12'56"E / 25°09'38"N-68°12'01"E), was found still intact. Indus period mining trenches, small debitage flake clusters, and chert artefacts, among which is a subconical blade core (Figure 6, n. 1), were recorded at the southern edge of the central part of the aforementioned mesa along a strip some 460m long and 20m wide (25°09'39"N-68°12'14"E/25°09'37"N-68°12'30"E: 63-80m asl) (Figure 4, nn. 1-3).

More evidence of Indus age mining and knapping was recorded at the north-westernmost edge of Daphro. Here the first group of structures consists of five aligned mining trenches and chert knapping workshops located between 25°09'45"N-68°09'54"E and 25°09'47"N-68°09'56"E (Figure 5, n. 1); the second, at c. 25°09'47"N-68°10'05"E, of six parallel, C-shaped mining trenches (Figure 5, nn. 2 and 3) and debitage workshops from which a pre-core and a subconical blade cores and potsherds were also recovered (Figure 5, nn. 4-6; Figure 6, nn. 2-6).

The survey was later extended to the Bekhain Hills, some 2.5km south of Daphro, at 60m asl. Although already heavily damaged by limestone quarrying, a few areas of the hills were still intact in 2008. Some of the Indus mining trenches and chert knapping workshops recorded at Bekhain are shown in Figure 4, n. 1 and Figure 7, nn. 1-4. Of major importance is the recovery of a large pre-core along the eastern edge of the westernmost hill at 25°08'09"N-68°09'27"E, together with two large decortication flakes (Figure 6, n. 7; Figure 7, nn. 5 and 6). This type of pre-cores is quite uncommon. Similar specimens are known from Mohenjo-daro (Marshall 1931: pl. CXXXI, nn. 17-19), the Rohri Hills around Ziārāt Pir Shābān, and Nuhato in Badin *taluka* (unpublished Jamshoro Museum) (Baloch 1973). They probably represent rough-out or chert 'blocks' ready to be transported elsewhere.

Moving west, no traces of prehistoric settlements were recovered all across the alluvial plain that separates Daphro from Meting railway station, some 5km to the west. The terraces west of Meting were also surveyed. They consist of fossiliferous limestones containing very small chert nodules unsuitable for knapping due to their dimension. Evidence of systematic limestone quarrying, most probably related to the construction of the railway in British times, are evident at the top of the flat mesas c. 100m high, that extend just west of Meting.

At present the illegal exploitation of the Ongar Hill has shifted from limestone to chert quarrying, resources that abound on the hills (Biagi and Nisbet 2011). These latter are employed for house building and decoration, irrespective of the government strict rules aimed at the preservation of the archaeological and national heritage of the country that are systematically unattended (Biagi 2006).

Jhimpir (P.B. and E.S.)

The territory around Jhimpir was accurately surveyed in 2010-11 following the indications of W. T. Blanford (1880: 152) on the presence of chert sources in the area (Figure 1, n. 3). The surveys led to the discovery of an impressive number of Late (Upper) Palaeolithic findspots (Biagi 2011, 2016) located close to a chert

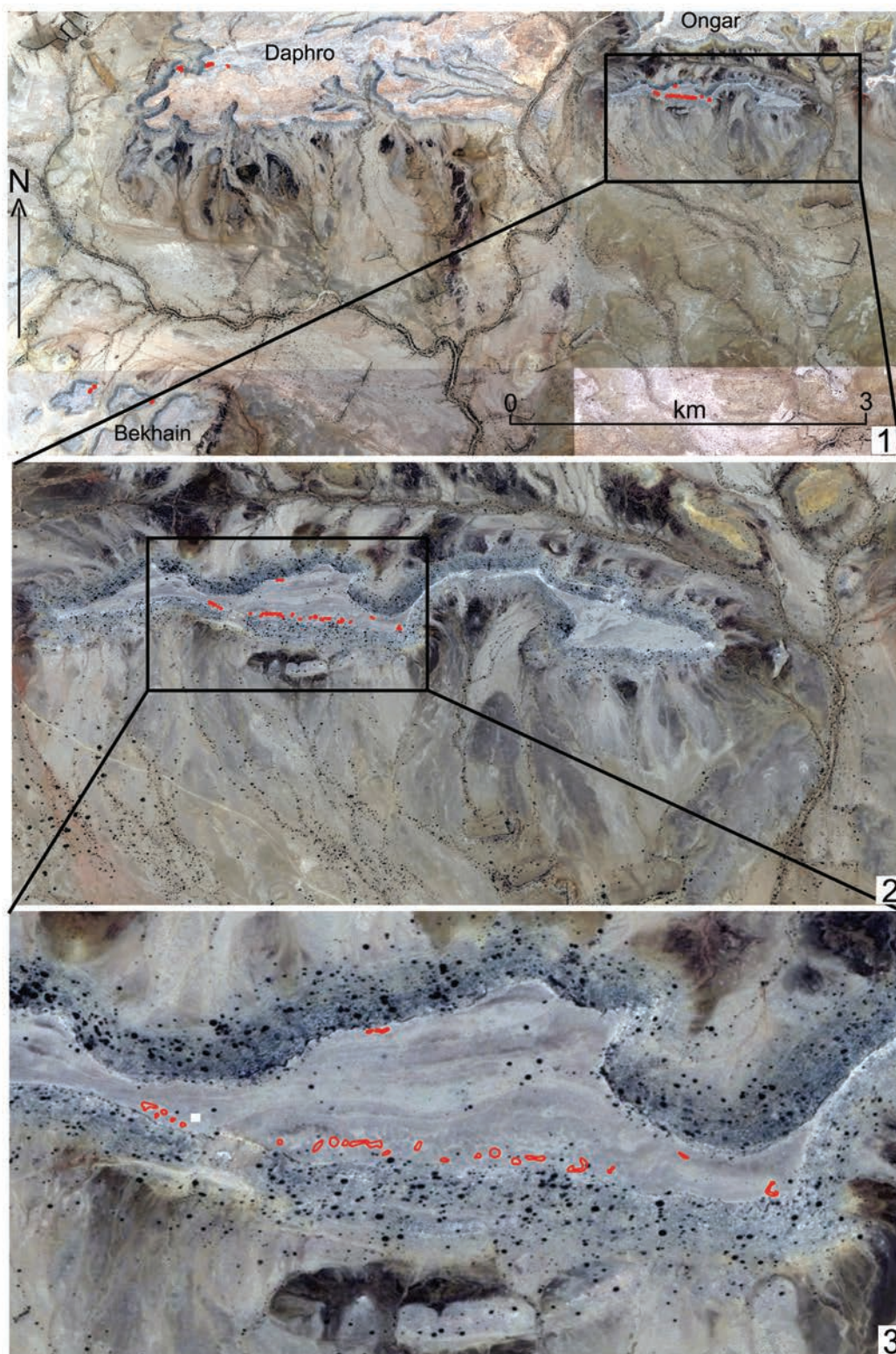


Figure 4. Ongar, Daphro and Bekhain Hills: Location on the Indus chert mines and workshops (1: red dots), along the edges of the hill between Ongar, in the east, and Daphro, in the west (2 and 3: red marks). The white dot marks the location of a typical Indus subconical blade core collected at $25^{\circ}09'39''\text{N}$ - $68^{\circ}12'16''\text{E}$ (maps by C. Franco).



Figure 5. Daphro Hill: The north-westernmost terrace on which Indus Civilization mining trenches have been recovered at 29°09'46"N-68°09'55"E (1), parallel mining trenches at the aforementioned location (2), the northernmost mining trench (3), blade core (4), chert workshop (5), and long, subconical blade core from the centre of the same structure associated with two potsherds, at 25°09'47"N-68°10'05"E (6) (photographs by P. Biagi).

outcrop (JHP-21) that was exploited most probably during the Chalcolithic period (Biagi and Nisbet 2010). Mining trenches and debitage workshops are clearly visible all over the surface of JHP-21 terrace (Figure 8, nn. 5 and 6). The aforementioned Palaeolithic sites are located on a limestone terrace facing the artificial Kalri Lake formed joining the waters of former Soneri and

Kinjhar natural basins (Figure 8, n. 1). The geography of the region in British times is shown in a very informative colour map by C. W. Tremenheere (1866).

The chert outcrops are clearly visible some 3.5 and 5.5km south-southwest of Jhimpir (JHP-21 and JHP-28 respectively) (Figure 8, nn. 2-4). They consist of long,

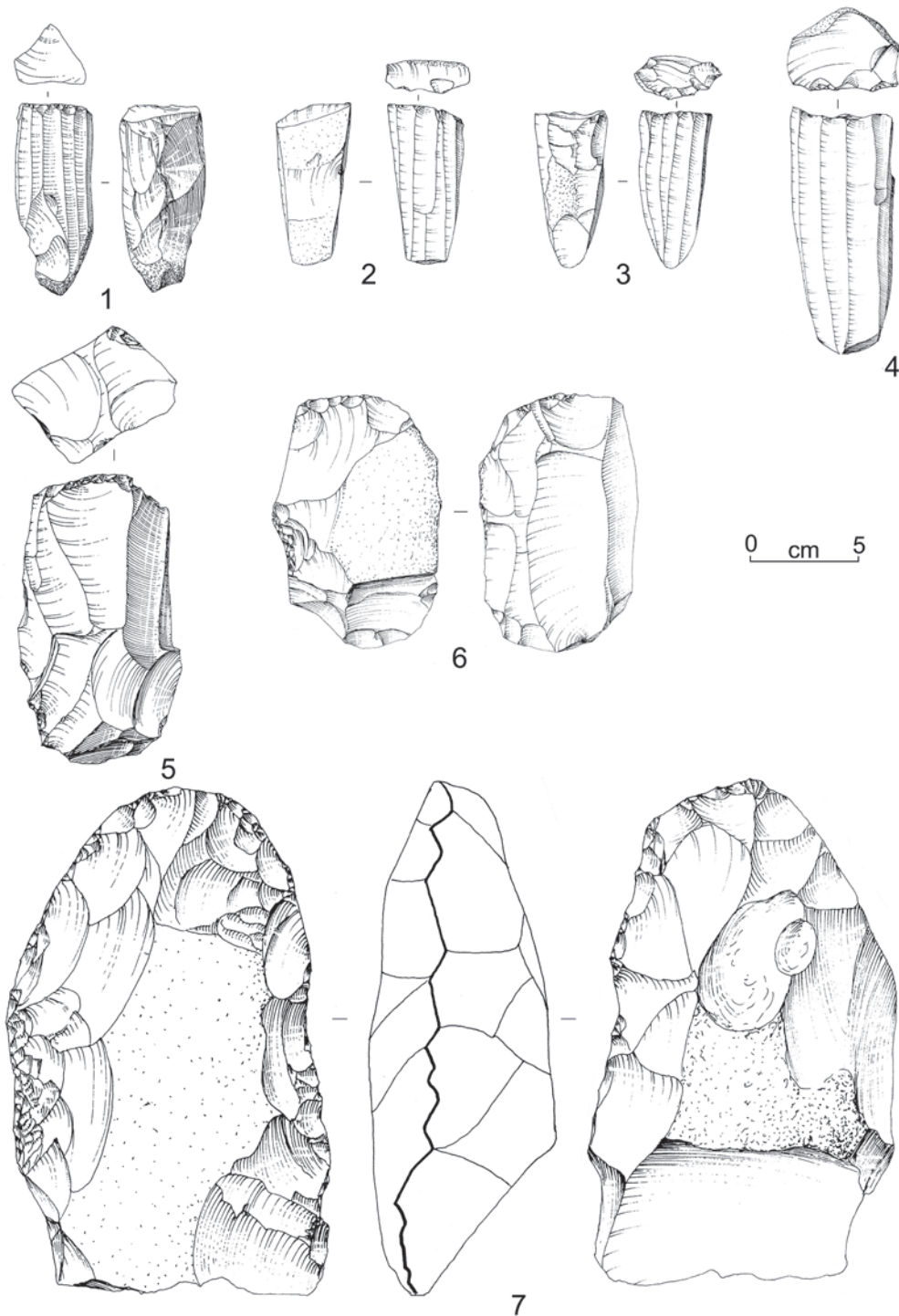


Figure 6. Ongar, Daphro and Bekhain Hills: Subconical blade core from Ongar (1), subconical blade cores (2-4) and pre-cores (5 and 6) from Daphro, and large pre-core from Bekhain (7) (drawings by P. Biagi, inking by G. Almerigogna).

narrow terraces oriented in E-W direction. They both yield very good quality nodular chert of light grey colour (2.5Y7/1-7/2), the characteristics of which are described below. Other chert sources were recovered some 5km west-southwest of JHP-21 showing that knappable raw material is quite common to the region.

Archaeometric characterization of Jhimpir JHP-21 outcrop (R.M.)

One sample of the chert fragment collected from the outcrop named JHP-21 discovered at Jhimpir (geographical coordinates: 24°59'37"N-68°00'08"E)

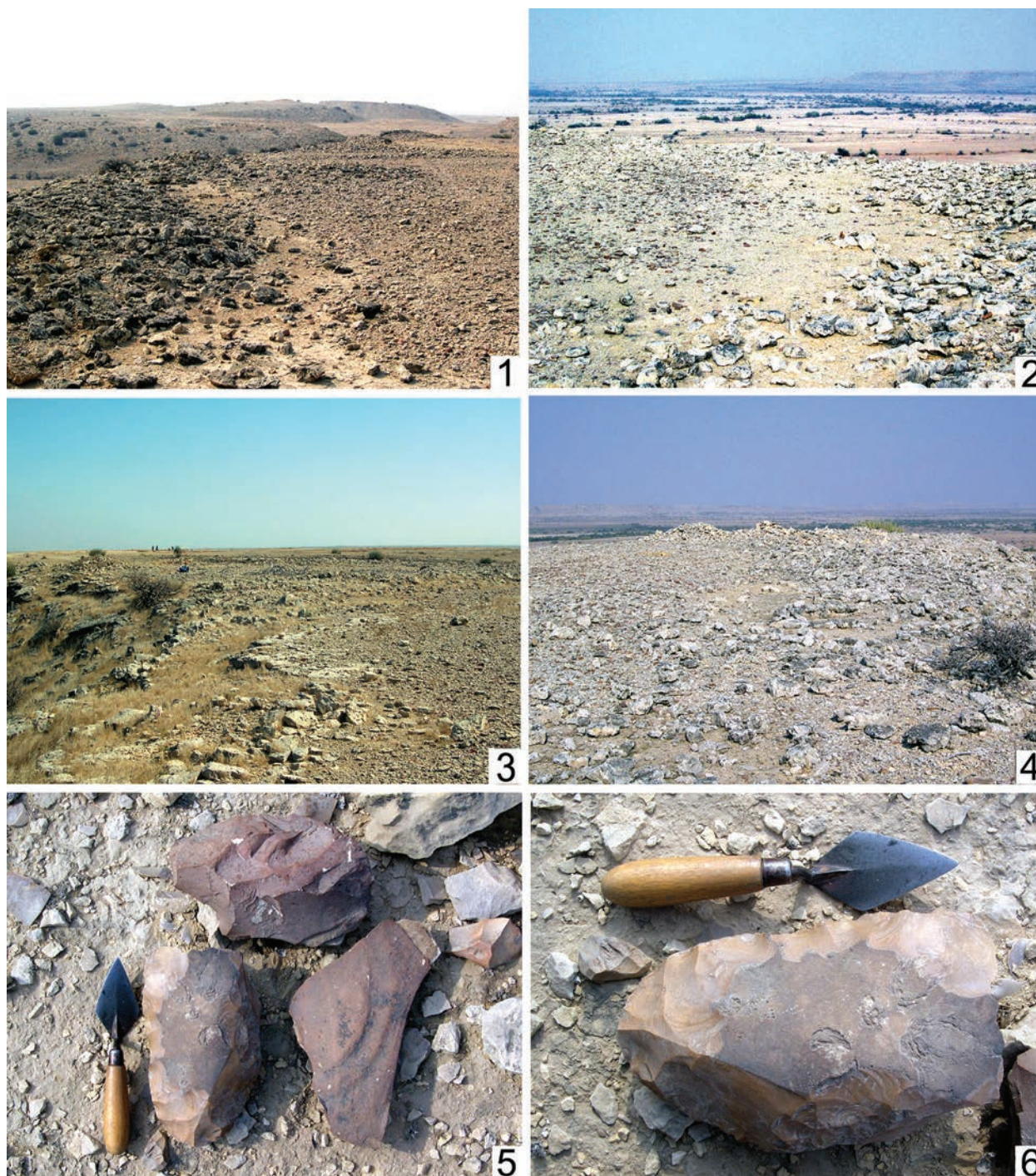


Figure 7. Bekhain Hill: Mining trenches discovered along the eastern edge of the westernmost hill between 25°08'13"N-68°09'30"E and 25°08'09"N-68°09'27"E (1 and 3), mining trench with a chert workshop along its edge, along the eastern edge of the central hill at 25°08'09"N-68°09'48"E (2), mining system at the north-easternmost edge of the central hill at 25°08'09"N-68°09'37"E (4), and a huge chert pre-core, and limestone decortication flakes from the eastern edge of the westernmost hill at 25°08'09"N-68°09'27"E (5 and 6) (photographs by P. Biagi).

with evidences of Chalcolithic exploitation (Biagi 2011; Biagi and Nisbet 2010) has been submitted for scientific analyses performed by one of the authors (R.M.) at the Institute of Geological Sciences of the Polish Academy of Sciences in Warsaw.

The macroscopic examination of the sample reveals that it is a cryptocrystalline siliceous rock characterized by compact texture, with a smooth, but lustreless, freshly broken surfaces, which are spotted and chromatically differentiated in hues from light to dark grey. The colour spots do not have sharp boundaries but blend



Figure 8. Jhimpir: Location of the chert outcrops and mines JHP-21, and JHP-28 (1), chert seams *in situ* at the top of JHP-28 (2 and 3), chert nodule *in situ* at JHP-21 (4), mining trenches (5) and chert workshop along the northern edge of JHP-21 terrace (6) (photographs by P. Biagi).

into one another. These features are characteristic for flints/nodular cherts; however, a strange aspect, rather untypical for flints, can be observed during the examination in thin section under petrographic polarizing microscope. As it is shown on Figure 9, n. 1-3, a micrograined structure could be seen, while the

closer analyses gave evidence of the cryptocrystalline character of this material. Such an impression is caused by microaggregates, which have the same size of the silica microcrystals (SiO_2). During the observation under crossed polars, the microcrystalline anisotropic

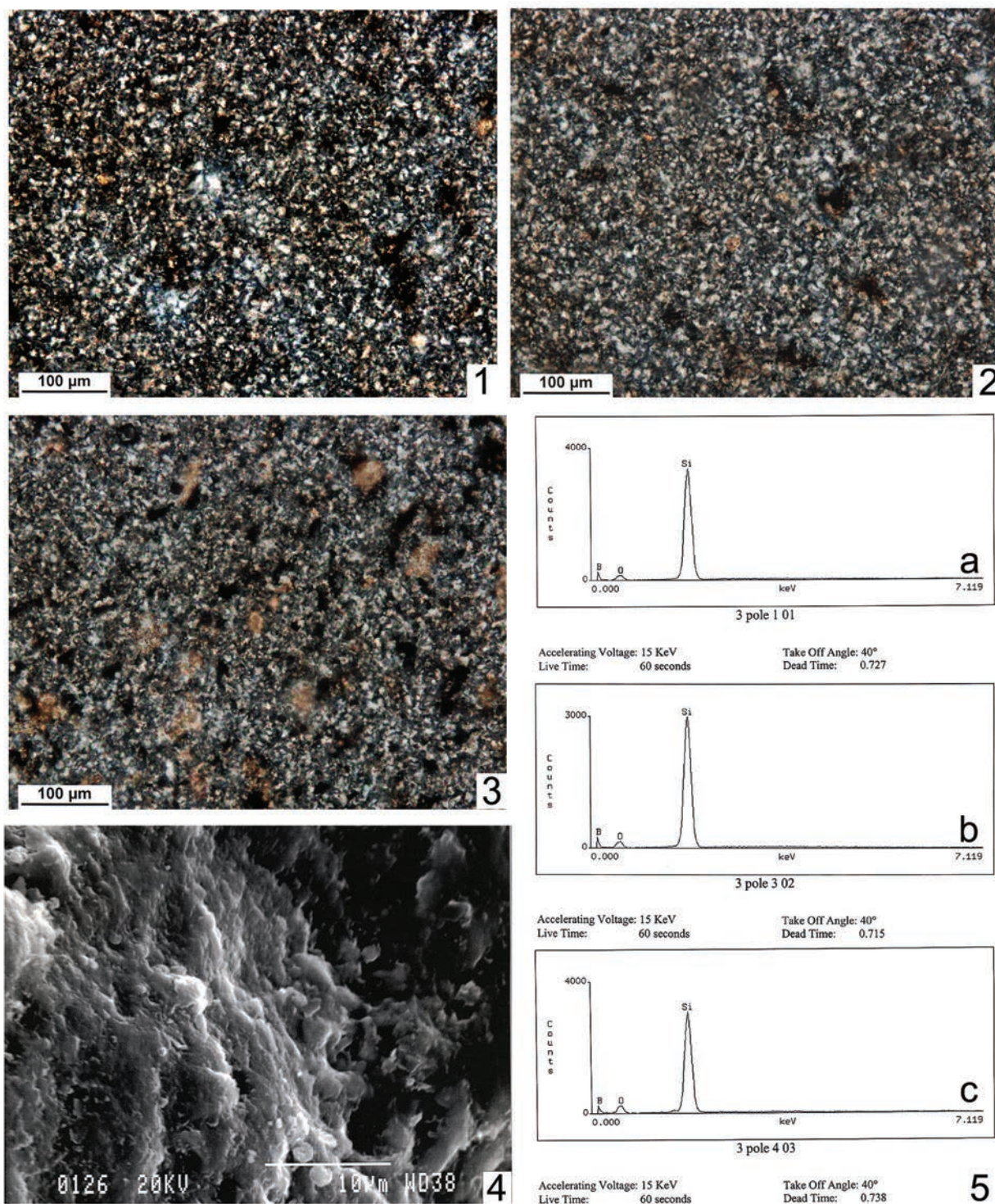


Figure 9. Jhimpir (JHP-21): Thin section microphotographs of the chert sample 20x, XPL (1 and 2), 40x, XPL (3), BSE image of the sample at 3000x magnification (4), SEM-EDS spectra, spot 1 (5a), spot 2 (5b), and window mode (5c) (photographs by R. Michniak).

character is shown by the birefringence typical of quartz (light grey interference colours).

The distribution of the quartz microcrystals evidences a microgranular texture and the birefringence excludes the presence of amorphous silica. Only calcite, as

accessory mineral, was found in very subordinate amounts. Calcite crystals are easy recognizable because of their strong birefringence (Figure 9, n. 3).

The sample microstructure is quite homogeneous without trace of re-crystallization, or evidences of

dissolution processes (Figure 9, n. 1-2). Instead, fine and linear fractures sealed by secondary silica mobilization and re-precipitation are well visible.

The scanning electron microscope (SEM) examination at 3000X magnification confirmed the microcrystalline structure.

Spot chemical analyses (SEM-EDS) were carried out in some points of the sample surface and confirmed the composition of nearly pure silica (spot 1: up to 99.18 wt% of SiO_2). SEM-EDS spectra evidenced that no calcium oxide (CaO) is present in this spot (Table 1 and Figure 9, n. 5a). In the four times smaller magnification (750X), it is possible to observe the presence of vein-filling silica of secondary generation. SEM-EDS spot analysis of the vein evidenced the presence of silica (Table 1 and Figure 9, n. 5b), (SiO_2 content reaches 98.45 wt%), with some other elements in subordinate amounts (CaO=0.14%, TiO_2 =0.60%, Cr_2O_3 =0.22% and FeO, as total iron=0.49%). Nevertheless, these chemical trace elements do not change at all the petrographic nature of the rock.

The SEM observation of a crack surface evidenced the iso-orientation of small quartz crystallites, which also on the other walls of this sample were randomly arranged (Figure 9, n. 4). The SEM-EDS analysis carried out in window mode on the surface shown on Figure 9, n. 4 is comparable with the previous spot-ones taken from the same rock fragment (Figure 9, n. 5c; Table 1). The lower silica (SiO_2 =95.39%), together with the higher calcium content (CaO=1.08%) and other minimal trace elements (Table 1), represent the results of a 'bulk' analysis that is quite representative of the bulk composition of the sample and includes the presence of some micrograins of accessory minerals.

From a petrographic point of view, the analyzed rock can be referred to the group of 'siliceous rocks' and it represents a nodular chert, i.e. nodular flint in archaeological terminology.

Discussion (P.B. and E.S.)

As already pointed out mines, quarries and chert knapping workshops are the most important components of a lithic production system (Biagi and Starnini 2008). The Sindhi Bronze Age extractive and knapping complexes provide us with an exceptional chance to shed light on this unique aspect of the Indus Civilization. The importance of studying extractive areas and production ateliers to understand the context of procurement, exchange and social organisation of a cultural system has been emphasised and recognised without any doubt (Ericson 1984; Purdy 1984).

Despite the fact that pressure debitage is known in South Asia from the 7th millennium cal. BC (Inizan and Lechevallier 1996), it is only from the beginning of the 3rd millennium cal. BC that a new technical advance can be recognised in the chert knapping technique employed for the production of regular blades and bladelets. The experimental tests demonstrated that the innovation consists in the introduction of metal points for pressing (Briois *et al.* 2006). As shown by the researches carried out in the Rohri Hills, the increase in the production of blanks, and the introduction of copper-tipped punches, seem to imply the involvement of skilled specialists, as already suggested by French scholars (Anderson-Gerfaud *et al.* 1989: 443).

Until a few decades ago, systematic surveys had never been undertaken in Sindh after the killing of M. J. Majumdar (1934), with the exception of the project carried out by L. Flam mainly in Sindh Kohistan and part of the Kirthar range (Flam 1987, 2006). The discoveries made at Ongar, Daphro, Bekhain and Jhimpir demonstrate that, apart from the Rohri Hills, other rich chert outcrops and mining centres did exist in the Indus Valley. The new discoveries greatly complicate our comprehension of the exploitation and circulation of the chert resources within the territory covered by the Indus Civilisation throughout its different stages of development that lasted some 1000 years (Possehl 1988). Our knowledge of the entire problem is very poor, mainly due to the approach the archaeologists followed to study the material culture remains of the Indus Civilization, and the little consideration always given to the lithic factor by most authors (see above).

The discovery of new important chert sources, and the probable presence of other still unidentified mining sites on top of the limestone terraces rising along the right, western bank of the Indus River, make the problem much more complicate than formerly suggested.

It is intriguing that 1) all cherts from the aforementioned sources show rather 'similar' macroscopic characteristics, texture and colour, 2) several sources are known on the Rohri Hills with macroscopically 'similar' although different characteristics (see Law *et al.* 2002-2003), and 3) no chert artefact or raw material specimen has ever been characterized from any of the Indus sites located close to the outcrops with the exception of Harappa in Punjab (Law 2011).

Considering mainly the Rohri Hills, other aspects still to be clarified regard the organisation of the production. Unfortunately, fieldwork in Sindh was halted a few years ago due to the insecure political situation in this part of the Indian Subcontinent leaving many questions unanswered.

Table 1. Jhimpir (JHP-21): Results of SEM-EDS microanalysis of a sample from the chert outcrop (see Fig. 9, nn. 5a-5c for the corresponding spectra).

Element	Element Wt %	Wt % error (1σ)	Components	Oxide Wt %
Sample 3 pole 1 01				
Si-K	46.36	± 0.34	SiO ₂	99.18
Ti-K	0.18	± 0.17	TiO ₂	0.30
Al-K	0.00	± 0.00	Al ₂ O ₃	0.00
Cr-K	0.00	± 0.00	Cr ₂ O ₃	0.00
Fe-K	0.04	± 0.34	FeO	0.05
Mn-K	0.00	± 0.00	MnO	0.00
Mg-K	0.04	± 0.05	MgO	0.07
Ca-K	0.00	± 0.00	CaO	0.00
Na-K	0.03	± 0.06	Na ₂ O	0.04
K-K	0.31	± 0.11	K ₂ O	0.37
O-K	53.05 S	--	--	--
Total	100.00			100.00
Sample 3 pole 3 02				
Si-K	42.02	± 0.35	SiO ₂	98.45
Ti-K	0.36	± 0.19	TiO ₂	0.60
Al-K	0.00	± 0.00	Al ₂ O ₃	0.00
Cr-K	0.15	± 0.24	Cr ₂ O ₃	0.22
Fe-K	0.38	± 0.36	FeO	0.49
Mn-K	0.00	± 0.00	MnO	0.00
Mg-K	0.06	± 0.05	MgO	0.09
Ca-K	0.10	± 0.13	CaO	0.14
Na-K	0.00	± 0.00	Na ₂ O	0.00
K-K	0.00	± 0.00	K ₂ O	0.00
O-K	52.93 S	--	--	---
Total	100.00			100.00
Sample 3 pole 4 03				
Si-K	44.59	± 0.39	SiO ₂	95.39
Ti-K	0.09	± 0.17	TiO ₂	0.15
Al-K	0.24	± 0.11	Al ₂ O ₃	0.46
Cr-K	0.00	± 0.00	Cr ₂ O ₃	0.00
Fe-K	1.46	± 0.37	FeO	1.87
Mn-K	0.25	± 0.30	MnO	0.33
Mg-K	0.21	± 0.07	MgO	0.36
Ca-K	0.77	± 0.13	CaO	1.08
Na-K	0.11	± 0.07	Na ₂ O	0.15
K-K	0.17	± 0.12	K ₂ O	0.21
O-K	52.09 S	--	--	--
Total	100.00			100.00

Among these are: 1) did the miners, and chert knappers live in neighbouring seasonal or permanent settlements? 2) was the production of blades an all-year-round or a seasonal activity? And, finally, 3) what was the distribution radius of the chert blades towards the Indus cities and handicraft centres, and how was it organised?

As already suggested (Biagi and Starnini 2008), these aspects are to be investigated at least at two levels, in particular: a) micro-regional scale, i.e. identifying the eventual presence of settlements at the foothills involved in the exploitation of the chert outcrops, if any, b) macro-regional scale, studying the distribution pattern of the workshop products at longer distances, either as semi-finished raw material items, or blades ready for use. As regards point a), Indus settlements do exist close to the Rohri Hills (Mallah 2010; Shaikh *et al.* 2004-2005) although none of them seems to have been involved in trade and exchange of lithic material; while point b) is still too badly known to rely on the oversimplified maps so far published by other authors (Kenoyer 1998: fig. 5.20a; see also Gupta 1996: fig. 15).

However, this latter aspect can be clarified only after a detailed study of the typology, technology and function of the chipped stone assemblages collected from old and recent excavations carried out at several cities of the Indus Civilization. As mentioned above the very few detailed traceological analyses published so far have demonstrated that the blades were undoubtedly used for several activities (Vidale *et al.* 2013), employed as polishers for making pottery (Anderson-Gerfaud *et al.* 1989), for the manufacture of semiprecious stone beads, for which they were turned into micro-drill points for piercing beads (Bondioli *et al.* 1984: 24; Bulgarelli 1986; Pracchia *et al.* 1985), and shell working (Deshpande-Mukherjee 1988, 2002; Deshpande-Mukherjee and Shinde 2014; Vidale 2000: 72). Others were undoubtedly employed for agricultural activities (Voytek 1994).

More recent works conducted by R. W. Law (2011) compared, by means of scientific analyses (INAA), 'tan-grey' chert samples from a few Rohri Hills outcrops and artefacts from a few Indus Civilization centres located outside Sindh. According to the author, the analyses confirmed the presence of Rohri Hills chert artefacts not only at Harappa, but also at Nagwada, Dholavira (Bisht 2015, 510; Law 2011: 176-177); while their presence has been suggested also from Datrana (Gadekar *et al.* 2013), Shikarpur (Gadekar *et al.* 2014) and probably Lothal in Gujarat (Rao 1985: 558), from which 'thousands of parallel-side blades' have been reported (Chakrabarti 1999: 187), and Rakhigarhi in Haryana. Rohri type chert artefacts come also from Balakot in Las Bela (Dales 1979) and Pir Shah Jurio, a Mature Indus site located along the left, eastern bank of the Hab River in Lower Sindh (Biagi 2004: 9).

However, the present evidence shows that the siliceous raw material of the Rohri Hills was transported in various forms, either as finished standardized blades and bladelets, or as unworked nodules, rough-outs, pre-cores and finished cores, from which we can infer a multiform demand, and the complexity of the procurement systems of which at present we know very little.

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

Conclusion

To conclude, it is important to point out that the study of chert usage at Harappa revealed an increase in quantity through time up to an almost exclusive use of Rohri Hills chert in coincidence with the Harappa Phase (Law 2011: 177) that is the Mature Indus Period, to which the radiocarbon dated RH-862 mining episode on the Rohri Hills, and its probably related bladelet production workshop, indeed belongs (Negrino *et al.* 1996).

Although S. Ratnagar recently suggested that 'blades of chert from Rohri (Sindh) were probably utilized for everyday tasks such as kitchen work or the harvest' and 'the distribution of chert blades reveals not trade according to variable regional demand but a regional distribution process handled by the rulers' (Ratnagar 2001: 354), the present archaeological evidence is still too poor to fully support both these hypotheses.

More recently, R. W. Law (2008: 754-755) observed that 'given the size and restricted geographic setting of the Rohri Hills within the Indus Valley, they could conceivably have been controlled by one community of Harappans based in northern Sindh that oversaw the extraction and monopolized the distribution of the valuable utilitarian resource there. I see that community as having been one of the many elite factions (merchants, landowners, ritual specialists, etc.) who, it is argued (Kenoyer 1994a: 77), were competing with one another for political dominance in Indus cities'. However, considering the far larger extension of chert sources with ascertained Indus age extractive activities in other areas than the Rohri Hills, such a social organization of chert extraction and distribution must be re-assessed and revised in a new perspective.



Figure 10. Rohri Hills: Large Indus chert workshop along the south western part of the Shadee Shaheed hills (1 and 2), modern limestone quarry on the road to Sorah opened during the construction of the new bridge between Sukkur and Rohri in 1998 (3), heaps and piles of chert blocks and prehistoric artefacts in the Shadee Shaheed Hills (4 and 5), and Unnar Hills totally erased by limestone block workers (6) (photographs by P. Biagi and E. Starnini).

To conclude, several problems and questions regarding chert extraction and distribution during the Indus Civilization are still open and unanswered due to absence of proper information, among which are:

1. The existence, in Sindh, of several outcrops of chert visually very 'similar' to those of the Rohri Hills and with clear evidences of exploitation attributable to the Indus period, challenges

the current, suggested hypothesis of one single procurement area;

2. The difficulty of characterizing siliceous rocks with scientific methods (Barfield 1999; Bressy *et al.* 2006), does not enable us to indisputably discriminate the sources in the same ways as for example obsidian;
3. The scarcity of systematic analyses (typological, technological and functional) of the chipped

stone assemblages recovered from the urban centres of the Indus Civilization.

The study of chert exploitation shows that this resource played indeed a crucial role in the operative chain of several handicrafts during the Indus Civilization. The strategic and economic importance of this raw material can be inferred by the impressive traces left on the landscape of Sindh in form of extraction and mining districts and knapping floors and workshops, where tons of chert have been extracted and millions of blades have been produced.

Yet, at the present state of our knowledge, we are unable to state whether the organization of production of this resource was controlled by a centralized organization, as recently hypothesized (Law 2008: 754–755), or perhaps it was an activity entertained by peripatetic groups of artisans comparable to those that still exist today (Berland 1992; see also Mughal 1994). In any case the sophisticated technological evidence (Inizan *et al.* 1994), coupled with the discovery of a unique preceramic Neolithic burial attributed to a chert knapper excavated at Mehrgarh (Inizan and Lechevallier 1985), undoubtedly suggests the existence of specialized artisans who indeed had an important role in the complex society of the Indus Civilization.

It is regrettable that most of the archaeological sites discussed in this paper have already been destroyed by illegal industrial limestone and chert quarrying still going on (Figure 10, nn. 3–6), and no attention has ever been paid for their protection by both national and local authorities despite their importance as unique prehistoric heritage of the country (Biagi 2006; Dennell 2014: 99).

Acknowledgements

The 2005–2010 surveys at Ongar and Jhampir were carried out in collaboration with the Institute of Sindhology, Sindh University (Jamshoro, PK). The authors are very grateful to the former Vice-chancellor of Sindh University, Mr Mazharul Haq Siddiqui, and the former Institute's Director, Mr Shoukat Shoro, for all their help before and during his permanence at Sindh University Campus. Many thanks are due to Mir Atta Mohammad Talpur, Mir Farooq Ahmed Talpur, Mir Ghulam Rasool Talpur and Mir Abdul Rehman Talpur, who took part in the Ongar and Daphro surveys, for all their help and assistance, to Dr C. Franco, who took part in the 2008 fieldwork season at Ongar and Daphro, and Dr R. Nisbet for his assistance during the surveys at Jhampir and Ranikot.

The research in Sindh was carried out thanks to the financial support of the Italian Ministry of Foreign Affairs (MAE) (Rome, I), Prehistoric Society (London,

UK), National Geographic Society (Washington, USA), Ca' Foscari University Archaeology Funds (Venice, I), EURAL Gnutti Ltd (Rovato, I), and the CeVeSCO (Ca' Foscari University, Venice, I).

Special thanks are due to R. Cabella and M. Piazza (Genoa University, I) and B. A. Voytek (Berkeley University, USA) for the linguistic revision of the original manuscript.

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