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Exploring the Archaeological Landscape of Seer Khad River Basin of Siwalik Frontal Range, Himachal Pradesh: A Preliminary Study

Worrel Kumar Bain[1], Dwipen Bezbaruah[2] and Sarat Phukan[3]
[1]Exploration Officer, Department of Anthropology, Gauhati University, Assam.
E-mail: worrel.bain@gmail.com
[2]Professor, Department of Anthropology, Gauhati University, Assam,
E-mail: dwipen09@gmail.com
[3]Professor, Department of Geological Sciences, Gauhati University, Assam,
E-mail: saratphukan@gauhati.ac.in

Abstract: *The Indian Siwalik Hills are globally significant due to their diverse eco-geographic regions full of fossiliferous and implementiferous localities. Although there have been sporadic discoveries of Palaeolithic remains, a considerable portion of the area remains unexplored, including the Seer Khad River Basin (SKRB) in Himachal Pradesh. The present study aimed to explore the archaeological landscape of the SKRB, focusing on fresh data from newly discovered lithic assemblages. The preliminary findings of the present study highlight the variability of the lithic assemblage found under the core and flake lithic traditions, showing numerous technological and typological features that reflect the cognitive level of the prehistoric population. The lithic assemblages in SKRB also reveal that the prehistoric population preferred water sources and locally available quartzite and sandstone as raw materials for stone tool-making, which reflects general Palaeolithic occupational behaviour. Moreover, the study sheds light on post-Siwalik depositions in the study area. The lithic artefacts exhibit different spatial distribution patterns, frequencies, and typo-technological patterns, assumed to originate from a range of chronologies no younger than the Middle Pleistocene. The study also focuses on the local geomorphology, lithology, and drainage network of the basin. The data presented in this paper will aid in further refining regional studies to understand the changing nature of the Siwalik Frontal Range during the post-Siwalik period. Overall, this study provides valuable insights into the prehistoric population's behaviour and technological advancements, contributing to a better understanding of the area's history and evolution.*

Keywords: *Siwalik Hills, Seer Khad River Basin (SKRB), Geomorphology, Drainage, Lithic artefacts, Typo-technology, Raw material exploitation*

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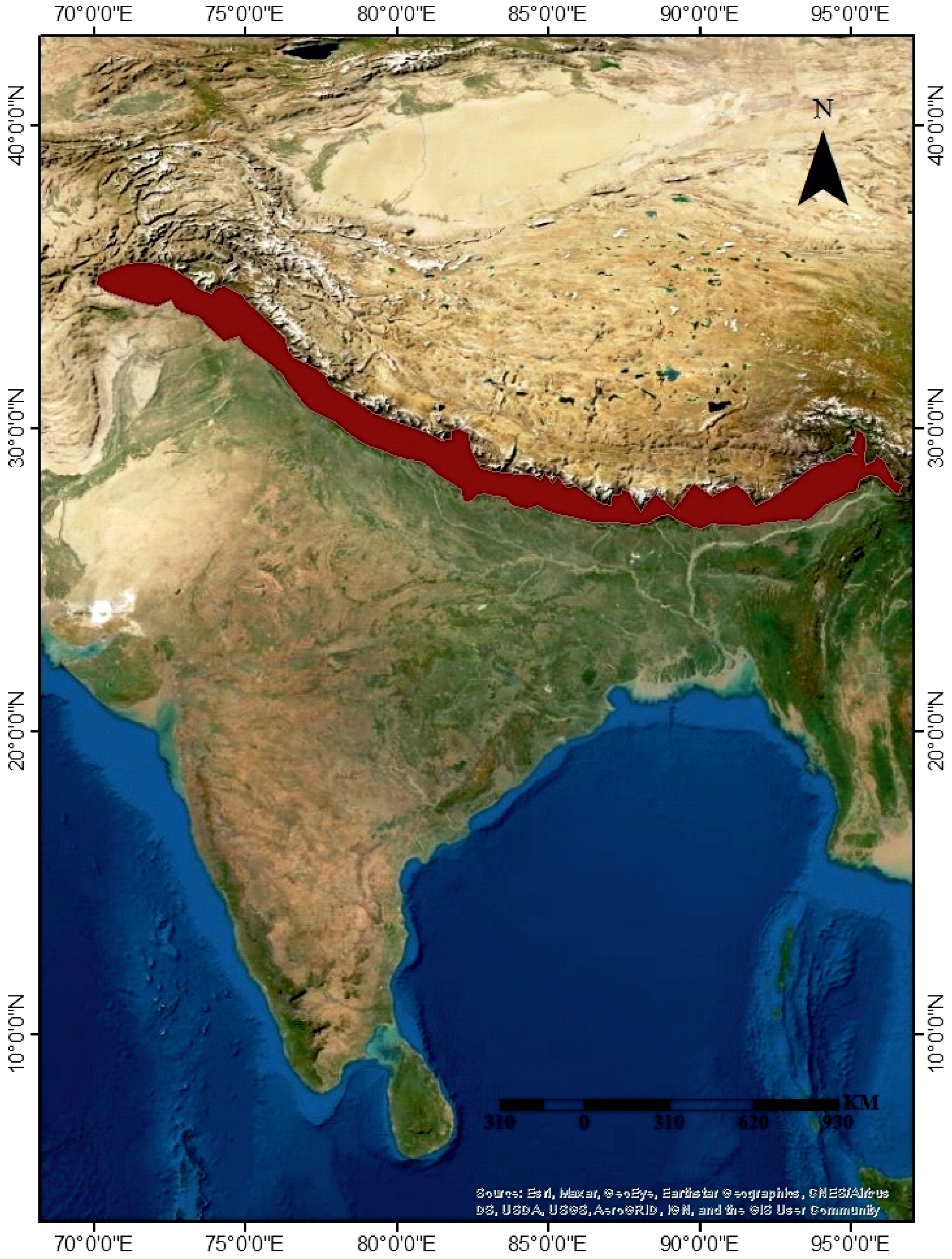
Introduction

The Siwalik Hills, which extend northeast-southeast parallel to the Himalayas, have a height ranging from 600 to 1200 meters above sea level. This group spans approximately 20 to 24 kilometres in width and extends about 2400 kilometres from the Indus River in the northwest to the Brahmaputra River in the northeast. The Siwalik sediments range in age from the Middle Miocene to the Middle Pleistocene and are about 6700 meters thick (Vasishat, 1985; Tripathi, 1986). Fluviatile sediments make up these deposits, mostly derived from the rising Himalayas. This sub-aerial waste of alluvial detritus was swept down the mountains by rivers and streams and was deposited at their base in a fore-deep, which resulted in the third and most powerful upheaval of the Himalayas at the commencement of the Middle Miocene Epoch (Brozovik and Burbank, 2000). The area south of the fore-deep is believed to have contributed at least a part of the sediments to these deposits. The last Himalayan upheaval subsequently folded, deformed, and elevated these deposits, as a result of which the pre-Siwalik rocks were thrust over the younger ones of the outer ranges. This thrust plane forms a significant tectonic feature known as the Main Boundary Fault, whose topographic expression is yet to be established. This fault is now constituted by a series of almost parallel faults rather than a single one. The Siwalik Hills' sediments are divided into lower, middle, and upper subgroups, further subdivided into various formations exposed in different patterns. These formations include Kamlial, Chinji, Nagri, Dhok Pathan, Tatrot, Pinjore, and the lower and upper Boulder Conglomerate Formation (BCF) (Randell *et al.*, 1989; Chauhan, 2003; Kumarvel *et al.*, 2005). The fluvial sediments in the foreland basin were deposited by hinterland rivers flowing southwards and southwestwards from the lesser and greater Himalayas. Various workers have subjected Siwalik deposits to different age estimations. Most of these estimates are based on faunal correlations with the mammaliferous horizons of Europe (Pilgrim, 1910; Lewis, 1937; Pilgrim, 1944; Pilbeam *et al.*, 1977). However, studies providing the absolute age of these rocks are few and only cover part of the succession. Some palaeomagnetic studies have also been conducted in some Siwalik locations of India and Pakistan, which received an age of 5.5 to 0.60 million years before the present (Opdyke *et al.*, 1979; Tauxe and Opdyke, 1982). These ages can also be applied to Indian Siwaliks. The study of hominoid evolution has been an intriguing area of research, with much of our knowledge derived from sedimentary deposits from the late Miocene period (approximately 13-5.5 million years ago) found in the Indian Siwalik Hills (Bain & Bezbaruah, 2019). These hills have yielded diverse information that will aid in understanding human evolution and behaviour under varied environmental conditions. The Siwalik Frontal Range (Figure 1) contains one of the most complete successions of mammalian fossil faunas preserved in various fluvial sedimentary situations, which have been instrumental in illuminating the early story of hominoid evolution. The Siwalik Frontal Range is a prominent topographical feature shaped by the folding and uplifting of the Siwalik group over an extended period, spanning from the Middle Miocene to the Middle Pleistocene. This feature spans the Indo-Gangetic plains and has directly impacted the region's topography. This process has resulted in the creation of a range of hills and mountains stretching across a significant portion of the region, offering a unique glimpse into the geological history of the area (Tudryn *et al.*, 2016). The Siwalik Hills host palaeoanthropological localities scattered across a vast geographical expanse in North-West India. These localities offer researchers a valuable source of information (Flynn *et al.*, 2016). In the Indian Subcontinent, the Palaeolithic periods are typified by the sporadic occurrence of handaxes and cleavers in the Acheulean assemblage. In contrast, the Soanian assemblage primarily comprises core, chopper, discoid, scraper, and flake. The Palaeolithic evidence in this region is primarily from open-air sites distributed across diverse eco-geographic zones, signifying different land use patterns and intra-regional mobility (Chauhan, 2003). However, most of this evidence is from the surface context and cannot be dated, which makes it challenging to fit them within a chronological framework. The majority of sites are situated in "post-Siwalik" locations, which refers to sediment deposits that have accumulated after the Boulder Conglomerate, the most recent Siwalik Formation (Mohapatra, 1976; Mohapatra and Singh, 1979; Stiles, 1978; Chauhan, 2003). In the present study, post-Siwalik deposits indicate sediment layers younger than the Boulder Conglomerate. These relatively recent sediments are dispersed throughout intermontane valleys, on Siwalik hill slopes, and in association with Middle to Upper Pleistocene river/stream terrace systems. The present paper aims to provide insight into the prehistoric terrain of the Seer Khad River Basin (SKRB), situated in the Indian Siwalik Frontal Range, Himachal Pradesh, which remains mostly unexplored. The paper utilizes an archaeological standpoint based on new data from recently discovered lithic assemblages in the region. The findings indicate that the Palaeolithic evidence in the study area comprises open-air sites scattered across diverse eco-geographic zones. The fresh comprehensive data retrieved from the lithic assemblages enables the authors to establish a broader timeline for the artefacts, thus proposing that the SKRB was a significant location for hominin settlements. The primary aim of this study was to gain a comprehensive understanding of the archaeological potential of the basin. The authors sought to gain insight into the lithic technology of the artefact-bearing localities through typo-technological analysis, which allowed for comparative assessments and a better understanding of the lithic reduction sequence. The research delved into raw material availability and exploitation in the study area to provide a more complete picture of the region's archaeological potential. The chosen area for the present study holds strategic significance due to its placement in the Siwalik frontal range, a vital geographical region in Himachal Pradesh. The SKRB and its surrounding area, with its topography, geography, and suitable ecology for prehistoric settlements, have played an equally critical role in the past. However, ongoing developmental work in the region, including road and bridge construction, extensive mining for natural resources, and agricultural activities, threaten the river basin. This is particularly concerning as it could impact the unexplored localities that hold promise for palaeoanthropological research.

Review of Earlier Studies

The Siwalik Hills region has been the subject of Quaternary research for over a century, with an initial emphasis on geological and environmental phenomena. A significant milestone in this area of study was reached by De Terra and Paterson, who conducted the first comprehensive Quaternary investigation of the region as part of the 1935 Yale-Cambridge expedition. Their study has laid the foundation for further research and understanding of the geo-environmental history of the Siwalik Hills (De Terra & De Chardin, 1936; De Terra & Paterson, 1939). The interdisciplinary nature of this work was a key factor in the significant outcomes achieved. With contributions from various fields, the effort was truly multidisciplinary and produced meaningful results that have stood the test of time. It quickly became a classic work of reference for all future prehistoric studies on the subcontinent, demonstrating its lasting impact. One notable aspect of this work was its role in informing de Terra's understanding about Indian Stone Age cultures (Bain, 2020). Furthermore, the study created cultural labels to identify the lithic artefacts of the region (Hawkes *et al.*, 1934; Movius, 1948; Soni & Soni, 2017) and firmly established their chronology (Dennell & Hurcombe, 1993; Chauhan, 2007). According to Wadia's findings in 1928, there was evidence of early humans in the western sub-Himalayas prior to the Yale-Cambridge expedition (Wadia, 1928). Moreover, Dianelli's study in 1922 had already laid the groundwork for the work of the Yale-Cambridge expedition (Dianelli, 1922). In 1954, the Indian National Council embarked on a significant project in the Karakoram region, marking a crucial milestone in studying early humans in the western sub-Himalayan area. Graziosi (1964), under this research project, made



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 1: Map showing the location of Siwalik Frontal Range. (The data for preparing the map has been retrieved from Google Earth and prepared through ARC GIS- 9.3 software)

remarkable discoveries of Palaeolithic sites which exhibited the presence of hominin occupation in the parts of north- western Punjab (now Pakistan). Since the partition of India in 1947, several lithic localities have been identified in the Indian part of the sub-Himalayan region, significantly contributing to our understanding of early human history. During the mid-20th century, the Archaeological Survey of India (IAR, 1954-55) investigated the Daulatpur area of Punjab (India) and discovered pebble tools. This discovery provided evidence of early human activity in the Soan Dun region, extending towards the Beas River. This finding has since been an essential piece of information for understanding the history and evolution of hominin habitation in this area. Prufer (1956) made an intriguing observation while exploring the Sirsa Valley. According to him, the general characteristics of Sirsa Valley chopper and chopping tools are closely similar to the late Soanian artefacts reported by De Terra and Paterson (1939). Still, the geological setting of the Sirsa chopper and chopping tools clearly testify to an early Soan industry. During his research, he stumbled upon several Palaeolithic sites of significant historical importance and provided valuable insights into the development of ancient societies. In the Kangra district, Lal (1956) and Joshi *et al.* (1978) identified the Soanian pebble industry in the Siwalik Frontal Range of Himachal Pradesh for the first time. This discovery further highlights the importance of the region in the study of human history. Similarly, Sen (1955) and Karir (1985) discovered the Soanian pebble industry in the Sirsa terraces of Nalagarh Dun, adding to the growing evidence of prehistoric human activity in the area. Sen thoroughly analysed his perceptions regarding Prufer's sites and scrutinised the lithic artefacts in this region (Sen, 1955). On the other hand, Mohapatra (1966, 1974, and 1976) focused on Soan lithics from a typo-technological perspective. Subsequently, various scholars and organisations started working in this area (Khatri, 1963; the Archaeological Survey of India, IAR, 1964-65, 1965–66, 1968–69, 1969–70; Mohapatra,1966, 1974, 1976; Mohapatra & Saroj, 1968; Joshi, 1970; Sankalia, 1971; Joshi *et al.*, 1974) and with their extensive research, they have recovered numerous Palaeolithic localities and a wide variety of artefacts, each providing valuable insights into the fascinating period of human history. Saroj conducted an in-depth examination of the Jammu region, specifically focusing on the area between the Chenab and the Ravi rivers (Saroj, 1974). Joshi *et al.* (1975) found some quartzite artefacts from the Markanda Valley of Himachal Pradesh. Upon conducting a thorough analysis and comparison of the retrieved artefacts with those found in other locations of Indian Siwalik Hills, it was suggested that the evolution of Palaeolithic industries and their stratigraphy occurred independently, without being labelled with the progressions described by De Terra and Paterson (1939) in the Soan Valley (Joshi *et al.*, 1978). In his extensive study of prehistoric cultural evidence from Himachal Pradesh, Mohapatra (1974) distinguished the Nalagarh industry from the lithic industries of the Sirsa Valley and the Beas-Banganga Valley, referring to the latter as the pebble-tool culture. The observations and conclusions drawn from these findings present a fascinating insight into the history and evolution of early human societies and their cultural practices. According to Mohapatra's study, the lithic industry in the Sirsa Valley is a well-developed representation of the Beas-Banganga industry, which is undoubtedly older and more established. In the mid-1970s, Mohapatra discovered the first Acheulean site (Atbarapur) in the Indian part of the Siwalik Hills. This significant finding provided valuable insights into the Acheulean industry from the Siwalik Hills (Mohapatra, 1981; 1990). Chauhan's findings from Toka, Himachal Pradesh, further highlight the typological diversity within the Soanian industry (Chauhan, 2007). These discoveries have contributed significantly to our understanding of the prehistoric landscape of India and the evolution of human technological advancements. Beginning in 2009, the Indo-French Prehistoric Mission has been dedicated to surveying the Siwalik Hills near Chandigarh, leading to the identification of a good number of Palaeolithic localities (Gaillard *et al.*, 2016). Despite extensive research spanning almost fifty years in Himachal Pradesh, the south-western region of the state still needs to be more adequately studied from an archaeological standpoint. Consequently, our understanding of the Palaeolithic industries in this area is limited and incomplete. Further exploration and investigation are necessary to fill these gaps and gain a more comprehensive understanding of the region's history and prehistoric human activity. Only a handful of studies have been conducted in this region (Sankhyan, 1981, 1983, 2017; Bain, 2020; Bain & Bezbaruah, 2020, 2021, 2022, 2023).

Material and Methods

The study area under consideration is located in the lower Sutlej Valley of Himachal Pradesh (Figure 2). SKRB covers an area of 107.07 km^2 and is situated between longitude coordinates 76.26 °- 76.36 ° E and latitude coordinates 31.22 °- 31.31 ° N, encompassing three districts of south-west Himachal Pradesh: Bilaspur, Hamirpur and Mandi. The basin has been created by Seer Khad and its tributaries. The study examined 22 localities (Table 1 & Figure 3), out of which 13 localities were found to be implementiferous. Several factors were considered while exploring the localities, including their geographical coordinates and elevation and their distances from the nearest reference villages and associated directions. The present study offers a comprehensive insight into each locality's precise

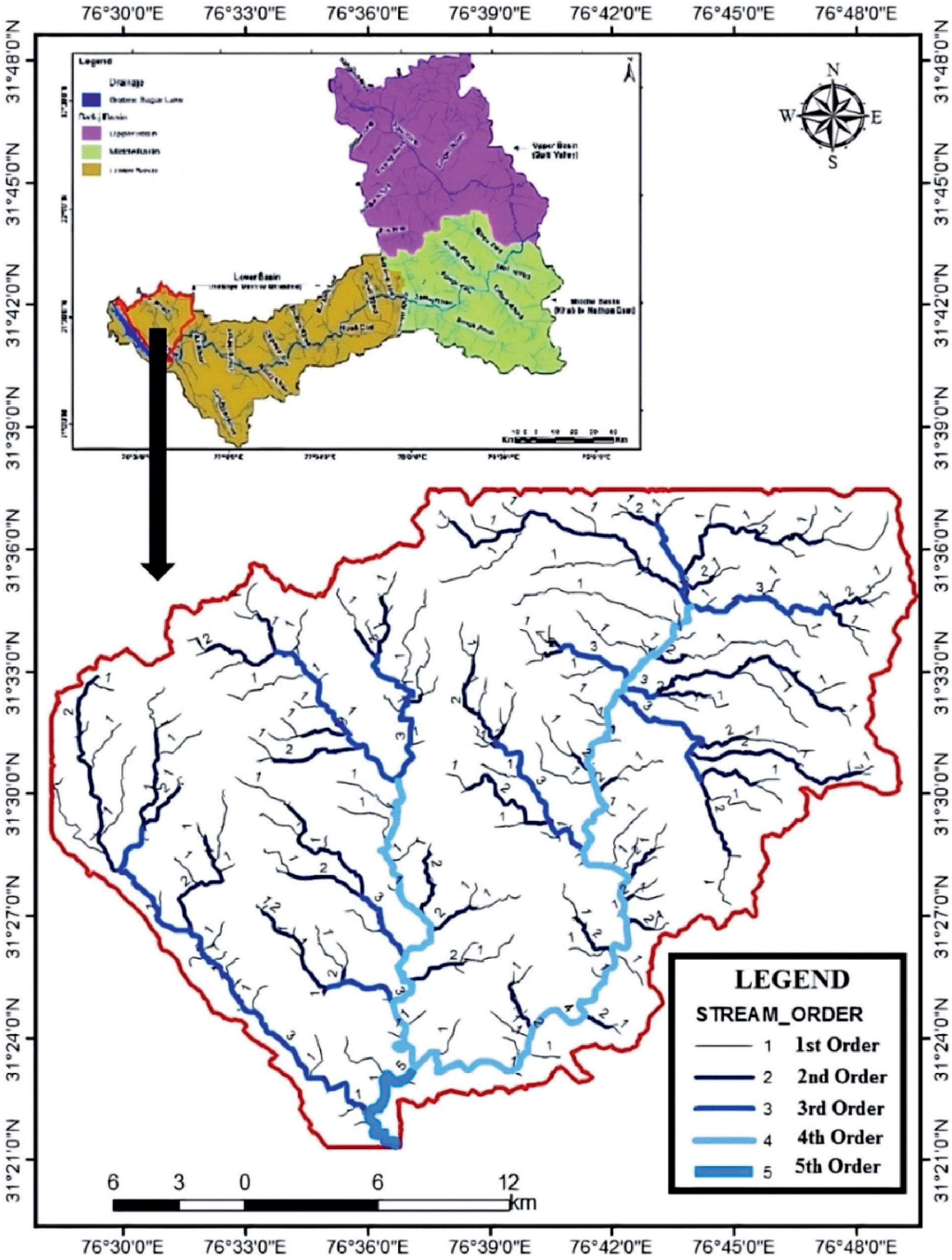


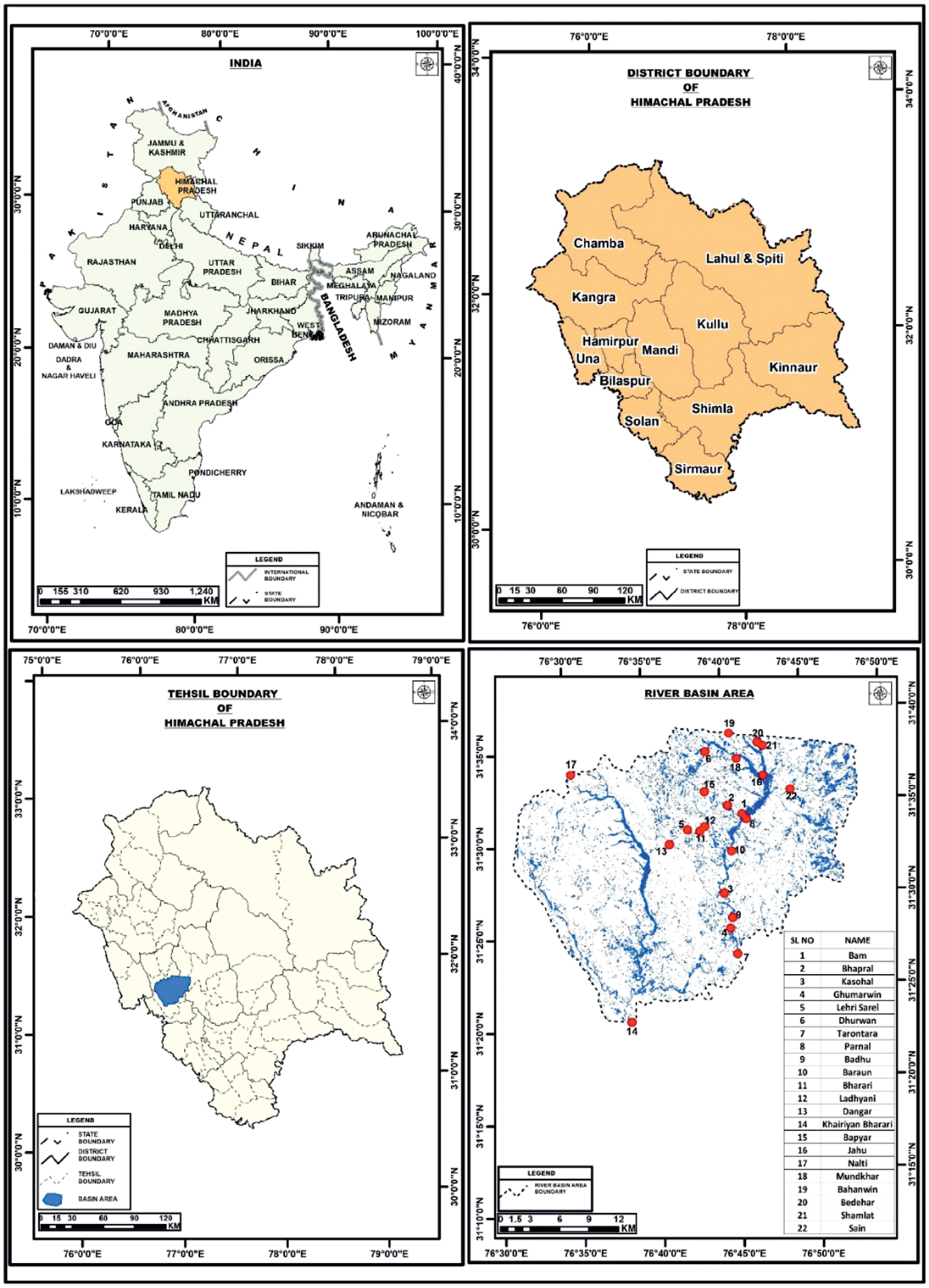
Figure 2: Location of Seer Khad River Basin and its stream order. (The data for preparing the map has been retrieved from Google Earth and prepared through ARC GIS- 9.3 software).

geographical location, including its proximity to nearby water sources and hilly areas, along with its size in square meters. To achieve this, the authors conducted multiple transect surveys along the Seer Khad River, between the hills and near them, covering a total area of 40 km^2. The data was recorded through a Garmin handheld outdoor GPS unit. Furthermore, satellite imagery and various maps were employed to better comprehend the geographical context and other critical features of the area under investigation. These maps were created using ARC GIS-9.3 software, and the data to create them was

Table 1: List of explored localities at Seer Khad River Basin

Locality	*District*	*Tehsil*	*Context of recovered artefacts*	*artefacts recovered*	*Elevation*	*Latitude*	*Longitude*
Bam	Bilaspur	Ghumarwin	River bank + Dried river bed+ Eroded hill slopes	202	2141 ft	31^{0}33’13.14 N	76^{0}42’19.84 E
Bhapral	Bilaspur	Bharari	River bank + Dried river bed+ Eroded hill slopes	112	2476 ft	31^{0}31’34.38 N	76^{0}41’22.03 E
Kasohal	Bilaspur	Ghumarwin	River bank + Dried river bed+ Eroded hill slopes	98	1962 ft	31^{0}28’49.16 N	76^{0}41’ 40.87 E
Ghumarwin	Bilaspur	Ghumarwin	River bank + Dried river bed + Eroded hill slopes	228	1949 ft	31^{0}26.6280’ N	76^{0}42.3520 E
Lehri Sarel	Bilaspur	Ghumarwin	-	-	2559.06 ft	31^{0}53’43.94” N	76^{0}64’93.,58” E
Dhurwan	Bilaspur	Ghumarwin	-	-	3280 ft	31^{0}63’65.99” N	76^{0}90’23.60” E
Tarontara	Bilaspur	Ghumarwin	-	-	2171.92 ft	31^{0}43’01.35” N	76^{0}72’35.56” E
Parnal	Bilaspur	Ghumarwin	Eroded hill slopes	67	2214 ft	31^{0}32’57” N	76^{0}42’18” E
Badhu	Bilaspur	Ghumarwin	Foot Hills	82	1904 ft	31^{0}45.90.35” N	76^{0}70.6179 E
Baraun	Bilaspur	Bharari	-	-	2565.62 ft	31^{0}31’7.96” N	76^{0}41’51.50 E
Bharari	Bilaspur	Ghumarwin	-	-	2319.55 ft	31^{0}53’86.47”N	76^{0}66’70.074” E
Ladhyani	Bilaspur	Bharari	-	-	2762.47 ft	31^{0}53’42.66” N	76^{0}66’24.077” E
Dangar	Bilaspur	Ghumarwin	-	-	2319.55 ft	31^{0}51’97.79” N	76^{0}63’21.27” E
Khairiyan Bharari	Bilaspur	Ghumarwin	-	-	2139.11 ft	31^{0}33’88.96” N	76^{0}62’53.45” E
Bapyar	Bilaspur	Bharari	-	-	2752.62 ft	31^{0}57’00.12” N	76^{0}66’34.12” E
Jahu	Hamirpur	Bhoranj	River Bank + Dry river bed + Eroded hill slopes	91	2307 ft	31^{0}58.584 N	76^{0}72.3333 E
Nalti	Hamirpur	Hamirpur	River bank + Eroded hill slopes	69	2034 ft	31^{0}54. 3268 N	76^{0}70.5837 E
Mundkhar	Hamirpur	Bhoranj	Alluvial fan deposition + Eroded foot hills + Dry river bed	54	2388 ft	31^{0}36’05 N	76^{0}41’45” E
Bahanwin	Hamirpur	Bhoranj	River Bank + Dry river bed + Eroded hill slopes	83	2962.6 ft	3162’4870” N	7668’3135” E
Bedehar	Hamirpur	Bhoranj	Eroded hill slopes + Foot hills	34	2480.31 ft	31^{0}36’56” N	76^{0}42’48” E
Shamlat	Mandi	Sarkaghat	River Bank + Dried gravel bed	100	2690.29 ft	31^{0}61’6850” N	76^{0}71’9880” E
Sain	Mandi	Sarkaghat	Dried gravel bed + Eroded hill slopes	54	3900.92 ft	31^{0}76’2613” N	76^{0}83’4561” E

obtained from ISRO satellites. The research employed a Digital Elevation Model (DEM) of ASTER (Advanced Space-borne Thermal Emission and Reflection Radiometer) to generate topographical information and calculate geomorphic indications of a basin. The resolution of the DEM was set at 30 meters, while the Universal Transverse Mercator (UTM Zone 43) was used. The software ARC GIS-9.3 was employed to process the images and perform the necessary calculations. The DEM was utilized to compute primary terrain attributes, such as slope aspect, curvature (plain and profile), and topographic wetness. This comprehensive methodology allowed a thorough analysis of the basin's topography and geomorphology. The methodology of systematic surface collection has been employed through the grid method, with a defined area of 3 meters by 3 meters. The field visit has allowed for the identification



SL NO	NAME
1	Bam
2	Bhapral
3	Kasohal
4	Ghumarwin
5	Lehri Sarel
6	Dhurwan
7	Tarontara
8	Parnal
9	Badhu
10	Baraun
11	Bharari
12	Ladhyani
13	Dangar
14	Khairiyan Bharari
15	Bapyar
16	Jahu
17	Nalti
18	Mundkhar
19	Bahanwin
20	Bedehar
21	Shamlat
22	Sain

Figure 3: Location map of studied localities under the Seer Khad River Basin.

of several localised features, including the site's distance from the riverbank, the discrete nature of the scatters, and the connection between the artefacts and the raw material blocks. The lithic artefact data utilised in this study are original data obtained from lithic assemblages discovered in the explored localities. These lithic assemblages underwent a comprehensive analysis involving quantitative and qualitative attributes. During the examination of lithic subtypes, various standard criteria were employed, including metric variables such as length (L), width (W), and thickness (T). Additionally, the blank type, raw material, completeness of the artefact, and any damage to the artefact's edges were also considered. These variables were combined with their respective typo-technological attributes, resulting in a more comprehensive comprehension of the lithic assemblages. The Geological Sciences Department of Gauhati University has thoroughly analysed various natural clasts and lithic artefacts from the study area. The analysis was performed at the department's thin section cutting laboratory using state-of-the-art equipment, including the Geosyndicate Cutting Machine (Floor Type) and the Geosyndicate Grinding and Polishing Machine. The samples were extracted, prepared as slides, and then interpreted using the Leica DM2700 P petrological microscope.

Results

Local geomorphology, lithology, and drainage system

The landform morphology of the study area presents a wealth of information about the region, providing significant insights into the landscape. The area is characterized by numerous high and moderately dissected hills and valleys, indicative of a complex topography. However, the most noteworthy geomorphological aspect of the study area is the unconformity between the contacts of Upper Siwalik sediments with post-Siwalik conglomerates (Bain & Bezbaruah, 2021). This unconformity is a crucial feature that offers valuable information about the geological history of the area. The study area boasts a variety of desirable rock types, including granite, syenite, diorite, siliceous sandstone, quartzite, and volcanic rocks. Gneiss is the most robust among the metamorphic rocks unless they exhibit a high degree of foliation (Sharma *et al.*, 2018). The region under consideration is characterized by the uplifted Siwalik Piedmont zone, located between the Lesser Himalayan slope to the east and the Upper Siwalik Boulder Conglomerate Formation to the west. The Middle Siwalik also constitutes a part of this terrain. One noteworthy geological feature of the area is the Boulder Conglomerate, deposited 1.8 to 1.1 million years ago (Valdiya, 1993; Kumar *et al.*, 2007). It is pertinent to mention that during the Middle Pleistocene period, approximately 500,000 years ago, the Himalayas underwent significant upheavals that marked the onset of post-Siwalik Quaternary sedimentation. Through aggradation, the events formed two prominent Quaternary fans (Qf-1 and Qf-2). The Himalayas region exhibits numerous geological features, including intra-montane hog-back basins characterized by elongated ridges parallel to the mountains. Over time, sedimentations and aggradations have significantly impacted the landscape and geology of this region. The Piedmont zone, for example, originated between the aggradations of Qf-1 and the recession of the Boulder Conglomerate Formation, which occurred approximately 0.5 million years ago. This information is supported by studies conducted by Tadon *et al.*, 1984, Valdiya, 1993; Kumar *et al.*, 2007. Notably, the Piedmont streams are the sole source providing water to the alluvial fans in the study area, with the Seer Khad stream being the most significant among them. The Qf-2 section in the study area is approximately 3–4 meters thick and comprises graded layers of boulders, cobbles, gravel, sand lenses, and silt. The study area has revealed various geological contexts, including dried river beds, foothills, eroded hill terrains, and alluvial fan deposits. This observation highlights the geological diversity present within the study area. During the field visit, several naturally exposed sections were observed, each comprising topsoil, followed by layers of brownish clay, shale, poorly sorted and crudely bedded conglomerate and boulder beds, and sandstone bedrock. Notably, the thickness of these layers varies significantly, with some being thicker than others. It is worth noting that the topsoil has been removed in certain areas due to anthropogenic activities, revealing various-sized gravels, mainly consisting of quartzite and low-density sandstone gravel. The seasonal rivers (*chos*) are responsible for the drainage system in the study area. To comprehensively understand the study area's stratigraphy, sediment samples were collected for analysis. The stratigraphic sequence comprises nine members (A–I) (Figure 4). Member A is composed of sediment, primarily clayish silt. This sediment type is characterized by its loose structure, which may affect certain geological processes. The sediment within this region exhibits a range of textures and compositions across its members. Member A consists of sand with a varying texture, from medium to fine. In contrast, Member B comprises different shapes and sizes of pebbles, intermixed with yellowish-brown silt. This member is notably more resilient than Member A. Member C can be distinguished by its predominant clay composition, whereas Member D is characterized by a blend of sandy silt and cobbly gravel, with the gravel size varying throughout the layer. It is worth noting that lamination needs to be evident in this member. Member E consists of brownish silt and breccia. The sedimentary layers in this area are quite diverse, with Member F featuring yellowish cross-bedded sand that varies in grain size. Member G exhibits yellow-brown, notably hard silt. Member H comprises unconsolidated silty clay, while Member I is a sandstone bedrock.

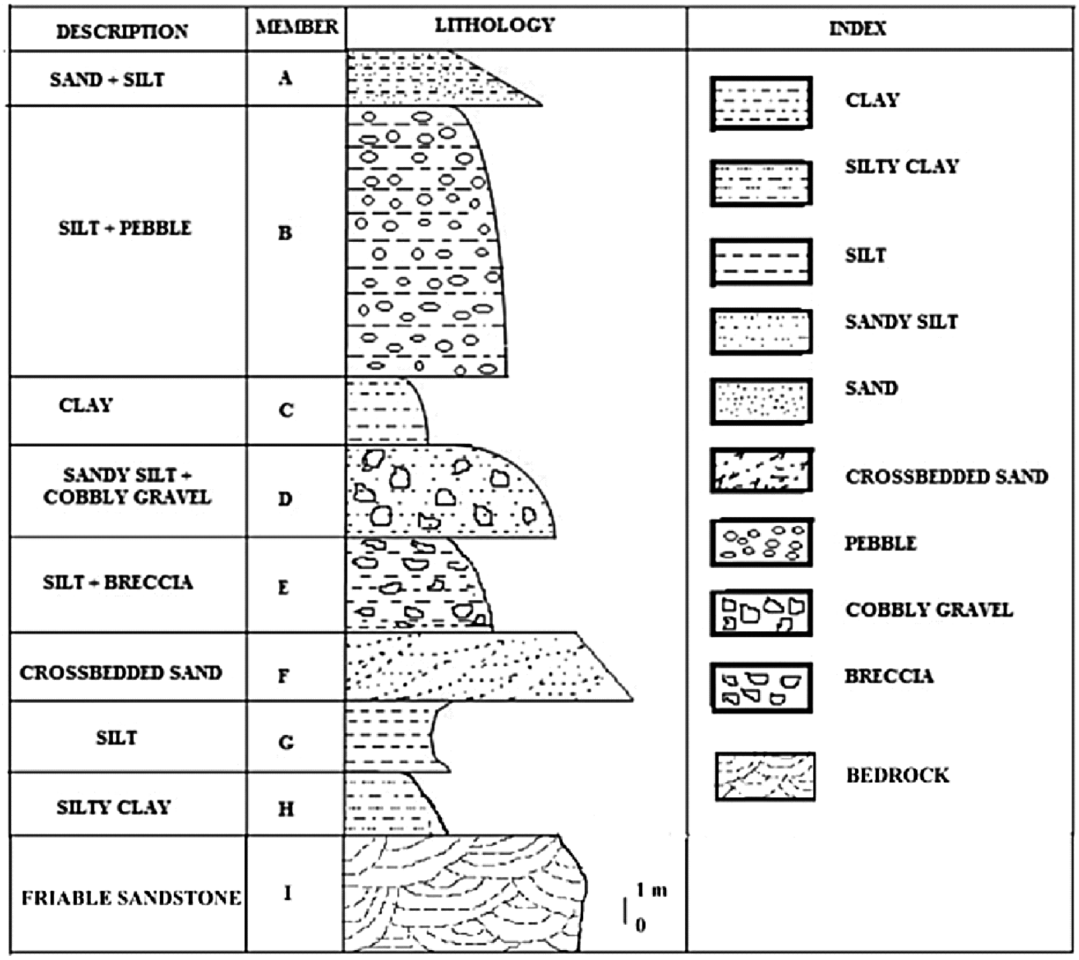
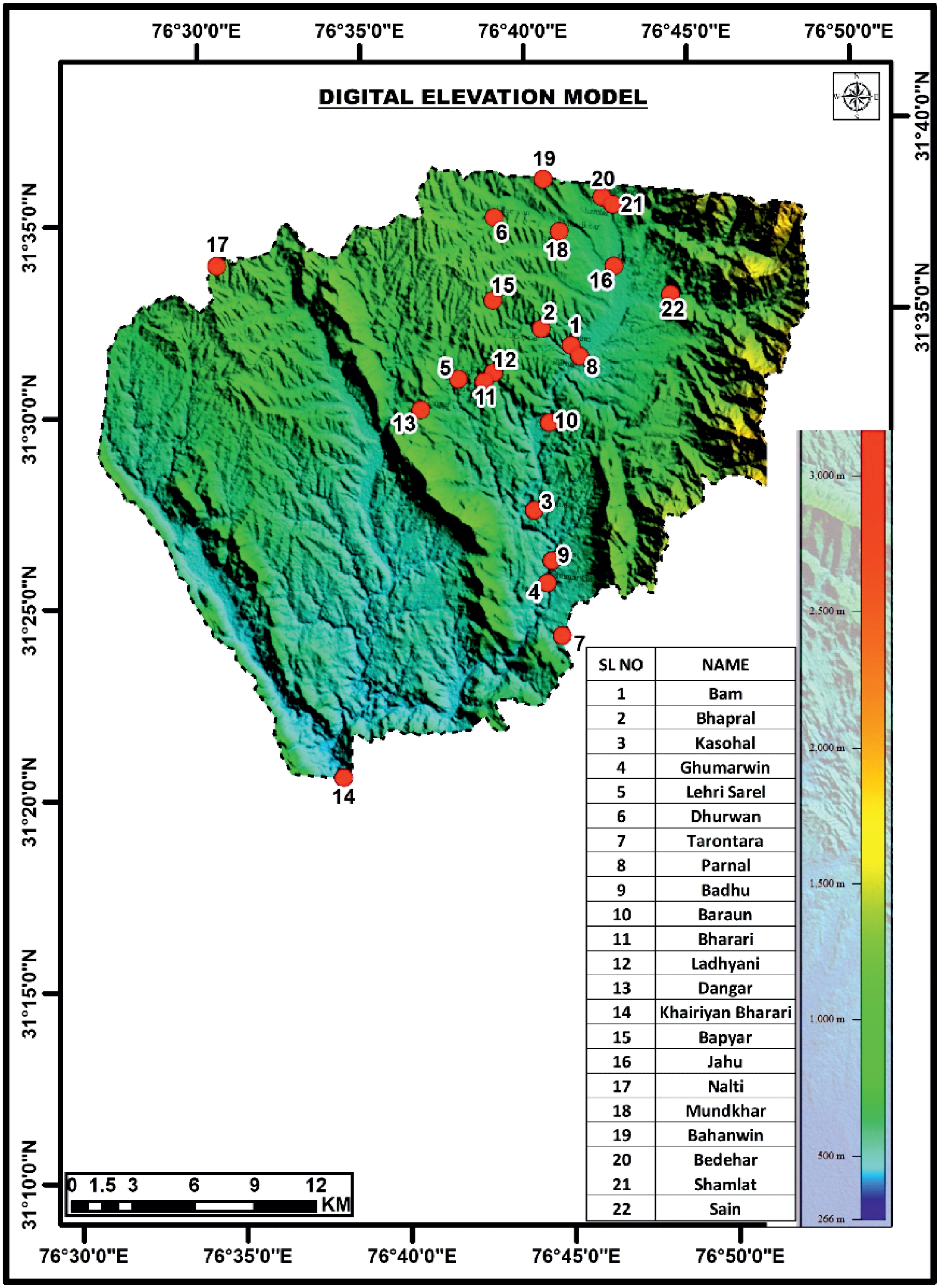


Figure 4: Stratigraphic log of the study area



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16	Jahu
17	Nalti
18	Mundkhar
19	Bahanwin
20	Bedehar
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22	Sain

Figure 5: Digital Elevation Model of SKRB

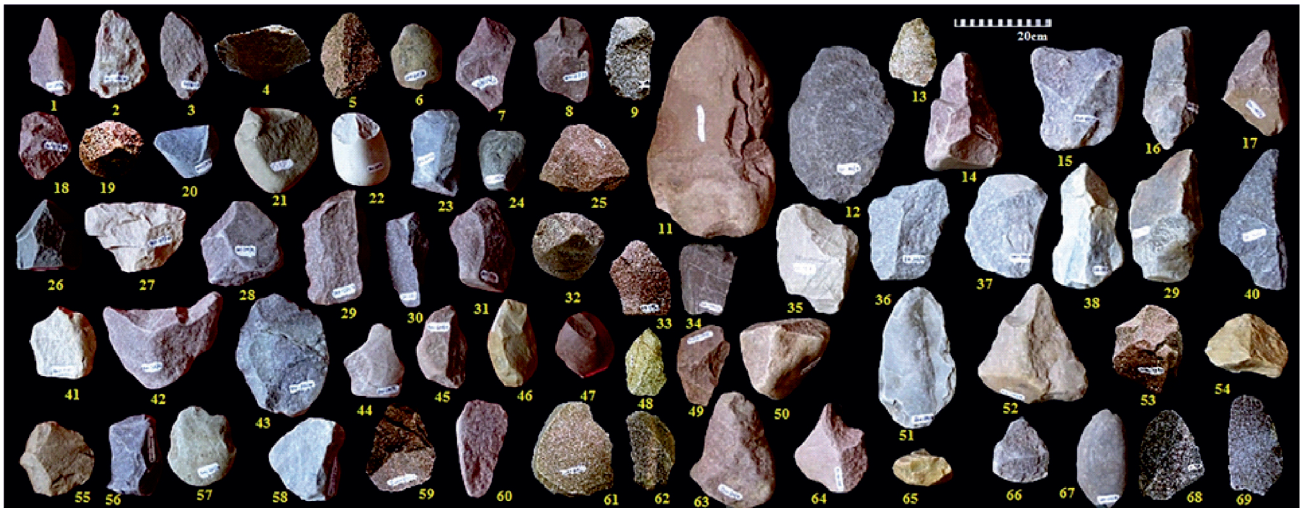


Figure 6: Lithic artefacts from Seer Khad River Basin

The topography of the SKRB area experiences a significant range of relief, varying from 452 to 1828 meters, due to the complex interplay of local and regional tectonic conditions. The Barsar Thrust Fault and Folds feature prominently in the region, making it a highly active tectonic zone. The variation in relief within this area indicates extensive denudation during the Pleistocene period, as reported by Sharma *et al.* (2018). Physiographically, the study area exhibits low to moderate hills extending from the northwest to the southeast. The terrain is undulating and punctuated by fertile valleys and streams, with the Seer Khad River being an important component of the region's drainage system. Moreover, the area has numerous minor streams that merge with the Seer Khad. The entire river basin area mirrors the later stages of fluvial geomorphic cycle development, ranging from late youth to earth maturity. The present study utilized Strahler's method (Strahler, 1952), a well-established technique for stream order delineation, to analyze the river basin. The analysis revealed that the basin is home to a first to fifth-order stream system with a dendritic to sub-dendritic type of river basin (Figure 2). The basin comprises 230 streams, of which 172 are first-order streams, accounting for 74.78% of the total basin area. The remaining streams are categorized into second, third, fourth, and fifth-order, consisting of 44, 11, 2, and 1, respectively. Measurement of basin asymmetry (AF) is a valuable tool to gauge the neo-tectonism of a drainage basin. In this case, the AF value indicates that the basin has an inclination towards the eastern side, possibly due to the presence of the Barsar Thrust, suggesting that the basin undergoes tectonic upliftment, which could significantly impact the surrounding geology and hydrology (Sharma *et al.*, 2018).

Lithic Assemblages

Throughout the exploration, 1215 lithic artefacts were recovered, as indicated in Figure 6, Figure 7, and Table 2. These artefacts were collected from various surface contexts (Table 3; Figure 8; Figure 9) and have since undergone further analysis. While the majority of the lithic pieces were identified, a few remained unidentified despite the authors' diligent efforts.

Table 2: Dimensional attributes of recovered lithic remains from Seer Khad Basin

Types of Artefacts	*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 fragment																		
Bipolar	10	0.82	18.10	10.80	12.11	2.30	13.70	6.70	10.08	2.13	8.00	5.00	6.23	0.94	2.59	0.68	1.06	0.60
Single platform	48	3.95	17.80	8.70	13.51	2.33	17.20	5.80	10.43	2.52	12.30	3.50	7.38	2.21	3.99	0.30	1.10	0.64
Multi platform	57	4.69	18.70	5.20	13.18	3.11	18.80	5.90	10.31	2.91	13.60	2.80	7.62	2.74	2.19	0.11	0.99	0.44
Double sided	13	1.06	16.50	11.70	13.98	1.38	12.80	9.10	10.75	1.10	9.00	6.80	7.70	0.79	1.03	0.59	0.73	0.13
Core fragment	71	5.84	17.40	7.70	12.93	2.24	14.60	6.10	10.14	2.07	11.70	4.60	7.83	1.57	2.58	0.59	1.23	0.47
Discoid	25	2.05	15.30	8.20	11.89	1.75	19.00	6.40	9.86	2.39	6.30	2.80	4.20	1.03	1.65	0.22	0.77	0.41
Unifacial																		
Bifacial discoid	22	1.81	12.90	7.70	9.80	1.32	9.40	5.20	7.13	1.00	5.70	2.50	4.24	0.76	0.74	0.20	0.44	0.13
Irregular discoid	45	3.70	15.00	7.00	10.91	2.04	11.80	5.80	8.86	1.74	7.30	3.20	5.56	1.10	1.32	0.13	0.77	0.35
Chopper	29	2.38	13.90	8.10	10.73	1.47	12.80	6.40	9.33	1.98	9.20	2.90	6.31	1.77	1.64	0.27	0.73	0.40
Unifacial end																		
Unifacial side	19	1.56	12.90	6.30	9.86	1.47	12.70	5.60	8.37	1.95	7.20	2.70	5.38	1.13	1.14	0.30	0.54	0.19
Unimarginal end	50	4.11	12.80	8.00	10.37	1.33	10.80	6.00	8.87	1.38	7.10	3.60	5.14	0.99	0.75	0.31	0.53	0.11
Unimarginal side	20	1.64	13.90	8.90	11.25	1.39	13.10	6.30	9.45	1.94	9.00	3.90	6.25	1.49	1.63	0.29	0.73	0.39
Bimarginal end	17	1.39	11.60	7.80	9.78	1.07	12.50	6.60	9.35	1.98	8.60	3.20	6.12	1.74	1.23	0.48	0.82	0.23
Bimarginal side	16	1.31	12.30	8.20	10.51	1.16	11.30	6.10	8.99	1.64	9.00	3.80	7.03	1.63	1.02	0.48	0.78	0.17
Bifacial side	14	1.15	12.30	8.40	10.12	1.15	8.10	5.00	6.46	0.92	6.20	4.10	5.26	0.66	0.48	0.27	0.36	0.07
Irregular	64	5.26	15.20	1.15	10.66	1.48	13.80	0.92	7.98	1.88	9.60	0.66	5.60	1.48	1.56	0.07	0.64	0.33
Hand axe	7	0.57	19.20	8.00	13.59	3.81	11.60	7.00	9.57	1.40	5.80	3.20	4.29	0.99	1.05	0.21	0.62	0.29
Cleaver	12	0.98	15.80	10.00	13.28	1.66	12.90	8.30	10.20	1.11	4.70	2.80	3.50	0.61	0.73	0.31	0.55	0.12
Pick	24	1.97	18.10	10.50	13.54	2.15	12.40	5.90	8.20	1.61	7.80	3.60	5.50	1.10	1.30	0.30	0.54	0.25
Scraper	112	9.21	17.80	5.00	9.72	2.46	15.20	3.00	7.76	2.43	8.40	1.50	3.60	1.32	1.20	0.03	0.38	0.25
Lateral sided																		
Double sided	32	2.63	16.80	5.10	10.12	2.72	17.50	3.80	8.13	3.52	6.10	1.90	3.65	0.98	1.06	0.05	0.45	0.27
Peripheral	54	4.44	18.80	6.30	10.01	2.40	15.80	4.00	7.61	2.84	6.20	1.60	3.78	1.14	1.57	0.06	0.38	0.28
Sub- peripheral	24	1.97	15.60	6.10	10.74	2.80	10.30	4.50	7.32	1.77	5.90	2.30	4.16	0.93	0.77	0.08	0.37	0.18
Flake	230	18.93	16.40	5.10	8.40	2.21	13.20	3.00	6.21	2.05	10.40	1.30	3.48	1.34	0.96	0.01	0.26	0.15
Unretouched																		
Retouched	114	9.38	24.50	4.90	9.29	3.07	19.20	3.40	7.63	2.89	8.00	1.10	3.61	1.40	1.82	0.01	0.36	0.32
Split cobble	42	3.45	11.20	6.10	8.21	1.23	8.00	3.20	5.35	0.95	4.60	1.80	3.03	0.62	0.32	0.06	0.19	0.06
Broken artefact	8	0.65	11.3	6.8	8.76	1.49	6.2	4.9	5.63	0.51	4.6	3.1	3.6	0.46	0.68	0.22	0.39	0.13
Unidentified artefact	36	2.96	15	6.3	8.96	1.92	11.7	3.7	6.33	1.55	6.1	2.7	4.05	0.82	0.98	0.13	0.36	0.13

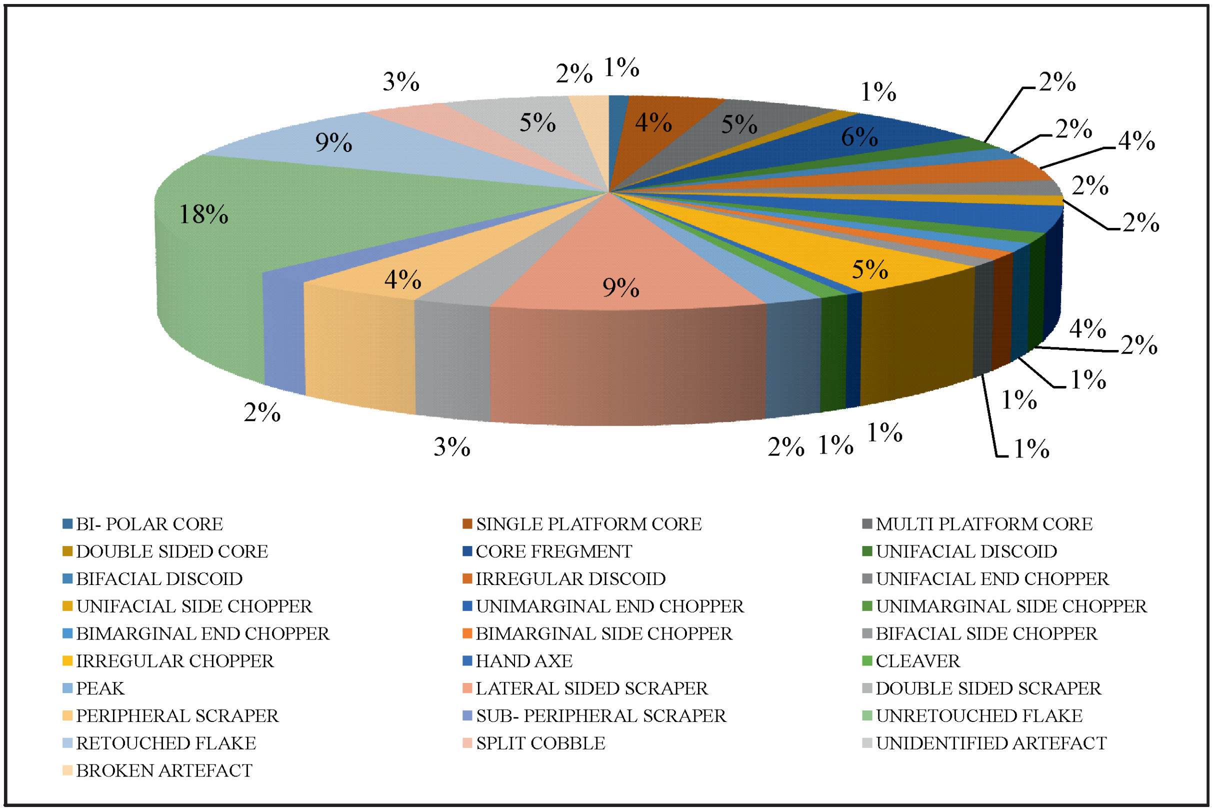


Figure 7: Pie chart shows the percentage value of the recovered lithic artefacts

Table 3: Frequency of artefacts collected from different contexts

Context	*Artefacts recovered*	*Frequency*
River bank	203	16.73
Dried river bed	836	68.80
Eroded hill slopes	57	4.69
Foot hills	75	6.17
Alluvial fan deposition	44	3.62
Total	1215	100

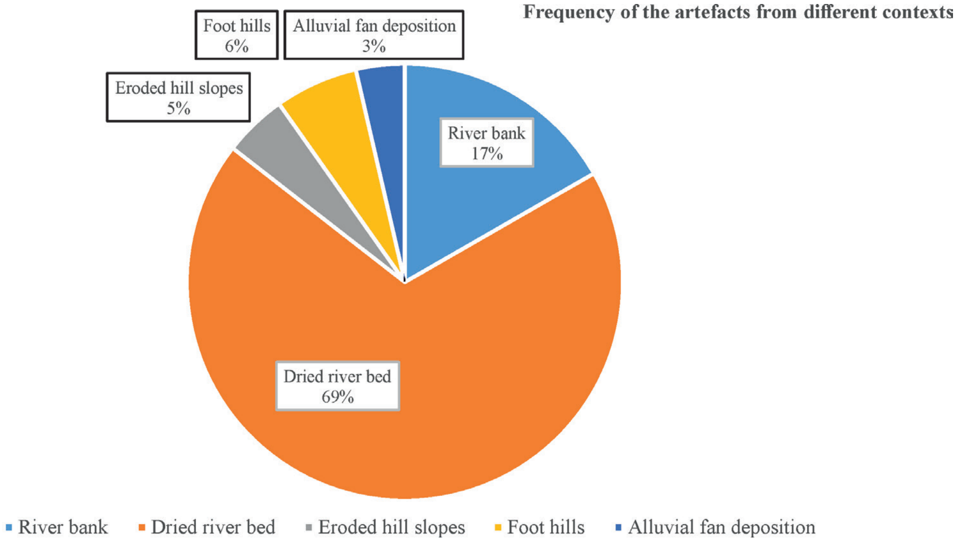
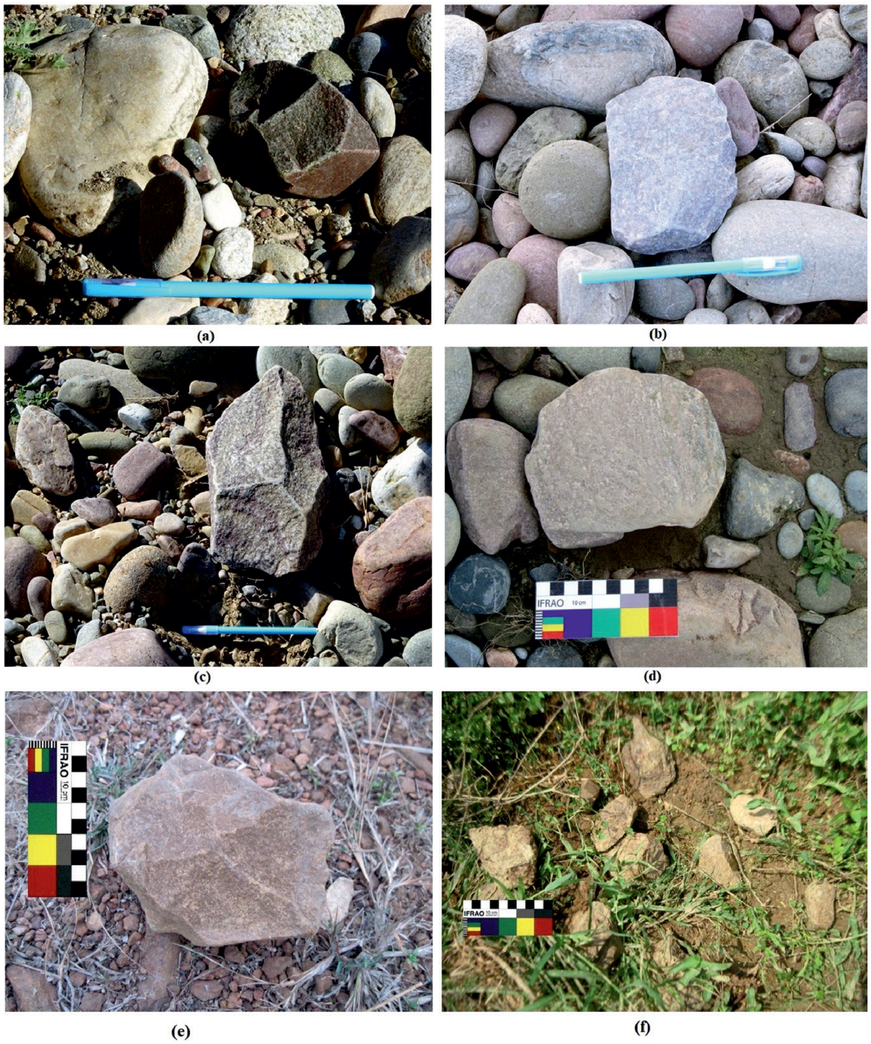


Figure 8: Pie chart shows the frequency of the recovered lithic artefacts from varied contexts

The artefacts unearthed within the examined region are most likely the result of erosion from the nearby hilly terrain or hydrogeologic processes. Upon closer inspection, the lithic assemblages discovered in the region encompass a diverse range of cores, core fragments, flakes, discoids, choppers, hand axes, cleavers, picks, scrapers, split cobbles, broken artefacts, and unidentifiable artefacts. Lithic artefacts have been categorized into various subtypes to facilitate analysis and enable a more comprehensive understanding of the discoveries. Unretouched flakes are the most commonly observed subtype, which accounts for 18.93% of the lithic assemblages. These findings provide a thorough comprehension of the lithic assemblages' composition. Quartzite and sandstone cobbles and angular fragments have been used to facilitate the production of lithic artefacts. The study of the local boulder-conglomerate formation in close proximity to the study area has revealed that it is the primary source of quartzite and sandstone. Hominins probably utilized fluvially rounded and angular quartzite and sandstone clasts (60-240mm). Fluvial clasts are believed to have originated from the local rock formations, constantly eroded by abundant streams in the SKRB area. Conversely, angular clasts are thought to arise from colluvial activities, and are readily available in the nearby hilly tracts of the studied area. Lithic artefacts were manufactured mainly from three blank types (Table 4). The lithic assemblages in the study area exhibit varying degrees of weathering resulting from river activities and have been categorized into four distinct groups (Table 5).



(a) (b) (c) (d) (e) (f)

Figure 9: Closer view of the contexts of the recovered artefacts

Table 4: Stone tools on different blank types at Seer Khad River Basin

	Nature of banks		
Stone tool type	*On complete cobbles*		*On flakes*
Unifacial discoid	**-**		**+**
Bifacial discoid	**-**		**+**
Irregular discoid	**-**		**+**
Unimarginal end chopper	+		+
Unimarginal side chopper	+		+
Bimarginal side chopper	-		+
Bimarginal end chopper	-		+
Unifacial end chopper	-		+
Unifacial side chopper	-		-
Bifacial side chopper	+	+	-
Irregular chopper	-	+	+
Hand axe	+	-	+
Cleaver	-	+	+
Pick	+	-	+
Peripheral scraper	-	-	+
Sub-peripheral scraper	-	-	+
Lateralsided scraper	-	-	+
Doublesided scraper	-	-	+

Table 5: Percentage of types of weathering of the artefacts

Type of wathering	***n***	**%**
Fresh	76	6.26
Slightly weathered	141	11.6
Moderately weathered	469	38.6
Heavily weathered	539	44.36

Thin Section Analysis for Raw Material Studies

A comprehensive thin section analysis was conducted to determine the raw materials used in lithic manufacturing. The study involved the analysis of various natural clasts and lithic artefacts specifically, natural clasts of quartzite and sandstone (n=26) from the studied area and the studied localities were selected, and artefacts (n=26) on quartzite and sandstone were analyzed. The results showed that coarse to medium-grained sandstone and quartzite cobbles were utilized to manufacture the artefacts. Thin section analysis of the recovered artefacts from studied localities and raw material samples from the studied area revealed similar features. In addition, chunks of bedrock from different localities were collected for thin section analysis. Bedrock samples from diverse locations have been gathered for analysis through thin sections. The sandstone bedrock primarily comprises assorted framework grains of quartz that constitute approximately 63% of the rock. The cementing material of the rock is a fine-grained siliceous cement matrix, which makes up around 33% of the rock. The siliceous cement is the primary cementing material, and it is accompanied by a small amount of ferruginous cement, which constitutes about 4% of the rock. The framework grains of the sandstone bedrock are fine-grained, assorted, and sub-rounded to sub-angular in texture (Figure 10 (i)). On the other hand, the quartzite bedrock is made up primarily of assorted framework grains of quartz. Notably, the cementing material and matrix are almost absent, and the quartz grains show significant secondary growth. Importantly, the quartz grains are medium size and display an interlocking grain boundary. Upon further analysis, it has been observed that the rock exhibits indications of low-grade metamorphism (Figure 10 (ii)). The bedrock in the study area is composed of sandstone, a type of metamorphic rock. The sandstone bedrock consists predominantly of quartz framework grains, accounting for approximately 85% of the rock's composition. Feldspar and rock fragments constitute roughly 7% and 4% of the rock, respectively. The framework grains of the sandstone bedrock are medium-grained, primarily interlocking, and exhibit secondary growth along the borders. The grains are sub-rounded to sub-angular in shape. Furthermore, the rock displays some signs of low-grade metamorphism (Figure 10 (iii)).

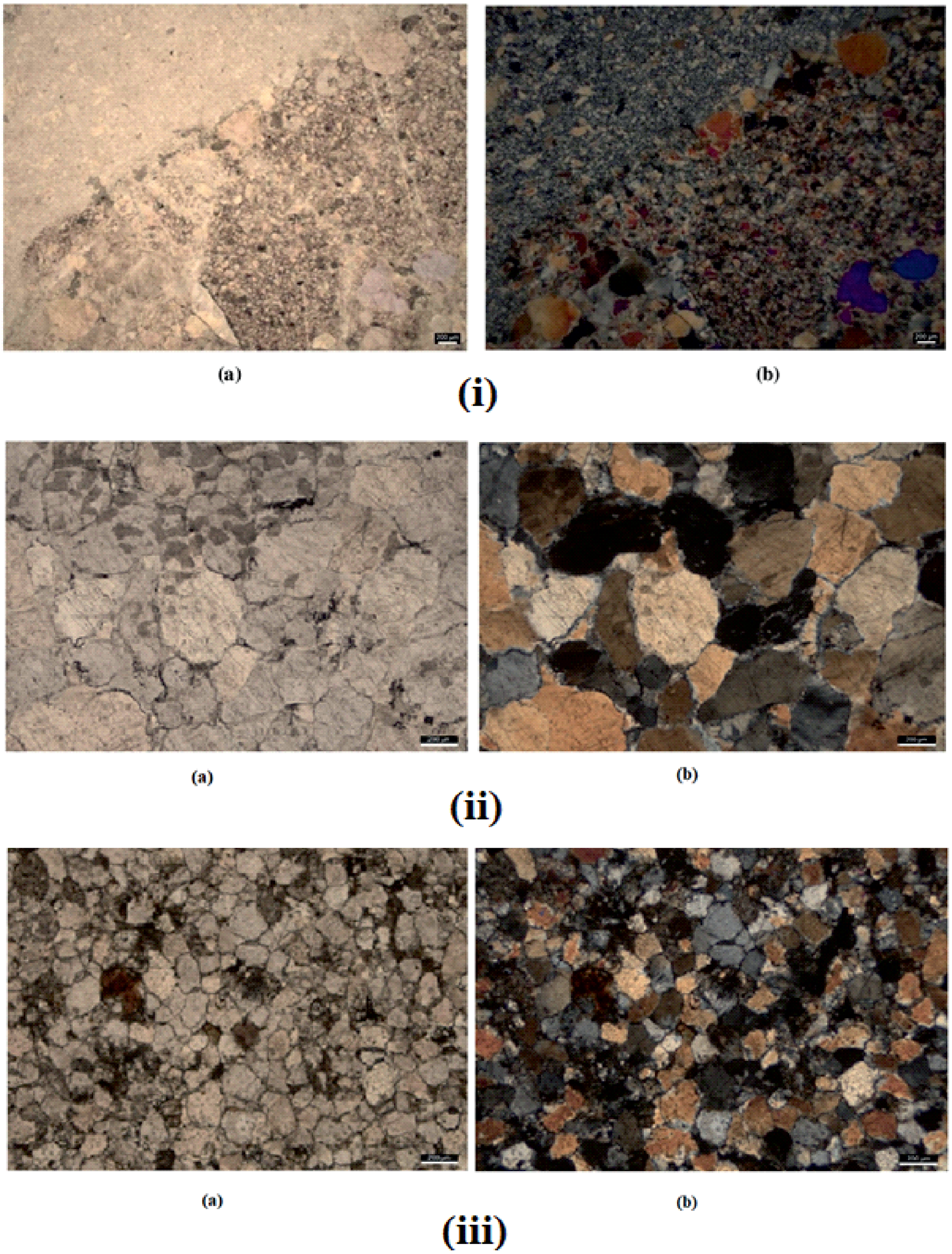


Figure 10: Photomicrographs of the thin sections of the raw material samples. (i)Thin section demonstrate the sandstone rock (Microphotograph of the Sample- B1/21: (a) under plane and (b) cross polarized light; (ii) Thin section demonstrate the quartzite rock (Microphotograph of the Sample- K3/21: (a) under plane and (b) cross polarized light); (iii) Thin section demonstrate the sandstone rock (metamorphic) (Microphotograph of the Sample- B/21: (a) under plane and (b) cross polarized light)

Cortex Coverage

Upon close examination of the Seer Khad assemblages, it was discovered that out of the 1215 artefacts that were examined, 492, accounting for 40.49%, had between 0 to 25% cortex. In addition, 232 artefacts, 19.09%, contained between 25 to 50% cortex, while 158 artefacts (13%) had between 50 to 75% cortex. Furthermore, 110 artefacts (9.05%) were discovered to contain 100% cortex, while 81 artefacts (6.66%) had no cortex at all. It was observed that the artefacts without cortex exhibited a high level of reduction. For 142 artefacts (11.68%), the amount of cortex was unclear due to abrasion (Table 6). Detailed observation of the artefacts revealed that the cortex was distributed in different locations, including the striking platform, dorsal left, dorsal right, dorsal middle, and proximal parts. Artefacts lacking cortex exhibited a noticeable intensity of reduction.

Table 6: Cortex percentage of the artefacts

Percentage of cortex coverage on artefacts (%)	*(n)*	*Artefact percentage (%)*
0–25	492	40.49
25–50	232	19.09
50–75	158	13
100	110	9.05
Absent	81	6.66
Unclear	142	11.68

Core and Core Fragments

Altogether, 128 cores have been analyzed (Figure 11). These cores are classified into four types based on their typological attributes: bipolar core, single platform core, multiple platform core, and double-sided core. Among these, the bipolar core was extracted using the bipolar technique by the knappers to obtain the maximum amount of raw material from the core. This type of core's length, width, and thickness vary between 10.8- 18.1cm, 6.7- 13.7 cm, and 5- 8 cm, with an average of 12.11 cm, 10.07 cm, and 5 cm, respectively. The single platform core generally provides a striking platform for removing flakes in a sequential and unidirectional manner. The average length and thickness of this type are 13.51 cm, 10.43 cm, and 7.37 cm, respectively. It is worth noting that the shapes of multi platform cores can vary significantly from site to site, indicating the diverse range of lithic techniques utilized by hominins. The length, width, and thickness range of this type of core is 5.2–18.7 cm, 5.9–18.8 cm, and 2.8–13.6 cm. The flaking type of the multiple platform core exhibits both sequential and multidirectional characteristics. In the case of double sided cores, the flake removal occurs from both sides of the core. This particular type of core provides unidirectional flake detachment. The average value of the length, width, and thickness of this type is 13.97 cm, 10.74 cm, and 7.7 cm (Table 2). In the SKRB, angular fragments and chunks (core fragments) (n = 71) are an important lithic type that consists of pieces or fragments that lack a standard core form and exhibit amorphous features. These fragments do not have any prominent evidence of a conchoidal fracture. Interestingly, within the assemblage, a few cores (n = 59) clearly show a surface cortex patch, indicating they are river cobbles or boulders. This detail is significant as it helps to identify the blank type of the artefact. The core fragment's length, width, and thickness vary between 7.7- 17.4 cm, 6.1- 14.6 cm and 4.6- 11.7 cm, with an average value of 12.92 cm, 10.13 cm, and 7.82 cm (Table 2).

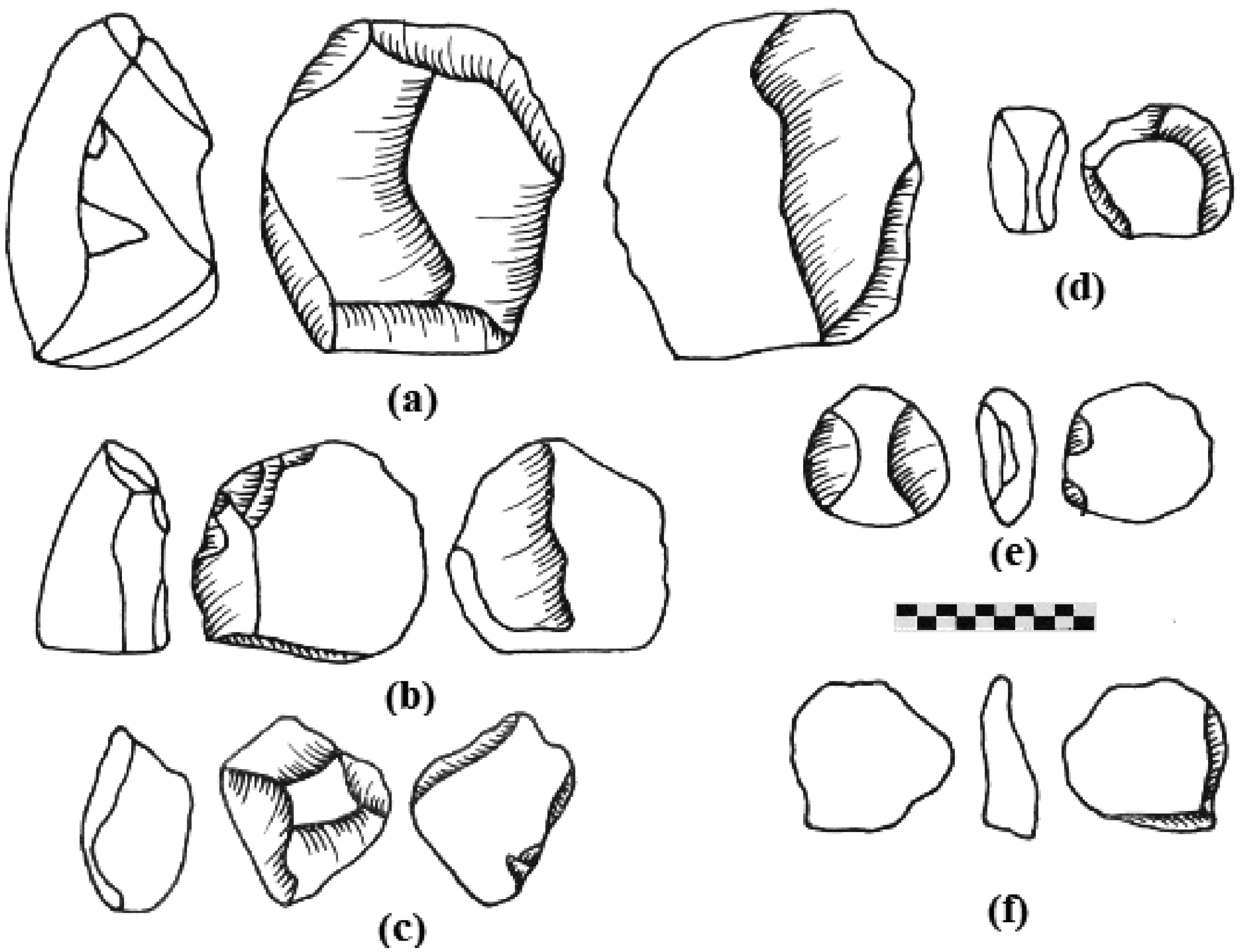


Figure 11: Illustration of the variety of cores on different kinds of quartzite clasts

Discoids

In the study area, ninety-five (*n* = 95) discoids have been identified and analyzed based on typo-technological characteristics (Figure 12). These discoids were further categorized into three types: unifacial discoids (*n* = 25), bifacial discoids (*n* = 22), and irregular discoids (n = 48). It has been observed that the dimensional attributes of the discoid types vary according to the localities (Figure 13). By thoroughly examining these discoids, authors can gain valuable insights into the technological practices and cultural traditions of the people who created them. These cores possess circular contours resulting from varying numbers of flake scars. It is observed that these cores exhibit an intriguing pattern of flake scars that show different ridges at the centre. The length, width, and thickness range of unifacial discoid is 8.2- 15.3 cm, 6.4- 19 cm and 2.8- 6.3cm with the average of 11.88 cm, 9.86 cm, 4.2 cm. for the bifacial discoid the length, width and thickness range varies between 7.7-12.9 cm, 5.2-9.4 cm and 2.5- 5.7 cm with an average of 9.79 cm, 7.13 cm and 4.24 cm, respectively. The irregular discoid category's length, width and thickness range varies between 7- 15 cm, 5.8- 11.8 cm, and 3.2-7.3 cm, with an average of 10.91 cm, 8.86 cm and 5.55 cm. The highest and lowest length values are found in the unifacial discoid (15.3 cm) and irregular discoid (7 cm). The highest width and thickness values have been found in the unifacial discoid (19 cm) and irregular discoid (7.3 cm) (Table 2). The discoids of SKRB exhibit a distinct characteristic: the absence of a bulb of percussion. Out of the entire discoid assemblage, irregular discoids comprise the majority (*n* = 48).

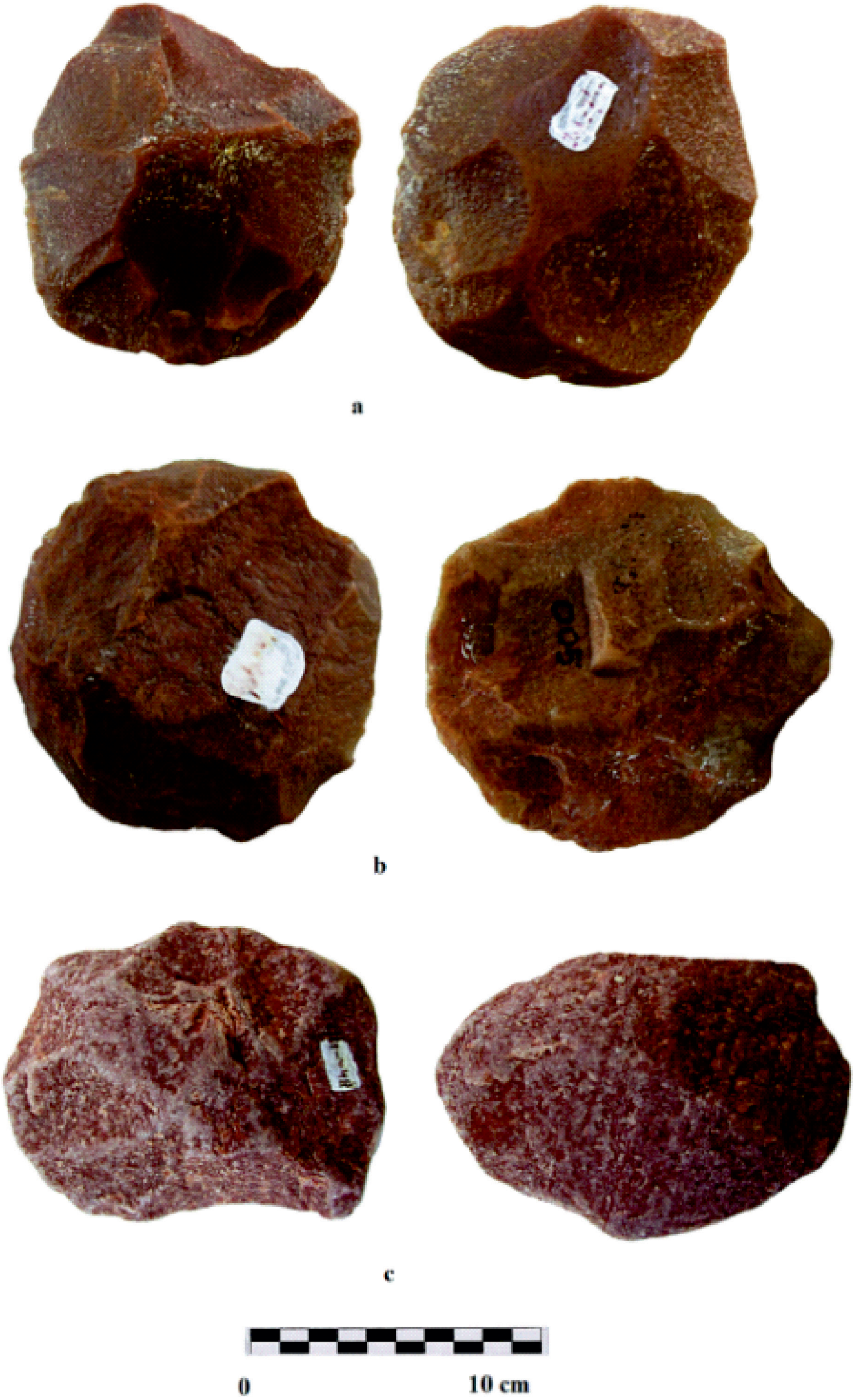


Figure 12: Recovered discoids

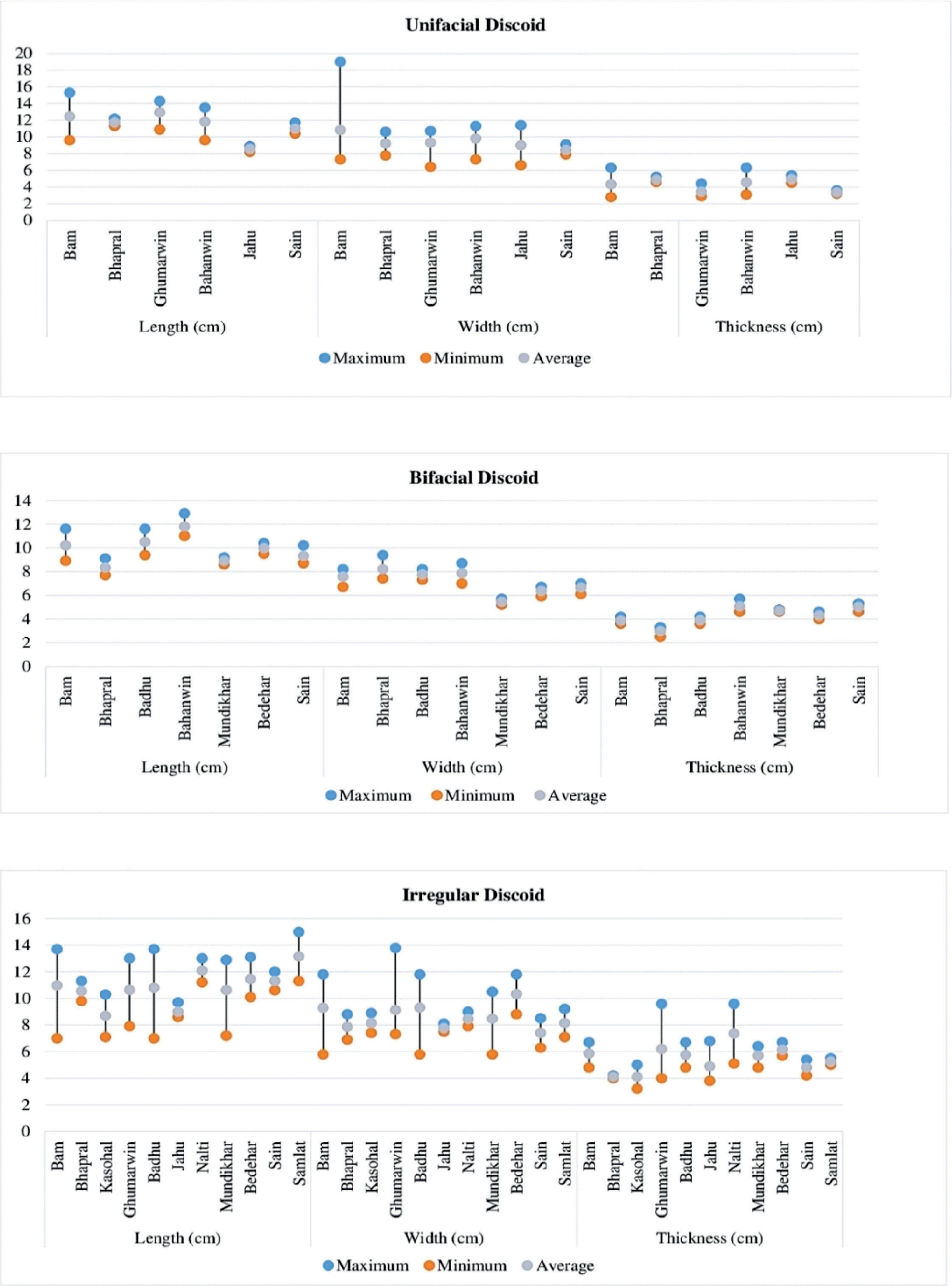


Figure 13: Locality wise variability in dimensional attributes of discoid types

Choppers

During fieldwork, 216 choppers were discovered from SKRB (Figure 14). These choppers were crafted on different blank types (Table 4). Choppers on split cobbles indicate that the knapper obtained the blanks by splitting the cobble on the anvil in half. The authors conducted an experimental study on the cobbles, which revealed that freehand hammerstones were utilized to obtain two half-split pebbles. This particular type may have been used to shape choppers. The edges of the choppers are occasionally sharp and not blunt. It's worth noting that these choppers have been categorized into eight distinct categories (Table 2). It has been found that the Seer Khad choppers feature a unique characteristic in which only one flake is removed to create a few choppers. Bimarginal end-choppers exhibit medium and heavy retouching, which adds to their distinctiveness. These artefacts are flaked along one edge while the two sides of the clast are left unworked, resulting in an S-shaped working edge. The bimarginal side choppers appear to have been manufactured through sequential flaking, with two in this category displaying a combination of consecutive and step-flaking techniques. It can be observed that the entire face of the unifacial end-choppers showcases flaking, resulting in a frequently observed appearance that closely resembles unifacial discoids. A unidirectional flaking pattern in the unifacial end-choppers was observed during the study. Specifically, it has been found that this sub-type of the chopper has longer working edges compared to end-choppers. The specimens in this category also exhibit marked retouches, which can be categorized into moderate and extensive edge-wear. Irregular choppers do not conform to the previously mentioned categories regarding typo morphology. Many broken choppers (n= 52) have been recovered during the study. Breakage was largely found along with the proximal end (n= 35). A few choppers (n= 17) had broken edges (Table 7). A closer view of the breakage exhibit shows that these are not recent. The breakage part also exhibits patination on both surfaces (dorsal and ventral). A high number of broken choppers (n= 178) have been recovered during the study. Most of the breakage was located at the proximal end, with 109 choppers exhibiting this type of damage. Additionally, a moderate number of choppers, 69 in total, had a broken edge. The authors could only recover a small number of complete choppers, with only 39 being found (Table 8). Upon closer inspection, it was apparent that these were not recent breakages, as both the dorsal and ventral surfaces exhibited patination.

Table 7: Chopper types with their broken areas

Chopper types	*Parameters*	*No*	*Percentage value*
Unifacial end	Broken (Proximal end)	12	23.07
	Broken (Edge)	3	5.77
Unifacial side	Broken (Proximal end)	9	17.3
	Broken (Edge)	7	13.46
Unimarginal side	Broken (Proximal end)	7	13.46
	Broken (Edge)	5	9.61
Irregular	Broken (Proximal end)	7	13.46
	Broken (Edge)	2	3.84
Total		52	100

Table 8: Chopper types with their broken areas

Chopper types	*Parameters*	*No*	*Percentage value*
Unifacial end	Broken (Proximal end)	13	6.02
	Broken (Edge)	11	5.09
	Complete	2	0.92
Unifacial side	Broken (Proximal end)	15	6.94
	Broken (Edge)	6	2.78
	Complete	3	1.39
Unimarginal end	Broken (Proximal end)	28	12.96
	Broken (Edge)	12	5.55
	Complete	10	4.63
Unimarginal side	Broken (Proximal end)	8	3.70
	Broken (Edge)	7	3.24
	Complete	5	2.31
Bimarginal end	Broken (Proximal end)	4	1.85
	Broken (Edge)	7	3.24
	Complete	6	2.78
Bimarginal side	Broken (Proximal end)	7	3.24
	Broken (Edge)	5	2.31
	Complete	4	1.85
Bifacial side	Broken (Proximal end)	3	1.38
	Broken (Edge)	9	4.16
	Complete	2	0.92
Irregular	Broken (Proximal end)	31	14.35
	Broken (Edge)	12	5.55
	Complete	7	3.24
Total		216	100

Handaxe

A total of seven (n = 7) handaxes have been retrieved (Figure 15); of these, three have been slightly retouched in a bifacial manner. These handaxes have been fashioned out of the blank of large flakes (≥10 cm) that have been detached from large river-borne quartzite cobbles or boulders. Removing flakes from the giant cores has been accomplished using a hard hammer or anvil technique. The shape of handaxes has been observed to be predominantly informal yet bifacial in appearance, with minimal labour input. Similar findings were reported by Sankhyan (2018) in his study of the Sub-Himalayan region of Himachal Pradesh. According to Sankhyan, selecting boulder shapes minimizes the need for cortex flaking, resulting in an informal flake hand axe with a bifacial core appearance. In the present study area, the production of artefacts was facilitated by exploiting flake blanks, sides struck, and end struck flakes. The dorsal face of the specimens exhibited a range of cortex cover. In particular, handaxes were identified by the presence of numerous flake scars. In order to gain insight into the intensity and technology of handaxe production, flake scar counts were conducted. The analysis revealed that the range of flake scars on the dorsal face of the artefacts varied between 5 to 9, whereas the ventral face exhibited a range of 3 to 6 flake scars. The range of flake scar lengths on handaxes is significant, measuring from 0.186 to 0.643 cm, with an average of 0.402 cm. Similarly, the width of flake scars spans from 0.263 to 0.735 cm, with an average of 0.407 cm. Flake scars are generally located around the edges of the handaxes rather than across their entire surfaces. However, one notable exception is a tool that falls between a handaxe and core, boasting a surface completely covered in flake scars. Notably, the handaxes are not pointed, with most tips showing moderate breakage. Only two handaxes

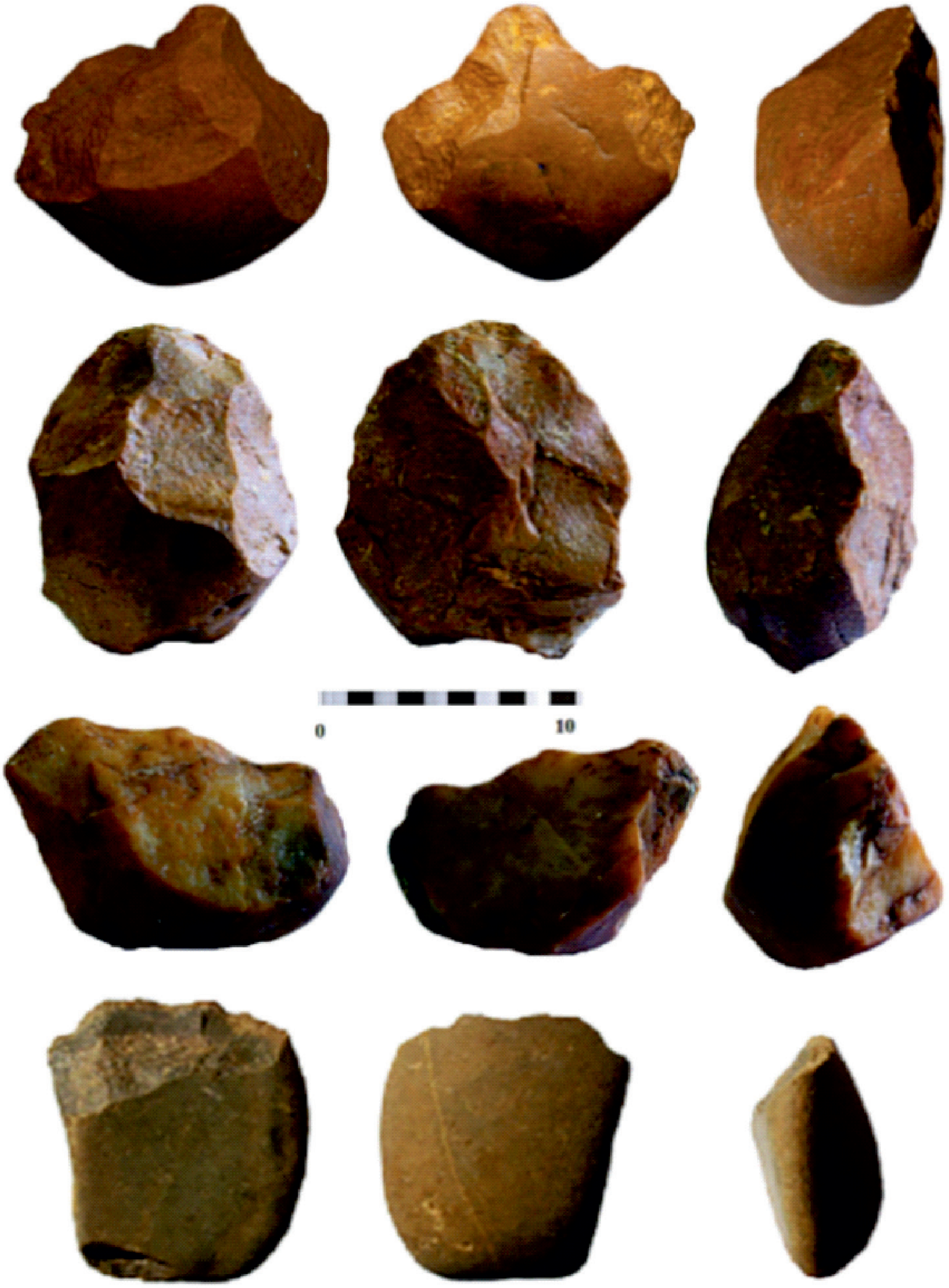


Figure 14: Choppers of different types from studied area

have rounded tips. It has been observed in the field that some of the tips have not been trimmed, and when they have, the retouch is predominantly unifacial rather than bifacial. Most handaxes' butt portions remain unworked. The two handaxes (n = 2) under examination display their broken butt ends. In some handaxes (n = 3), the butt appears to have been utilized for chopping, as evidenced by the presence of chop marks on both faces and the ventral or dorsal face. The handaxes from the studied region are fashioned out of large flakes, which exhibit minimal modification by flaking and scarcely cover more than half of each face. The range of the handaxe's length, width, and thickness varies between 8- 19.2 cm, 7- 11.6 cm, and 3.2- 5.8 cm with an average value of 13.58 cm, 9.57 cm, and 4.28 cm (Table 2).

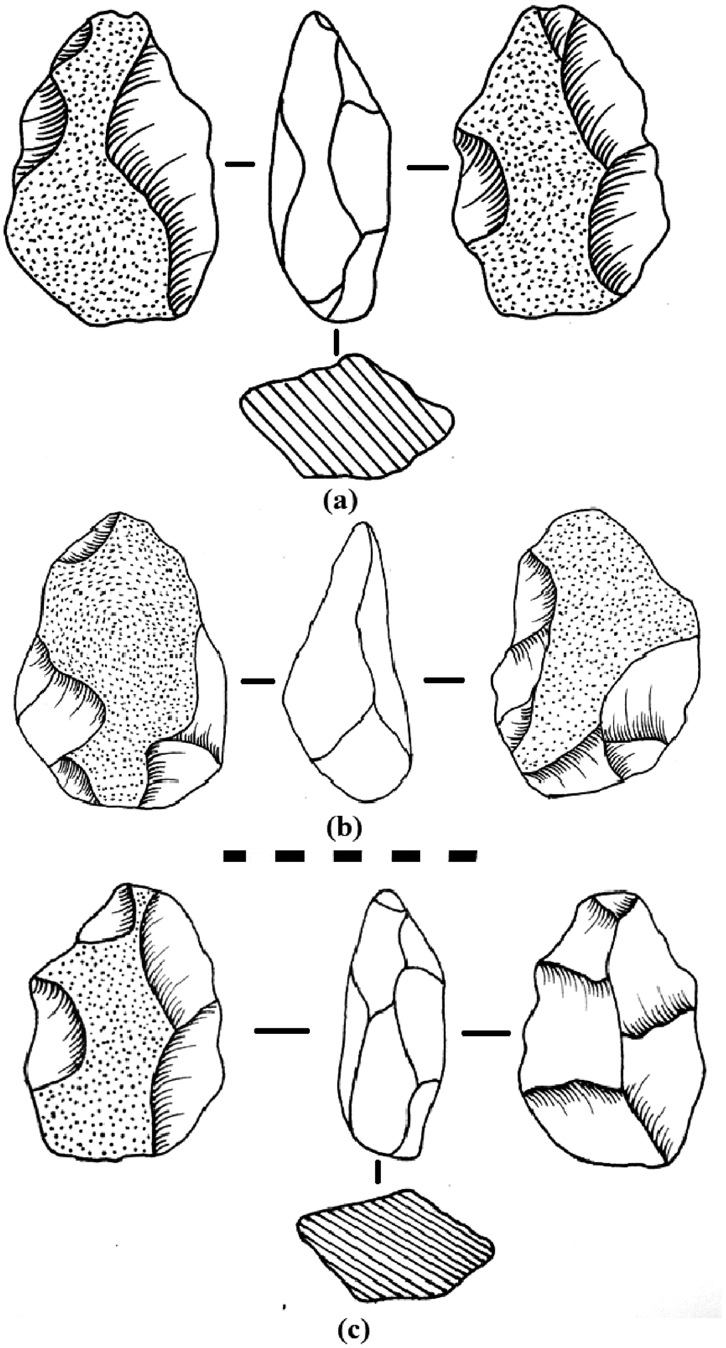


Figure 15: Illustration of recovered handaxes

Cleaver

The study area has yielded twelve (n=12) cleavers (Figure 16), comprising 0.98% of the entire assemblages (Table 2). Eight cleavers were manufactured on side-struck flakes, while only three were fashioned on end-struck flakes. One cleaver was found on an undetermined flake (n=1). The physical characteristics of the recovered cleavers reveal noteworthy details. Two cleavers have cortical striking platforms (n=2). Furthermore, dihedral platforms were observed in some cleavers (n=3). Most cleavers (n=5) have a prominent bulb. The percussion point is primarily located in the middle of the cleaver, but in some instances, it is angled toward the flaking face or in between. The cleavers are generally trimmed on the margins only. Consequently, the original shape of the blank flakes remains largely unmodified. By definition, cleavers are a type of cutting tool characterized by an unretouched cutting edge. This particular edge is considered to be the primary functional component of the tool, although the other edges can also be utilized for various purposes (Gaillard *et al.*, 2008). It is interesting to note that at SKRB, the edges of the cleavers are all slightly convex, adding to their distinct features. Several artefacts featuring cutting edges along a cortical dorsal face resemble the cleavers documented by Atbarapur (Gaillard *et al.*, 2008). The cleavers discovered at SKRB display a broad cutting edge on the lateral side of the flake, formed by the earlier removal from the same striking platform. In a quarter of the flakes, the point of percussion at the angle still needs to be clarified and requires further observation and experimentation to be understood in detail. The core reduction sequence was oriented and customized to produce blanks for manufacturing cleavers. The artefacts are fashioned from large flakes obtained through simple core reduction methods and short production sequences. The present study highlights the unique features of cleavers manufactured in the studied area, which require minimal shaping, are primarily limited to the edges, and are transformed into tools. It is noteworthy that these cleavers display techno-typological features that align with the "Large Flake Based Acheulian" (Sharon, 2007) found extensively in Africa, the Near East, and South Asia (Mishra *et al.*, 2010). The recovered cleavers were observed to have a mean cutting edge length of 9.71 cm, while the mean cutting edge angle was recorded as 40.1°, with values ranging between 30° and 49.6°.

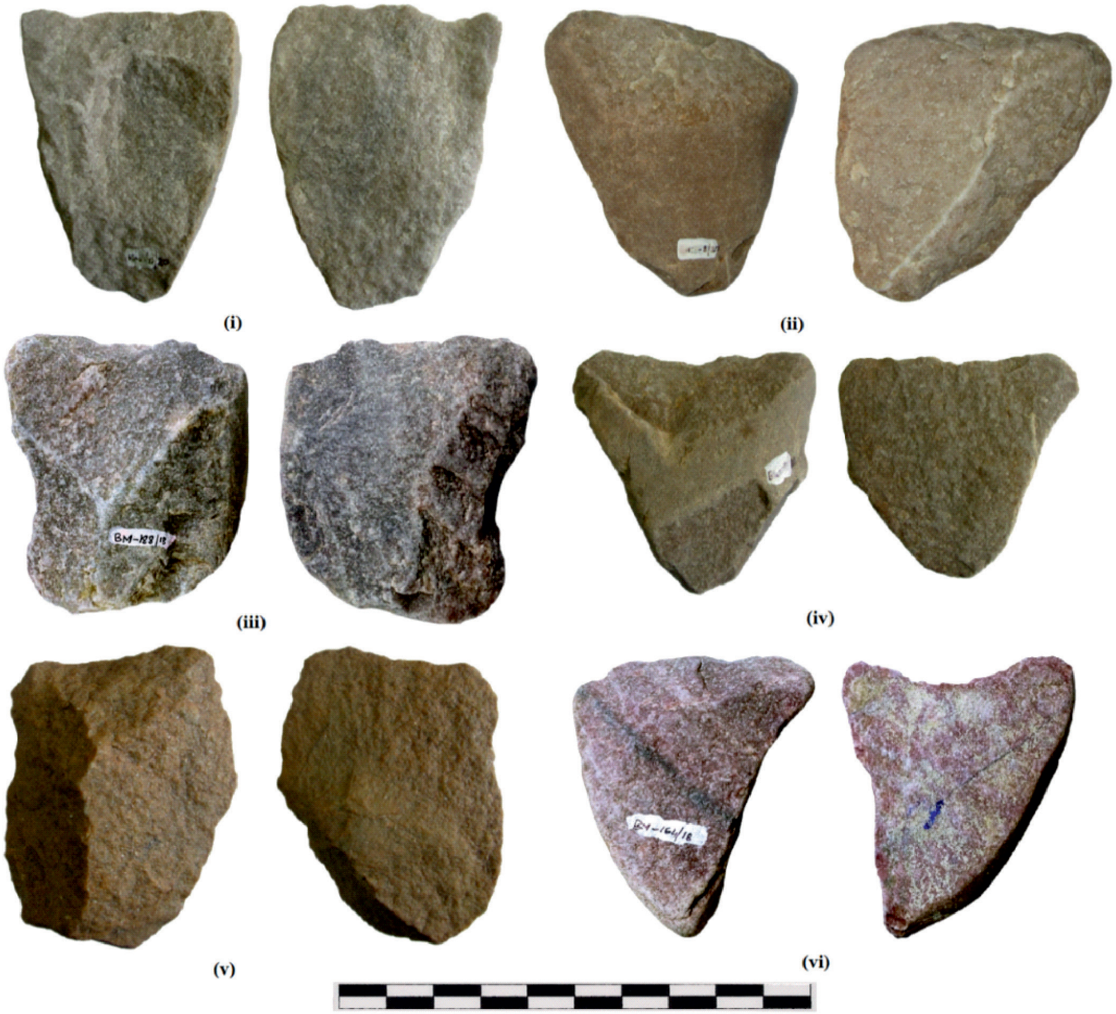


Figure 16: Recovered cleavers from Seer Khad River Basin

The cutting edge of the artefacts was found to be straight and oblique in shape. The mean length of the cutting edge was reported to be 7.6 cm. On the dorsal surface of the cleaver, the scar counts ranged from 1 to 7, while the ventral surface showed a slightly lower range of scar counts, with the minimum and maximum counts being 0 and 4, respectively. These observations indicate that the specimen may have undergone low-range flake removal, which could have contributed to the formation of these scars. It was observed that the cleavers were manufactured using flake blanks (≥ 10.5 cm), which resulted in minimal shaping and retouching on their ventral faces. The flake scars on the cleavers exhibited hard hammer percussion. The cleaver's length, width, and thickness range varies between 10- 15.8 cm, 8.3- 12.9 cm and 2.8- 4.7 with an average value of 13.27 cm, 10.2 cm and 3.5 cm (Table 2). Analysis of the artefacts reveals that the proximal end of five ($n = 5$) cleavers (41.66%) is broken. The butt end is broken for three ($n = 3$) cleavers (25%), and two ($n = 2$) cleavers show edge damage (16.67%). Two ($n = 2$) cleavers have been found without any breakage (16.67%) (Table 9). The degree of damage on some of the cleavers suggests that the breakages aren't recent, as there are noticeable similarities in patination and weathering on both the dorsal and ventral surfaces of the damaged areas.

Table 9: Percentage value of the broken areas of recovered cleavers

Parameters	*Cleaver (n= 12)*	
	No	*Percentage*
Broken (Proximal end)	5	41.66
Broken (Butt end)	3	25
Broken (Edge)	2	16.67
Complete	2	16.67
Total	12	100

Pick

Twenty-four ($n = 24$) picks have been recovered, constituting 1.97% of the Seer Khad lithic assemblages (Table 2 & Figure 17). The tool makers utilized elongated cobbles, which were generally cylindrical in shape, to fashion the implements. Although the artefacts have undergone rolling, some flake scars have been observed on their surfaces. It is worth noting that the trimming of the pick is generally unifacial in character. Interestingly, the butt section of a few picks ($n = 4$) shows some hitting marks. The butt portion and mesial surface of the artefacts exhibit 25–50% cortex. The artefact's length, breadth, and thickness range from 10.5 to 18.1 cm, 5.9 to 12.4 cm, and 3.6 to 7.8 cm, with an average value of 13.54 cm, 8.20 cm, and 5.49 cm (Table 2).

Scraper

Two hundred twenty seven ($n = 227$) scrapers have been reported from the study area (Figure 18). Recovered scrapers are categorized into four sub-types (Table 2). They are made from flakes. The most commonly found scraper among the sub-types is lateral sided scrapers ($n = 112$). Peripheral scrapers ($n = 56$) are characterized by a sharp working edge encompassing the flakes. These flakes tend to be round or oval. It has been noted that the scraper types exhibit varying dimensional attributes depending on their respective localities (Figure 19). Most artefacts exhibit an extensively prepared dorsal surface, achieved by removing flakes. This technique has resulted in steep flaking on the dorsal surface. Specifically, the sub-peripheral scrapers ($n = 24$) feature a working edge covering more than half of the flakes' periphery, equating to almost three-quarters. The toolmakers used thick, oval-shaped flakes to manufacture this artefact. It is worth mentioning that most flakes exhibit a defused bulb of percussion. This has resulted in the central area of the artefacts being thicker than the periphery. The

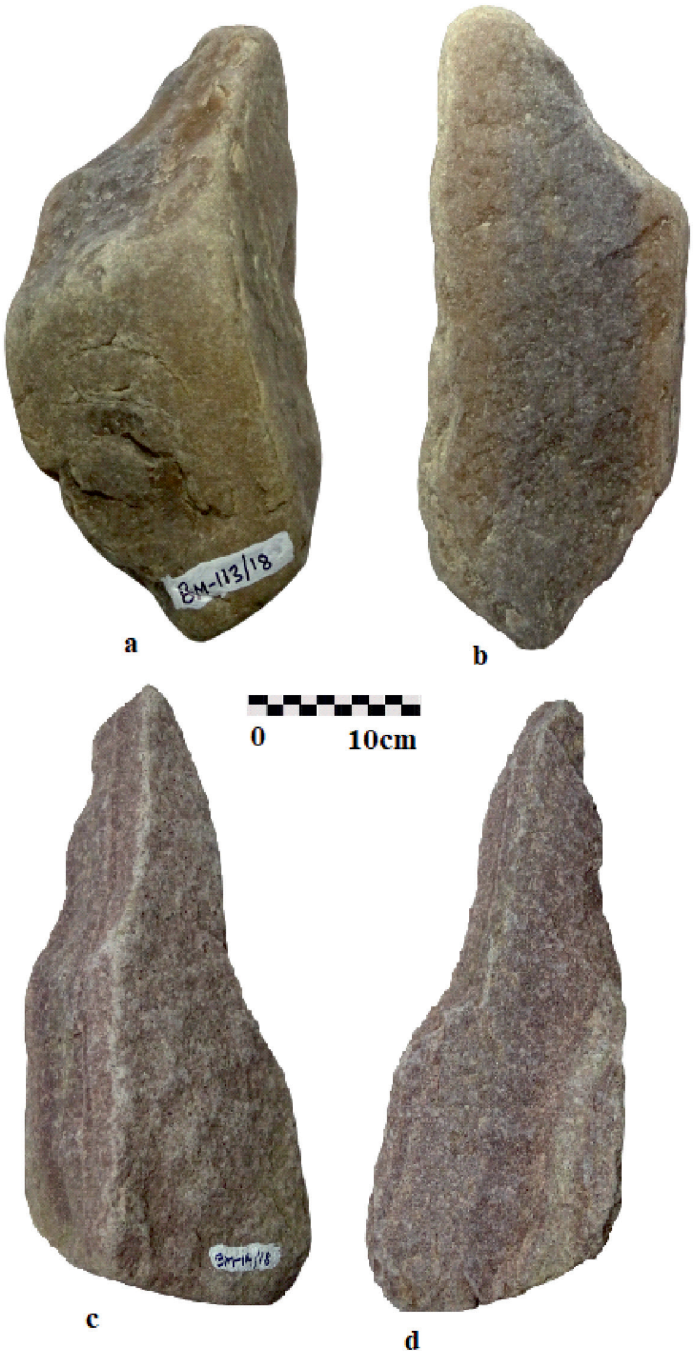


Figure 17: Picks from Seer Khad River Basin

lateral sided scrapers exhibit a working edge aligned with the longitudinal axis on the lateral side. A few scrapers (*n* = 27) in this sub-type feature a concave working edge created by deliberately removing flakes. These scrapers have been fashioned from thick flakes. The cortical platform of these scrapers is rather large. A few scrapers (n = 18) have a straight working edge due to retouching. In contrast, thirty-five (*n* = 35) double-sided scrapers are produced by the intersection of primary flaking, resulting in two functioning ends. These tools are made from long, thin flakes of varying lengths. A few scrapers (*n* = 19) have completely worked dorsal surfaces, indicating high skill and attention to detail in their manufacture. In the field, it has been noted that certain locations (Bam, Bhapral, Kasohal, Tarontara, and Nalti), have shown a higher percentage of scraper artefacts than others. These locations are near seasonal streams (*chos*) originating from hilly areas. This pattern may indicate potential subsistence strategies during the prehistoric era, or it may be a result of geological factors. Multidisciplinary research is required to gain a clearer understanding of this observation. One can further investigate this phenomenon by researching and uncovering new insights into prehistoric lifestyles and geological interference.

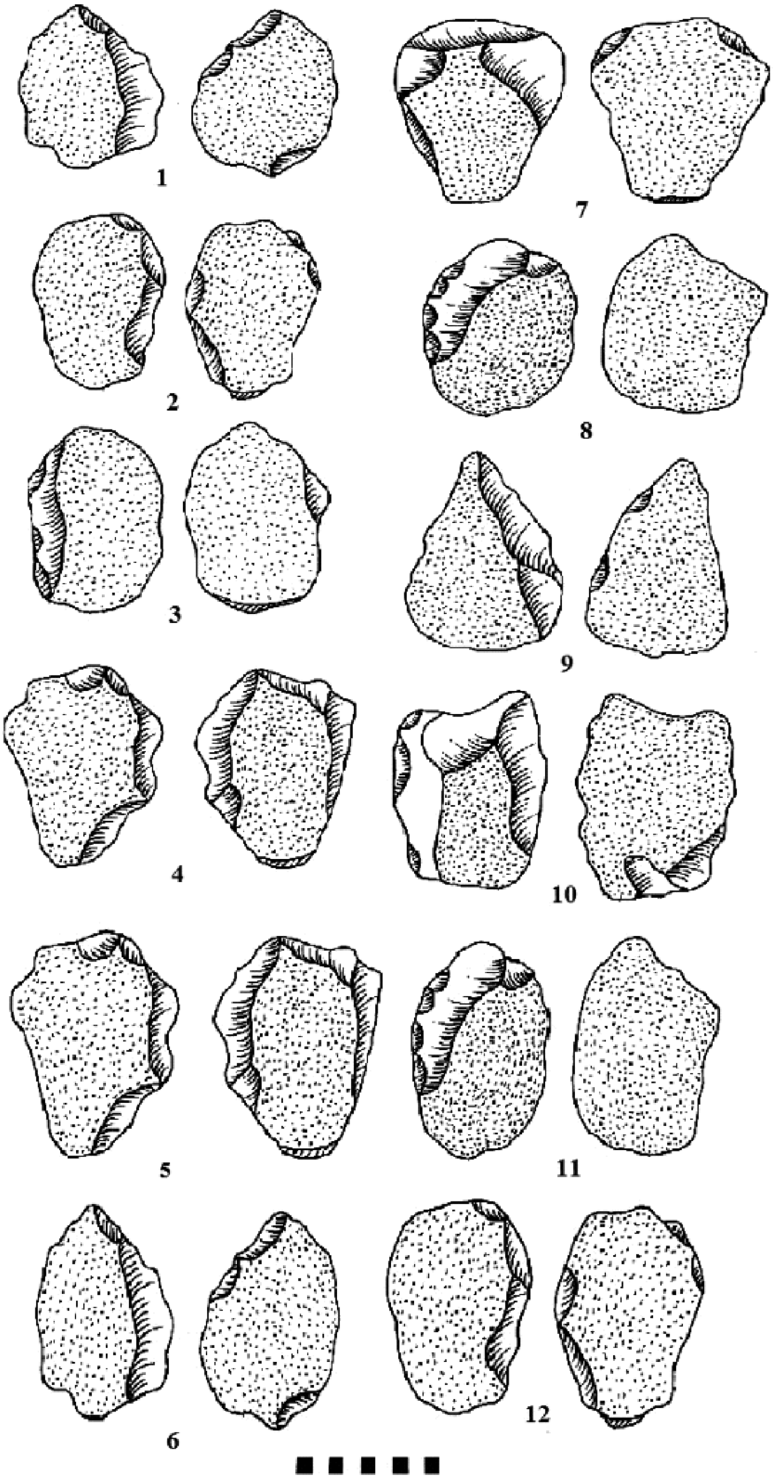
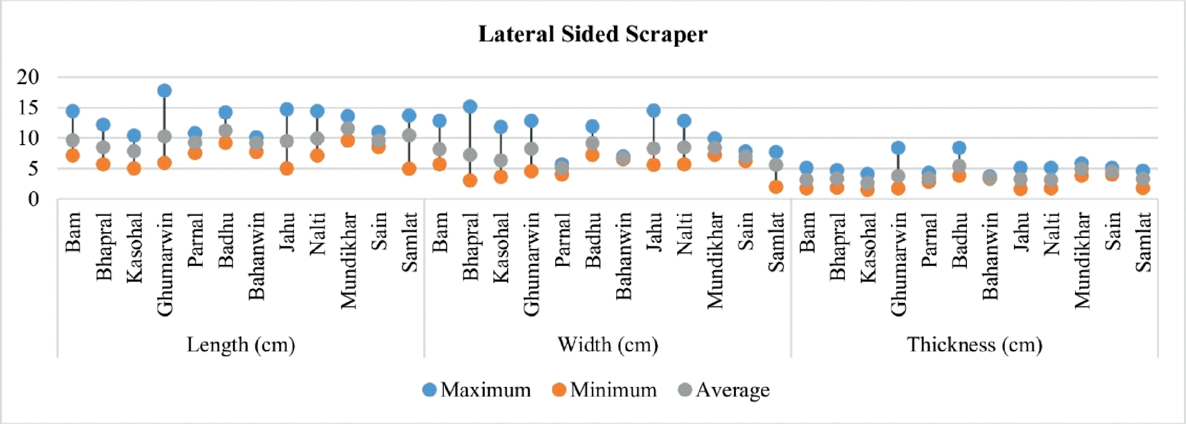
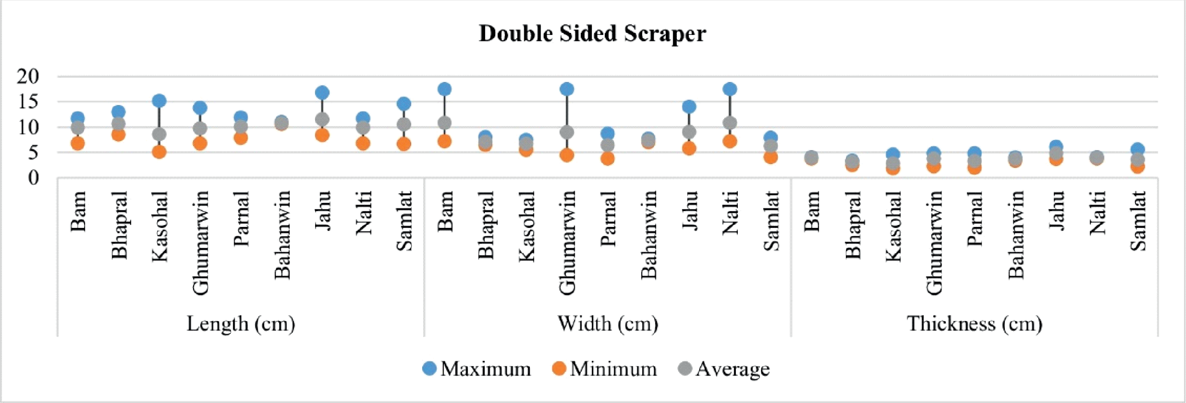
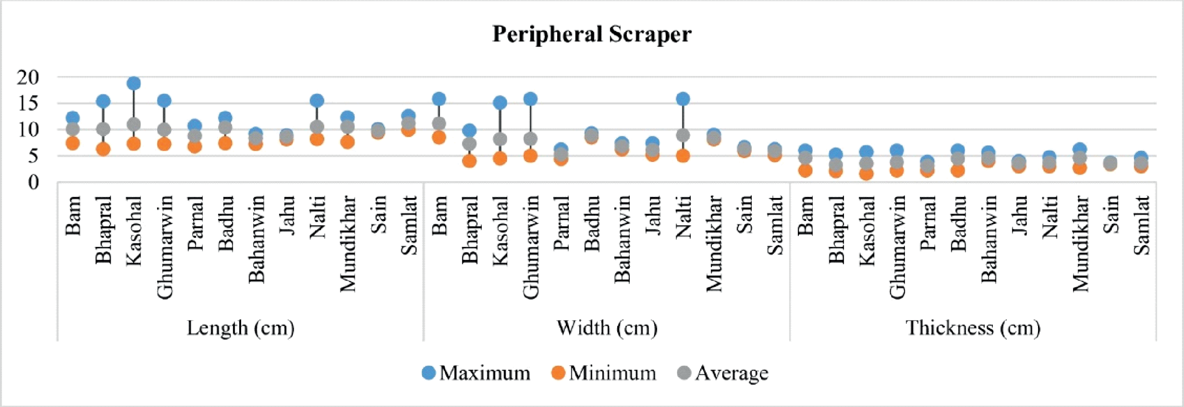


Figure 18: Recovered scrapers from the studied area







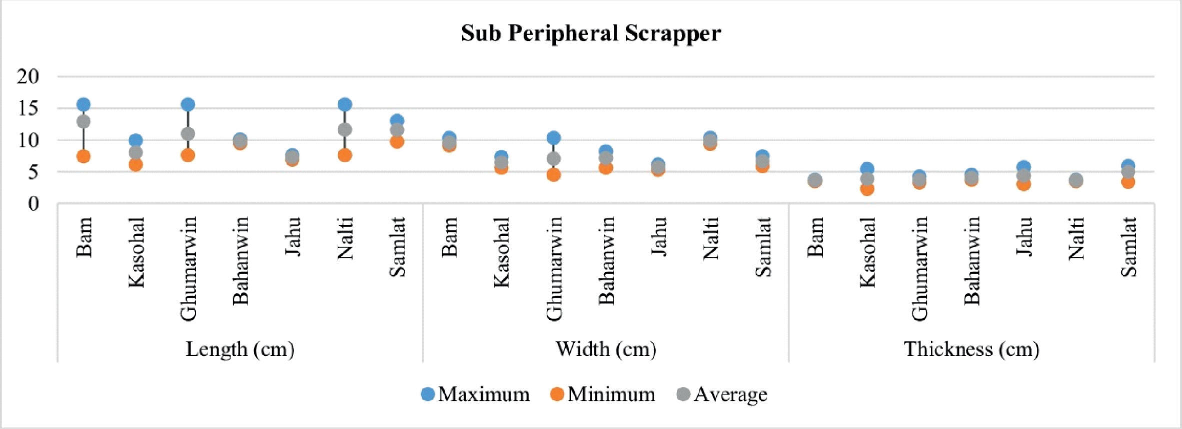


Figure 19: Locality wise variability in dimensional attributes of scraper types

Flake

The lithic assemblages of SKRB comprise various types of flakes (*n* = 344) (Figure 20). These flakes have the greatest frequency at 28.31% (Table 2). Typologically, they have been classified as retouched and unretouched flakes and technologically, side struck, and end struck flakes. A few large flakes (≥ 10 cm) were collected during the field study and identified as the most distinctive technological feature of the SKRB. These large flakes accounted for 1.93% of the overall assemblages. Upon closer examination of the artefacts, it was noted that the negative scars on four flakes (*n* = 4) exceeded 10 cm in length. Additionally, it was observed that the large flakes retained some cortex on their dorsal surface, while their platforms were relatively plain. There is no way to discern the sequence of primary, secondary, and tertiary flakes once separated from the core. Some of the flakes have a partial to completely cortical dorsal region. The flakes contain three types of platforms: flat (*n* = 201), complex (*n* = 82), and abraded (*n* = 61) (Table 9). The maximum length and width value have been found in retouched flakes (24.5 cm; 19.2 cm) (Table 2), whereas the maximum thickness has been found in the unretouched flake (10.4 cm). The dorsal portion of most flakes (*n* = 74) is completely cortical. A few specimens (*n* =23) exhibit flat ventral and cortical surfaces. The striking platform of the flakes is sometimes cortical. A few linear or punctiform platforms were observed in both larger (≥10 cm) and smaller (< 10 cm) flakes as a consequence of strokes placed on a ridge or corner of the cones. These findings suggest that there is significant variation in the structure and composition of flakes. A few flakes (*n* = 14) exhibit signs of being produced by bipolar-on-anvil percussion. Retouching on flakes has been found on different sides of the artefacts (Table 10 & Figure 21). Additionally, the percussion point has been identified at different positions of the dorsal surface among the flakes. The number of flake scars on the dorsal surface varies between 3 and 13, while those on the ventral surface range from 2 to 9. It has been observed that the range of edge angles for both the unretouched flakes (99°-133°) and retouched flakes (94°-124°) exhibit a striking resemblance to those found in the neighboring localities of the Indian Siwalik Hills (Table 11).

Table 9: Platform types of the flakes

Type of platform	*n*	*%*
Flat	201	58.43
Complex	82	23.84
Abraded	61	17.73

Table 10: Number of sides retouched on flake

Side	*No of flake scars*
Left side	5
Right side	2
Left and right side	8
Dorsal end	4
Proximal end	3
Dorsal end and proximal end	2
Left side and dorsal end	4
Left side, right side, and dorsal end	6

Table 11: Edge angle of the flakes of different sites of Siwalik Frontal Range

Artefact type	*Site*	*Range*	*Average*	*Reference*
Unretouched flake	Khoiwala, Himachal Pradesh	75^{0}- 112^{0}	95^{0}	Karir, 1985
	Marhanwala, Himachal Pradesh	90^{0}- 118^{0}	108^{0}	
	Baddi, Himachal Pradesh	104^{0}- 112^{0}	108^{0}	
	Sandholi, Himachal Pradesh	102^{0}- 111^{0}	107^{0}	
	Nalagarh, Himachal Pradesh	103^{0}- 107^{0}	105^{0}	
	Dhang, Himachal Pradesh	104^{0}- 122^{0}	115^{0}	
	Dabhar, Himachal Pradesh	105^{0}- 109^{0}	107^{0}	
	Dagah, Jammu	100^{0}- 122^{0}	Not available	Saroj, 1974
	Seer Khad River Basin, Himachal Pradesh	97^{0}- 130^{0}	108^{0}	Present study
Retouched flake	Khoiwala, Himachal Pradesh	88^{0}- 99^{0}	94^{0}	Karir, 1985
	Marhanwala, Himachal Pradesh	103^{0}- 123^{0}	112^{0}	
	Sandholi, Himachal Pradesh	93^{0}- 122^{0}	108^{0}	
	Nalagarh, Himachal Pradesh	107^{0}- 123^{0}	111^{0}	
	Dhang, Himachal Pradesh	83^{0}- 105^{0}	95^{0}	
	Dabhar, Himachal Pradesh	89^{0}- 109^{0}	99^{0}	
	Dagah, Jammu	91^{0}- 114^{0}	Not available	Saroj, 1974
	Ambran, Jammu	81^{0}- 132^{0}	Not available	
	Seer Khad River Basin, Himachal Pradesh	91^{0}- 119^{0}	101^{0}	Present study

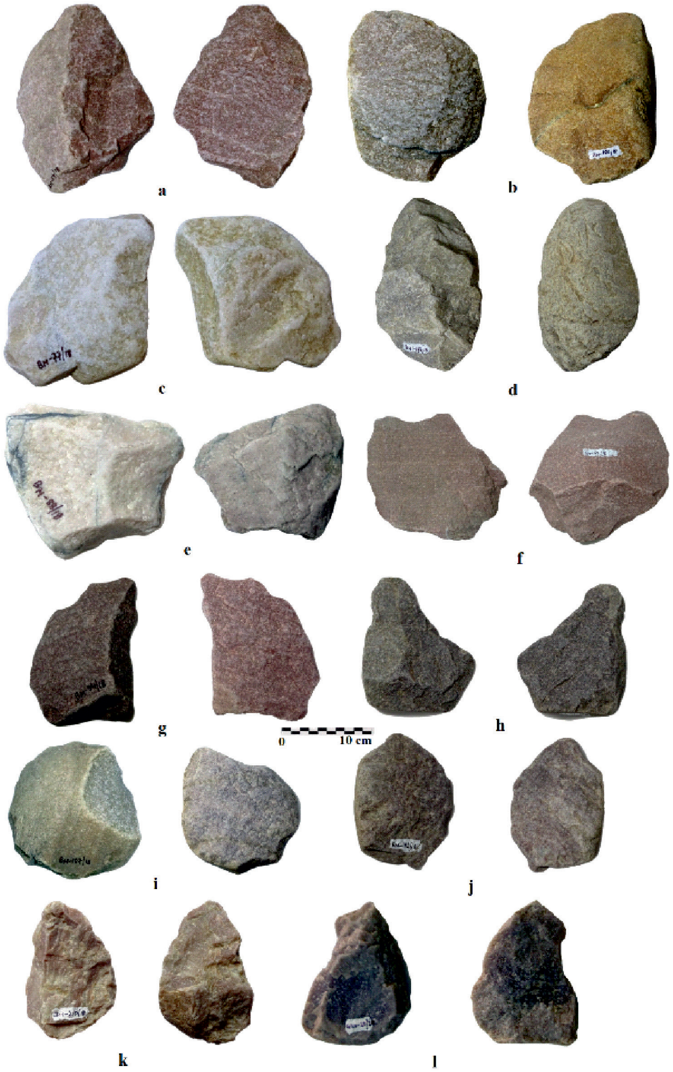


Figure 20: Diverse flake types from Seer Khad River Basin

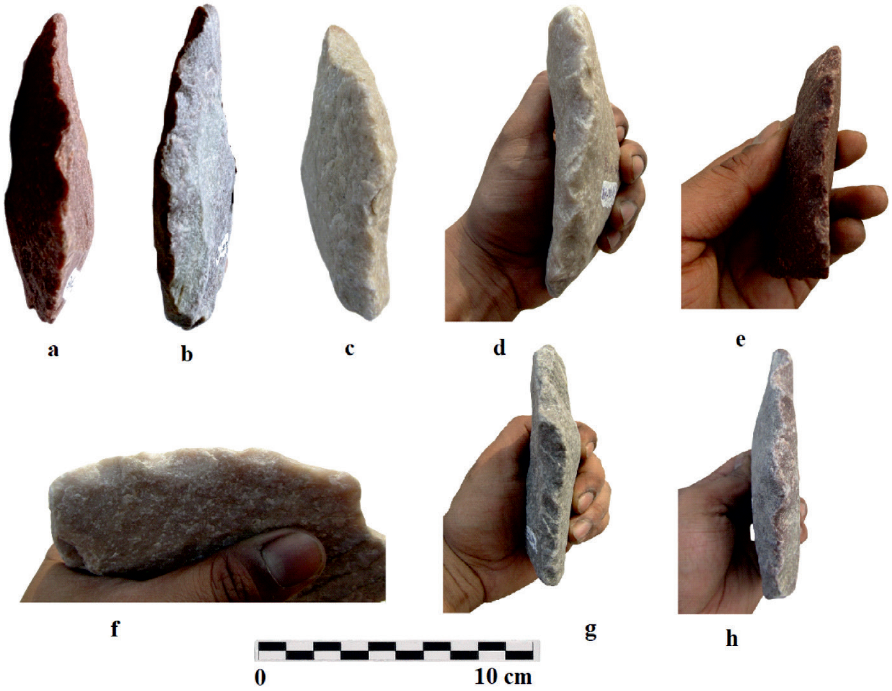


Figure 21: Retouching on flakes at different sides of the artefacts

Split Cobble

From the study area, 42 artefacts have been recovered. It was observed that some cobbles were intentionally split into two parts before being transformed into cores (Figure 22). The analysis of these artefacts shows the presence of flat or slightly convex surfaces between the split cobbles. The length of the split cobbles varies from 6.1 cm to 9.8 cm, with an average length of 7.37 cm (Table 2).

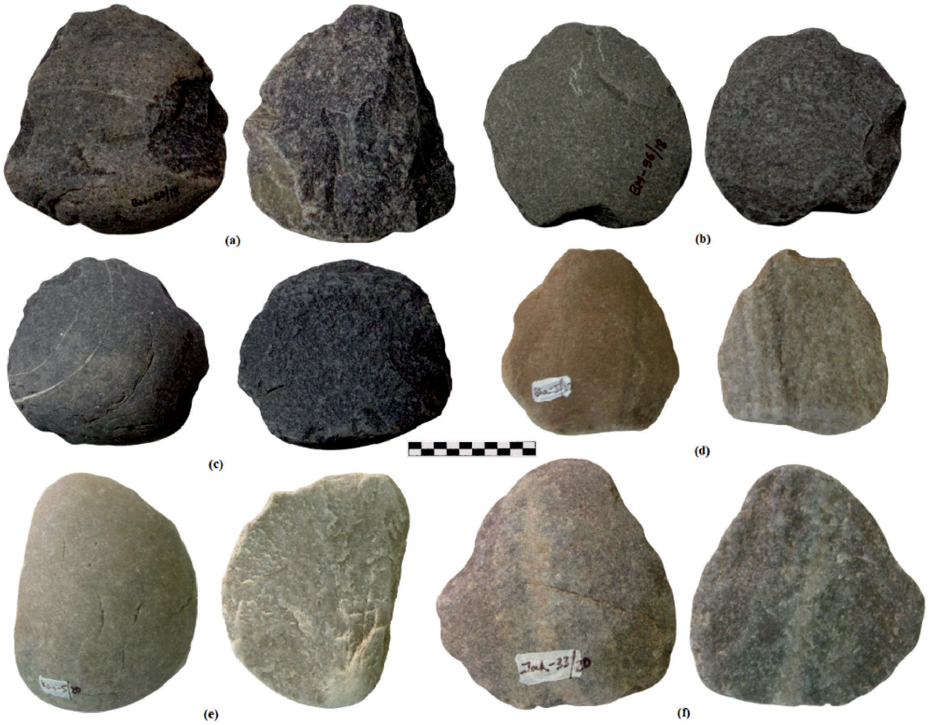


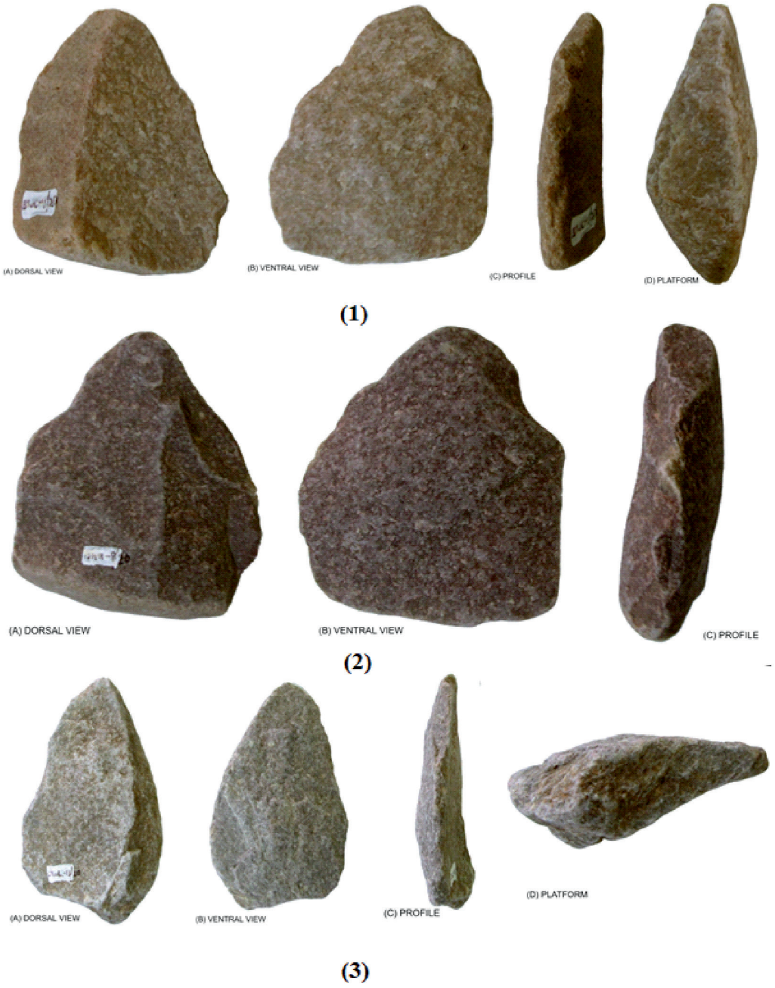
Figure 22: Split cobbles from SKRB

Broken Artefacts

One of the key observations in the present study is the significant prevalence of broken and edge-damaged artefacts. This finding suggests that the artefacts were subjected to geological processes, such as high-energy river activity. It is also worth noting that, due to continuous development work in the study area, some of the artefacts have been discovered broken, with the broken ones appearing relatively fresh. In the field, it has been noticed that certain lithic objects can undergo post-depositional alterations when damaged. These alterations can have a significant impact on the artefacts themselves, as well as on the overall understanding of their use. For example, in the Bhapral and Samlet, seventeen (*n* = 17) pebble artefacts with scar marks were recovered on soft sediment surfaces. The objects resembled choppers and scraper-like tools due to the scar types on the working area. However, further examination revealed that the scar surface and edges appeared sharper than other lithic artefacts from the same layer. This observation suggests these objects are relatively new and have undergone minimal post-depositional alterations. This information will be invaluable in developing a more accurate understanding of the use and significance of these lithic objects.

Unidentified Pieces

During the field investigations, the authors observed the occurrence of geological clasts that closely resembled lithic implements (Figure 23). These clasts were most likely formed in high-energy contexts



(1)

(2)

(3)

Figure 23: Unidentified pieces from the Seer Khad River Basin

or due to the exfoliation process. The latter occurs when constant temperature changes cause the rock surface to crack and come off, resulting in clasts. On the other hand, high fluvial energy can lead to natural flaking that produces reels, cores, and flakes in the gravel context. Moreover, it is worth noting that various scholars have made similar observations in different parts of India (Chauhan, 2009).

Discussion

Our understanding of hominin technological behaviour in areas such as Seer Khad River Basin and other prehistoric locations is based on the materials that hominins chose, manufactured, utilized, discarded, and sometimes re-used. In the Siwalik region, quartzite is the most accessible raw material, appearing as river-worn pebbles and cobbles (Stiles, 1978; Chauhan, 2003, 2008, 2011). The Seer Khad River Basin has been found to contain a significant number of lithic artefacts, with quartzite being the predominant material used for their construction, accounting for 83% (n = 1008) of the total artefacts. However, 207 artefacts were crafted using sandstone clasts. A small percentage (6%) of the artefacts displayed a calcium carbonate coating, indicating a unique deposition environment. Intriguingly, the encrustation extends from the cortex of the sediments to the flaked areas, supporting the notion that hominins crafted the artefacts, which were then encrusted before being deposited in an environment that facilitated the deposition of calcium carbonate. The hard hammer percussion technique was used in most lithic artefacts in the Seer Khad Basin assemblages. Due to the size and thickness of most flakes, the soft hammer technique was not extensively employed. The authors conducted an experimental knapping on quartzite and sandstone cobbles collected from the studied localities, which revealed that the use of soft hammers made of bone and wood was not particularly efficient despite the relatively fine-grain quality of quartzite that allowed the extraction of relatively thin flakes, albeit with a compromise in length. The technological and typological features of the lithic assemblages found in the SKRB suggest a high level of cognitive sophistication among the hominins that crafted them. The collection of stone tools from the study area exhibits a diverse range of reduction strategies, including the chopper, discoid, hand axe, cleaver, scraper, pick, flake types, along with varying flaking patterns and degrees of retouch. Among them, the unifacial reduction strategy is the most frequent (83.17%), characterized by removing two to three flakes from the dorsal side. In contrast, bifacial artefacts account for only 16.83%. The tool types found in the study area are consistent with those commonly found in known Soanian sites, including the bifacial assemblages from Nepal (Corvinus, 1994, 2002). Notably, the various SKRB tool types do not exhibit a gradual change in their dimensional attributes, namely in length, width, and thickness, across the aforementioned localities (Table 1). The means and ranges of individual values for each dimension, both type-wise and locality-wise, reveal that the mean values of each dimension in different localities do not significantly deviate from the mean values obtained for the entire assemblages. This observation implies high technological uniformity in producing different tool types across the SKRB. The broad technological homogeneity suggests that the SKRB and other Soanian localities may have been contemporaneous during the Middle to Upper Pleistocene. However, it is important to note that these interpretations remain tentative until absolute dates are available. According to stratigraphic and palaeomagnetic evidence, it has been determined that most Soanian assemblages can be dated back to a time bracket of approximately 400 to 200 kya (Misra, 2001; Mishra, 1994). The stability of landforms and sedimentary features has been analyzed to support the observation. However, to accurately determine technological or cultural changes, extensive studies or stratified cultural sequences must be conducted. To acquire the most comprehensive comparative data for the present lithic assemblages, the authors of this study have compared their dataset with those of Durkadi in the Narmada Valley (Armand, 1979, 1983), the Sutlej Valley of North West India (Karir, 1985), Toka at the Indian Siwalik Hills (Chauhan, 2004), Atbarapur (Gaillard *et al.*, 2008), and Masol (Gaillard *et al.*, 2016) in Panjub. These locations have provided invaluable insights into the cultural and technological changes during the Soanian period. The tool assemblages discovered in the current examined localities predominantly comprise choppers, discoids, and flakes, with many conforming to the Soanian tradition. Although the shared clasts form of the river-laid cobbles and boulders may explain much of the general typological similarity, there are discernible subtle differences in technique and geological context. Meanwhile, the Narmada Valley is a plentiful source of stone tools, spanning the Lower Palaeolithic to the Chalcolithic periods. Acheulean and non-bifacial lithic artefacts exist in Lower Palaeolithic assemblages in this valley, similar to those in the Siwalik Frontal Region (De Terra & Paterson, 1939). The authors of the present study found that the mean refinement value of a few bifacial artefacts of the SKRB is lower when compared to the Narmada Valley sites (Singh, 2023). This could be attributed to the differences in shape and size of the cobble blanks utilized in producing the bifacial tools at SKRB. In the Narmada Valley region, the prevalence of Acheulean is significantly higher than that found in the SKRB. The archaeological investigation of Durkadi and Toka regions has revealed the presence of artefacts associated with a gravel bed. These artefacts are believed to have been crafted and utilized by hominins who accessed the raw materials from the site. In contrast to the Seer Khad River Basin and post-Siwalik times, the Narmada region offered a more open landscape, abundant forest resources, and a stable topography over a longer period. The abundance of Palaeolithic artefacts, spanning a broad temporal scale in the Seer Khad River Basin, suggests that the region was ecologically favourable for Pleistocene hominin groups for a significant duration. The hominins had an intimate understanding of the environment, enabling them to adjust effectively to various climates and situations in the Siwalik Hills. The current study brings to light the extensive range of typological variations in the core and flake assemblages within North-West India. Moreover, the technological organization of this region is far more intricate than previously believed (Chauhan, 2007). However, it is worth noting that the archaeological record of the Siwalik region does not conform to a linear model of cultural evolution (Yi and Clark, 1983) during the prehistoric occupation in this area. Rather, the evidence suggests multiple phases of occupation (Chauhan, 2008; Gaillard *et al.*, 2010), dating back to the Lower Pleistocene and intermittently existing until the Upper Pleistocene. The archaeological record of the Siwalik region in South Asia presents a discontinuous cultural sequence, with a notable absence of typical Middle Palaeolithic flake assemblages (Chauhan, 2004). It is noteworthy that, to date, the geological context of the artefacts found in almost all instances is a secondary surface type. It poses challenges to establish a chronological and technological order, definition, and explanation of the Soanian, Acheulean or other lithic industries of the Siwalik region. Therefore, it is essential to document and explore primary stratified sites, excavate them, and date them on a longitudinal scale. This approach will facilitate a better understanding of the cultural sequence and technological advancements of the early human occupants of the Siwalik region.

Conclusion

In this paper, the authors explored the intriguing archaeological landscape of the Seer Khad River Basin in the Indian Siwalik Hills. The study aims to enhance our understanding of hominin technological adaptation to India’s intricate and diverse Siwalik terrain, primarily focusing on the Himachal Pradesh region. The study has uncovered lithic assemblages highly indicative of the core and flake lithic traditions found in North-West India. By analyzing the various spatial distribution patterns observed in the lithic artefacts, their frequencies, and typo-technological patterns, it can be inferred that the assemblages represented in the SKRB originate from a diverse range of chronologies. However, the absence of absolute dates hinders the authors from accurately determining a specific timeframe for their findings. The lithic assemblages of the SKRB exhibit a common surficial occurrence with other Palaeolithic sites in the Indian Siwalik Hills region. The study area only reveals one cultural horizon, implying a potentially limited occupation period. However, further investigations, such as sedimentary and geochronological analyses, must validate this assumption. The lithic assemblages in the study area are consistent with the typical Palaeolithic occupational behaviour observed in other regions of the Siwalik Hills. The frequency of core, flake, chopper, and scraper types in the SKRB may indicate distinct lithic production behaviours adopted by its inhabitants over time. These behaviours may have been influenced by the region's diverse cultural and ecological adaptations. It is possible that Palaeolithic hominins in the area preferred fixed water sources such as the Seer Khad River and its smaller streams, as well as raw materials suitable for stone tool making. This hypothesis warrants further investigation through multidisciplinary studies. Post-Siwalik depositions in the study area were preferred for raw materials, suggesting the hominins' strategic use of location and resources. This likely contributed to their success in surviving and thriving in their environment. The technological analysis artefacts presented in this paper have the potential to refine regional comparative studies and shed light on the nature of change in the Siwalik Frontal Range during the post-Siwalik period. The authors posit that much of the previous work conducted in the Indian Siwalik Hills requires revisiting with fresh objectives, methodologies, and a greater emphasis on geoarchaeological research. Such measures will undoubtedly yield more accurate and comprehensive insights into the archaeological history of the region. The Siwalik Hills are renowned for their prehistoric past, still shrouded in mystery. However, the prominence of secondary surface sites in the area has challenged our understanding of various aspects such as site function, absolute chronology, typo-technological development, and change through time. Despite the limitations, the evidence presented by the study area is highly significant in advancing our understanding of the prehistoric colonization of South Asia. To ascertain the technological and cultural contemporaneity of the post-Siwalik deposits, we must correlate them through absolute dating at a regional level. However, this process necessitates multidisciplinary research comprising Seer Khad River Basin excavations. Adopting this approach would enable us to identify the primary sites and obtain absolute dating, thereby providing insights into the potential existence of multiple lithic industries and the timing and behavioural complexity of the hominins who inhabited this region.

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