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RESEARCH PAPER

Fresh Light on the Mass Production of Stone Adzes and Chisels in the Southern Bonaigarh, Odisha

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Fresh investigation carried out in the southern part of Bonaigarh subdivision of Sundargarh district, Odisha, brought to light some very significant dimensions of lithic celt production sites located in the village Sulabhdih and its surrounding region. Not only valley floors and foothills, but slope and top of hills were also utilized for mass production of semi-finished celts, particularly chisels and adzes. Our study suggests that mass production of these craft specialized semi-finished items were probably intended for not only local use at settlement areas where these were further modified into finished products, but these were presumably transported to different regions of highland Odisha and also beyond through trade and/or exchange network. Although no datable material could be recovered during our limited section scrapping, keeping in view available dates from within Odisha, Jharkhand and Karnataka, these sites are tentatively dated to the beginning of second millennium BCE. The present paper intends to bring out some new aspects of celt production in the southern part of Bonaigarh subdivision, hitherto unknown in Odisha and other parts of the sub-continent.

Introduction

Systematic studies on lithic production workshops provide new insights on not only very important data relevant to the problem of interpreting lithic production systems of the prehistoric communities, but such sites also offer tremendous potential for testing hypotheses pertaining to contemporary socio-economic processes, production and technological organization, craft specialisation and regional or inter/extra-regional exchange systems (Torrence 1986; Ericson and Purdy 1984; Renfrew and Shennan 1982; Ericson and Earle 1982; Ericson 1981; Bosch 1979; Ammerman 1979; Hughes 1977; Earle and Ericson 1977; Singer and Ericson 1977; Bucy 1974; Clegn, Wright and Renfrew 1970: 169–75, etc.). The potential of this class of archaeological evidence is hardly appreciated in the Indian sub-continent and sites of this category remain mostly neglected. In this connection it may be recalled that in the late nineteenth century British geologist Robert Bruce Foote reported a few stone axe factory sites in the Bellary district of Karnataka and in the Shevroy hill ranges of Tamilnadu (1887 and 1916). Nearly fifty years later renewed comprehensive investigations conducted in the Sanganakallu-Kupgal-Hiregudda complex in the Bellary district of Karnatakaby different scholars (Subbarao 1947, 1948; Ansari and Nagaraja Rao 1969; Korisettar, Venkatasubbaiah and Fuller 2001a: 151–238; Korisettar *et al.* 2001b: 47–66; Fuller and Korisettar 2004: 7–27; Fuller *et al.* 2004: 115–29; Fuller, Boivin and Korisettar. 2007: 755–78; Boivin *et al.* 2002: 937–8; Boivin, Korisettar and Fuller 2005: 63–92; Brumm, Boivin and Fullager 2006: 165–90; Brumm *et al.* 2007: 65–95, etc.) have brought to light several new dimensions of the axe production workshops in the region, *viz.*habitation areas represented by ashmounds, chronology, quarry and manufacturing areas, grooved surfaces indicating grinding and polishing of the axes, palaeobotanical remains indicating agriculture of millet, wheat and barley and faunal remains with a predominance of domesticated cattle, sheep and goat, besides a small representation of hunted games, mainly antelope and deer. Chronologically, stone axe production and related developments at the Sanganakallu-Kupgal-Hiregudda complex has been dated to *c.* 1750–1250/1200 cal BCE (Risch *et al.* 2009: 1–4). Comparable evidence for large-scale production of axes and/or other category of such tools, *viz.* chisels and adzes, and associated archaeological features has not been recorded elsewhere in India. However, our investigation conducted in the southern part of Bonaigarh subdivision of district Sundargarh has brought to light several localities associated with mass production of stone chisels/adzes, located mostly on the foothill slope and top of the hills (Behera 1989, 1992–93: 124–32). This paper intends to highlight some preliminary results of our investigationsin southern Bonaigarh and its bearing on future research on mass production of specialized lithic tools.

The Area and Its Environmental Settings

Compared to other two subdivisions of Sundargarh district of Odisha, *viz.* Panposh and Sundargarh, Bonaigarh subdivision (Lat. 21°35′–22°10′ N and Long. 84°30′–85°25′ E), occupying the southeastern block of the

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district and forming a part of the 'Northeastern Hill Region of Odisha Highlands' (Singh 1971: 754–74), presents an almost different geographic picture (Senapati 1975). Spreading over approximately 3,356.64 square kilometer area, it is an isolated hilly tract, bounded on all sides by rugged hill ranges, cutting off Bonaigarh from Singhbhum district of Jharkhand state on the north-east and from the districts of Kendujhar, Angul, Deogarh, and Sambalpur of Odisha on the east, southeast, south, and west, respectively, and from Panposh and Sundargarh subdivisions on the north (**Figure 1**). The river Brahmani which forms the major drainage system, flows from north to south and divides Bonaigarh into two almost equal zones. With the exception of the somewhat flat cultivated plains of about 145–160 square kilometers area varying from 120–200 meters in elevation from mean sea level on either side of the Brahmani, the whole of Bonaigarh is extremely mountainous and thickly wooded. Excepting a few fairly large villages adjacent to the alluvial tracts of the Brahmani and its tributaries, small settlements are scattered here and there in the intervening valleys of the western as well as eastern Bonaigarh. Physiographically, the area is characterised by chain of hills with intervening narrow intermontane valleys, isolated residual/denudational hills and flat to gently undulating plains. Major parts of the western and eastern sectors of Bonaigarh present linear hill ranges and valleys. The generalslope is towards the river Brahmani which runs from north to south.

The area is drained by the river Brahmani and its several major/minor tributaries, among which the notable ones are the Kurhari, Korapani, Saplata and Rukura streams, which retain water even during the summer season. The drainage pattern is dendritic and influent in nature. Most of the mass production localities for adzes and chisels in Bonaigarh are located in the upstream of the Korapani stream. The area enjoys a sub-tropical climate with the average annual precipitation of 1647.6 mm. The climate of Bonaigarh area supports northern tropical dry deciduous and mixed type of natural vegetation with the predominance of *Sal* (*Shorea robusta*). The forest cover occupies about 2,186 square kilometer area in Bonaigarh. The tribal and peasant communities of this area largely depend on these deciduous forests for their diet and other consumption requirements. Despite continued human interference Bonaigarh can still boast of numerous big game and large varieties of animal lives (Senapati 1975: 29–37).

The lithostratigraphy of Bonaigarh area is represented by a variety of rocks of Pre-cambrian to Quaternary era (**Table 1**). The oldest rock formation belongs to the Archaean succeeded by Lower to Upper Proterozoic, Cenozoic and Quaternary era. Several massive dykes of dolerite, which served as the principal raw material for mass production of adzes and chisels in southern Bonaigarh, are found intruded into the Iron-ore series, Bonai granite and the Dhanjori formations lying towards the north and northeastern part of the subdivision (**Figure 2**). They

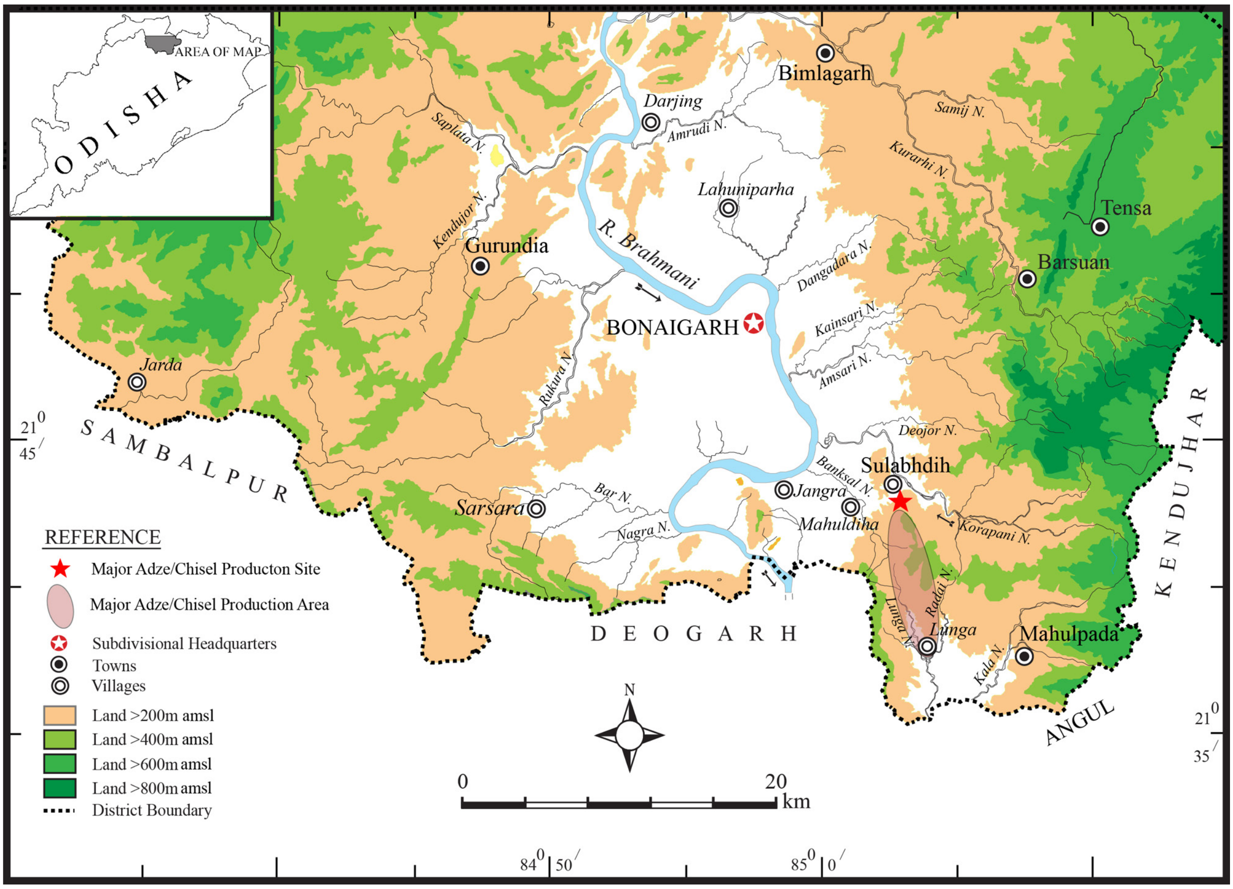


Figure 1: General topographic map of southern Bonaigarh, showing major drainage system and location of major and minor celt production sites.

Table 1: Lithostratigraphy of Bonaigarh subdivision (after Senapati 1975: 13–14).

Recent		**Alluvium& secondary laterites**
Pre-cambrian	Newer Dolerite	Quartz reefs, aplitic granite & gneiss, dolerite & gabbro.
	Kolhan Series	Carbonaceous phyllites & quartzites. Shales & phyillites, quartzites & conglomerates.
		Unconformity
	Basic and Ultra-basic rocks	Meta-gabbro & meta-dolerites. Peridotites & pyroxenites.
	Volcanics	Ferruginous shales or altered lava and tuffs. Lava flows tuffs, hornblende chlorite rocks and amphibolites.
	Dhanjori Group	Calcarious schists, quartzite, Quartz-sericite-schists, cericite chlorite, phyillites, greywackes, grits & conglomerates.
		Unconformity
	Singhbhum granite	Bonai granite & gneiss
	Volcanics in the Iron-Ore Series	Lava flows, hornblende-chlorite rocks and amphibolites.
Iron-Ore Series	Iron-Ore Stage	Banded granulites phyillites, banded haematite quartzite, tuffs, chert lavas.
	Chaibasa Stage	Quartzites and quartz schists, mica schists and chlorite schists.

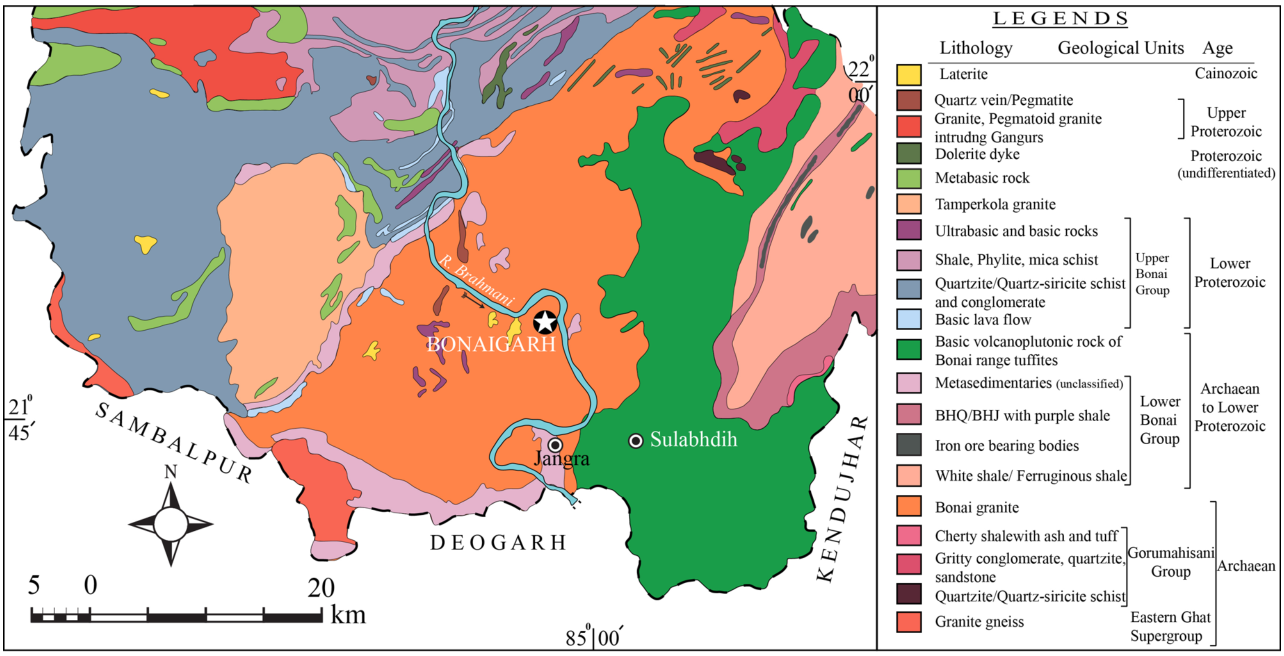


Figure 2: Geological formations of southern Bonaigarh (after District Resource Map, GSI).

are not found in the Kolhans and aplitic granite. However, massive fine-grained dolerite dykes are found intruded into the basic volcanoplutonic rock of Bonai range tuffites belonging to the Archaean to Lower Proterozoic age, between the massproduction site of adze/chiselat Sulabhdih extending as far south asLunga and beyond (**Figure 3**).

Previous Research

In the late fifties of the last century G.C. Mohapatra carried out exploration in the Bonaigarh area and reported a number of Middle Palaeolithic sites besides a few stray ground stone tools near the village Jangra (21°43′37.26″ N and 84°58′18.22″ E), but, except reporting the discovery, his work does not contain any other details (Mohapatra 1962). Subsequently, the first author conducted a thorough investigation of the Brahmani valley and its tributaries in Bonaigarh subdivision during 1985–87, as part of his Ph.D. programme, and brought to light a large number of localities (Behera 1989) with evidence for, a) minor workshop/celt-dressing sites associated with large-small scatters of macro/micro debitage, semi-finished/finished celts (here axes/chisels and adzes), broken parts of semi-finished celts, and celt blanks, b) habitation site associated with a broken part of semi-finished chisel/adze, celt-dressing micro chips and a few sherds of grit-tempered red ware of medium fabric and c) sites associated with mass production of chisels and adzes near dolerite dykes, particularly at the village Sulabhdih (**Figure 3**). During the subsequent visit to the mass production site of Sulabhdih in 1990, it was noticed that the local people had already transported several truck loads of celt manufacturing waste for constructing the State Highway-10, which passes hardly four kilometers west of Sulabhdih. People also quarried the waste products for constructing village roads and buildings. Gradually it becomes a regular phenomenon in this area, as a result of which large part of these massive debris mounds has been laid bare leaving deep exposures and pits (**Figure 4**). The exposed sectionsof two of the

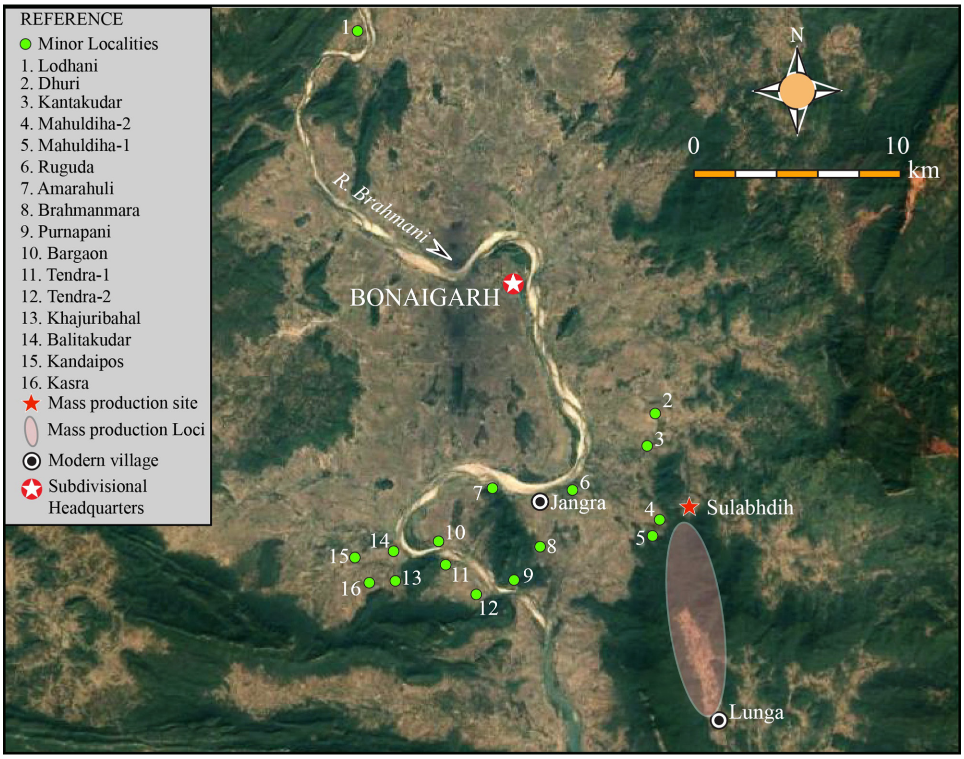


Figure 3: Google Earth image of southern Bonaigarh showing distribution of sites bearing lithic celts in the Brahmani river valley and celt production center of Sulabhdih-Lepachua-Lunga complex.

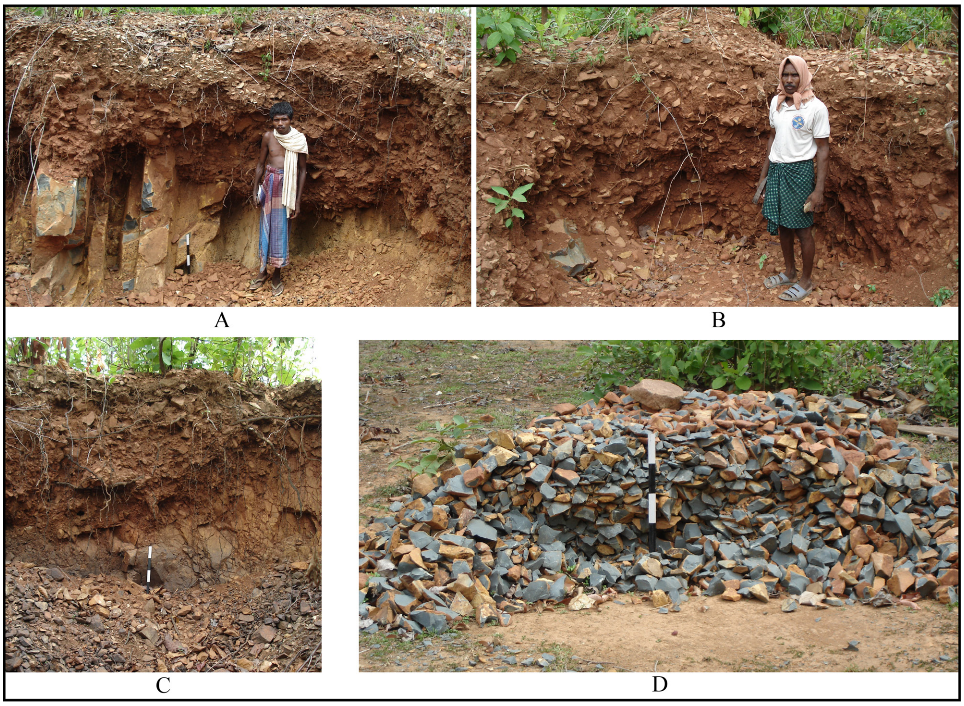


Figure 4: Exposed modern quarried sections at celt debris mounds at Sulabhdih **(A–C)** and **(D)** showing pile of artefacts recently quarried from one of the debris mounds ready to be transported for building materials by local contractors.

debris mounds was scrapped in 1990 (Behera 1992–93: 124–132) and subsequently in 2008. During 2018–19 fresh investigation was carried out in southern Bonaigarh to trace the extension of the Sulabhdih evidence and to understand spatial patterns of manufacturing loci, a brief account of which is given below.

Major Celt Production Sites

As mentioned above, evidence for mass production of celts was reported near the village Sulabhdih during the latter half of eighties of the last century and fresh investigation within a radius of ten kilometers brought to light extensive remains of a group of eight celt production siteson the top/slope of the Lepachua hills located further south of Sulabhdih and five such sites, viz., near the villages Patarpunji, Daleisara, Ratakhandi, Ekpadi and Lunga on the foothill slope along the left bank of the Lunga stream, a tributary of the river Kala (**Figure 5**). There might be more such sites located on the slope/top of hills on either side of the Lunga stream, as accounted by the nearby villagers. A brief description of sites and associated material finds are given below.

Sulabhdih

Sulabhdih (21°43′26.70″ N and 85°02′35.54″ E, Elevation 193 m amsl) is a small land-locked village of 67 households, located about 18 kilometers southeast of the sub-divisional headquarters of Bonaigarh, district Sundargarh, and bounded on the northwest and west by the Kundeibera hills, on the northeast by the Ranja hills, and on the south by the Lepachua hills. The Korapani stream, a perennial tributary of the river Brahmani, flows southeast-northwest direction between the Kundeibera and Ranja hills and passes about less than a kilometer east of the village Sulabhdih. The village is predominantly inhabited by Munda tribe, besides Gour, Bhumij, and Oraon. Except the Mundas all other communities migrated to Sulabhdih within the last twentieth century. The Mundas still practice traditional way of life with a mixed subsistence economy of hunting-gathering of wild

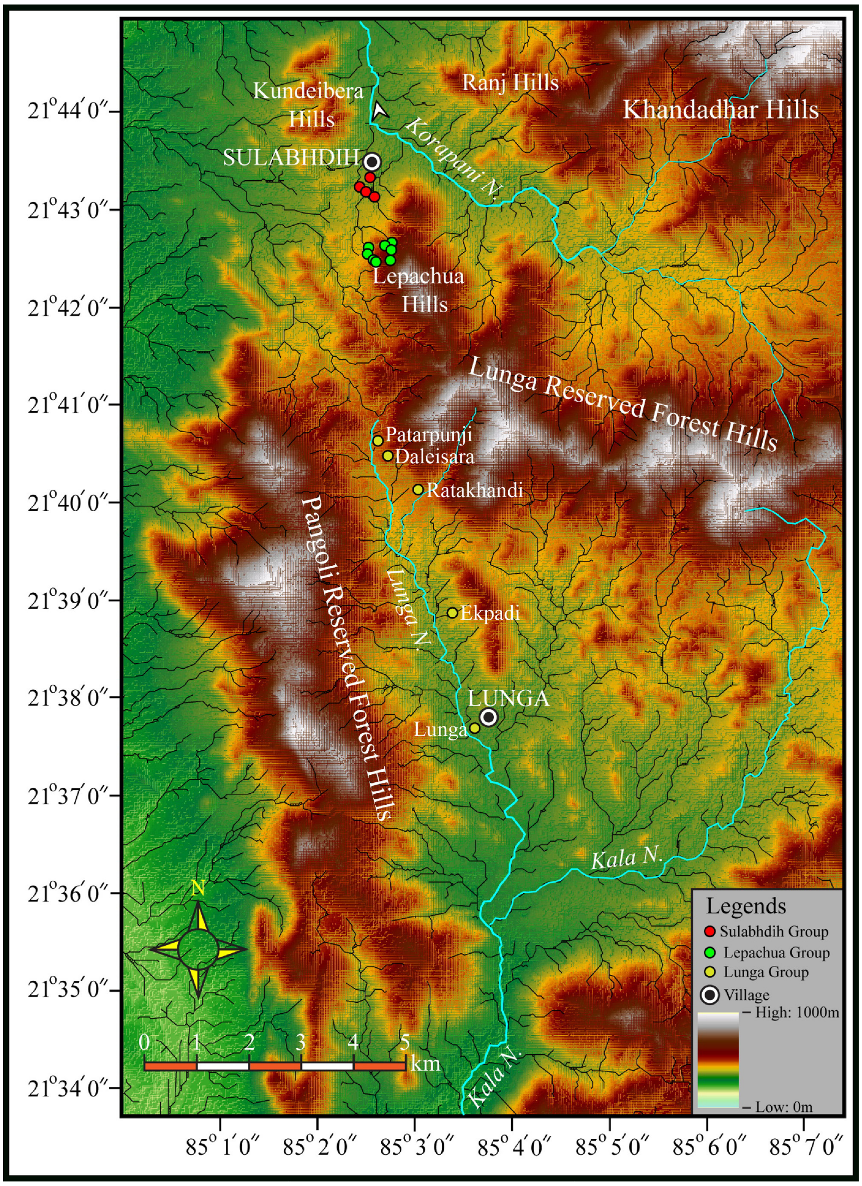


Figure 5: Spatial distribution of celt production sites in the Sulabhdih-Lepachua-Lunga complex in southern Bonaigarh.

food/non-food resources, animal husbandry and limited agriculture. The inhabitants dispose their dead in burial pits, over which they erect megalithic structures (cairns with a heavy capstone at the top) of different dimensions (**Figure 7**). The site is situated near a dolerite outcrop represented by four massive debris mounds of varied elevation and size (**Table 2**), located towards the southern part of the village Sulabhdih. The enormous debris/manufacturing waste are found embedded in a loose sandy-silt soil matrix and include, modified boulder cores as well as unmodified boulders, numerous thick broad/elongated flake-blade blanks, celt dressing flakes, macro/micro chips, hammers of various sizes with battering marks, spheroids, celt roughouts/preforms, micro-chipped chisels and adzes, broken parts of celts and very few pecked as well as edge-ground finished chisels and adzes (**Figure 6**). The approximate length, width and height from the surrounding plains of these debris mounds of Sulabhdih are given in **Table 2**. Considering the height of debris accumulation as well as extent of the mounds, it is only

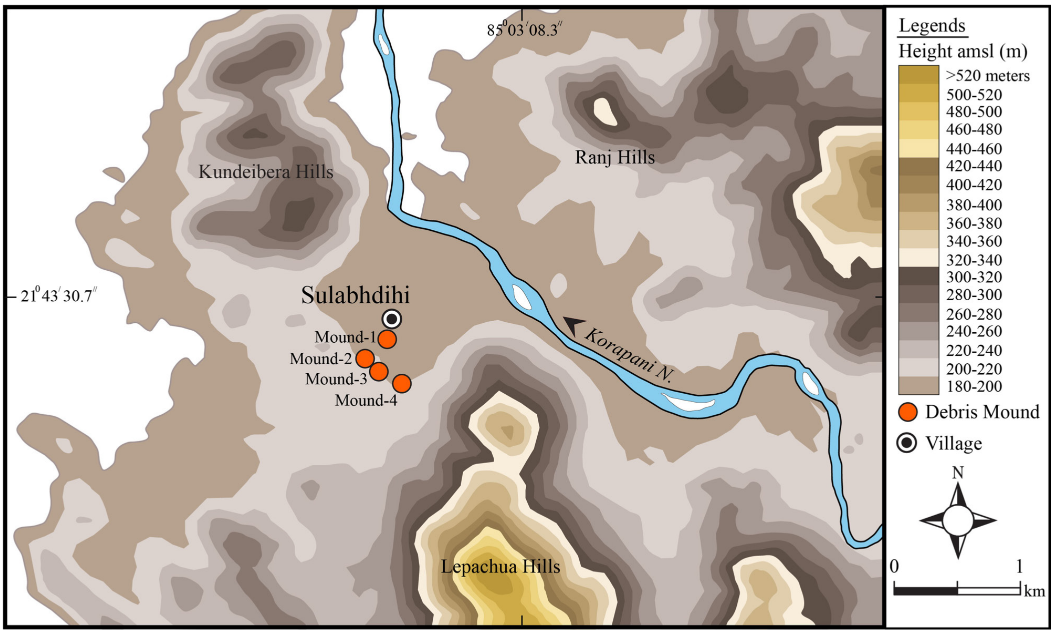


Figure 6: Topographic map of Sulabhdih area showing location of the celt manufacturing debris mounds.

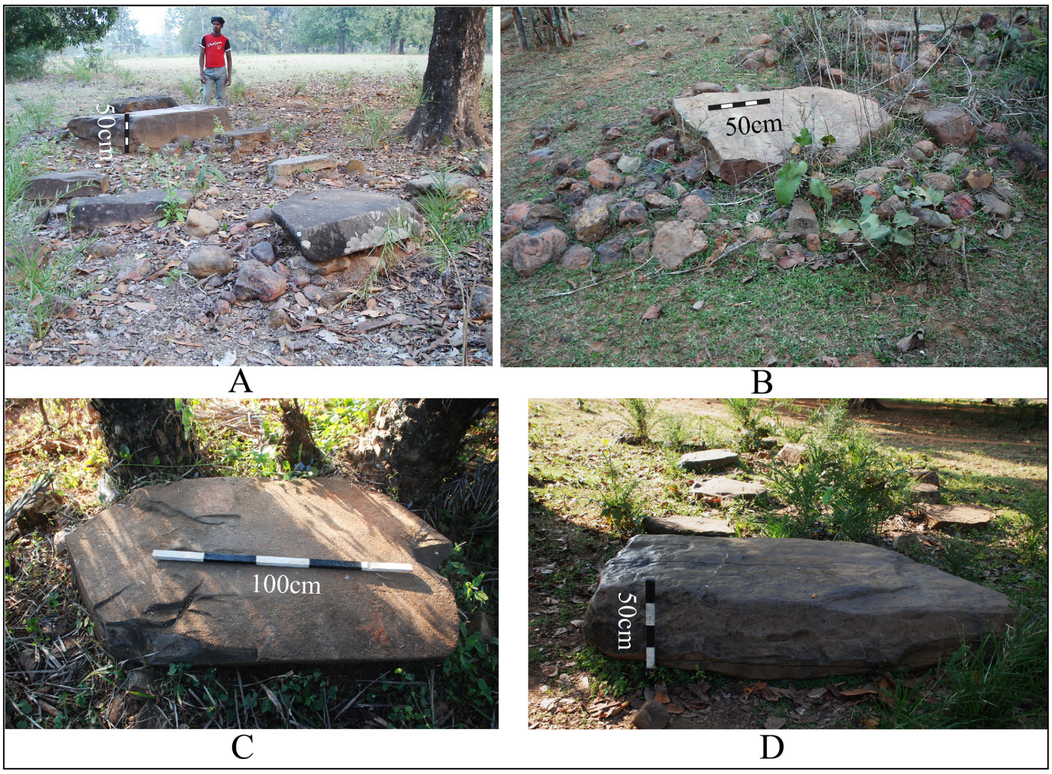


Figure 7: Single **(B & C)** and multiple **(A & D)** megalithic structures raised by the Munda community at Sulabhdih.

Table 2: Description of four celt manufacturing debris mounds at Sulabhdih.

SITE	Locality	Latitude	Longitude	Elevation (amsl)	Circumference (meter)	Max. Length/Width
Sulabhdih	1	21°43′07.3″ N	85°02.35′6″ E	199 m	690	255 m/157 m
	2	21°43.11′2″ N	85°02′30.1″ E	209 m	401	154 m/51 m
	3	21°43′17.3″ N	85°02′30.8″ E	196 m	251	95 m/58 m
	4	21°43′19.7″ N	85°02′33.2″ E	205 m	213	80 m/55 m

reasonable to presume that the site must have served as a very large celt manufacturing centre in this part of eastern India, for a long span of time.

Raw Material Procurement Strategy

Raw materials used extensively for manufacturing chisels and adzes at Sulabhdih and adjoining areawereprocured mainly from two sources, namely a) fine-grained boulders and cobbles (>20 cm size) on the nearby beds of ephemeral streams, originating from the hill ranges of Lunga and Pangoli reserved forests, located south of the Sulabhdih village (**Figure 8**), and b) blocks quarried from the massive dolerite dykes (**Figure 4: A**) intruded into the basic volcanoplutonic rock of Bonai range tuffites of Archaean to Lower Proterozoic age. Petrographic study of thin section of artefacts and blocks quarried from the site reveal that it is fine-grained with average grain size below 0.1 mm and consists predominantly of three minerals, namely actinolite, chlorite and quartz (**Figure 9**). Their optical properties are as follows:

> Actinolite: Moderate relief, pleochroic in shades of green, two sets cleavage at an angle of nearly 55° in cross-sectional grains, interference colours of yellow, orange and blue of upper first order to lower second order.
> Chlorite: Moderate relief, pleochroic from colourless to pale green, anomalous bluish interference colour.
> Quartz: Low relief, colourless, absence of cleavage, first order grey interference colour.

Thus the studied rock appears to be a fine-grained basic igneous rock such as basalt or fine-grained dolerite which has undergone intensive hydrothermal alteration. The primary minerals in the rock are no more identifiable because of the alteration. A large number of partially/fully modified boulder cores and unmodified boulders have been found embedded in the manufacturing waste, which clearly suggests that these were brought to the site by the knappers from the nearby sources or quarried from the bedrock. Their maximum size ranges between 30 cm and >45 cm, some of which bear deep negative scars of core processing and large-flake/blade (>10 cm) removals. Besides boulders from the stream beds, the celt knappers also quarried large angular/sub-angular blocks from the highly jointed fine-grained dolerite dyke, a portion of which was exposed during the section scraping of debris Mound-III (**Figure 10**).

Figure 8: First order stream bed bearing boulders of fine-grained dolerite on the foot of the Lepachua hills, possible source of raw materials for manufacturing celts.

Celt Production at Sulabhdih

As noted above, the debris mounds at Sulabhdih are composed of numerous semi-finished as well as unfinished performs/roughouts and broken parts of celts, besides tons of manufacturing debitage. It was difficult for us to determine the precise methodology which could be successfully followed for a detailed study of lithic reduction (*chaîne opératoire*) strategy adopted by the knappers and techno-morphological study of the end products, which are rarely found at such sites. Under the circumstances, we are left with no other alternative but to make a detailed study of the composition of the accumulated manufacturing debris by scraping of an already exposed section of the debris Mound-III (**Figure 6**). A section of Mound-III, measuring 2.5 m × 1 m, was scrapped, 10 cm spit-wise, to a

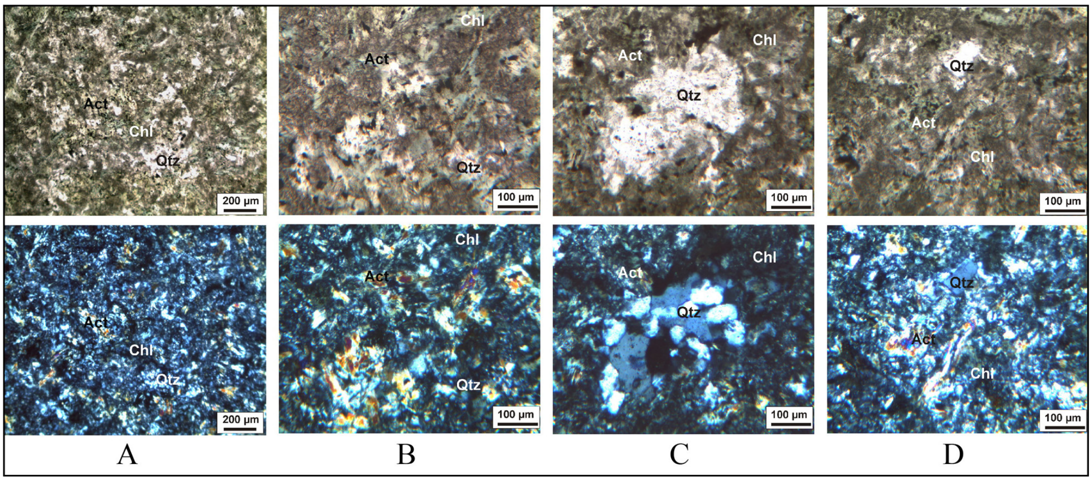
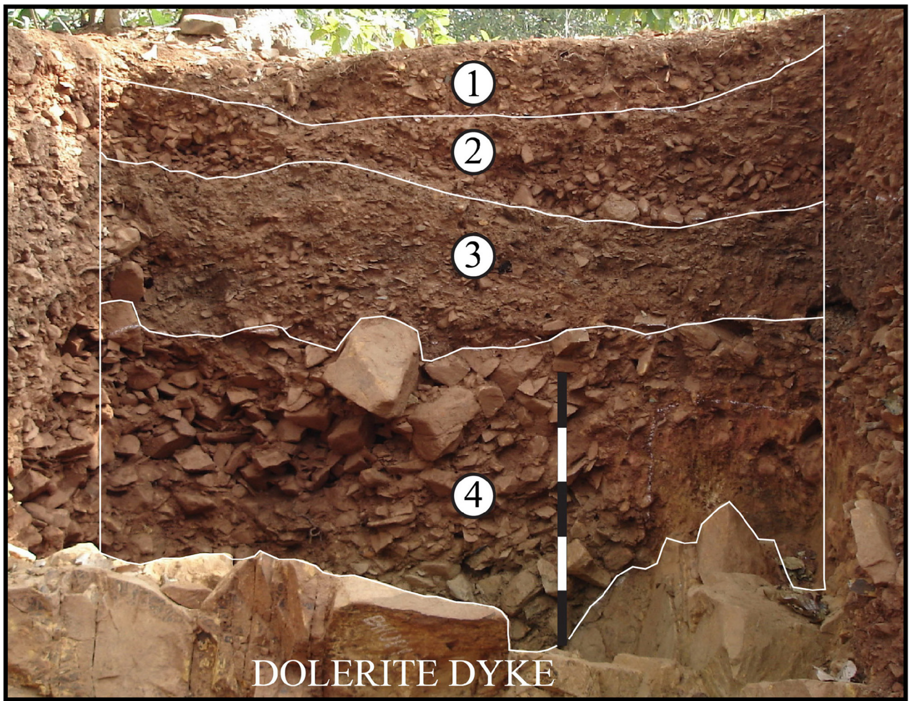


Figure 9: Photomicrographs in plane polarized light (upper figures) and crossed nicols (lower figures) showing actinolite (act)–chlorite (chl)–quartz (qtz) assemblage. **(A)** Actinolite has higher relief than chlorite; interference colour of chlorite in crossed nicols is ink blue. **(B)** Chlorite shows pleochroism in shades of green in plane polarized light; actinolite shows first order yellow and violet interference colours. **(C)** Quartz grains occurring in a cluster; interference colour of quartz is first order grey. **(D)** Prismatic grains of actinolite and tabular-shaped quartz.

Figure 10: Showing the quarried blocks of highly jointed dolerite dyke, revealed during the section scraping at Mound-III of Sulabhdih.

depth of two meters and twenty centimeters. From bottom upward the excavated section clearly revealed four layers, composed of flake/blade blanks of various sizes, a boulder core, broken and complete specimens of celt preforms and roughouts, a few spheroids/hammers and scores of manufacturing debris embeddedin a reddish-brown to brownish-grey coloured loose silty-sand soil matrix, directly overlying the fine-grained highly-jointed dolerite dyke (**Figure 11**). The layers were demarcated mainly on the basis of size of artefacts and colour of the soil matrix. The Layer-4 yielded mostly large-sized (**Figures 14** and **15A**) and thick unmodified cortical/partly cortical/non-cortical flakes/blades with thick and broad cortical/prepared platforms, large celt roughouts showing initial preparation (**Figures 16** and **17: 12–15**), broken parts of celt roughouts, a boulder core (**Figure 13: 3**), and a large number of medium-sized (70–40 mm) core dressing and blank modification flakes/blades, all embedded in a thick deposit of slightly compact sandy-silty-clay soil matrix. The overlying Layer-3 is composed mainly of medium-sized (maximum length 10–50 mm) non-cortical flakes (**Figure 15: B**), micro-chips (**Figure 15: C; maximum length <10 mm**), and occasional micro-flakelets



Layer-1: Greyish-brown, loose silty-sand with micro chips (<10mm), micro flakelets (<2mm), complete and broken parts of celt preforms, pecked spheroids/hammers (Figure 18: 1-3).

Layer-2: Brownish, loose silty-sand with micro chips, micro flakelets, broken and complete specimens of celt roughouts/preforms and pecked spheroids (Figure 18: 4 & 5).

Layer-3: Greyish-brown, loose sandy-silt with micro chips and flakelets, initial tertiary stage celt-dressing flakes (10-50mm) and spheroids (Figure 18: 6 & 7).

Layer-4: Reddish-brown, slightly compact, sandy-silty-clay with mostly large (>100mm) flakes/blades, one boulder core, few unmodified cobbles and boulders and broken as well as complete celt roughouts.

Figure 11: Stratigraphic profile of the scrapped section at Mound-III of Sulabhdih, showing four distinct layers of manufacturing debris accumulation in a loose silty-sand soil matrix.

(**Figure 15: C; maximum length <3 mm**), complete and broken parts of celt roughouts and preforms (**Figure 17; 4–11**) and spheroids with pecking/flaking marks all over the surface (**Figure 18: 6 and 7**), all embedded in a matrix of loose sandy-silt of greyish-brown colour soil deposit. There is complete absence of boulder cores and large flake/blade blanks in this layer. The overlying two layers do not differ much in cultural material contents and nature of soil matrix. However, the deposits yielded a huge quantity of micro-chips and micro flakelets, besides more refined and definable celt preforms (**Figure 17: 1–3**). Thus we noticed a gradual decrease in overall size of flake/blade blanks and celt roughouts, and increase in the intensity of reduction of blanks which modified into different types of celt preforms. Although a few edge-ground and partially ground chisels and adzes were recovered from around the debris mounds of Sulabhdih (**Figure 19**), none such specimens could be recovered during the limited section scraping of Mound-III. As stated earlier, during the process of scraping, a portion of a rectangular pit was encountered just below the Layer-4 (**Figure 10**), suggesting on-site quarry of dolerite blocksfor celt blank production.

On the basis of a preliminary on-site study of artefacts recovered from the limited section scraping and those scattered on the surface of the debris mounds, a flow chart was prepared indicating broad stages of celt manufacturing process adopted at the site (**Figure 12**). First, large and thick primary/secondary flakeswere detached from the boulders/quarried blocks (cores with prepared/cortical platforms) by hard hammer percussion (**Figure 13**). The resulted flakes are of two types, namely i) elongated blade-like flakes showing pronounced bulb with irrailure fractureand deep negative scars with mostly high mid rib/ribs, and ii) broad/transverse-shaped thick flakes with

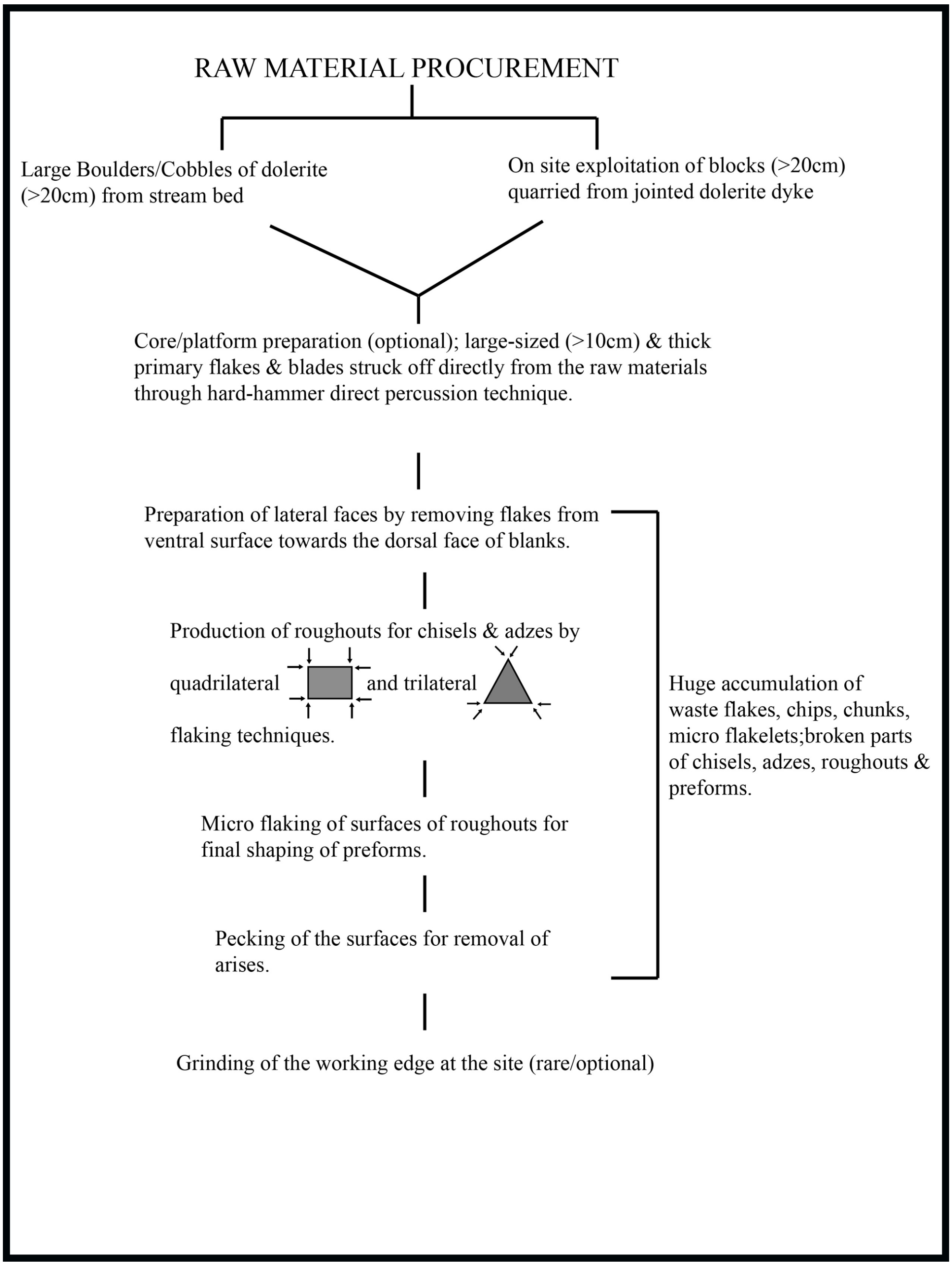


Figure 12: Reconstructed lithic reduction sequence adopted at Sulabhdih celt manufacturing localities.

broad and thick platform (**Figures 14** and **15A**). In the subsequent stage, the former type of flakes/blades were flaked bilaterally, mostly from ventral surface by removing broad/elongated semi-invasive/invasive flakes, while in the case of latter category invasive flaking was done alternately from the ventral-dorsal surfaces on the proximal and opposite distal end of the debitage, leaving the sharp lateral edges unmodified. In the latter cases the lateral edges were then modified alternately in the next stage to make working edge and the narrow butt end of the celt roughouts. Two distinct types of chisel/adze roughouts/ preforms were found from the scrapped section, namely, i) narrow-elongated shaped roughouts with quadrilateral flaking marks, quadrangular/rectangular mid-section and roughly bi-convex/straight profile, and ii) narrow-elongated shaped roughouts with trilateral flaking marks, roughly triangular mid-section, plano-convex profile and bevelled working edge (**Figures 16** and **17**). During the subsequent stage, through micro-chipping, the former categories of preforms were given the shape of chisels and the latter types mostly adzes. However, there are also adzes with quadrilateral preparatory marks on their surfaces, rectangularmid-section and beveled working edge. In the case of beveling a series of narrow-elongated and parallel sided burin like spalls were removed from the convex-shaped ventral surface of the preforms. Subsequently, the pronounced arises appearing on the surfaces of the preforms were removed by meticulous pecking probablyby soft hammer technique, scores of remains of which have been found through 2 mm screen (**Figure 15: C**). Metrical observations, viz. maximum length, breadth and thickness were taken on 60 complete celt preforms recovered

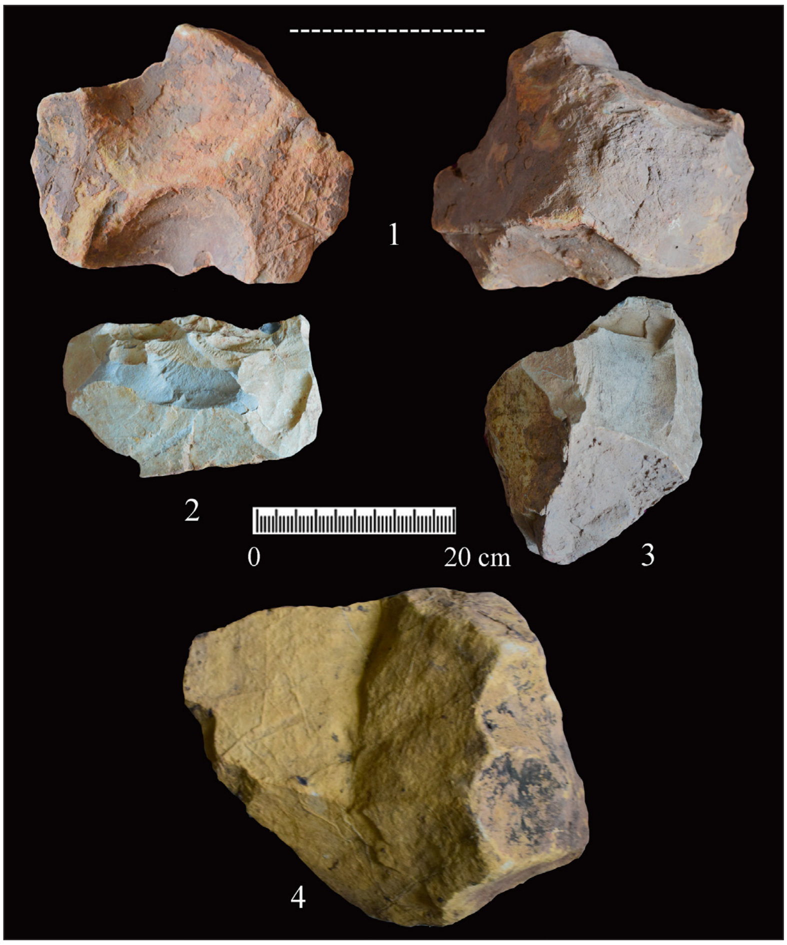


Figure 13: Giant cores of dolerite used for detaching large-sized blanks at Sulabhdih.

Figure 14: Different shape and size of detached large blanks for celt production at Sulabhdih.

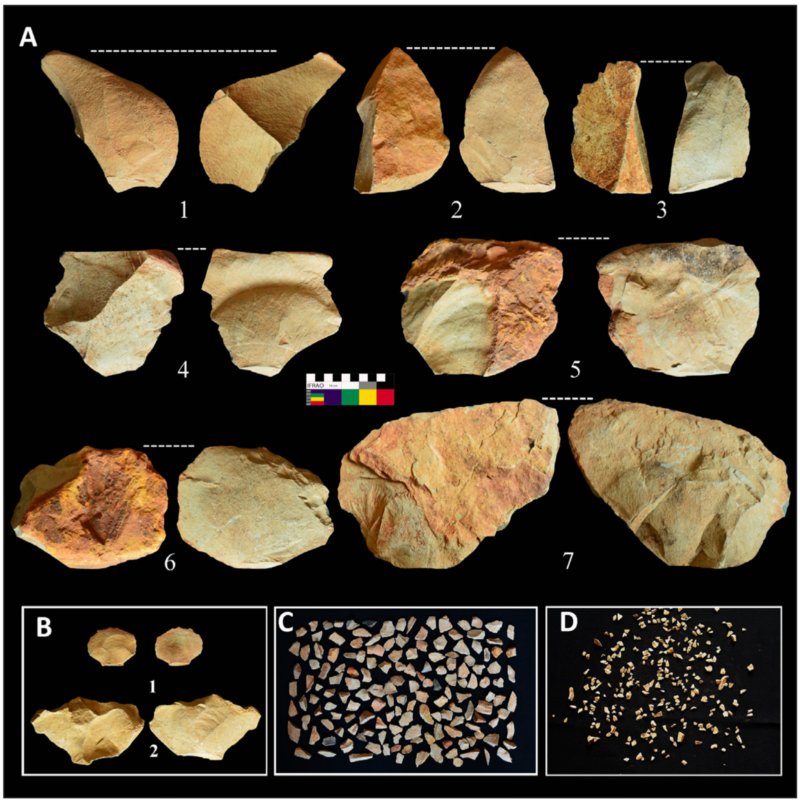


Figure 15: Showing lithic products detached from the boulder cores and subsequent celt dressing process; **A-** >20 cm blanks, **B-** <10 cm flakes, **C-** <5 cm micro-flakes/chips and **D-** <3 mm micro-flakelets resulted from pecking of the celt preforms.

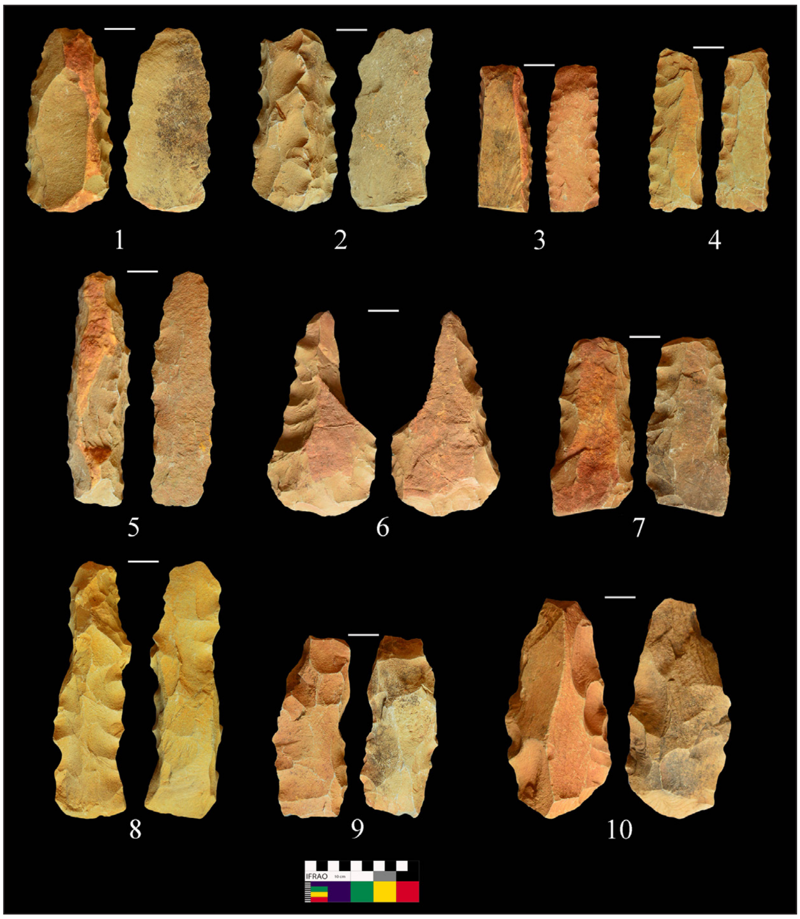


Figure 16: Initial stage of celt roughouts showing parts of original dorsal/ventral surfaces of blanks.

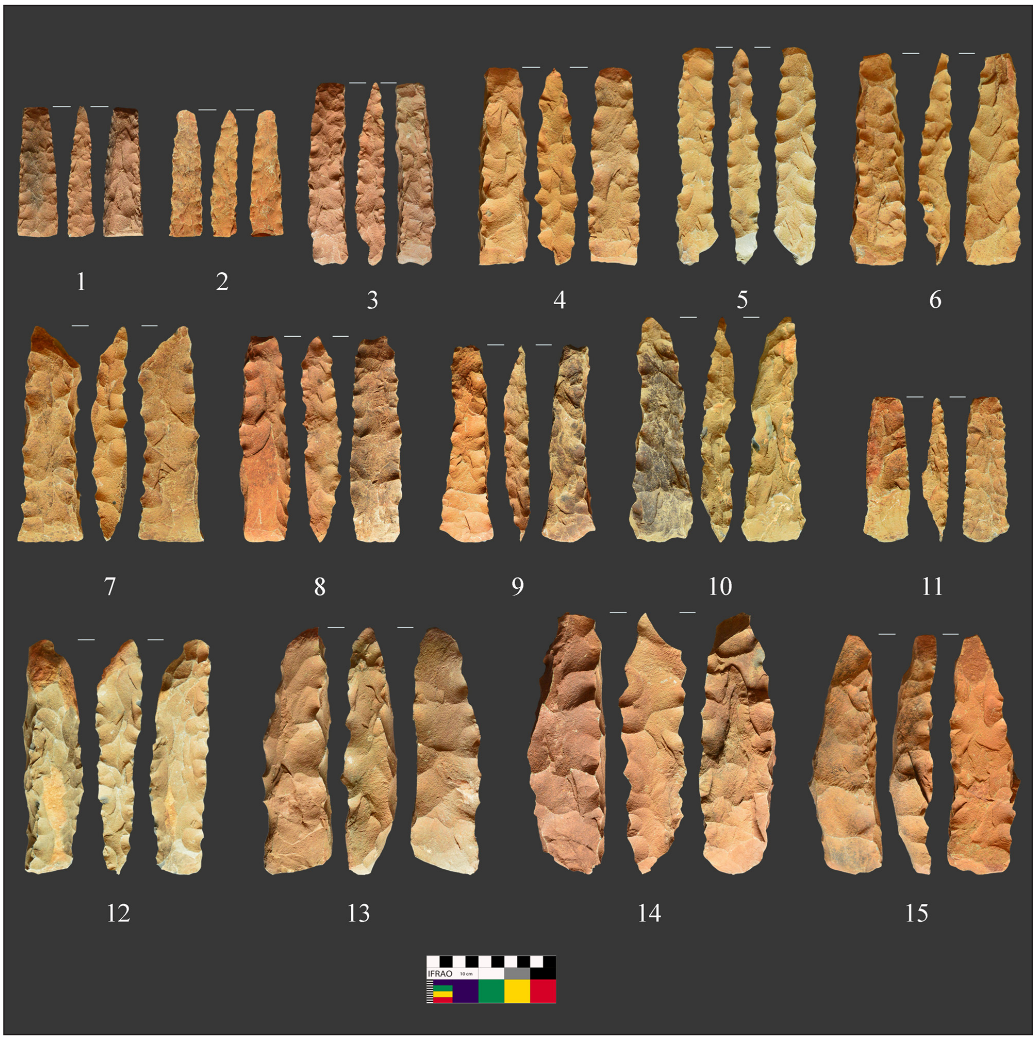


Figure 17: Celt preforms from Sulabhdih.

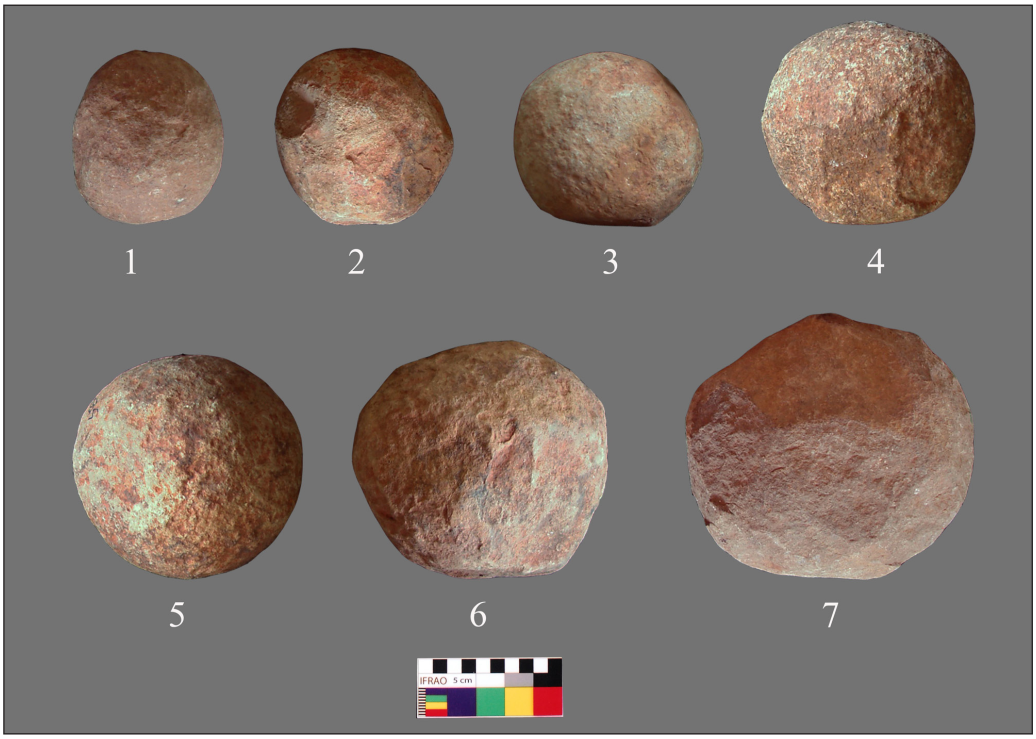


Figure 18: Spheroids/hammers of dolerite recovered during the process of section scrapping at Mound-III of Sulabhdih.

Figure 19: Few specimens of edge-ground chisels and adzes from Sulabhdih.

Table 3: Metrical description on 60 complete celt preforms from Sulabhdih.

Variable	Size range (mm)	Mean	S.D.	C.V.
Length	260–102	170.85	32.70	19.14
Breadth	90–27	52.00	12.82	24.65
Thickness	70–24	42.65	11.36	26.64

from the site, which is shown in **Table 3**. The table clearly shows that the celts manufactured at Sulabhdih are mostly large and narrow-elongated in shape. Except a very few edge-ground chisels and adzes, thoroughly ground celts (**Figure 20**) are totally absent in and around Sulabhdih. However these are fairly represented in the sites located close to the river Brahmani (Behera 2000: 222–263). The spheroids (**Figure 18**) recovered during the section scraping were probably used as hammers in the process of celt manufacturing. Thus, the artefact-debris accumulations at Sulabhdih are mainly represented by giant cores, core-dressing flakes, large-sized flake/blade blanks, flakes removed during the process of making celt roughouts and preforms, microchips and micro-flakelets resulted out of pecking, besides other artefact types as noted above.

Minor Celt Production Sites

In order to trace the spatial extension of the celt manufacturing localities in the area, further exploration was conducted towards south of Sulabhdih complex, which resulted in the discovery of eight celt manufacturing localities (**Table 4**) of various dimension on the slope and top of the Lepachua hills, situated about two kilometers south

Figure 20: Fully ground bar celts from sites located close to the river Brahmani.

of Sulabhdih and five such sites were found on the foothill contexts of Lunga Reserved Forest (**Table 5**), located not very far from the left bankof the Lunga, a third order minor tributary of the river Brahmani (**Figure 5**).

In the former category of sites, extensive manufacturing debris comprising of boulder cores, large primary/secondary flakes, celt dressing flakes, broken and complete specimens of celt roughouts/preforms and scores of tertiary flakes of varied dimensions have been found on the slope as well as top of the hills at an elevation from 243 m–373 m amsl. Boulders were carried to these sites from the nearby ephemeral streams, rising from the Lepachua hills, for detaching large flake-blade blanks, which were later on converted into preforms of chisels and adzes. Hardly any semi-finished/finished chisels/adzes could be recovered from this group of sites. Probably micro-chipping and subsequent pecking of surfaces of these semi-finished celts was carried out at the Sulabhdih complex. Except the hill top site (**Figure 21: site no. 8**) which is located about 373 meters above mean sea level with 20–30 cm thick deposit of celt manufacturing debris, other sites have been found with thin scatters of celt dressing flakes and other waste products besides broken parts of celt roughouts/preforms and cores.

Further exploration was carried out, south of the Lepachua hills to examine the extension of celt manufacturing activities, which resulted in the discovery of five extensive sites, viz. near the villages Patarpunji, Daleisara, Ratakhandi, Ekpadi and Lunga, located close to the Lunga stream, a third order stream of the river Kala, a tributary of the river Brahmani (**Figure 5**). Except Daleisara where there is an exposed deposit of about 30–50 centimeters (**Figure 22**), in all other cases thin to thick surface scatters of celt manufacturing debris were noticed. During our exploration we were informed by the nearby villagers that similar celt production debris are also found on the slope and top of hills in the Pangoli and Lunga Reserved Forests. In all these cases fine-grained dolerite remained the principal raw material for manufacturing celts, i.e., chisels and adzes. Techno-typologically, the cultural material finds from Lepachua hills and Lunga stream show almost similar pattern as we find in case of Sulabhdih, except of course they widely differ in scale of manufacturing activities.

Discussion and Concluding Remarks

The foregoing accounts on our preliminary investigation in the Sulabhdih-Lepachua-Lunga celt manufacturing complex clearly indicates that the typical specimens manufactured in this area of southern Bonaigarh subdivision, are semi-finished, thick and narrow-elongated chisels and adzes, having mostly rectangular medial cross-section, thin and narrow convex/straight butt, plano-convex/bi-convex long-section, and bevelled or medial working edge. There are also a sizeable number of adzes with triangular medial cross-section with almost equidistant lateral sides and bevelled working as well as butt ends. Techno-typologically such varieties resemble those with the Luzon and pick-adzes of Southeast Asia (Duff 1970). These specimens, though represented in low proportion, appear to be very specialized tool type of Sulabhdih celt production site.

Our study appears to indicate that except the final stages of reduction, i.e., grinding and polishing and to some

Table 4: Location of eight celt manufacturing localities in the Lepachua hills.

SITE	Locality	Latitude	Longitude	Elevation (amsl)
Lepachua Hills	1	21°42′36.30″ N	85°2′31.33″ E	243 m
	2	21°42′37.92″ N	85°2′42.42″ E	258 m
	3	21°42′39.35″ N	85°2′45.84″ E	252 m
	4	21°42′35.50″ N	85°2′45.14″ E	263 m
	5	21°42′32.89″ N	85°2′31.20″ E	261 m
	6	21°42′28.74″ N	85°2′34.66″ E	276 m
	7	21°42′27.99″ N	85°2′37.47″ E	297 m
	8	21°42′28.34″ N	85°2′45.01″ E	373 m

Table 5: Description of five sites on the foothills located close to the Lunga stream.

SITE	Locality	Latitude	Longitude	Elevation (amsl)
Patarpunji	9	21°40′22.06″ N	85°02′44.86″ E	264 m
Daleisara	10	21°39′57.28″ N	85°03′07.49″ E	250 m
Ratakhandi	11	21°39′12.55″ N	85°03′13.41″ E	216 m
Ekpadi	12	21°38′56.11″ N	85°03′19.38″ E	208 m
Lunga	13	21°37′49.61″ N	85°03′43.19″ E	195 m

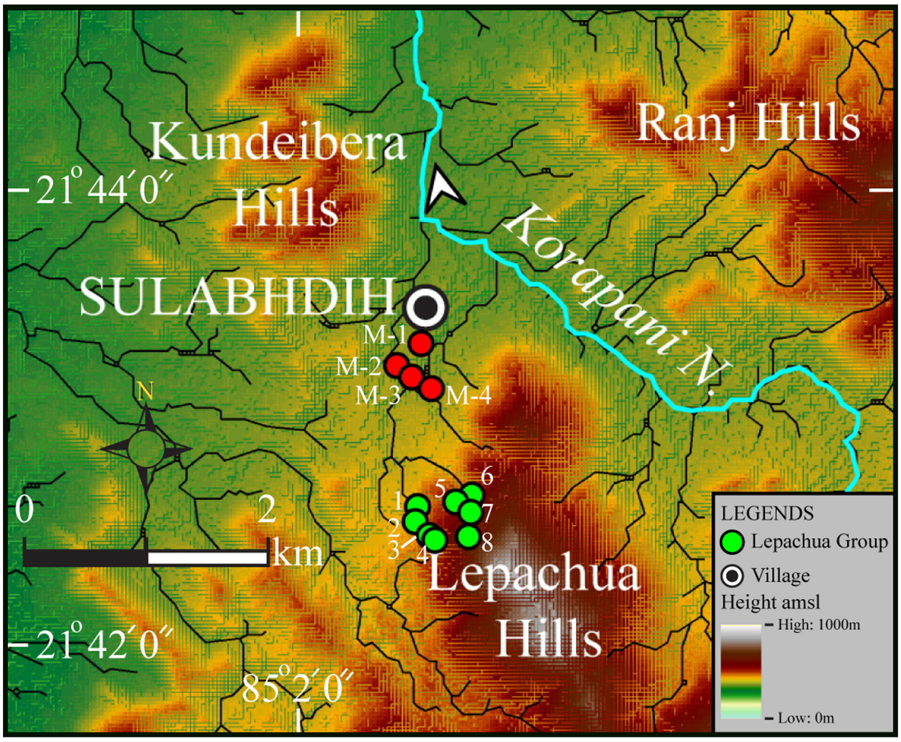


Figure 21: Location of celt manufacturing localities in the Lepachua hills.

Figure 22: Exposed section at Daleisara village located on Lunga stream, showing celt manufacturing debris in stratigraphic context.

extent pecking of the surfaces, almost all the other stages of lithic reduction, starting from detaching blanks from the cores to the hammer dressing and shaping of the preforms were carried out at the Sulabhdih-Lepachua-Lunga complex. In the absence of evidence for habitation area near these sites it may be presumed that the raw material source areas were occupied repeatedly during multi seasons by mobile bands of specialized and skilled celt makers for mass production of chisels and adzes. It should be borne in mind that every site need not be necessarily a place where implements were manufactured and used. In the present context only semi-finished celts were produced in large-scale, leaving final stages, like pecking and grinding of the implements to the people who used them in their habitation and areas of activities. The type of lithic reduction strategy adopted at these sites is often referred to as sequential production system, normally to produce utilitarian exchange items (Ericson 1984: 1–9). In this context it is relevant to cite ethnographic evidence for adze production by the modern adze makers of Langda village in Indonesian Irian Jaya, who produce adze roughouts at the quarry sites close to perennial water sources like Ey

River which also forms the source of raw materials, while they carry those to their camp sites/settlement areas for micro trimming/pecking, grinding and finally hafting of the implements (Stout 2002: 693–722). Besides, social distance between the production loci and the area of use also greatly influence the lithic production strategy. As the social distance increases the producer tends to produce less specific forms (Ericson 1984: 6). This would suggest that the celt knappers of the Sulabhdih-Lepachua-Lunga complex were either carrying the semi-finished chisels and adzes to their areas, which are not yet properly detected, or they were engaged in supplying the celt preforms to their distantly located consumers of this part of Odisha highland or probably beyond through regional/extra-regional trade and/or exchange network system. In fact, several small sized celt dressing sites with scatters of micro chips and broken as well as complete specimens of celt preforms, have been reported further south of Bonaigarh subdivision in the bordering Keonjhar, Angul and Deogarh districts of Odisha (Dash, R.N. 1987–88, Dehuri 1998, Basa, Das and Mohanta 2000: 264–84, Dehuri 2012: 71–78, Dehuri 2013, Dehuri 2014: 112–120). However, though promising, no detailed information is available on these sites so far. Nevertheless, the area lying south and southeast of the present study area, representing the districts of Deogarh, Dhenkanal and Keonjhar, appear to hold tremendous potential for future comprehensive investigation from multidisciplinary perspectives.

Future research focusing on detailed petrographic study alongside chemical characterization of artefacts from different quarry-based celt production sites and sources of raw materials, and contemporary habitation sites if any in southern Bonaigarh and adjoining regions would definitely provide further information pertaining to spatio-temporal significance of such celt production loci in the region. Since celt production is a highly skilled and labour intensive process, it is inextricably interwoven with the broader socio-economic milieu in which the entire lithic reduction activities take place. Thus, future investigation would definitely try to address the socio-economic contexts from chrono-stratigraphic perspectives in the Sulabhdih-Lepachua-Lunga group of sites and those located very close to the river Brahmani and its tributaries in southern Bonaigarh subdivision of Odisha.

Although a large number of ground and polished stone implements has also been reported from different parts of Thapar's *Central-Eastern Neolithic Region*, covering the Chhotanagpur plateau with its peneplains extending to West Bengal and Odisha (Thapar 1985: 25), only three sites, such as Kuchai in the Mayurbhanj district (I.A.R. 1961–62: 35–36) and Hikudi in the Subarnapur district of Odisha (Behera and Thakur 2016: 89–97) and Barudih (Ghosh & Ray 1984: 24–28) in Singbhum district of Jharkhand have so far been excavated. While the Neolithic horizon, at Barudih has been dated to ca. 1200–800 B.C., which agrees with the TL dating of potsherds from Kuchai (Thapar 1985: 46), the Neolithic habitation deposit at Hikudi has been dated to between 3740 ± 80 Cal. BCE (BS-3275) and 1745 ± 215 Cal. BCE (IP-617). Although no datable material could be retrieved from the limited section scraping at Sulabhdih, the stratified artefact bearing deposit at Daleisara appears significant for establishing chronological framework for the mass production site complex of Sulabhdih-Lepachua-Lunga. Future work in the area will focus on systematic excavations of a few debris mounds of Sulabhdih and Daleisara for a comprehensive understanding of lithic *chaîne opératoire* involved in celt production, intra as well as inter-site lithic variability, spatio-temporal distribution of such sites beyond the present study area, location and systematic study of contemporary habitation area, chronometric dating of manufacturing loci and habitation area, and chemical characterization of artefacts and source rock to understand contemporary lithic tool mobility across the region.

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Competing Interests

The authors have no competing interests to declare.

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