Understanding Soanian occurrences at Bam locality of Siwalik frontal range, north-western India

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Abstract Paleolithic evidence of the Indian subcontinent is often expressed through the wealth of lithic antiquities from the Stone Age. In this region, the earliest known lithic remains comprise simple cores and flakes recovered from the Siwalik Hills. The Siwalik Hills are the foothills of the southern edge of the Himalayas, and area goldmine zone for Soanian lithic implements. Although Acheulean remains have also been reported, their occurrences are few. Nevertheless, these remains have been known date from the Pleistocene, which shows varied patterns of land use and intrainregional versatility. In the Siwalik Hills, Soanian implements are of two kinds: (i) a chopper type of the Lower Paleolithic period and (ii) a flake type belonging to the Middle Paleolithic period. The present study was undertaken at a newly discovered Stone Age locality, Bam, located within the frontal range of the Siwalik Hills in the Bilaspur district of Himachal Pradesh, India. The area under study plays an important role in understanding the relationship between people and land. The paper explores the Soanian cultural remains of the site to obtain an in-depth understanding of its nature against the backdrop of raw material availability and exploitation. The study also throws light on the local geological and geomorphological settings of the area.

Key words: Siwalik Hills, Bam, Geomorphology, Soanian, Raw material exploitation

Introduction

The Indian Himalayan ranges cover the states of Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Arunachal Pradesh, Sikkim, Assam, and the hilly areas of West Bengal, and comprise three segments: (i) the higher Himalayas toward the Tibetan plateau, (ii) the lesser Himalayas, and (iii) the sub-Himalayas. The higher Himalayas are formed from metamorphic rocks and magnetic rocks. Grades of metamorphic rocks with intrusions of amphibolites, stones, pegmatites (generally crystalline rocks or various volcanic stones with a few centimetres of crystals), and quartz constitute the lesser Himalayas (Abdessadoka et al., 2016). As indicated by Mohapatra (2007), lithologically and ecologically the sub-Himalayas comprise three zones: (i) the Siwalik frontal range (abruptly transcending and flanking the Indo-Gangetic plains); (ii) the Duns (a progression of flat-bottomed longitudinal structural valleys with well-developed terraces); and (iii) the lesser Himalayas piedmont against which abut the terraces of the Duns. The Siwalik Hills comprise a 2400 km long stretch. They stretch from the Potwar plateau region of Pakistan to the north-eastern part of India and onto Myanmar, the south-western Himalayan frontier (Figure 1).

Geologically, the Siwalik Hills show sediments of natural freshwater molasses accumulated in a long narrow foredeep. They formed to the south of the rising Himalayas, and had their origins in the third and most dramatic uplift during the Middle Miocene to Middle Pleistocene. Structurally, the Siwalik Hills were folded, and over thrust toward the south by the Lower Tertiary formations (Tripathi, 1986). The foreland basin of the Siwalik Hills comprises fluvial deposits (Chauhan, 2009). It is an active collisional foreland basin system that covers five nations, i.e. India, Nepal, Pakistan, Bhutan, and Bangladesh, with a width of 450 km (280 miles) and a length of 2000 km (120 miles) (DeCelles, 2012). Records of sedimentary rocks accumulated in the more extensive Himalayan territory encompassing India and Nepal go back to the underlying creation of the foreland basin. It began around 45–50 million years ago in the Paleogene time when the Indian and Asian plates crashed together. The stratigraphic progression of the basin is remarkable as it maintains and identifies with the Himalayan orogenesis. It is the proof of the collision between the Indian and Eurasian plates. The significance of the Siwalik foreland basin’s stratigraphy is unrivalled because of its role throughout geographical time in the development of the basin. This basin comprises fluvial dregs kept by hinterland rivers streaming southwards and south-westwards (Gill, 1983; Chauhan, 2009, 2010) from the lesser and greater Himalayas when the south area of these mountains were initially a basin (Brozovic and Burbank, 2000). Stratigraphically the deposits of...
the Siwalik Hills are divided into three subgroups (Table 1), which in turn are divided into eight formations (Randell et al., 1989; Chauhan, 2003; Kumarvel et al., 2005).

Starting from the Miocene Epoch, the Siwalik Hills are notable for the remains of fossil primates and are considered to be the critical developmental centre for sub-Himalayan primates. India shows evidence of the early history of hominoid evolution in sediments from the Siwalik Hills of the north-western sub-Himalayas in the Late Miocene (c. 13–5.5 million years ago). The north-western part of India in the Siwalik Hills showcases well-preserved evidence, enabling researchers to comprehend human evolution and behavior in terms of the evolving climate of the Earth during the prehistoric period. The Neogene strata in northern India and Pakistan's Siwalik range offer one of the most complete progressions of mammalian fossil faunas on Earth. Since the mid-1800s, hominoid fossils such as Sivapithecus and Gigantopithecus have been sporadically reported from the Siwalik Hills. Evidence shows that they all prospered in the Siwalik Hills essentially simultaneously and vanished from these hills because of the cooler climate existing from 8 to 6 million years ago (Dutta, 1984). Fossils of small mammals from this part of the Siwalik Hills include hedgehogs, tree shrews, squirrels, shrews, dormice, gundis (Ctenodactylidae), bamboo rats (Rhizomyines), and Late Miocene porcupines and rabbits, felids, viverrids, creodonts (until Late Miocene), lorises, hipparionine equids (Late Miocene onward), rhinocerotids, anthracotheres, giraffids, tragulids, and bovids. These are recovered at different points of times. It is important to mention that few archaic lineages continued much later here, at times when such continuity is found nowhere else in the Old World (Flynn et al., 2016). There is plentiful evidence of hominin occupation in the Siwalik area of the Indian subcontinent since at least the Middle Pleistocene. Such evidence has been found in multiple ecogeographic locales of north-western India as well as in Pakistan (Chauhan, 2006). The Paleolithic locales of these regions are divided into two lithic traditions, the Acheulean and Soanian, which present different forms (Chauhan, 2009). Lithic assemblages from the Siwalik Hills mainly comprise lithic artefacts popularly known as Soanian. These Soanian lithic assemblages are of two kinds: the chopper type from the Lower Paleolithic, and the flake type from the Middle Paleolithic.

Review of Earlier Studies

Quaternary investigations in the Siwalik Hill region started a century ago and were mostly based on geological and environmental events. The first comprehensive Quaternary study of this region was carried out by de Terra and Patterson under the aegis of the 1935 Yale–Cambridge expedition (de Terra and de Chardin, 1936; de Terra and Paterson, 1939). This work was interdisciplinary and yielded significant out-

| Sub-group         | Formation                  | Corvinas and Raimal, 2001 (Ma ago) | Prasad, 2001 (Ma ago) |
|-------------------|----------------------------|-----------------------------------|-----------------------|
| Upper Siwalik     | Upper Boulder Conglomerate | 0.9–0.2                           | 0.9–0.2               |
|                   | Lower Boulder Conglomerate | 5.9–7                             | 2.4–0.9               |
|                   | Pinjore                    |                                   | 5.1–2.4               |
|                   | Tatrot                     |                                   |                       |
| Middle Siwalik    | Dhok Pathan                | 7.9–5.2                           |                       |
|                   | Nagri                      | 10.1–7.9                          | 10.8–5.1              |
|                   | Chinji                     | 13.1–10.1                         |                       |
| Lower Siwalik     | Kamlial                    | —                                 | 18.3–10.8             |
comes. It became a standard work of reference on which all subsequent prehistoric research in the subcontinent relied. Indeed, even de Terra himself utilized this study as a standard reference to explain his perceptions of Indian Stone Age cultures (Bain, 2020). Additionally, this British–American group constructed the cultural labels to designate the lithic remains of this region (Hawkes et al., 1934; Movius, 1948; Soni and Soni, 2017) and extensively set their inception in the Middle Pleistocene (Dennell and Hurcombe, 1993; Chauhan, 2007). Before the Yale–Cambridge expedition, proof of the existence of early people in the western sub-Himalayan was given by Wadia (1928). Dianelli’s work in 1922 was a forerunner of the subsequent work carried out by the Yale–Cambridge expedition. Later, the Indian National Council initiated an undertaking in the Karakoram in 1954. Under the aegis of this endeavour, Graziosi (1964) found and analysed a number of lithic artefacts and sites in north-western Punjab (Pakistan); this represented another achievement in the research on early people in the western sub-Himalayan region and its surrounding areas. Following de Terra and Paterson’s work, various lithic localities have been discovered in the Indian part of the sub-Himalayan region after the partition of the subcontinent in 1947. In the mid-20th century the Archaeological Survey of India (IAS, 1954–1955) retrieved some pebble tools from Daulatpur area, Punjab (India), which unexpectedly provided the primary decisive proof of the presence of early people in the Soan Dun towards the Beas River. During that time Prufert (1956) found various Stone Age sites in the valley of Sirsa within Pinjore-Nalagarh Dun while looking for expansion of the Harappan civilization in the Sutlej valley. The first occurrence of the Soanian pebble industry in the Siwalik Hills of Himachal Pradesh was discovered in Kangra district (Lal, 1956; Joshi et al., 1978) and in the Sirsa terraces of Nalagarh Dun (Sen, 1955; Karir, 1985). Lal (1956) led an expedition and investigated the Beas valley and the Banganga in the Kangra valley of Himachal Pradesh. He considered the terraces of the Banganga around Guler and tried to relate the horizons of the implement-bearing deposits. He additionally saw the occurrence of paleoliths in Kangra, Dehra and Dhalliara situated upstream, to the north and west in Guler. Sen (1955) published a detailed study of his perceptions in the field concerning Prufert’s sites and analysed the lithic artefacts from this zone, specifically around Nalagarh. Although Sen compared the Nalagarh lithic industry with the early Soan of West Pakistan, Mohapatra (1966, 1974) has studied Soan lithics from a typo-technological view. Subsequently, various scholars and organizations started working in this area, including Khatri (1960), Krishnaswami (IAS, 1964–1965), the Archaeological Survey of India (IAS, 1965–1966, 1968–1969, 1969–1970), Mohapatra (1966, 1974), Mohapatra and Saroj (1968), Joshi (1970), Sankalia (1971), Joshi et al. (1974), and came up with different Stone Age localities along with artefacts. Saroj (1974) examined the Jammu region of the Kashmir valley between the Chenab and the Ravi, expanding de Terra and Paterson’s work in Potwar in the west and Lal’s and Mohapatra’s work in Kangra in the east. He found 16 sites and assigned different lithic industries as Jammu A, B, C, and D, and compared these to the Soanian industries. Moreover, he likewise recorded finding certain neoliths from this zone (Saroj, 1974). Joshi et al. (1975) noted sub-triangular points on quartzite flakes along with small choppers on pebbles from the Saketi area of Markanda valley of Himachal Pradesh, and after analyzing and comparing the recovered artefacts with those from other sites he has suggested the evolution of Paleolith industries and their stratigraphy independently without labelling them with the progressions as described by de Terra and Paterson (1939) in the Soan Valley (Joshi et al., 1978). The discovery of the hand axe and chopper industry from Pahalgam in the Kashmir valley in relation to inferred glacial boulder clay deposits has generated significant enthusiasm for that region (Sankalia, 1971; Joshi et al., 1974). The essential in situ position of the paleoliths discovered from the terraces of Kangra valley of Himachal Pradesh remains dubious, although enormous assortments have been found during an excavation conducted on the third terrace of the Beas at Dehra Gopipur (Mohapatra, 1966). The assortment of paleoliths collected by various researchers at various times and places in the Beas–Banganga basin show choppers to be the most predominant tool type, with Unifacial choppers exhibiting greater strength than bifaces. The presence of unifacial choppers in great numbers is essentially unique to the sub-Himalayas: in the Acheulean industries of India the hand axes and cleavers are typically bifacially worked. Findings made at Guler on the Banganga chopper group ought to be recognized as a different entity and recognized as Guler industry. Mohapatra (1974), in his research on prehistoric cultural evidence from Himachal Pradesh, distinguished Nalagarh industry from that of the Beas–Banganga valley principally based on many facts that led him to consider Beas–Banganga and the Sirsa valley to be the Soan or pebble–tool culture of the Indian early Stone Age. The lithic industry of the Sirsa valley, as noted by Mohapatra, is a developed manifestation of the Beas–Banganga industry, which is undoubtedly older. It is important to note that the lithic complex of the Chikni valley, adjacent to the Pinjore–Nalagarh Dun, actually resembles that of the Sirsa valley, and taking into account their similarity, Mohapatra and Singh (1979) consider the former as a vital part of the latter. Sharma (1977) found Acheulean bifaces from Upper Siwalik sediments close to Chandigarh, and Mohapatra (1981) later tested the stratigraphic position of these antiquities. Joshi (1967) likewise reported Acheulean artefacts in the Kangra valley, and these were later morphologically classified as non-Acheulean (Karir, 1985). Khanna (1981) discovered a few stone implements from the Saketi area of Himachal Pradesh, and this investigation led researchers to discover more locales in this area. During the mid-1970s, the first Acheulean site (Atbarapur) in the Indian part of the Siwalik Hills was found by Mohapatra (1981; 1990; Mohapatra and Singh, 1979). This is one of the most significant Acheulean locales in the Siwalik zone from where the largest collections of Acheulean artefacts have been reported. The antiquities from Atbarapur provided significant data with respect to the technological behaviour of the Acheulean population of the Punjab plain. Chauhan (2007) discovered a new Soanian locality, Toka, in Sirmaur district of Himachal Pradesh, and this discovery connotes typological diversity within Soanian industry. Since 2009, a
A group of archaeologists’ under the Indo-French Prehistoric Mission has been surveying the Siwalik frontal range in the vicinity of Chandigarh, and has revealed a dozen Stone Age localities (Gaillard et al., 2016). The prehistoric sites in the Bilaspur district of Himachal Pradesh nevertheless remain unexplored. In this region, very few studies have been conducted (Sankhyan, 1979, 1983, 2017).

Materials and Methods

This study was conducted at the Bam site, Ghumarwin Tehsil, Bilaspur district, Himachal Pradesh (Figure 2 (a)). It is located about 15 km away from Ghumarwin Tehsil and situated near the bank of the Seer Khad River (a third tributary of the Sutlej River). Jhandutta Tehsil encompasses Bam to the south, Bijnhi Tehsil to the west, Bilaspur to the east, and Bhoranj Tehsil to the north. The main river system of Ghumarwin is Seer Khad, situated in the lower Sutlej basin (Figure 3), which rises at Wah Devi (10 km from Sarkaghat) in Mandi district and drains the Kot-ki-Dhar and the more noteworthy segment of the Ghumarwin tahsil. It goes through Bilaspur district and meets the right bank of the Sutlej at Serimatla village approximately 15 km downwards from Bilaspur town. The total length of the Seer Khad River is 35 km, and its average width is 150 m (Micro, Small & Medium Enterprises Development Institute, 2016–2017). It lies at 31°55'59"N and 76°70'55"E (Figure 4). This area has been chosen because (i) the prehistoric archaeology of the Ghumarwin region has yet to be explored; (ii) the stretches between Bilaspur and Ghumarwin (where the area of study is located) are currently under threat due to development work such as road and bridge building and agricultural activities; (iii) the study area lies in the Ghumarwin, which is better known for hominoid fossil remains, but less acknowledged from a prehistoric archaeology point of view; and (iv) the Seer Khad River and its encompassing regions may have been a similarly significant region in the past due to its strategic location, geology, topography, and reasonable environment for Stone Age settlement.

The study was carried out to explore and systematically record the area before it loses all its Stone Age cultural evi-
dence because of ongoing development work. The present study uses basic archaeological methods. The investigation looked at the preliminary approach to landscape to deal with the archaeological materials of the site. Two seasons of extensive field investigation have been carried out to assess its prehistoric potential. The work has utilized the topographical maps and previous works carried out in the region. Pedestrian surveys have been used to identify potential zones. The typo-technological method has been used to analyse the lithic artefacts recorded at the studied locality. A litholog has been built up from the naturally exposed sections of the site to understanding the stratigraphic succession of layers. For better understanding of the studied area in terms of its geographical setting and other important features, satellite imagery and detailed geological, geomorphological, and topographical maps were used. The maps have been collected from the ISRO Bhuvan website and prepared with ARC 9.3 software.

Local Geology, Geomorphology, and Stratigraphy

The district of Bilaspur is mostly surrounded by Himalayan foothills with the exception of the easternmost parts of the hills, which are grouped with the lower Himalayas. Geologically, Ghumarwin Tehsil comprises the Lower Siwalik groups, the Middle Siwalik groups, and the Upper Siwalik groups, the Tertiary and Quaternary periods and the unidentified Muree groups, the Dharmasala groups, and the Kasauli and Dagshai groups of the Oligocene and Miocene periods. The area under investigation comes under the Upper Siwalik group (Figure 5).

Different aspects of local geomorphology have been observed during fieldwork, and certain features such as geomorphic units, relief, surface material, topographic texture, drainage, and deposition have received special consideration. The survey provided field-based findings that were approved by the 1:250000-scale topographic sheet (Survey of India). The area’s geomorphology comprises several large Middle Pleistocene and Holocene Himalayan alluvial piedmont fans and terraces. The terraces are placed and cut into the toe-edge of the fans. Local geomorphic features are identified with these two characteristics that are related in terms of both depositional and erosional processes as the results of tectonic and climatic events. The important geomorpholog-

Figure 4. Location of the Seer Khad River (red line) and its cross-sectional profile (ARC GIS 9.3 software has been used to prepare the map with the help of satellite imagery of ISRO Bhuvan and Google Earth).

Figure 5. Geological map of Ghumarwin Tehsil.
cal feature of the studied area is the unconformity between the contacts of Upper Siwalik sediments with Post Siwalik conglomerates (Figure 6). The region is a gently sloping track comprised mainly of coarse gravel and subject to alteration caused by a small amount of surface runoff, demonstrating little of the substantial impacts of mass-wasting and mechanical weathering so typical of the Siwalik Hills. It is important to note that the surface material is comprised of soil over the vast majority of the locale, which contains an enormous number of pebbles and cobbles of quartzite.

The site’s elevation is 663 m AMSL. The relief fluctuates enormously in this area from 452 to 1828 m (Figure 7), due to local and regional tectonic conditions as well as depositional and erosional nature. The relief variability in this area is representative of the immense measure of denudation that occurred in the Pleistocene period since the final uplift of the Himalayas. It can be seen that the eastern side of the site is undulating and rough. The height of the south-east side’s slope is higher than that of the west side.

Topsoil has been expelled in certain areas due to agricultural activity, and the pebbly gravel layer has been exposed. The gravels are of different sizes and comprise mainly quartzite through the gravel of sandstone where their density is low. The structure of the topography is very fine. A few chos (seasonal rivers) drain the studied locality and its surroundings.

Seven sediment samples were collected from the studied locality to establish the composite stratigraphy. The whole stratigraphic log is represented by eight members (A–H) (Figure 8). Member A (0.5 m thick) comprises clayish silt. This sediment is loose in nature. The texture of the sand varies from medium to fine. Member B (~2.7 m thick) is comprised of pebbles of different shapes and sizes, which are associated with yellowish-brown silt. It is harder than member A. Member C (0.9 m thick) contains sandy silt and cobbly gravels. The size of the gravel varies. The grain size of the sandy silt also varies. No lamination has been observed. Member E is 1 m thick and composed of brownish silt and breccia. This
member is harder than member D. Member F (0.6 m thick) comprises yellowish cross-bedded sand. Its grain size varies from coarse to medium. Member G (0.67 m thick) comprises yellow-brown silt. This sediment is hard in nature. Member H (0.7 m thick) comprises unconsolidated silty clay.

The Seer Khad River is connected to this region’s drainage system. Strahler’s method (Strahler, 1952, 1957) was used in this study to delineate the stream order. The river basin is classified into five stream orders. The river basin area map indicates that first-order streams have more stream frequency. The basin comprises a total of 230 streams, 172 of which are first-order streams, which is 74.78% of the total basin area, and second-, third-, fourth-, and fifth-order streams number 44, 11, 2, and 1, respectively. The magnitude of permeability and the infiltration properties of the studied area have been designated by the maximum numbers of first-order streams (Figure 9).

The water sources for the Seer Khad River are snow-melt and monsoon runoff. There are several little streams and nullahs associated with Seer Khad. The streams bear flash flood release as a significant part of the precipitation is connected to monsoonal deluges. The Seer Khad River contributes to the primary geomorphological attributes of the studied region alongside the streams and chos. Geological evidence of the area shows that the drainage pattern was established during the Pleistocene. Terraces characterize the south-western segment of the site and geomorphologically this is one of the site’s common attributes. The cutting and the filling process by the river made the terraces. Three terraces have been found in the studied area, alongside the course of the Seer Khad waterway: terraces T-1, T-2, and T-3. T-1 is the sub-Himalayan piedmont region and represents the first broad terrace with a thickness of about 25 ft, comprised of Upper Siwalik boulder conglomerate.

A few in situ Paleolithic stone tools were found on this terrace. Many more were found at the base. Underneath the T-1, there is T-2 which may have been around 20 ft but has gradually been cut down in various stages by the waterway and, in this manner, in the end, slid to the ongoing channel bed. It is important to note that in certain spots local cultivators have endeavoured to convert the unfertile and pebbly land surface to plots of arable fields and have reclaimed land by removing the sheet of the uppermost surface of T-2. Some parts of T-2 are implementiferous. The T-3 is blended in with Seer Khad’s boulder-cobble stream bed. It was noted that the Pleistocene deposit of the area is generally of the fluvial root. Due to the washout of the sediments, the thickness of the exposed sections fluctuates.

### Lithic Assemblage

Exploration at the Bam site has revealed a total of 238 lithic artefacts (Sup Figure 1). Different artefacts of the Bam assemblage show different intensities of weathering because of direct exposure on the surface in different seasonal periods. In the Study area, fluvial transportation is the main reason for weathering on artefacts. Weathering on the studied artefacts has been classified into four categories: fresh, slightly weathered, moderately weathered and heavily weathered. It is observed that 14.29% of artefacts are in fresh condition, while 8.82%, 32.35%, and 44.54% of arte-
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Table 2. Percentage of types of preservation of the artefacts

| Type of preservation      | n  | %   |
|---------------------------|----|-----|
| Fresh                     | 34 | 14.29 |
| Slightly weathered        | 21 | 8.82 |
| Moderately weathered      | 34 | 33.35 |
| Heavily weathered          | 106| 44.54 |
| Total                     | 283| 100 |

Table 3. Frequency distribution of the artefacts of at Bam

| Type of artefact          | n  | %   |
|---------------------------|----|-----|
| Core and core fragments   | 16 | 6.72 |
| Single-platform core      | 11 | 4.62 |
| Multiple-platform core    | 3  | 1.27 |
| Bipolar core              | 31 | 13.02 |

| Type of artefact          | n  | %   |
|---------------------------|----|-----|
| Flakes                    |    |     |
| Unretouched flake         | 63 | 26.48 |
| Retouched flake           | 19 | 7.98 |
| Discoids                  |    |     |
| Unifacial discoid         | 13 | 5.46 |
| Bifacial discoid          | 4  | 1.68 |
| Irregular discoid         | 9  | 3.78 |

| Type of artefact          | n  | %   |
|---------------------------|----|-----|
| Choppers                  |    |     |
| Unimarginal end-chopper   | 12 | 5.04 |
| Unimarginal side-chopper  | 9  | 3.78 |
| Bimarginal side-chopper   | 6  | 2.52 |
| Bimarginal end-chopper    | 4  | 1.68 |
| Unifacial end-chopper     | 4  | 1.68 |
| Unifacial side-chopper    | 5  | 2.10 |
| Irregular chopper         | 7  | 2.94 |

| Type of artefact          | n  | %   |
|---------------------------|----|-----|
| Scrapers                  |    |     |
| Peripheral scraper        | 5  | 2.10 |
| Sub-peripheral scraper    | 3  | 1.27 |
| Lateral-side scraper      | 10 | 4.20 |
| Double-sided scraper      | 4  | 1.68 |
| Total                     | 238| 100 |

Table 4. Dimensions of recovered lithic artefacts

| Type of artefact          | n    | Length (cm) | Width (cm) | Thickness (cm) | Weight (kg) |
|---------------------------|------|-------------|------------|----------------|-------------|
|                           |      | Max  Min Mean SD | Max  Min Mean SD | Max  Min Mean SD | Max  Min Mean SD |
| Core and core fragments   |      |             |            |                |             |
| Single-platform core      | 16   | 18.30 8.70 13.58 2.72 | 17.20 5.80 10.88 3.42 | 11.00 3.50 6.54 2.31 | 3.986 0.303 1.440 1.00 |
| Multiple-platform core    | 11   | 13.80 5.00 9.05 3.16 | 13.9 6 8.37 2.57 | 7.40 2.80 4.70 1.49 | 1.915 0.109 0.730 0.63 |
| Bipolar core              | 3    | 15.10 10.80 12.30 2.43 | 13.70 10.60 11.97 1.58 | 8 5 6.67 1.53 | 2.589 0.811 1.540 0.93 |
| Core fragment             | 31   | 17.40 8.90 12.41 2.54 | 11.50 7.50 9.90 2.10 | 8.70 5.80 7.76 1.33 | 1.942 0.179 1.504 0.58 |
| Flakes                    |      |             |            |                |             |
| Unretouched flake         | 63   | 16.40 4.00 8.55 2.50 | 13.20 2.60 3.61 1.38 | 10.4 1.10 3.61 1.38 | 0.965 0.101 0.310 0.19 |
| Retouched flake           | 19   | 19 5.80 11.52 3.11 | 13.80 3.60 10.20 2.46 | 8.00 1.70 3.84 1.35 | 1.819 0.119 0.710 0.49 |
| Discoids                  |      |             |            |                |             |
| Unifacial discoid         | 13   | 15.30 9.60 12.48 1.65 | 11.30 10.80 10.26 1.45 | 6.30 5.50 4.52 1.13 | 1.650 0.119 1.030 0.30 |
| Bifacial discoid          | 4    | 11.60 8.90 10.20 1.26 | 8.20 6.70 7.58 0.71 | 4.20 3.60 3.88 0.25 | 0.587 0.365 0.460 0.09 |
| Irregular discoid         | 9    | 13.70 7.00 10.61 2.04 | 11.80 5.80 8.79 2.01 | 6.70 3.90 5.51 0.90 | 1.324 0.657 0.970 0.22 |
| Choppers                  |      |             |            |                |             |
| Unimarginal end-chopper   | 12   | 12.80 7.60 9.99 1.57 | 10.80 5.80 8.60 1.61 | 6.80 3.10 4.78 1.05 | 0.748 0.365 0.550 0.10 |
| Unimarginal side-choppers | 9    | 14.20 9.20 11.33 1.50 | 13.10 7.50 9.94 1.90 | 9 3.90 6.11 1.81 | 1.625 0.483 0.860 0.33 |
| Bimarginal end-chopper    | 4    | 9.80 8.20 8.88 0.73 | 10.10 6.80 8.65 1.38 | 5.20 3.80 4.67 0.64 | 0.793 0.541 0.680 0.11 |
| Bimarginal side-chopper   | 6    | 12.30 9.80 10.85 1.00 | 12.50 10.30 11.13 0.81 | 8.60 6 7.55 1.11 | 1.234 0.898 1.020 0.12 |
| Unifacial end-chopper     | 4    | 13.90 10.50 11.68 1.52 | 9.90 7.60 8.68 0.94 | 7.50 3.20 5.58 0.23 | 1.641 0.302 1.000 0.56 |
| Unifacial side-chopper    | 5    | 11.10 8.50 9.76 1.08 | 9.90 7.10 8.08 1.17 | 6.50 3.60 4.94 1.14 | 0.743 0.380 0.600 0.17 |
| Irregular chopper         | 7    | 12.60 9.60 11.03 1.06 | 13.80 8.60 9.99 1.86 | 9 5 6.50 1.32 | 1.455 0.53 0.970 0.30 |
| Scapers                   |      |             |            |                |             |
| Peripheral scraper        | 5    | 12.20 7.40 10.08 1.92 | 15.80 8.50 11.16 3.27 | 6 2.20 4.58 1.42 | 0.838 0.228 0.620 0.24 |
| Sub-peripheral scraper    | 3    | 15.60 7.60 12.90 4.59 | 10.30 9.10 9.60 0.62 | 3.70 3.50 3.63 0.12 | 0.700 0.322 0.570 0.22 |
| Lateral-side scraper      | 10   | 14.10 7.10 9.90 2.67 | 12.80 5.70 8.49 2.48 | 5.10 1.70 3.13 1.00 | 0.793 0.114 0.350 0.22 |
| Double-sided scraper      | 4    | 11.70 6.80 9.48 2.36 | 8.50 5 7.13 1.51 | 4.10 3 3.70 0.48 | 0.942 0.219 0.440 0.34 |
Table 5. Stone tools on different blank types at Bam

| Stone tool type          | Nature of banks                                      | Total |
|--------------------------|------------------------------------------------------|-------|
|                          | On complete cobbles | On split cobbles/broken cobbles | On flakes |       |
| Unimarginal end-chopper  | 2                     | 8                        | 2           | 12    |
| Unimarginal side-chopper | 1                     | 5                        | 2           | 9     |
| Bimarginal side-chopper  | —                     | 4                        | 2           | 6     |
| Bimarginal end-chopper   | —                     | 2                        | 2           | 4     |
| Unifacial end-chopper    | —                     | 1                        | 3           | 4     |
| Unifacial side-chopper   | —                     | 5                        | —           | 5     |
| Irregular chopper        | —                     | 4                        | 3           | 7     |
| Peripheral scraper       | —                     | —                        | 5           | 5     |
| Sub-peripheral scraper   | —                     | —                        | 3           | 3     |
| Lateral-side scraper     | —                     | —                        | 10          | 10    |
| Double-sided scraper     | —                     | —                        | 4           | 4     |

Figure 10. High density of clastic material in the Seer Khad River at the Bam site. Inset shows core with large flake scars.

Toolmakers had probably chosen the cores and blanks specifically for their desired tools. River-born pebble and cobble (Figure 10) were the preferable types to manufacture the artefacts, and the raw materials are noticed at this site and seem to be fluvial in nature from nearby hilly tracts. In all probability, the source of the raw material is boulder conglomerate formation, which has been observed near ≤7 km north-west the study area. The artefacts have come mostly from the surface context (Figure 11). Artefacts extend over the gravel surface with a density exceeding ~3–5 artefacts/m². Since there was the differential density in the spatial occurrence of artifact, a grid method has been applied for systematic surface collection.

The analysed artefacts have provided valuable information on the technological aspects of this region and how technology worked in the social and mechanical worldview of the individuals who manufactured these items during the Pleistocene period. Lithic remains and their qualitative attributes are depicted in detail. It is important to mention that the hard hammer percussion technique was the method used at this site for removal of flakes.

Core and core fragments

Altogether, 61 core and core fragments (angular fragments/chunks) (Sup Figure 3) have been analysed. These comprise 25.63% of the entire Bam assemblage. Core and core fragments are subdivided into four types: single-platform core (n = 16), multiplatform core (n = 11), bipolar core (n = 3), and core fragments (n = 31) (Table 3). Of these, 18 cores clearly show a cortex patch on the surface, which signifies that they are river cobbles or boulders. Among the core types, the single-platform cores exhibit the highest lengths and widths though a little irregularity is observed (Figure 12). The highest mean value within cores are found for single-platform core (13.58 cm), followed by other subtypes such as bipolar cores (12.30 cm) and multiplatform cores (9.05 cm). The highest SD for mean length is found for multiplatform cores (3.16 cm). The core width is in the range of 17.2–5.8 cm. The highest mean width is found in bipolar cores (11.97 cm), followed by single-platform cores (10.88 cm) and multiplatform cores (8.37 cm). The highest SD for mean width is found for single-platform cores (3.42 cm). The maximum core thickness is 11 cm, and the
minimum 2.8 cm. The highest mean thickness is found for bipolar cores (6.67 cm), and the maximum SD for thickness is found for single-platform cores (2.31 cm). The highest mean weight among the core types is 1.54 kg for bipolar cores, but the SD of the mean weight has been found in single-platform cores. In the case of core fragments, the maximum and minimum length is 17.4 and 8.90 cm (mean 12.41 cm). The SD for the mean length of these artefacts is 2.54 cm. The width of the artefacts varies between 11.5 and 7.5 cm (mean 9.90 cm). The thickness varies between 8.7 and 5.8 cm (mean 7.76 cm). The core fragments weigh 1.079–1.942 kg (mean, 1.54 kg) (Table 4).

The single-platform cores ($n = 16$) constitute 6.72% of the total assemblage (Table 3). It generally provides a single platform plain or striking platform for sequential and unidirectional flake detachment. Multiplatform cores ($n = 11$) represent over 4.62% of the total assemblage. The flaking type of these artefacts is sequential but multidirectional. Large numbers of this type have been utilized randomly to obtain flakes of different types. Morphologically these artefacts are comparatively similar with angular core fragments. Nevertheless, based on the amount of flaking, multiplatform cores differ from angular core fragments. Half of the cores are based on split cobbles. Half (50%) of the multiplatform cores show minimal edge damage, probably due to river activities. Only three ($n = 3$) bipolar cores have been found, representing only 1.27%. It can be hypothesized that the bipolar technique was usually employed by the prehistoric
people of the studied locality when the suitable raw material was available in minimal quantities. This kind of activity resembled the maximum exploitation of the raw material from small clasts. Core fragments \((n = 31)\) are higher in frequency \((13.02\%)\) among the core and core fragment categories \((Table 3)\), and from the relative dimensional perspective, it has been observed that multiphase cores are comparatively smaller than this type of artefact \((Table 4)\). Core fragments within the studied assemblage exhibit lower portions of the cortex and complete flake scars.

Flakes

Altogether, 82 flakes \((43.46\%\) of the entire assemblage) have been recovered from the site. The flakes are typological observation and metrical parameters of the flakes, they can be divided into unretouched \((n = 63)\) and retouched flakes \((n = 19)\) \((Table 3)\) and from technologically categorized into side-struck and end-struck flakes \((Sup Figure 4)\). There is no indication whatsoever available to determine the order of flakes, such as primary, secondary, and tertiary ones as they were detached from the core. The length of the unretouched flake varies between 4 and 16.4 cm \((mean, 8.55\ cm)\). The SD for the mean length of these artefacts is 2.50 cm. The maximum and minimum value of unretouched flake width is 13.20 and 2.60 cm \((mean, 3.61\ cm)\). The thickness varies between 1.10 and 10.4 cm \((mean, 3.61\ cm)\). The SD for the mean thickness of the artefacts is 2.89 cm. The weight varies between 0.101 and 0.965 kg \((mean, 0.71\ kg)\). The SD for the mean weight of these artefacts is 0.49 kg \((Table 4)\).

The dorsal portion of most of the flakes \((n = 54)\) is fully cortical. Among the flakes, a few specimens exhibit a flat ventral surface and a cortical surface. Three types of platform have been observed within the flake implements: flat \((n = 46)\), complex \((n = 19)\), and abraded \((n = 17)\) \((Table 6)\). The length, width, and thickness of the flat platform vary between 3.7 and 13.5 cm \((mean, 7.61\ cm)\), 0.9 and 6.4 cm \((mean, 3.17\ cm)\), and 1.5 and 6.7 cm \((mean, 3.57\ cm)\). Complex platforms range in length from 3.5 to 11.8 cm \((mean, 6.47\ cm)\). The width of the complex platform varies between 1 and 5.6 cm \((mean, 3.18\ cm)\). The thickness of the complex platform varies between 1 and 5.6 cm \((mean, 3.18\ cm)\). The weight of these artefacts varies between 0.101 and 0.965 kg \((mean, 0.71\ kg)\). The SD for the mean weight of these artefacts is 0.49 kg \((Table 4)\).

The number of sides retouched on flake is 11.8 3.5 6.47 2.32 5.6 1 3.18 1.24 6.1 1 3.25 1.32

Discoids

Three different categories of discoids \((n = 26)\) have been found: unifacial, bifacial, and irregular \((Table 3)\). These are the residual cores having circular contours due to varying numbers of flake scars \((Sup Figure 5)\). It is noted that the direction of the flake scars in the discoid types show converging, semi-converging and non-converging ridges at the centre of each specimen. These cores were exploited heavily to obtain a number of flakes. The longest discoids are in the unifacial category, 15.30 cm, and the shortest in the irregular category, 7 cm. The highest mean length is found in unifacial discoids. The width and thickness of the artefacts vary between 5.8 and 11.8 and 3.6 and 6.3 cm. The highest and lowest mean width and thickness is 10.26 and 7.58 cm and 4.52 and 3.88 cm. The weight varies between 1.119 and

| Type of platform | n | % |
|-----------------|---|---|
| Flat            | 46| 56.10 |
| Complex         | 19| 23.17 |
| Abraded         | 17| 20.73 |
| Total           | 82| 100  |

| Platform type | Length (cm) | Width (cm) | Thickness (cm) |
|---------------|-------------|------------|---------------|
|               | Max | Min | Mean | SD | Max | Min | Mean | SD | Max | Min | Mean | SD |
| Flat          | 13.5| 3.7 | 7.61 | 2.89 | 6.4 | 0.9 | 3.17 | 1.50 | 6.7 | 1.5 | 3.57 | 1.50 |
| Complex       | 11.8| 3.5 | 6.47 | 2.32 | 5.6 | 1   | 3.18 | 1.24 | 6.1 | 1   | 3.25 | 1.32 |
| Abraded       | 12.6| 3.2 | 6.65 | 2.49 | 5.3 | 1   | 2.95 | 1.14 | 4.9 | 1   | 3.05 | 1.19 |

Table 6. Platform types of the flakes

Table 7. Dimension of the flake platform
0.365 kg. The maximum mean weight is 1.03 kg, and the minimum 0.46 kg (Table 4). Bi-dimensional diagram (Sup Figure 2) represents the dimensional homogeneity of the discoids. In the discoids, no bulb of percussion is visible. Unifacial discoid comprise the majority of the entire discoid assemblage of the site \((n = 13)\) and are flaked completely on one side. Bifacial discoids are flaked on both sides and only four of this type has been documented from the site. Irregular discoids \((n = 9)\) show similarities in flake detachment technique with the round-shaped discoids. These artefacts are made on split cobbles which vary from shapeless to oval.

**Choppers**

Altogether 47 choppers were found from the site, which constitutes 19.74% of the entire assemblage (Table 3). These are made on complete cobbles and sometimes on split cobbles or broken cobbles and flakes (Table 5). The choppers are classified into seven categories: (i) unimarginal end-chopper, (ii) unimarginal side-chopper, (iii) bimarginal end-chopper, (iv) bimarginal side-choppers, (v) unifacial end-chopper, (vi) unifacial side-chopper, and (vii) irregular choppers (Table 3). The choppers were made by only removing one flake; this is one of the major features of the Bam lithic assemblage. Among the chopper types, unimarginal side-choppers show the highest length and irregular choppers exhibit the highest width, though there are anomalies. The lowest value of the length and width are found for unimarginal end-choppers (Figure 13). The highest SD for mean length is found in the unimarginal end-choppers (1.57 cm), and the lowest in the bimarginal end-choppers (0.73 cm). Width varies between 5.8 and 13.8 cm. The maximum and minimum mean value for the width is 11.13 and 8.08 cm. The highest SD for mean width is found in the irregular choppers (1.86 cm), and the lowest in the bimarginal side-choppers (0.81 cm). The thickness of the chopper varies between 3.1 and 9 cm with the highest and lowest means of 7.55 and 4.67 cm. The dimensional attributes (maximum, minimum and average of length, width, and thickness) of the chopper types indicate that unifacial end-choppers, unimarginal side-choppers, irregular choppers, and bimarginal side-choppers are homogeneous in nature, whereas other types, i.e. bimarginal end-choppers, unimarginal end-choppers, and unifacial side-chopper, are discrete from each other (Figure 13). The weight of the artefacts varies between 0.302 and 1.641 kg. The highest mean weight was found in bimarginal choppers (1.02 kg.), and the lowest in unimarginal end-choppers (0.55 kg). The highest amount of SD for mean weight is 0.56 kg, and the lowest 0.10 kg (Table 4).

Unimarginal end-choppers comprise the main chopper category \((n = 12)\) within the Bam assemblage. These artefacts occur in varying shapes, and among them the oval is significant (Sup Figure 6). Only seven of the specimens are pointed. Two of these specimens were made on complete cobbles and others were made on rolled cobbles or split cobbles and flakes (Table 5). Unimarginal side-choppers are the next most abundant chopper category \((n = 9)\). These specimens are flaked along one edge (mostly the proximal edge). Most of this category \((n = 6)\) are oval to semi-rounded in shape and made on cobbles or split cobbles (Table 5). Bimarginal end-choppers \((n = 4)\) exhibit medium and heavy retouching. This sort of artefact is flaked along one edge yet on the two sides of the clast, accordingly creating an S-shaped working edge. It has observed that all specimens of this chopper category display step-flaking. Bimarginal side-choppers are also not abundant \((n = 6)\) in Bam, but are more numerous than bimarginal end-choppers. All artefacts of this category were manufactured through sequential flaking, and among them two choppers show both consecutive and step-chipping. Three \((n = 3)\) specimens exhibit heavy retouching. The entire face of the unifacial end-choppers exhibit flaking and frequently look like unifacial discoids but the dimension of this chopper category is generally different varied from that of the discoid category (Table 4). A unidirectional flaking pattern of this chopper category has been observed. Unifacial side-choppers \((n = 5)\) exhibit longer working edges, in contrast to end-choppers. According to Chauhan (2007), the higher recurrence of this category is standard in different regions of the Siwalik Hills. Irregular choppers \((n = 7)\) are amorphous and do not ty-
Scrapers

Twenty-two (n = 22) artefacts of this type are reported from the site (9.25% of the entire assemblage). Recovered scrapers are categorized into four groups: peripheral scrapers, sub-terminal scrapers, lateral sided scrapers, and double-sided scrapers (Table 3). They are made from flakes (Table 5). Among the scraper categories, lateral sided scrapers are dominant (n = 10) (Sup Figure 7). The maximum and minimum lengths of the scraper are found in sub-terminal scrapers (15.6 cm) and in double-sided scrapers (6.80 cm). The highest width has been found in peripheral scrapers (15.80 cm), and the lowest in double-sided scrapers (8.50 cm). The maximum and minimum thickness of the scrapers is 6 and 3 cm. The dimensional attributes of the scraper types demonstrate that all the scrapers seem to be more or less similar in their thickness, but progressively vary in their length and width. Moreover, the minimum, maximum, and average dimensions of the double-sided scrapers are less than those of other scraper types (Figure 14). The weight of the scrapers varies between 0.114 and 0.942 kg (Table 4).

Peripheral scrapers (n = 5) show a sharp working edge running almost all around the flakes and are mostly roundish or oval. It is interesting to observe that thick, broad, pear-shaped quartzite flake had been utilized for making this type of artefact. In this type of tool, the bulb of percussion is insignificant. In most of the tools, the dorsal surface is fully prepared by detaching flakes all over. Steep flaking is found on the dorsal surface of the artefacts. The length, width, and thickness are between 7.40 and 12.20 cm (mean, 10.08 cm), 8.50 and 15.80 cm (mean, 11.16 cm), and 2.20 and 6 cm (mean, 4.58 cm). The weight ranges between 0.228 and 0.838 kg (mean, 0.62 kg) (Table 4). Sub-terminal scrapers (n = 3) have a working edge covering more than half of the periphery (nearly three-quarters of the entire periphery) of the flakes. More or less thick and oval-shaped flakes have been exploited for this type of artefact. Most of the flakes have a defused bulb of percussion. The dorsal surface of the artefacts exhibits numerous small and shallow flake scars which were produced by percussions given from the periphery towards the centre of the tool, thereby making it thicker at the center. The length, width, and thickness of the sub-terminal scrapers vary between 7.60 and 15.60 cm (mean, 12.90 cm), 9.10 and 10.30 cm (mean, 9.60 cm), and 3.50 and 3.70 cm (mean, 3.63 cm). The weight of this category is between 0.322 and 0.700 kg (Table 4). Lateral side-scrapers (n = 10) have working edge placed on the lateral side just in line with the longitudinal axis (Sup Figure 7). Among this category, a few scrapers (n = 4) have a concave working edge produced by selectively removing flakes. These types of scrapers have been shaped on thick flakes. These scrapers have a broad cortical platform. A few scrapers (n = 3) have a straight working edge, which had been produced through retouching. The length, width, and thickness of this category range between 7.10 and 14.10 cm (mean, 9.90 cm), 5.70 and 12.80 cm (mean, 8.49 cm), and 1.70 and 5.10 cm (mean, 3.13 cm). The weight varies between 0.114 and 0.793 kg (mean, 0.350 kg) (Table 4). Double-sided scrapers (n = 4) have two working ends produced through the intersection of primary flaking (Sup Figure 7). More or less long thin flakes have been utilized for the manufacturing of the tools. Some of the scrapers show a prominent bulb of percussion. Most of the specimens show a narrow cortical platform. The dorsal surface of a few artefacts is fully worked. The mean length, width, and thickness of this category is 9.48, 7.13, and 3.7 cm, and the mean weight is 0.440 kg (Table 4).
Cortex Amount of the Recovered Artefacts

The cortex of the artefact is an important characteristic for identifying raw materials to manufacture artefacts. Nevertheless, sometimes it is difficult to understand due to their deposition as well as their movement from one place to another due to both natural agents and anthropogenic activity. Within the Bam assemblages 59 artefacts (24.79%) have 0–25% of cortex, 73 artefacts (30.68%) have 25–50% cortex, 47 artefacts (19.75%) have 50–75% cortex, 28 artefacts (11.76%) have 100% cortex; 19 artefacts (7.98%) have no cortex. Artefacts without cortex show a high intensity of reduction. Cortex amount is unclear for 12 artefacts (5.04%) (Table 9).

Conclusions

Every single stone tool is the cultural manifestation of the biological behaviour of our early ancestors. The Indian subcontinent’s prehistoric culture is in any event apparent from the rich lithic artefacts, mostly the styles of tools and related debitage. The north-western part of this zone is significant in numerous respects in this regard. The Ghumarwin region of Bilaspur district of Himachal Pradesh is well established on the world’s paleoanthropological map from the fossil remains of Late Miocene apes. Yet, we still have no proof concerning the Paleolithic toolmakers of this region. The lithic assemblage of Bam is a component of the widespread flake and cobbles tool tradition of the Paleolithic phase of north-western India. This comprehensive study features the significance of fresh data from the investigation of anew Palaeolithic locality in the Indian Siwalik Hills. It underscores the lithic variability within the Soanian tradition of the Indian subcontinent. The use of two parallel reduction strategies in the manufacture of the lithic assemblage of the studied locality has implications for understanding the cognitive flexibility of the Palaeolithic groups of this region. The unique diversity of Soanian lithic remains from Bam sheds light on the different types of specialized occupations that prehistoric man had embraced in this region. Stone Age hunter-gatherers of this area had an intimate knowledge of ecology and its activities and adjusted well over a wide range of climate and circumstances. Concerning the region’s conveying limit, a wide range of forest items appears to have been available in this region. Doubtless, a significant number of lithic remains found had different purposes or specialized functions. The expansion in tool sizes, structures, and designs demonstrate ways to exploit different kinds of food items or different kinds of subsistence. Seer Khad at Ghumarwin was likely the home of prehistoric man as there are numbers of natural shelters, forested ambience as well as perennial water and natural reservoirs. It is vital to mention that the terrain morphology of the entire Siwalik Hills was not the same during the prehistoric period due to the tectonic unsteadiness of Siwalik frontal range. It is noteworthy to mention that such reservoirs, brimming with fish, freshwater from the river and seasonal chos, and the Siwalik forest, made the territory appealing to prehistoric individuals. In this study, the sources of raw materials and patterns of site distribution do not reveal any data to understand the size of the geographical territory of the Paleolithic people. It remains unclear whether the archeological remains in surface settings are the product of persistent or irregular occupation. Certainly, the present study proposes scope for further Paleolithic and geo-archaeological investigations in the lower Sutlej valley and contiguous regions. There might be numerous locales along the Sutlej River that have since sunk into Bilaspur’s Govindsagar Lake. Intensive exploratory work should be carried out in the upper and middle Sutlej River valley and its tributaries to discover more sites that can give a better understanding into the prehistoric archaeology of this region.

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Competing Interests

The authors have declared that no competing interests exist.

Authors’ Contribution

Conceived and designed the research: W.K.B., D.B.; field investigation: W.K.B., D.B.; analysed the data: W.K.B.; analysed the artefacts: W.K.B., D.B.; wrote the paper: W.K.B.; paper revision, suggestions: D.B.

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