
Stories from Silent Stones: On the Shape of Wedge Marks as a Diagnostic of Stone-Craft of Different Periods

Meghana Kuppa¹ and Srikumar M. Menon²

¹. St. Joseph's College (Autonomous), 36, Langford Road, Langford Gardens, Bengaluru, Karnataka 560 027, India (Email: meghana.kuppa@yahoo.com)

². National Institute of Advanced Studies, Indian Institute of Science Campus, Bengaluru, Karnataka 560 012, India (Email: srikumar.menon@gmail.com)

Received: 18 July 2018; Revised: 03 September 2018; Accepted: 05 October 2018

Heritage: Journal of Multidisciplinary Studies in Archaeology 6 (2018): 438-486

Abstract: *The Malaprabha Valley in north Karnataka, with the well-known sites of Badami, Aihole, Pattadakal etc. are regarded as some of the earliest sites of temple architecture in stone in southern India. At the sites of the temples itself, as well as the quarries from which the stone for the temples were sourced, wedge marks created by the Early Medieval stonecutters can be noticed. These wedge marks, created by hammering in steel wedges to split the stone, are noticeably different from the wedge marks of the Late Medieval stonecutters of the Vijayanagara Empire at Hampi and surrounding areas. In this paper, we develop a method to characterize the shape of wedge marks, and suggest that it can be used to differentiate between monuments created by successive dynasties in regions which have architectural interventions of different periods. We demonstrate this in the case of Badami, by attempting to differentiate parts of the fort wall constructed by the Early Chalukyas from the interventions of Vijayanagara artisans, on the basis of the shape of wedge marks on split stones which form part of the wall.*

Keywords: Malaprabha Valley, Badami, Early Chalukya, Hampi, Vijayanagara, Ancient Quarries, Wedge Marks

Introduction

The Malaprabha Valley located in the Bagalkot district of Karnataka, South India, is an important center of early temple architecture in stone in the Deccan plateau, with the well-known sites of Aihole, Pattadakal and Badami, in addition to several smaller but significant sites like Mahakuta, Huligemma Kolla, Siddhanakolla etc. These sites are strung out along the valley of the Malaprabha River, which flows in a north-easterly direction across the Deccan towards its confluence with the Krishna River (Michell 2011). Out of these three places, Badami, formerly known in medieval times as Vatapi, was the capital of the Early Chalukyan dynasty, also known as the Chalukyas of Vatapi (543 to 757 CE), who consolidated their power across a large part of South India from the 6th to 8th century CE. The earliest sanctuaries to come up in the Malaprabha Valley were the rock-cut temples of Badami and Aihole, scooped out of sandstone cliffs these sites. However, these and other sites in the Malaprabha Valley also saw structural

temples constructed both in the northern Nagara, and southern Dravida traditions, as well as the very local Malaprabha idiom (Michell 2014). The Dravida temples of the Malaprabha Valley were the earliest progenitors of what was to become the Karnata Dravida tradition of constructing temples, which was to evolve as “the products of a continuous, coherent tradition lasting about seven hundred years, during which time the architectural forms undergo a gradual but dramatic transformation” (Hardy 1995).

This tradition, which is distinct from the Dravida tradition that evolved in present-day Tamil Nadu, was patronized by dynasties which succeeded the Early Chalukyas, such as the Rashtrakutas, the Chalukyas of Kalyana, and the Hoysalas. Though early Dravida temples in both Kannada and Tamil countries look similar enough to relate with each other, the Karnata Dravida temples undergo much transformation in form over time. Late Karnata Dravida temples, by around the 11th century, “look very different from their early predecessors and from contemporary Drāviḍa works of the far south” (Hardy 2012). After the decline of the Hoysala dynasty, the Karnata Dravida tradition also seems to have gone into decline, and the next intense phase of temple-building was under the emergent Vijayanagara dynasty, which borrowed more from the Tamil Dravida tradition, though Deccani elements also got incorporated, lending a unique flavour to Vijayanagara temple architecture.

The period of Early Chalukyan rule at Badami was undoubtedly a time of great experimentation in monument-building. Apart from temples built in the Nagara, Dravida and Malaprabha idioms mentioned earlier, there are even examples like the Papanatha Temple at Pattadakallu, where definite fusion of a Nagara *shikhara* with a Dravida temple can be observed. It is quite possible that artisans from various parts of the subcontinent found employment in the construction of monuments under the Early Chalukyas. Padigar (2010) speculates on the presence, in the Valley, of artisans from present-day Andhra Pradesh, as well as from the north – northern Deccan and beyond, on the basis of inscriptions which name several artisans.

Though Badami ceased to be the capital of any empire after the Rashtrakuta victory over the Early Chalukyas, it, and continued to be one of the centers of temple-building activities, along with Aihole till at least the 12th – 13th centuries (Michell 2011). The fortifications built by the Early Chalukyas, too, were strengthened and extended by later dynasties which controlled the region. The earliest fortification of Badami was by the Polekesi I in 543CE, as spelt out in the foundational inscription of the Chalukyas (Padigar 2012), but there are at least two inscriptions from the period of Vijayanagara occupation of Badami (dated to 1339 and 1543) which refer to the additions to the fortifications (Michell 2011). For instance, an inscription dated to 1543 on a pillar in the Malegitti Shivalaya states that a bastion (most probably the circular bastion facing the temple) was constructed by Hadapadalara Krishnappa Nayaka (Fleet 1881), under the Vijayanagara Empire, then ruled by Sadashivaraya. There is another inscription in Cave 3 at Badami, which mentions the construction of another bastion, most probably in the South Fort, dated to the same period. The Vijayanagara rulers had not only

strengthened the original fort area but had also erected a new fort wall along with a moat that ran from the south rock hill to the area of Malegitti Shivalaya (Padigar, 2012). During several visits to the Malaprabha Valley, as well as Hampi, we noticed distinctive wedge marks on split pieces of stone used in various building components in temples and fort walls. Broadly speaking, it was noticed that the wedge marks encountered on the Early Chalukyan stone-work were U-shaped, and those on Vijayanagara constructions were angular, while the wedge holes sunk into stone to split them, in these contexts, were lenticular and rectangular, respectively (Figures 1, 2).



Figure 1: Two rows of lenticular wedge holes and a row of u-shaped wedge marks on a rock surface at an Early Chalukyan quarry near Pattadakal

The unique shape of the wedge marks of Early Chalukyan stonecutters have been used to discover their intervention in modifying a prehistoric megalith at the Galaganatha temple complex at Aihole (Menon 2015). Though Menon (2015) generally refers to these marks resulting from splitting of stone using steel wedges as “chisel marks”, we have, in this paper, used the term “wedge holes” for the cavities created for insertion of wedges in unsplit stone, and “wedge marks” for the resultant marks left at these locations after the stone is split.

In this paper, we have attempted a detailed examination of the shapes of wedge marks from monuments and sites definitely attributed to artisans of the Early Chalukya as well as Vijayanagara dynasties, and tried to characterize these shapes analytically. Using the methods developed, we have attempted to differentiate parts of the fortifications at Badami which have been constructed during the rule of the Early Chalukyas from those built under Vijayanagara rule.



Figure 2: A large boulder near Sita's Cave at Hampi, which has been split using wedges. Wedge holes on the uncut rock as well as wedge marks on the split surfaces are visible

Splitting Stones – Different Approaches

The construction of both rock-cut as well as structural monuments involve the removal of stone blocks of various sizes. This involves splitting of stone along lines which enable the removal of stone blocks of required sizes. One of the earliest methods of splitting stone, which is used even today by some communities, is firesetting (Weisberger and Willies 2000). This method, which seems to have been used in the extraction of stone slabs for most megalithic constructions in the subcontinent (Menon 2018a), consists of heaping fuel (usually firewood) on the rock bed, and setting it ablaze, so that the uneven expansion cracks the rock. However, this method is best suited for relatively thin slabs and it is not easy to control size of the extracted slabs.

Another method involves scooping out holes along the intended line of fracture of the rock and inserting either wooden or metal wedges into them. In the case of wooden wedges they are soaked with water till they expand and split the rock along the line of wedge holes. More commonly, steel wedges are hammered into the wedge holes till the stone fractures along the line of wedge holes.

The size of the chisels used depends on the size of the block being extracted. In the case of small posts of stone being prepared at a modern granite quarry (Figures 3, 4), the wedge holes are relatively small and square. After several visits to quarries and monuments indubitably attributed to Early Chalukyan artisans, it was observed that the wedge holes in these contexts were invariably lenticular (Figure 5) in shape, while the resultant wedge marks on split stone surfaces were invariably U-shaped (Figure 6).



Figure 3: A line of wedges being hammered into a rock slab to split it into two posts, at a modern granite quarry near Karkala, South Karnataka

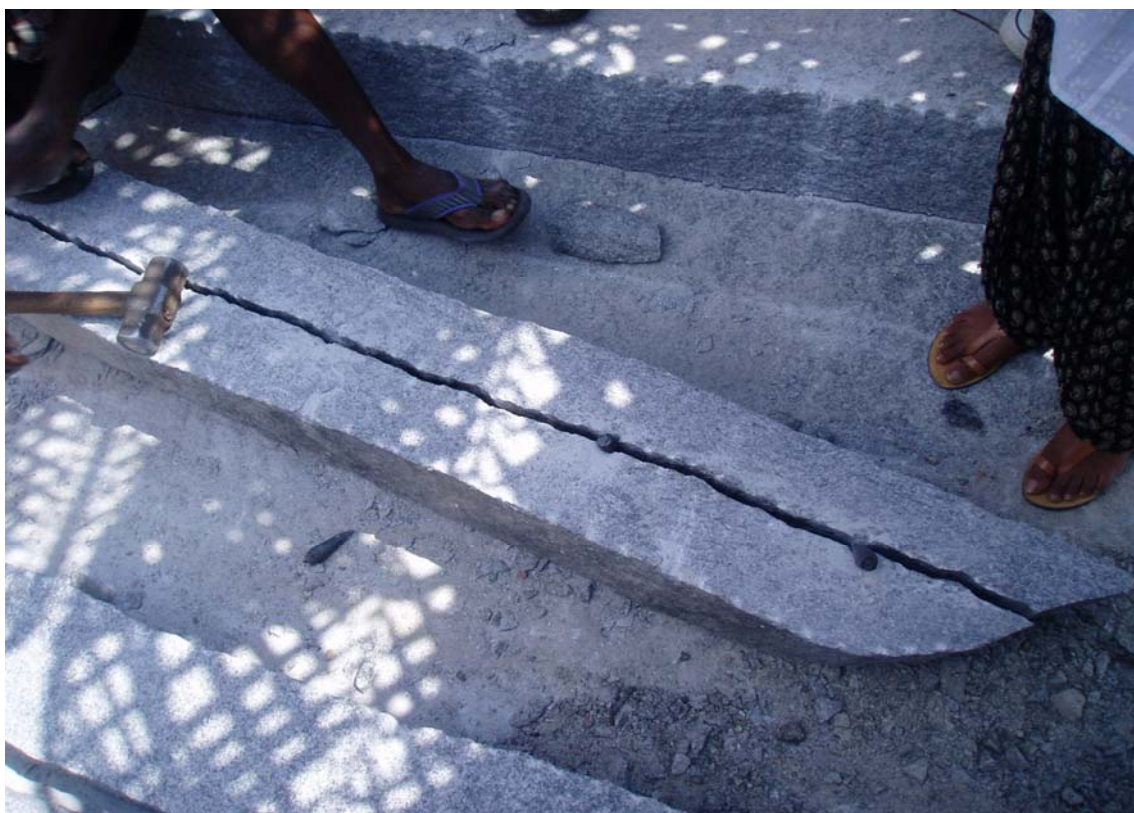


Figure 4: The same stone after it has split



Figure 5: A row of lenticular wedge holes on a column in the entry gateway of the Virupaksha Temple at Pattadakal

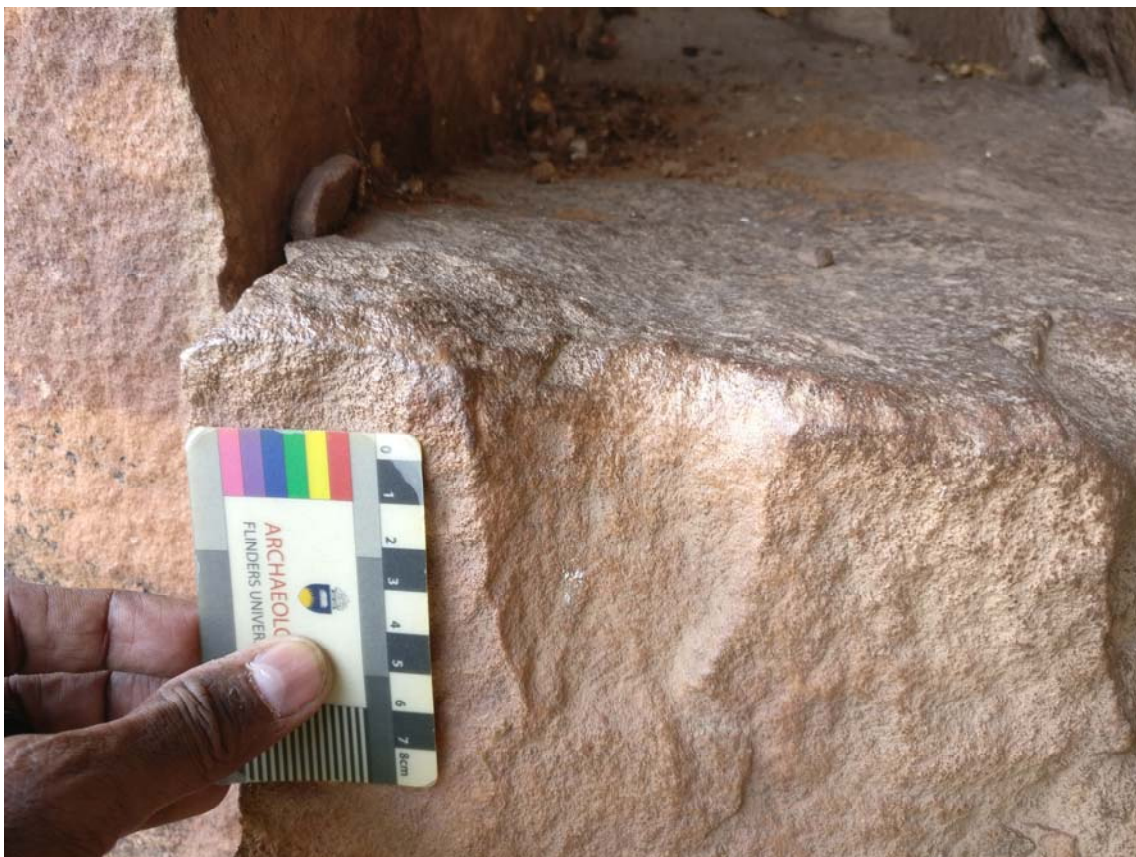


Figure 6: A U-shaped wedge mark at an Early Chalukyan quarry near Pattadakal

A quarried piece of stone at the Early Chalukyan sandstone quarry at Shankaralingana Gundu, roughly 5km north of Pattadakal, demonstrates the technique which was used to split stone at the quarry (Figure 7). First the line along which the stone is to be split is marked on the surface. Along this line, points are marked at intervals where the wedge holes are to be scooped out. Then the outlines, lenticular in shape, of the wedge holes are outlined, before actually scooping out the rock within the outline. Following this, presumably, steel wedges are placed in each of these wedge holes, and pounded with a mallet till the stone splits along the line.



Figure 7: A quarried piece of stone with stonecutter's marks demonstrating the technique by which stone is split, at the Early Chalukyan quarry at Shankaralingana Gundu

A steel wedge and hammer found at one of the quarries (Singh 2009) near Pattadakal supports this view of the process of splitting of stone, over the competing hypothesis that the process involving wooden wedges soaked with water was used. Robert Brubaker (Personal Communication, 2014) avers that “Exactly how Vijayanagara masons separated their granite blocks and the significance of the square lines of quarrying holes along the edges has been something of a mystery. Some have suggested that the rectilinear quarrying holes were chipped out so that wooden blocks could then be inserted and soaked with water - thereby expanding and cracking the stone along the lines of holes to split the blocks off. The exhibit in the Badami Museum, however, with its mallet and chisel, suggested to me the possibility that masons prepared the lines of rectangular holes and then used mallets and chisels in tandem to fracture the blocks.”

Our Observations and Hypotheses

During extensive field studies from 2012 to 2018, it was noticed that, in contexts where there is certainty that all interventions were due to Early Chalukyan artisans, all wedge marks noticed are U-shaped, and all wedge holes lenticular, whereas in contexts where interventions from different periods are present, both angular and U-shaped wedge marks are encountered, as also rectangular and lenticular wedge marks. For instance, in split stones which are used in the structural components of Early Chalukyan temples, such as the stones inside the incomplete *sukanasi* of the Galaganatha Temple at Pattadakal (Figure 8), as well as the sandstone quarry at Motara Maradi, where there is evidence of use by only Early Chalukyan artisans, all wedge marks noticed are U-shaped, and all wedge holes lenticular in shape (Figure 9).

In comparison, all wedge marks in contexts definitely, and without doubt, associated with the period of Vijayanagara rule are invariably angular, and the wedge holes in these contexts are rectangular, such as these examples from one of the fortification walls at Hampi (Figure 10) and a Vijayanagara period tank at Chik Benakal (Figure 11). Moreover, at sites like Badami, where there have been episodes of construction and reconstruction of fortifications and other structures during various phases of history from the periods of Early Chalukyan to Vijayanagara rule, and even later, wedge marks and wedge holes of both types can be found. For instance, on the rock surface near the rock-cut temples in the South Fort, both lenticular (Figure 12) and rectangular (Figure 13) wedge holes can be seen. Similarly, in the several lines of fortifications, both U-shaped (Figure 14) as well as angular (Figure 15) wedge marks can be noticed.

We have, after detailed observations of marks created by stone splitting at several Early Chalukyan and Vijayanagara sites, concluded that the wedge holes and wedge marks made by stone masons during these two periods are distinctly different in shape. We propose that by characterizing the shape of these marks, it would be possible to differentiate the constructions of artisans from these periods at sites like Badami, where they intermingle. In the case of monuments like temples etc. it is easy to distinguish between monuments from different periods, but such a technique based on

the shape of wedge holes and wedge marks will make such distinction possible even in the case of, say, fortification walls. Robert Brubaker (Personal Communication, 2014) opines that, though there might not be much variation in the quarry marks across construction sites in Vijayanagara, “it certainly sounds like there may be some variation on a broader historical level that could be useful for the attributing of sites to particular eras where this is not otherwise clear on epigraphic grounds.”



Figure 8: A view of the unfinished sukanasi of the Galaganatha Temple at Pattadakal, showing wedge marks and wedge holes on the structural members within



Figure 9: Lenticular shaped wedge holes and U-shaped wedge marks on a quarried slab at the Early Chalukyan sandstone quarry at Motara Maradi



Figure 10: Rectangular wedge holes and angular wedge marks on stone blocks of a fortification wall at Hampi



Figure 11: Quarried pieces of stone near a tank of the Vijayanagara period at Chik Benakal, showing typically Vijayanagara wedge marks



Figure 12: Weathered lenticular wedge holes on the rock surface near Cave 1 at Badami



Figure 13: Rectangular wedge holes on a vertical rock face near the rock-cut temples at Badami



Figure 14: U-shaped wedge mark on a portal in the fortification wall near Agastya Teertha, Badami



Figure 15: Angular wedge mark on a stone block in the fortification wall near Agastya Teertha, Badami



Figure 16: Inscriptions of Early Chalukyan artisans on a boulder in the quarry at Motara Maradi



Figure 17: Sketches of Early Chalukyan artisans incised on a rock face in the quarry at Shankaralingana Gundu

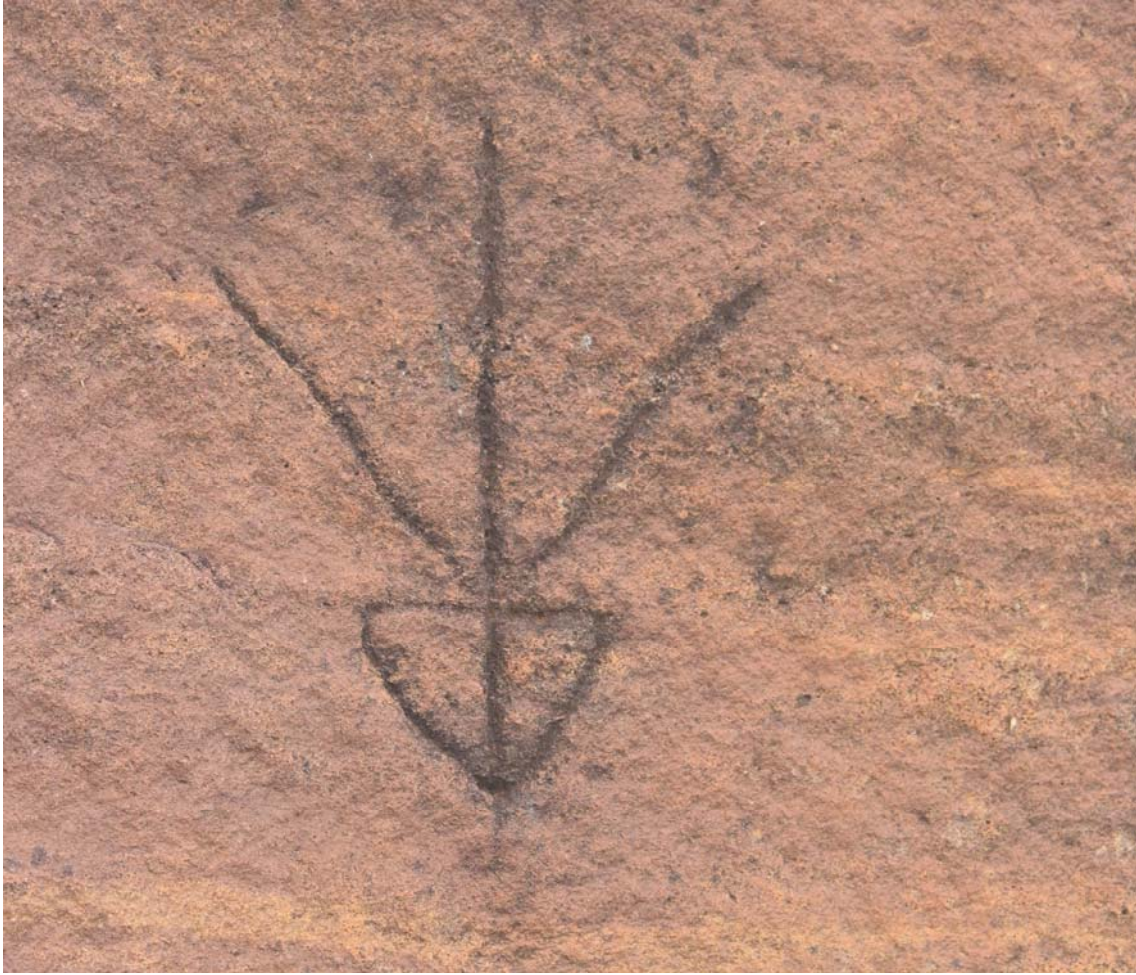


Figure 18: Masons' Mark at Motara Maradi

Wedge Marks of Early Chalukyan Artisans

Wedge marks of the Early Chalukyans can be found in profusion at the sandstone quarries of this period at Shankaralingana Gundu and Motara Maradi (Menon 2015), as well as another quarry locally known as Shankaralingana Betta. These quarries, which were used by the architects of the Pattadakal temples during the Early Chalukyan period, contain inscriptions (Figure 16), sketches (Figure 17), masons' marks (Figure 18) etc. in addition to marks of quarrying (Figure 19) and marks which have been identified as attendance marks of the artisans who worked there (Figure 20). The association of these quarry sites with the temples at Pattadakal is indubitable, for apart from the evidence from paleography of the inscriptions, there are sketch studies at the quarries for iconographic schemes found in the temples, such as this sketch study (Figure 21) for an idol of Mahishasuramardini Durga (Figure 22) found in a niche inside the Papanatha Temple at Pattadakal.

The wedge holes created for splitting stones by the Early Chalukyan stone masons are lenticular, or oval shaped, with rounded and not angular edges, a typical example being the row of wedge holes from Motara Maradi (Figure 23). The inside of such



Figure 19: Quarried slabs with wedge marks at Motara Maradi



Figure 20: Tally marks which have been interpreted as attendance marks of artisans at the quarry at Shankaralingana Betta



Figure 21: A sketch of Mahishasuramardini Durga at Shankaralingana Gundu



Figure 22: An idol of Mahishasuramardini Durga at the Papanatha Temple, Pattadakal, for which the sketch in Figure 21 seems to have been a study



Figure 23: A row of typical lenticular wedge holes at Motara Maradi



Figure 24: Close up of one of the lenticular wedge holes showing the ovoid cavity



Figure 25: A row of typical U-shaped wedge marks on a structural member inside the unfinished *sukanasi* of the Galaganatha Temple, Pattadakal, shown in Figure 8



Figure 26: A close view of Early Chalukyan wedge marks, showing the rounded edge at the top of the wedge mark

wedge marks are smooth, too, with no angular faces, and defines ovoid shaped cavities (Figure 24). Upon splitting by insertion of metal wedges and hammering, the shape that such a wedge mark leaves on the split surface of the stone is typically U-shaped, as can be seen from the row of wedge marks on a stone beam (Figure 25) within the unfinished *sukanasi* of the Galaganatha Temple at Pattadakal. The signature left on the original rock surface on which the wedge hole was originally scooped out is, typically, half an oval, on one side of the long axis of the original oval (Figure 26). It will be shown below how the shape of the wedge mark can be characterized geometrically as a diagnostic for determining the type of wedge mark.

Wedge Marks of Vijayanagara Artisans

In comparison, the wedge holes of the Vijayanagara stone masons are, as noted earlier, rectangular or square. The extensive site of the erstwhile capital city of the Vijayanagara Empire at Hampi, with its profusion of monumental architecture from the Vijayanagara period, provides a large number of wedge marks and wedge holes (Figure 27), especially in the extensive fortification walls, but also in several other contexts.

The wedge holes created for splitting stones by the Vijayanagara stone masons are rectangular, with sharp angular edges, a typical example being these rows of wedge holes on a split boulder on Hemakuta Hill at Hampi (Figure 28). The inside of such wedge marks make a cuboidal cavity, with angular faces (Figure 29). Upon splitting by insertion of metal wedges and hammering, the shape that such a wedge mark leaves on the split surface of the stone is typically angular, as can be seen in this view of wedge marks on a split boulder at Hampi (Figure 30), on the trail from Virupaksha Temple to Vitthala Temple. The signature left on the original rock surface on which the wedge hole was originally scooped out is, typically, half a rectangle, on one side of the long axis of the original rectangle (Figure 31).

Though all the wedge holes and wedge marks encountered at Hampi and surrounding areas are in the context of the granite abundantly available in the region, both wedge holes as well as wedge marks of similar shape can be seen in the sandstone of Badami and Aihole in the Malaprabha Valley, too. Since these two sites have seen construction activity, especially on fortifications, during the period of Vijayanagara rule too, it is of interest to investigate if the Vijayanagara artisans employed techniques resulting in rectangular wedge holes and angular wedge marks at Badami and Aihole, too.

Characterizing the Shape of the Wedge Marks

The shape of the wedge holes encountered in the Chalukyan context in Malaprabha Valley (Figure 32) are easy to differentiate by sight alone from those at Hampi in the Vijayanagara context (Figure 33). However, it is not always easy to distinguish between the wedge marks left after splitting the stone using wedge holes of the two shapes (Figure 34), especially in a context where there has been architectural interventions from more than one period. This could be because actual marks are the

result of the manner in which the rock fractures, which might not result in identical marks always. Sometimes, though the original wedge hole is rectangular and its cavity cuboidal, uneven fracture might blur the perception of the resultant wedge mark as angular.



Figure 27: Typical Vijayanagara wedge holes and wedge marks at Hampi



Figure 28: Rectangular wedge holes and angular wedge marks on a split boulder near Sita's Cave at Hampi

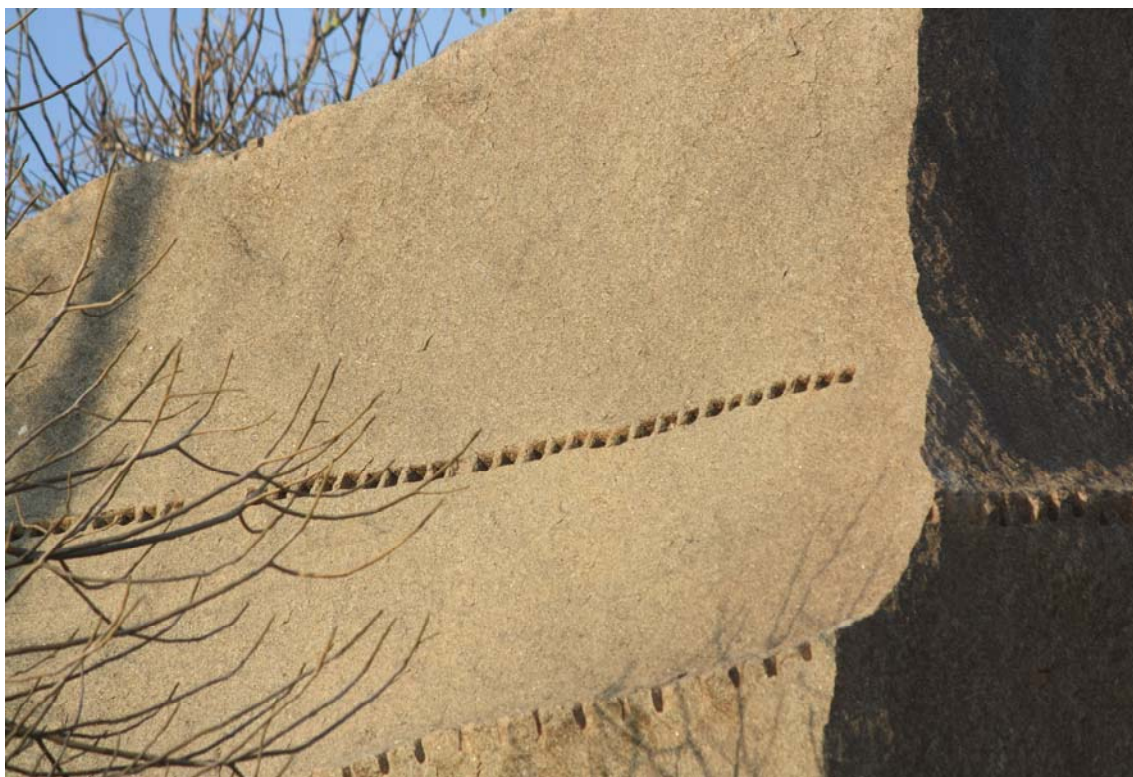


Figure 29: A close view of wedge holes at Hampi showing the cuboidal cavity scooped out of the rock



Figure 30: Angular wedge marks on a split boulder at Hampi



Figure 31: A close view of Vijayanagara wedge marks at Hampi showing the sharp, angular edges



Figure 32: A row of wedge holes from the Early Chalukyan quarry at Motara Maradi, with the lenticular shape of the holes clearly discernible



Figure 33: Rectangular wedge holes from Hampi



Figure 34: A row of wedge marks from a quarried boulder at South Fort Badami. The shapes are not clearly classifiable as angular or U-shaped, due to uneven fracturing of stone



Figure 35: One way of identifying the shape of the original wedge hole is by examining the remaining edge on the original rock surface into which the wedge hole was carved, in this case, at Alampur, definitely one half of lenticular, or curved



Figure 36: In this case, at Hampi, the remaining edge on the original rock surface into which the wedge hole was carved, is definitely one half of rectangular

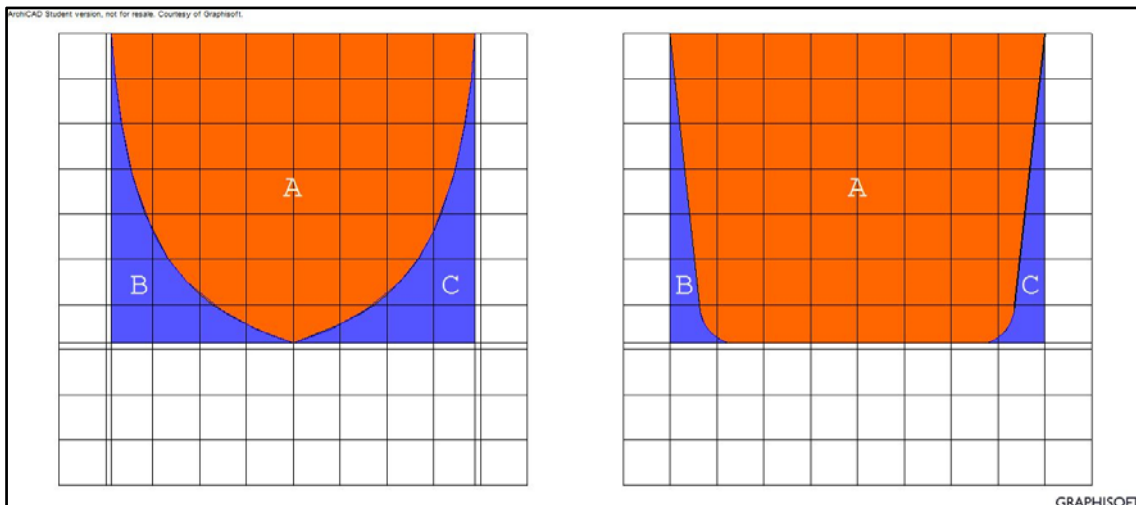


Figure 37: A geometrical method to characterize the shape of wedge marks applied to an idealized Early Chalukyan wedge mark (L) and Vijayanagara wedge mark (R)

One way to distinguish between the wedge marks created by the two types of wedge holes is to examine the shape of the remaining portion of the edge of the wedge hole left after splitting on the top surface of the stone (Figures 35, 36), as mentioned earlier. However, in order to make identification of wedge marks in contexts where there are no wedge holes immediately adjacent, we have attempted to characterize geometrically the actual shapes of the wedge marks themselves, created by using lenticular as well as rectangular wedge holes. The method we have devised is to enclose the wedge mark in

question within the tightest rectangle into which it can be fitted (Figure 37), followed by estimation of the area contained within the boundary of the wedge mark (A) and the area outside the wedge mark, but within the bounding rectangle (sum of B and C). The ratio of the two areas, $A: (B+C)$ is a dimensionless constant, and can be used to check if there is any consistency in the form of the wedge marks created using the two types of wedge holes. We have used this method to examine wedge marks from Chalukyan and Vijayanagara contexts, as outlined below.

Analysis of Wedge Marks in Early Chalukyan Context

We have analyzed a total of thirteen wedge marks from contexts which are definitely identified as Chalukyan. Of these, eleven are from various contexts at the Pattadakal group of temples, and one each from the Sangameshwara Temple at Alampur, Telengana and the Early Chalukyan sandstone quarry at Motara Maradi (Table 1).

Table 1: Showing the Characteristics of Wedge Marks in Early Chalukyan Context

S. No.	ID of Wedge Mark (indicated in photograph)	A (cm ²)	B (cm ²)	C (cm ²)	k	Average
Sukanasi of Galaganatha Temple, Pattadakal (Figures 38, 39)						
1	A	59.24	15.02	13.21	2.1	2.07
2	B	62.93	15.23	11.22	2.38	
3	C	58.05	14.70	11.99	2.17	
4	D	80.85	34.03	16.62	1.6	
5	E	60.91	20.67	8.12	2.12	
Basement, Galaganatha Temple, Pattadakal (Figure 40)						
6	A	48.37	7.34	3.69	4.4	3.13
7	B	83.57	15.09	15.66	2.7	
8	C	61.41	15.30	10.89	2.3	
Paving slab, Galaganatha Temple, Pattadakal (Figure 41)						
9	A	31.46	4.12	6.64	2.9	2.66
10	B	44.38	10.08	11.83	2.02	
11	C	43.68	6.41	7.84	3.06	
Quarried slab, Motara Maradi (Figure 42)						
12	A	49.23	7.49	13.15	2.3	2.3
Stone block, Alampur (Figure 43)						
13	A	40.48	7.32	8.33	2.59	2.59

Of the eleven wedge marks from Pattadakal, five are from a beam within the unfinished *sukanasi* of the Galaganatha Temple shown in Figures 8 and 25, three are from a rough block in the basement of the same temple, and three from a paving slab nearby. The wedge mark at Alampur, which is another centre of Early Chalukyan temple architecture, was on a block of stone within the Sangameshwara Temple premises, while that from Motara Maradi is from a quarried slab of sandstone at the quarry.

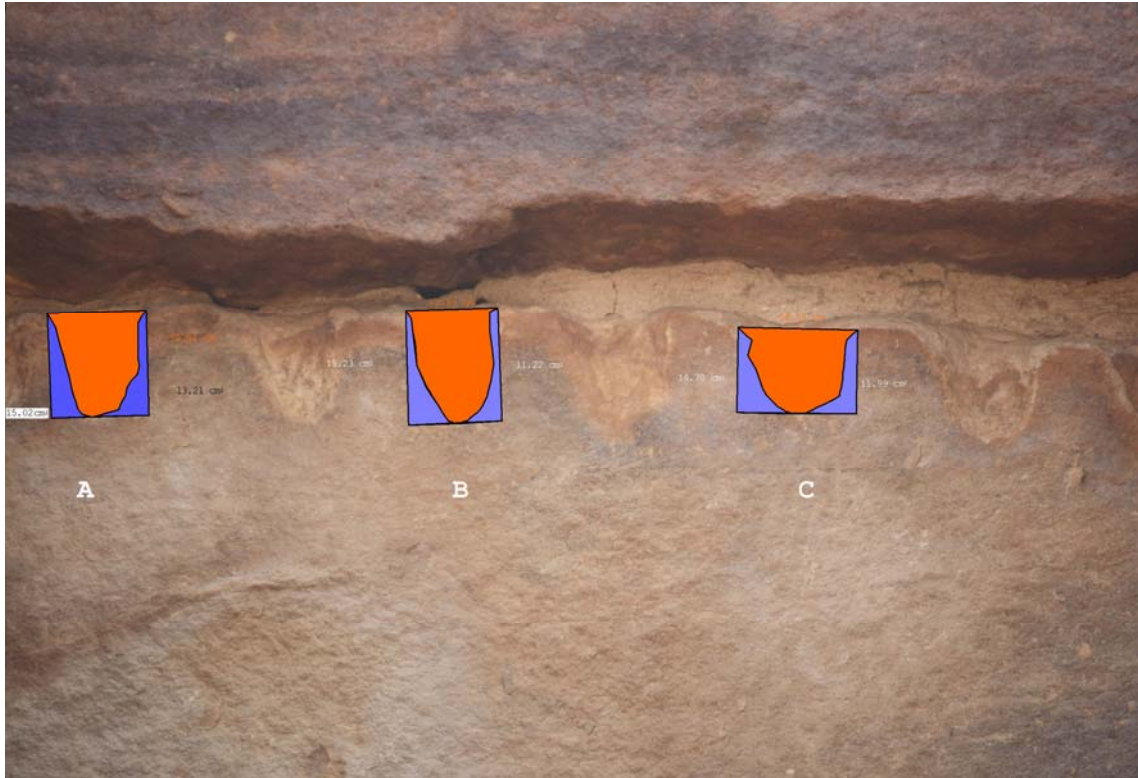


Figure 38: Analysis of wedge marks on a structural member in the unfinished *sukanasi* of the Galaganatha Temple at Pattadakal (Part 1)

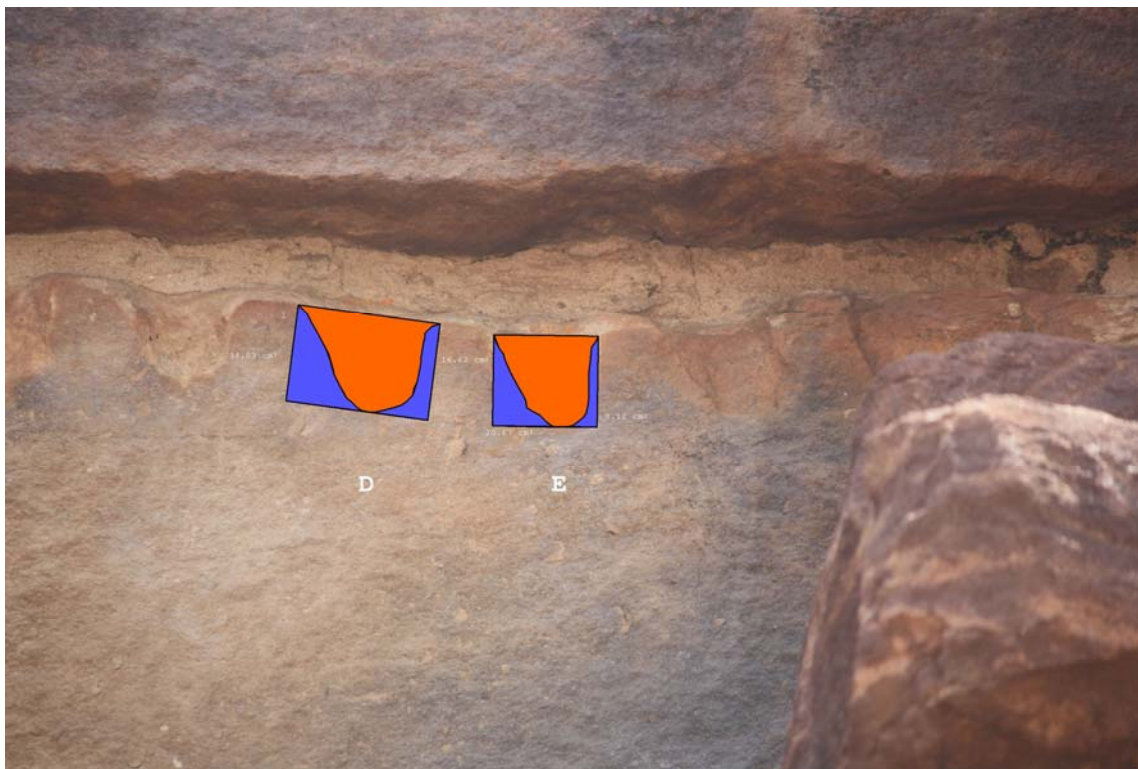


Figure 39: Analysis of wedge marks on a structural member in the unfinished *sukanasi* of the Galaganatha Temple at Pattadakal (Part 2)

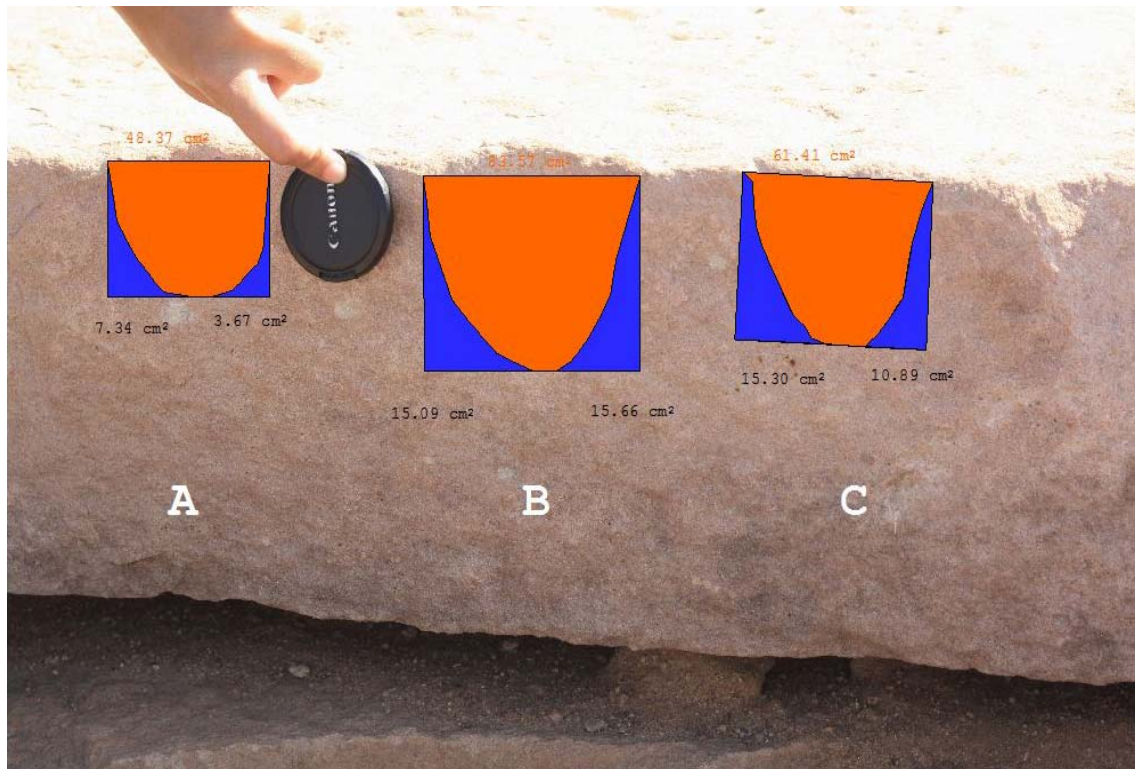


Figure 40: Analysis of wedge marks on a stone block in the basement of the Galaganatha Temple at Pattadakal

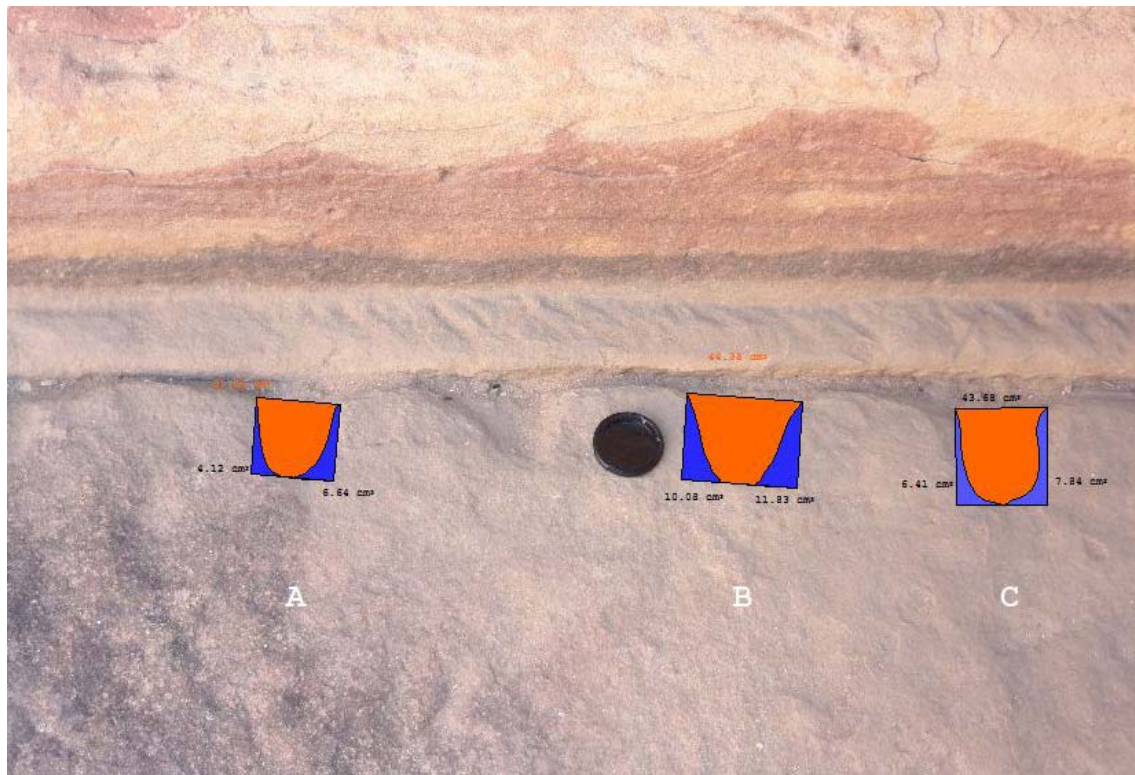


Figure 41: Analysis of wedge marks on a stone paving block near the Galaganatha Temple at Pattadakal



Figure 42: Analysis of wedge marks on a quarried block of stone at the Early Chalukyan sandstone quarry at Motara Maradi

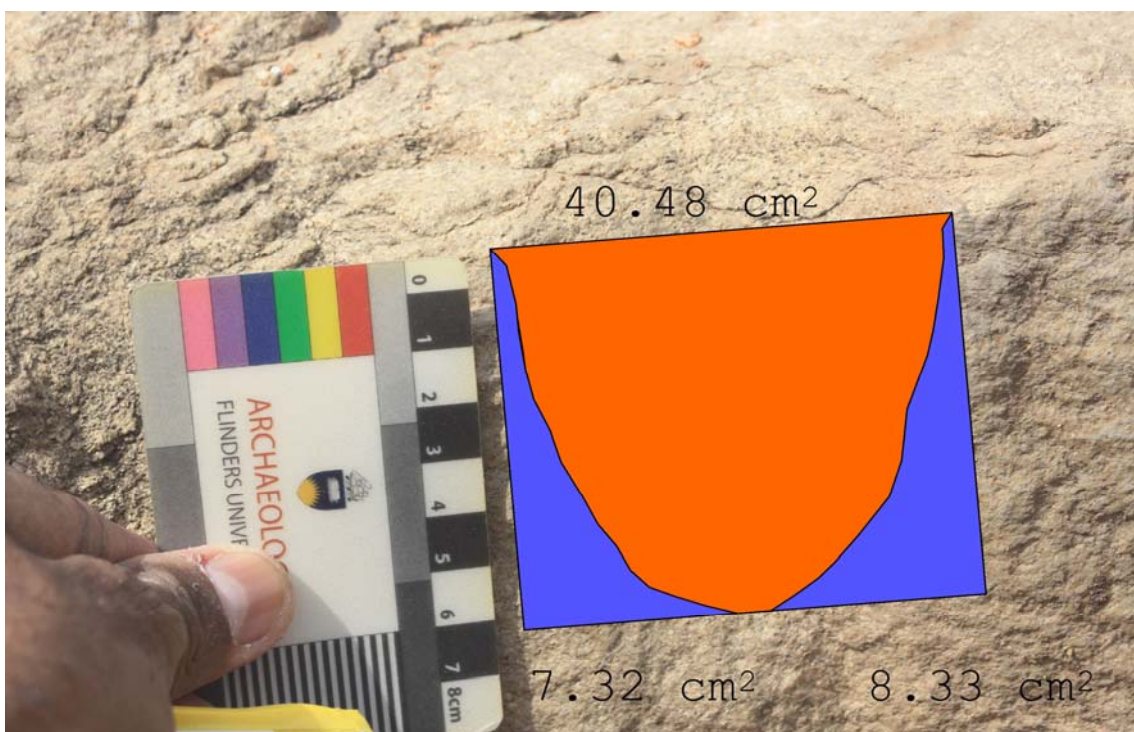


Figure 43: Analysis of a wedge mark on a stone block near the Sangameshwara Temple at Alampur

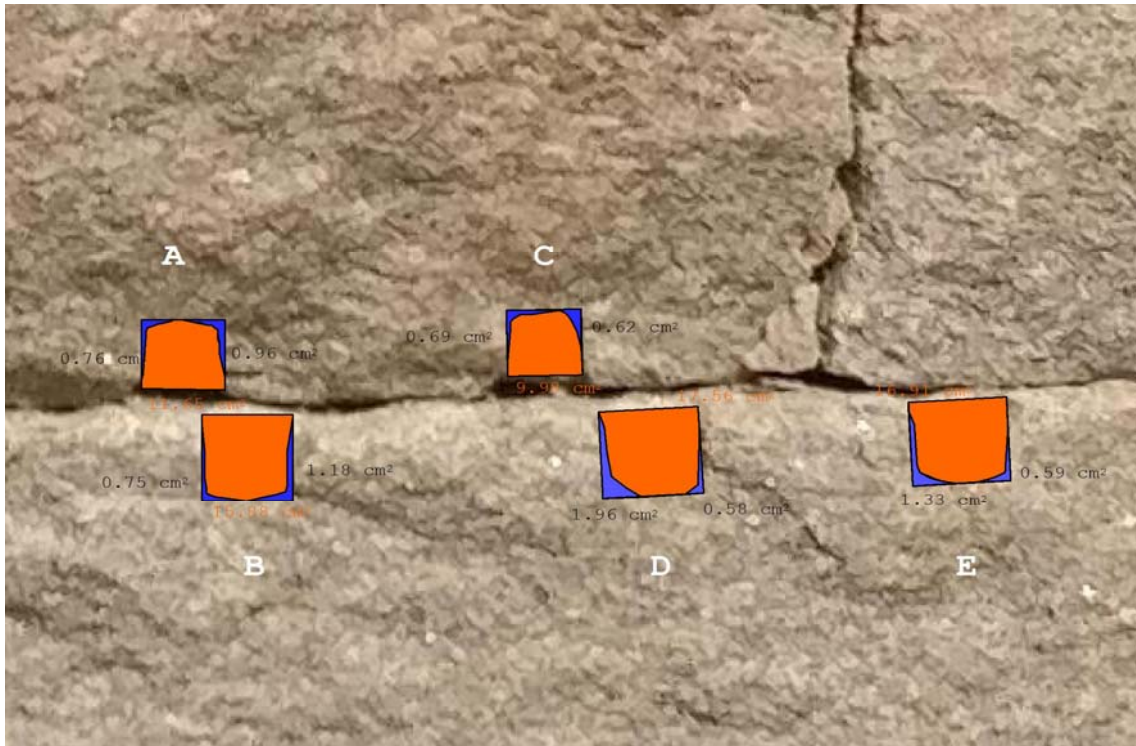


Figure 44: Analysis of wedge marks on two stone blocks within a fortification wall at Hampi

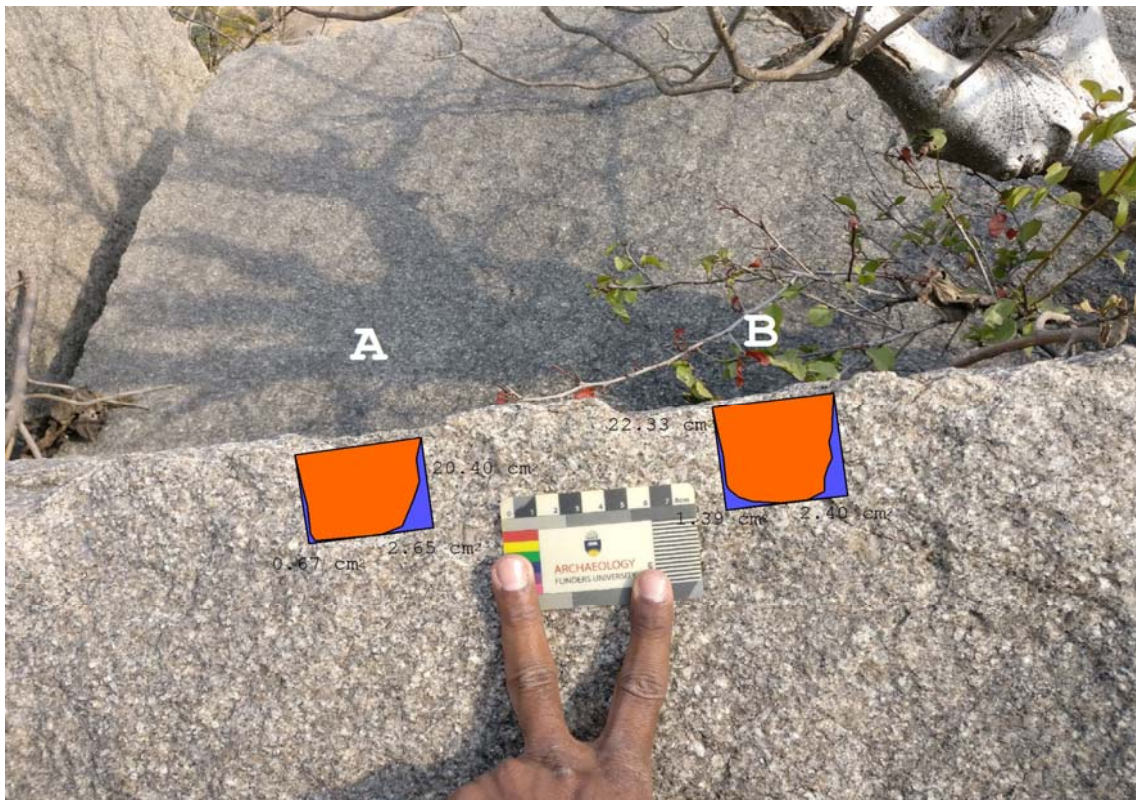


Figure 45: Analysis of wedge marks on a stone block near a Vijayanagara period tank at Mallapur

We have imported the photograph of each wedge mark into a CAD software and scaled it to the actual size, though, strictly speaking, scaling is not necessary, since the quantity k that we are deriving is a dimensionless ratio. The tightest fitting rectangle that bounds each wedge mark was marked on top of the raster image of the wedge mark. Subsequently, areas A (the area within the boundaries of the wedge mark), B and C (the area outside the wedge mark but within the bounding rectangle) are estimated by tracing over the outline of the wedge marks, and the ratio $k = A / (B+C)$ determined. Wedge marks whose boundaries were unclear were eliminated from the analysis.

Analysis of Wedge Marks in Vijayanagara Context

We have analyzed a total of seven wedge marks from contexts which are definitely identified as belonging to the period of Vijayanagara rule. Of these, five are from two stone blocks within a fortification wall at Hampi, and two from a piece of quarried stone near a tank of the Vijayanagara period at Mallapur. The process detailed in the preceding section was repeated with these wedge marks too, and the results are displayed in Table 2. As can be seen the average values for k varies from nearly 6 to 7.6, and shows clear separation from the k -values for the Chalukyan wedge marks, which display average k -values from just over 2 to 3.13.

Table 2: Showing the Characteristics of Wedge Marks in Vijayanagara Context

S. No.	ID of Wedge Mark (indicated in photograph)	A (cm ²)	B (cm ²)	C (cm ²)	K	Average
Fort wall, Hampi (Figure 44)						
1	A	11.65	0.76	0.96	6.7	7.64
2	B	15.88	0.75	1.18	8.2	
3	C	9.98	0.69	0.62	7.61	
4	D	17.56	1.96	0.58	6.9	
5	E	16.91	1.33	0.59	8.8	
Quarried stone block, Mallapur (Figure 45)						
6	A	20.40	0.67	2.65	6.14	5.97
7	B	22.33	1.39	2.40	5.8	

Applying Results to Contexts at Badami

The monuments at Badami are distributed in two sections known as the North Fort and the South Fort, on these respective sides of the Agastya Teertha. The four main rock-cut temples are scooped out of the cliffs of the South Fort, while many of the prominent structural temples are situated in the North Fort. The extensive fortifications straddle both these locations and also runs within the modern settlement to the west of the tank, as well as along it.

The cliffs near the rock-cut temples show evidence for removal of rock beside the steps which lead to these sanctuaries. Both lenticular and rectangular wedge holes are

encountered, as seen in Figures 12 and 13. Similarly, both U-shaped as well as angular wedge marks are also encountered near the caves. This is true of sections of the fort wall near Agastya Teertha, as well as excavations noticed above the cliffs of the South Fort, too.



Figure 46: A row of wedge marks near the rock-cut cave temples of South Fort, Badami

We have chosen a few of these marks for analysis using the technique developed and outlined in this paper. The wedge marks chosen for analysis are: a row of wedge marks in the cliffs near the rock-cut caves of the South Fort (Figure 46); a row of wedge marks on an upright of a portal set within the fort wall adjoining the Agastya Teertha near the Archaeological Museum (Figure 47); and a row of wedge marks on a stone block in the fort wall adjacent to this portal (Figure 48), as well as the row of wedge marks of unknown provenance in the cliffs above the South Fort mentioned earlier, and shown in Figure 34.

The results of the analysis of these features is given in Table 3. For the row of wedge marks near the rock-cut caves, only one wedge mark was clear enough to analyse. From the k-values obtained by analysis, the following conclusions can be arrived at. The excavation near the rock-cut caves, which was studied, seems to be of Vijayanagara intervention ($k = 6.5$). In support of this conclusion, there is independent evidence for stone-work of Vijayanagara origin in this neighbourhood, such as this typically Vijayanagara rock-cut device to tether horses (Figure 53). Similar devices have been encountered at four locations at Hampi (Rao 1983).



Figure 47: Wedge marks on one of the uprights of a portal in the fort wall along Agastya Teertha near the Archaeological Museum, Badami

Table 3: Showing the characteristics of wedge marks at select locations at Badami

S. No.	ID of Wedge Mark (indicated in photograph)	A (cm ²)	B (cm ²)	C (cm ²)	k	Average
Near the rock-cut caves, South Fort (Figure 49)						
1	A	32.27	2.77	2.18	6.5	6.5
On upright of portal in Fort Wall near Agastya Teertha (Figure 50)						
2	A	36.33	6.37	11.39	2.07	2.26
3	B	35.93	9.12	5.68	2.43	
4	C	45.77	11.34	10.69	2.07	
5	D	41.22	10.69	5.31	2.5	
On stone block in fort wall adjacent to portal (Figure 51)						
6	A	31.58	2.00	0.37	13.32	10.53
7	B	27.71	1.53	2.05	7.74	
On split rock above cliffs of South Fort (Figure 52)						
8	A	36.65	1.04	3.27	8.5	6.26
9	B	30.86	0.86	3.24	7.53	
10	C	29.37	1.87	2.24	7.15	
11	D	27.21	1.66	4.81	4.21	
12	E	23.62	1.77	1.81	6.6	
13	F	36.39	3.70	2.60	5.78	
14	G	35.15	3.66	5.06	4.03	

Similarly, it would also seem that the portal near the Agastya Teertha dates back to the construction of the Early Chalukyas ($k = 2.26$), while the fort wall adjacent to it seems to be built by the Vijayanagara artisans ($k = 10.53$). Here, too there is independent evidence for authorship of Vijayanagara artisans, testified by typical Vijayanagara motifs like the crouching lion (Figure 54) and eclipse motif (Figure 55) in blocks of the same fort wall nearby. The eclipse motif, commonly encountered in Tamil Nadu (Deekshithar 2010a, 2010b), makes its entry into Karnataka only during the period of Vijayanagara rule and is seen in the architecture of the Keladi Nayakas thereafter (Menon 2018b). The row of wedge marks in the split boulder above the cliffs of the South Fort too, is of Vijayanagara origin, as suggested by the analysis ($k = 6.26$). This technique seems to be an efficient tool to investigate the provenance of wedge marks.

Extension of Analysis to Other Periods

Though we have mainly confined our analysis to sites of Early Chalukya and Vijayanagara interventions, we investigated a set of wedge marks from a site of Vishnukundin (4th century CE) architecture at Kesaragutta (Figure 56), in Telengana, and two sets from the center of Rashtrakuta architecture at Sirival (Figures 57, 58), in north Karnataka. The results of this analysis are given in Table 4. Both visually, as well as by the results of the analysis ($k = 2.6$ for Kesaragutta and $k = 2.5$ for Sirival), these wedge marks seem to be closer to those of the Early Chalukya artisans rather than those of the Vijayanagara artisans.

Table 4: Showing the characteristics of wedge marks at Keesaragutta and Sirival

S. No.	ID of Wedge Mark (indicated in photograph)	A (cm ²)	B (cm ²)	C (cm ²)	k	Average
On a structural member of a shrine at Keesaragutta (Figure 59)						
1	A	26.45	4.88	4.38	2.86	2.6
2	B	5.25	3.03	28.13	3.4	
3	C	16.39	3.63	2.67	2.6	
4	D	14.32	2.21	2.95	2.78	
5	E	11.75	1.87	2.36	2.78	
6	F	17.94	6.39	4.20	1.69	
7	G	15.09	3.67	3.67	2.06	
On a structural member of a shrine at Anabi, near Sirival (Figure 60)						
8	A	28.02	4.63	3.56	3.42	2.31
9	B	26.34	9.29	5.92	1.73	
10	C	33.07	10.11	8.36	1.79	
On a structural member of a shrine at Anabi, near Sirival (Figure 61)						
11	A	37.23	6.03	5.25	3.3	2.69
12	B	30.25	8.16	6.57	2.08	

**Figure 48: Wedge marks and wedge holes on a block of stone in the fort wall adjoining the portal**

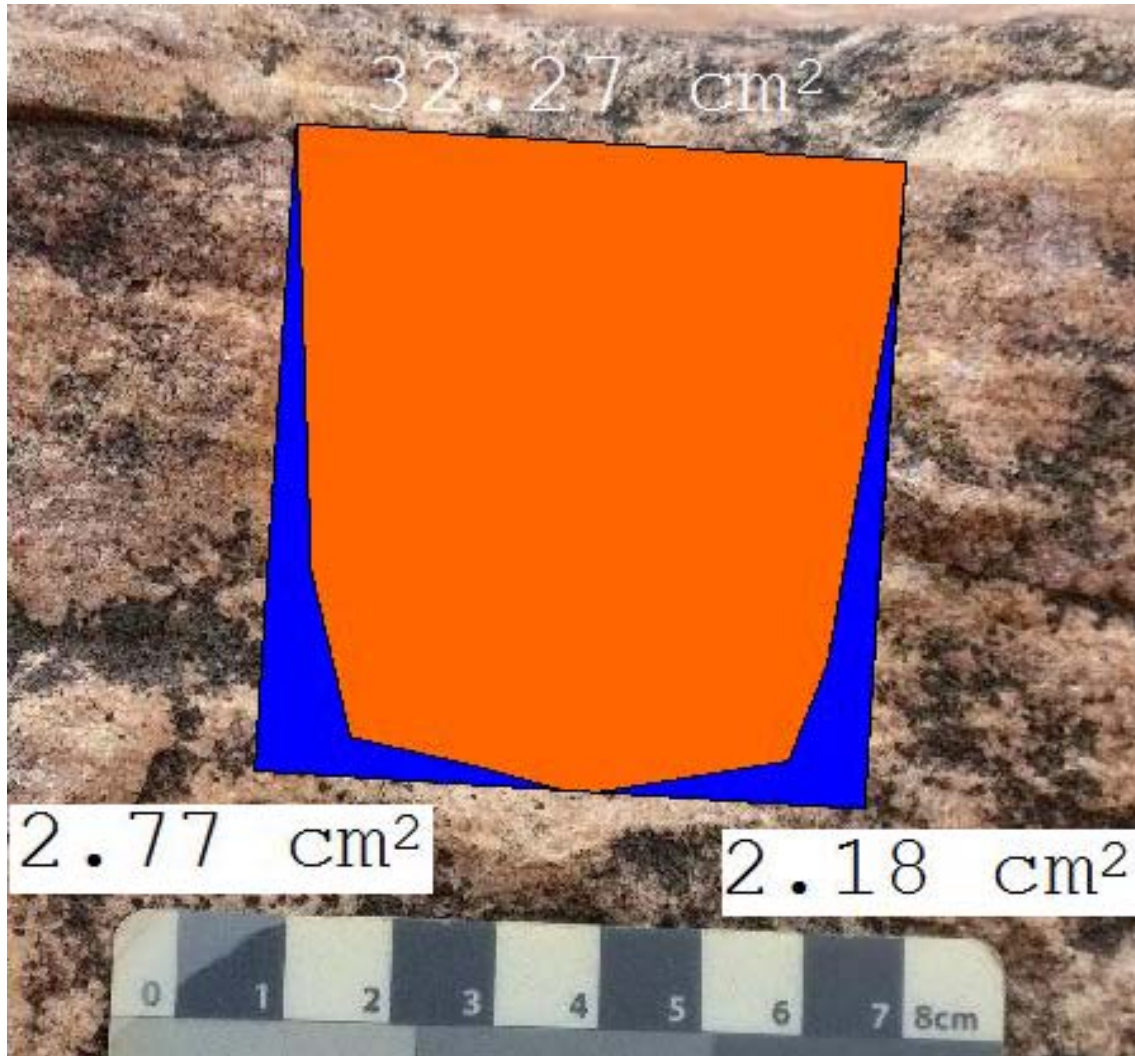


Figure 49: Analysis of one of the wedge marks shown in Figure 46



Figure 50: Analysis of some of the wedge marks shown in Figure 47

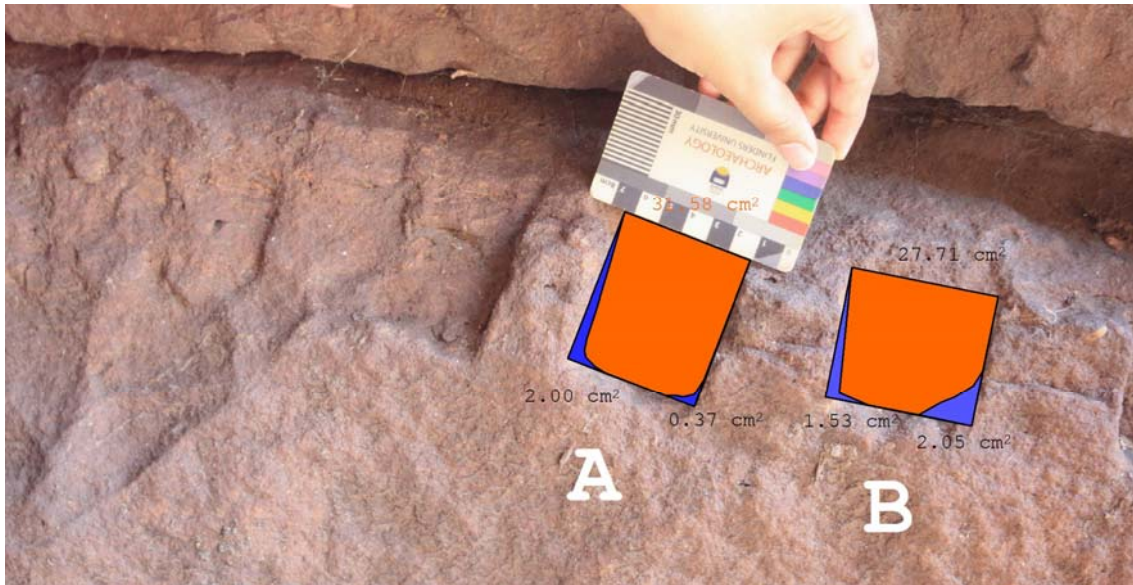


Figure 51: Analysis of two of the wedge marks shown in Figure 48

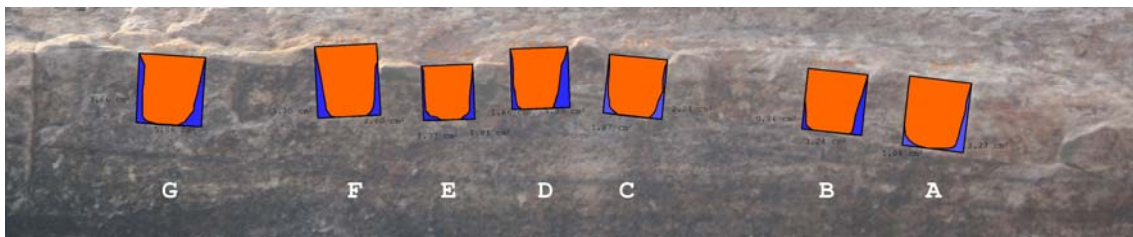


Figure 52: Analysis of some of the wedge marks shown in Figure 34



Figure 53: A rock-cut device, apparently to tether horses, which is a common feature at Hampi, during Vijayanagara rule



Figure 54: A portion of the fort wall adjacent to the portal whose upright was featured in Figures 47 and 50, with a Vijayanagara motif of a crouching lion indicating its authorship by Vijayanagara artisans



Figure 55: An eclipse motif, which can be attributed to period of Vijayanagara rule in this region on a section of fort wall to the north of the portal whose upright was featured in Figures 47 and 50

Discussion

We have been able to establish, for the first time, that the wedge holes carved to split stones using steel wedges, as well as the wedge marks left after splitting the stones, are distinctly different in appearance and form, in the contexts of Early Chalukya and Vijayanagara stone-working sites. Though the shape of the wedge holes is easily differentiable by sight alone, the wedge marks sometimes pose difficulties in differentiating between the two types. We have put forward a technique that seems useful to distinguish between the wedge marks of the two different types.

It can be argued that the nature of the stone involved in the monuments of the Early Chalukya and Vijayanagara artisans, sandstone and granite respectively, could have necessitated the different types of wedge holes used. However, it has been shown how Vijayanagara artisans persisted in the use of rectangular wedge holes even on sandstone, in Badami. The two different shapes of wedge holes can be seen on the sandstone of the quarried parts of Meguti Hill at Aihole, right next to each other (Figures 62, 63). Similarly, U-shaped wedge marks are encountered even in granite used in Kesaragutta (Figure 56) and Sirival (Figures 57, 58).

The implications of this technique of examining sites of stone-working for clues of authorship are many. At composite sites, such as Badami and Aihole, which have been worked upon in different phases of history, it could possibly allow differentiation of

interventions from various periods. It can also help trace migrations of artisans from various geographical regions. For instance, is it possible that the stone workers from the Andhra-Telangana region could have worked on the Early Chalukya architecture of Badami and Aihole. Padigar (2010) seems to believe this is possible, based on studies of artisan names. Our evidence from Keesaragutta supports this. It is possible that the technique of splitting stones using lenticular wedge holes could have come with these artisans to Badami.



Figure 56: Wedge marks on a structural member of an unfinished shrine at Keesaragutta



Figure 57: Wedge marks on a structural member of an unfinished shrine at Sirival



Figure 58: Wedge marks on a structural member of another unfinished shrine at Anabi, near Sirival



Figure 59: Analysis of some of the wedge marks shown in Figure 56

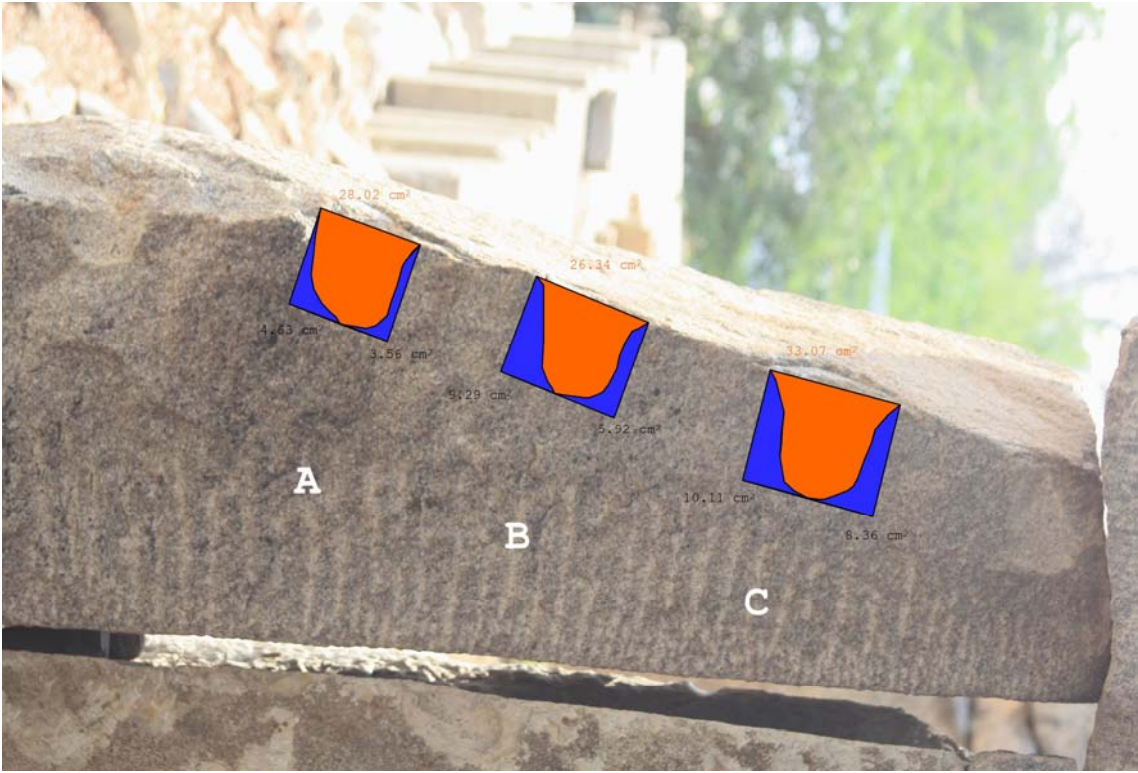


Figure 60: Analysis of three of the wedge marks shown in Figure 57

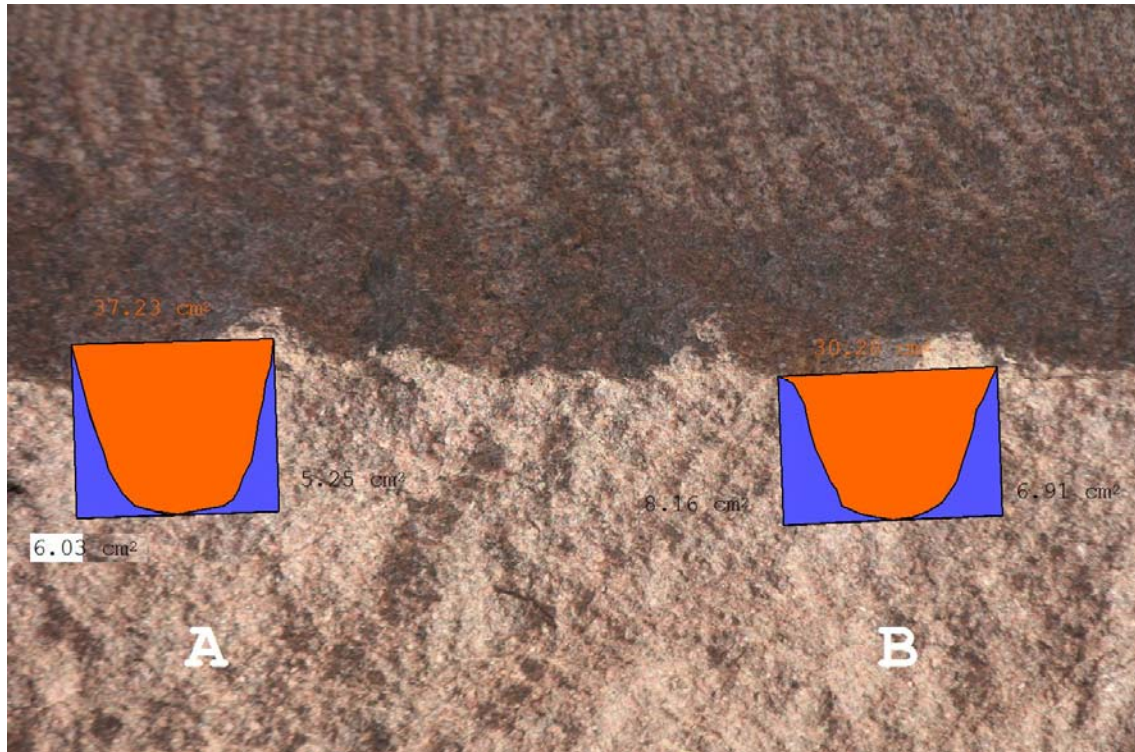


Figure 61: Analysis of two of the wedge marks shown in Figure 58



Figure 62: Lenticular wedge holes at Meguti Hill, Aihole



Figure 63: Rectangular wedge holes at Meguti Hill, Aihole

We have not studied the stone splitting techniques in Pallava country, but recent work on stone carving in the Indian subcontinent (Dehejia and Rockwell 2016) seems to show angular wedge marks there. The little evidence we have from the Rashtrakuta period, which succeeded the period of Early Chalukyan rule, from Sirival favours continuation of the lenticular wedge holes to split stone, at least to the immediate succeeding period.

Is it possible that the use of rectangular wedge holes to split stone came to Karnataka heartland only with the Vijayanagara artisans, who, in any case, were most probably drawn from Tamil country (Hardy 1995)? It is not possible to answer that question with the limited study we have undertaken. However, the tool we have outlined in this paper can be used to study monumental architecture during the various periods between Early Chalukyan rule and the advent of the Vijayanagara Empire. More studies at quarries which sourced stone for the building of monuments during the various periods of dynastic rule, is bound to shed more light on this important question. Within present-day Karnataka, studies on the monuments of Rashtrakuta (including at Ellora in Maharashtra), as well as Kalyani Chalukya and Hoysala patronage is needed to follow up this study. In this paper, we have put forward a tool to conduct this investigation. Such studies could shed further light on the artisans behind the construction of the various types of monuments and help us gain an

understanding about the evolution of temple architecture in the Indian subcontinent, outlined in the first section, especially the various phases in the evolution of the Karnata Dravida idiom.

Conclusion

In this paper, we have advanced a study of the different stone splitting techniques which were apparently adopted by artisans during two different periods in history separated by nearly a millennium, by examining the marks left behind on stone by the processes used. Though this technique seems to be capable of differentiating between stone-work of the Early Chalukya and Vijayanagara artisans, it needs to be employed and tested in a large number of contexts to ensure its robustness. If found suitable in all or most of the contexts encountered, it promises to open up another narrative, quite important and untapped as of yet, in the understanding of the migrations and continuity of guilds of artisans and the subsequent consequences on the evolution of monumental architecture in the subcontinent.

Acknowledgements

We are deeply grateful to Prof. Shrinivas V. Padigar and Dr. Corinna Wessels-Mevissen for advice and stimulating discussions. We wish to thank Ms. Kadambari Komandur, Prof. Sudhakara G, Ms. Sharbari Mukherjee, Mr. Kalakappa and Mr. Somasekhara Kallappa Kudachi for their cheerful company on several of the field trips. We thank Prof. Nithin Nagaraj for critical comments and advice about the analysis technique.

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