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The Lomās Ṛṣi: Another Look[1]

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THE Barābar hill caves in Gayā district, Bihar, are highly significant documents in the history of Indian rock-cut architecture. Yet, perhaps the most important of these, the Lomās Ṛṣi cave, is the subject of considerable controversy regarding certain features, some of which have a bearing on its chronological position. It is the purpose of this article to re-examine the physical properties of the cave in comparison to two of the other caves at the site to try to determine if certain suggestions made by various scholars can be confirmed by the evidence of the cave itself.[2]

There is general agreement about the date of the excavation of the Barābar caves. Three of them are dated by inscription to the reign of Aśoka Maurya, accepting the epithet *Piyadasi* as indicative of Aśoka, thus, providing a firm basis from which to start. Unfortunately, the Lomās Ṛṣi is not dated but the two caves that will be used for comparison are: the Karṇa Chopār cave bears the date of the 19th regnal year (of Aśoka), and the Sudāma cave is inscribed with his 12th regnal year. For the purposes of this article, I will accept these inscriptions at face value and, given the various theories of the date of Aśoka's ascension to the throne, ranging from 274-260 B.C., can establish a date of 255±7 B.C. for the date of Sudāma cave and 248±7 for the Karṇa Chopār cave. It is apparent that the Karṇa Chopār is later than Sudāma cave by seven years, whatever the absolute date, and, since both of these are finished while the Lomās Ṛṣi is not, it is possible to suggest that the Lomās Ṛṣi is third in the sequence and that work would have begun there no earlier than 248±7 B.C. It should be pointed out that since the Lomās Ṛṣi excavation is unfinished, there is little likelihood that it ever had an inscription. Such inscriptions are dedicatory in nature and inherently suggest that the finished work is being turned over to its users.

Actually, there are four caves at Barābar, the fourth being the Viśvāmitra cave which also contains an inscription of the 12th regnal year, again presumably referring to Aśoka. Since three of the caves at the site contain what are assumed to be Aśokan inscriptions and since the ground plan of the Lomās Ṛṣi cave is virtually identical to that of the dated Sudāma cave, it stands to reason that the initial excavation of the Lomās Ṛṣi must have taken place in the Aśokan period proper, presumably in the last twenty years of his reign, i.e. 247±7—227±7 B.C. Further evidence for this may be seen in the fact that Aśoka's grandson, Daśaratha, excavated caves in the nearby Nāgārjunī hill, where three inscriptions confirm his activity. This suggests that the work at the Barābar site was essentially stopped at the end of the reign of Aśoka or soon thereafter, providing a terminus of ca. 227±7 B.C. At a later date, an inscription of Anantavarman Maukhari was placed over the entrance of the Lomās Ṛṣi cave stating that he installed an image of Krishna in the cave. It is usually accepted that this event occurred while he was still a prince, just prior to A.D. 450[3]. As this inscription is of a much later date than the excavation of the cave, it concerns us only in passing and possibly in relation to the so-called "altar" in the center of the hut.

The Lomās Ṛṣi cave is excavated into the south face of a low outcrop of granite (Fig. 1). Next to it, in the same face of the rock, is the Sudāma cave, the entrance of which may be seen at the far left in Fig. 1. The paths in the foreground are the work of the Archaeological Survey of India, but the relative elevation of the entrances suggests that the ground level must have been very nearly the same when the caves were excavated. The Lomās Ṛṣi and Sudāma caves are nearly identical in plan (Figs. 2 and 3). The degree of similarity in the measurements would indicate that the excavators were attempting to produce two virtually identical

Fig. 1. Situation of the Lomāś Ṛṣi and Sudāma caves.

caves. Presumably, if such accuracy was to be used in measurements, other aspects of the caves would have been similar as well. It is, therefore, probable that the interior of the Lomās Ṛṣi cave had been planned to duplicate exactly the Sudāma cave. However, there are differences both in the interior and, of course, on the exterior that suggest that this may not have been true. Most notable is the façade ornamentation in the form of a *dvāratoraṇa* of the Lomās Ṛṣi cave, the striated surface of the hut in the interior of Lomās Ṛṣi, and the niche in the east wall of the Sudāma cave. There are several other minor features which will also be examined in the progress of this article, including the "altar" in the hut of the Lomās Ṛṣi, and the taper of the door frames.

General Description of Sudāma and Karṇa Chopār Caves

The Sudāma Cave:

The Sudāma cave is a two chambered excavation with its longitudinal axis running parallel to the face of the granite outcropping. It is to the west of the Lomās Ṛṣi cave and is entered through an unadorned opening in the face of the rock. The rock has a slight overhang along the lower four to five feet of the outcrop, and a large rectangular section was excavated to provide a vertical face for the actual entrance (Fig. 4). The opening is actually a tall trapezoid, wide at the bottom and narrowing by about two and a half degrees towards the top.[4] Once inside the cave, one finds that the opening is actually in the long side of a rectangular chamber, 32′9″ by 19′6″. It is barrel vaulted with the vault springing from slightly inward inclined side walls. The angle of the incline is almost exactly two degrees. At the left, toward the west end of the cave, a hut is formed out of the matrix of the rock (Fig. 5). Its hemispherical roof, overhanging the walls, is an abstracted version of thatch work still in use in parts of India. The outer walls of the hut, like the walls of the rectangular chamber, incline at about two degrees toward the top. The door of the hut is trapezoidal with an average two and a half degree incline at the top. The interior of the hut is nearly circular and has the same diameter as the width of the rectangular chamber. Its walls were highly polished, like those of the rest of the cave (Fig. 6).

At the opposite end of the cave, the eastern wall is flat but for what appears to be a niche slightly recessed in the center (Fig. 7). It has been speculated that this niche was a later addition or part of an abandoned attempt to excavate another chamber. Since the niche does not have the same polish as the rest of the cave, it does appear to be unfinished; however, the fact that the curve of the arch so exactly repeats that of the vault of the ceiling suggests that it must be the work of the artisans who produced

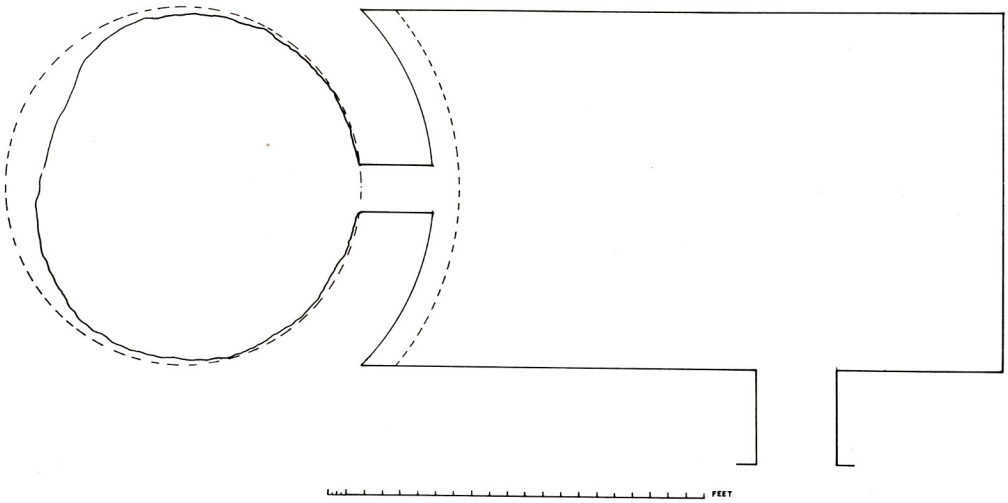

Fig. 2A

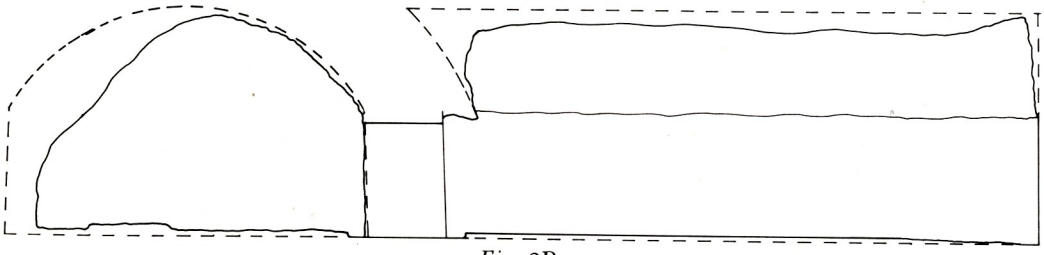

Fig. 2B

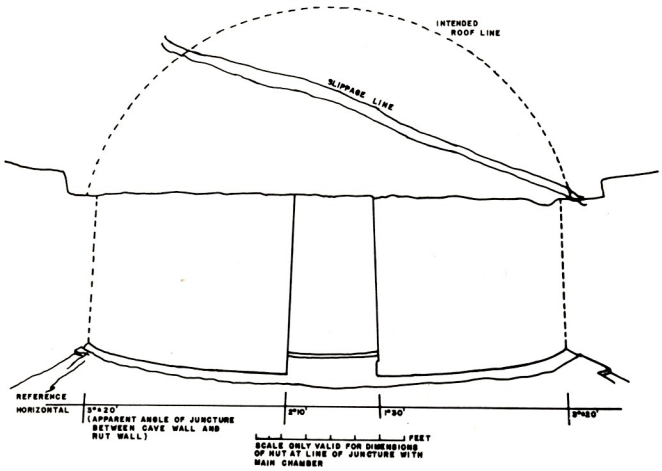

Fig. 2C

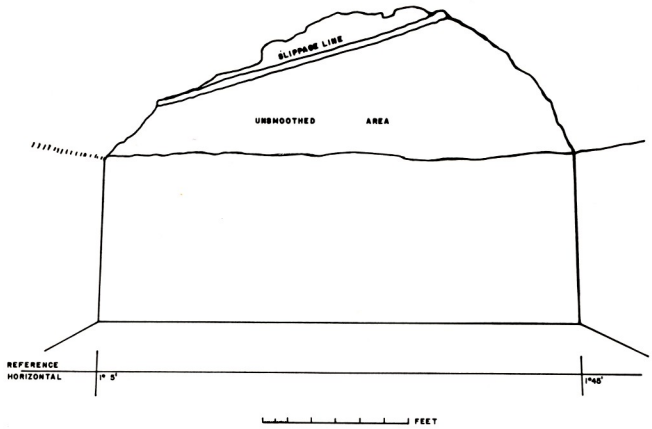

Fig. 2D

Fig. 2. *Plan and elevations of the Lomāś Ṛṣi cave.*

the cave. Its center is only slightly off that of the curve of the vault, but is so close (six inches higher and less than one inch to the right of that for the vault), that it seems well within reasonable limits. That is, one inch off axis constitutes less than a one and a half per cent margin of error against the 19′9″ wall. The purpose of the niche is unknown: whether it had ephemeral materials placed in it (thereby obviating the need for final finishing), was an attempt at a new chamber, or had some other purpose cannot now be determined. However, I would argue against the suggestion of an intended opening on the basis that all of the other openings in the caves, through which one may actually pass (as opposed to the decorative forms of the Lomās Ṛṣi façade) are trapezoidal and not arched. All one can say is that, by virtue of the design structure of the wall in which it is situated, it must have been contemporary with the rest of the excavation.

The interior surfaces of the cave are polished to a high degree as proved by the specular highlights from the electronic flash in the photographs, seen especially well in the shadow areas of Figs. 5 and 6. Some portions of the surface have deteriorated due to water seepage which resulted in the pocking and flaking of the polished surface. A line in the polish appears at the juncture of the wall and the point from which

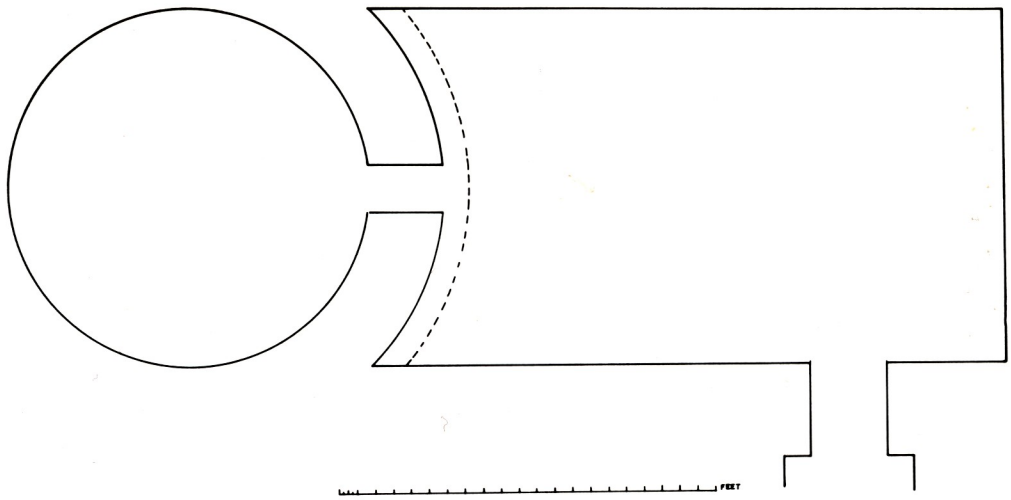

Fig. 3A

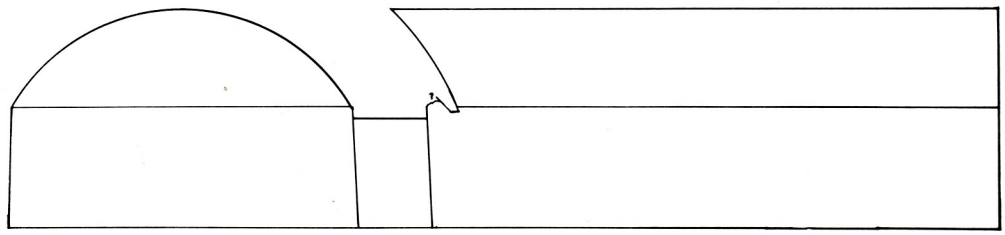

Fig. 3B

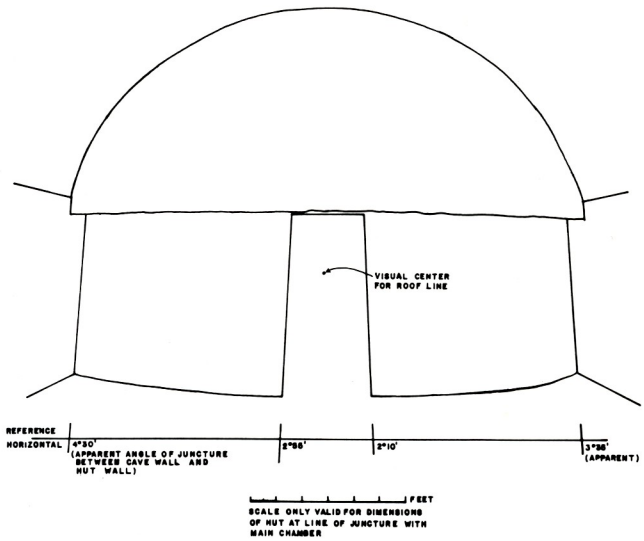

Fig. 3C

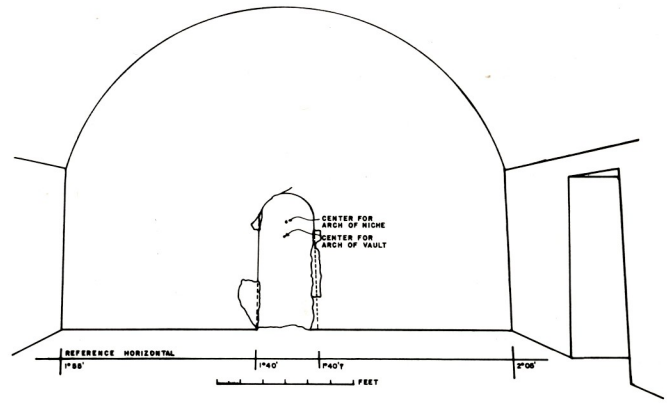

Fig. 3D

Fig. 3. *Plan and elevations of the Sudāma cave.*

the arch of the vault springs. This feature is consistently present in the three caves discussed in this paper and may be considered a characteristic of the excavation technique (see Figs. 5 and 6).

Karṇa Chopār Cave:

Karṇa Chopār cave (Fig. 8) is on the north side of the same granite outcropping that contains the Lomās Ṛṣi and Sudāma caves. It is entered through a simple trapezoidal opening in the rock face (Fig. 9). The angle of the sides of the entrance averages slightly over two degrees, less than one-half degree difference from the Sudāma cave. Inside, a single rectangular chamber runs parallel to the face of the outcropping (Figs. 10 and 11). The interior is starkly plain, the only feature being a low platform or bench in the center of the west wall. However, the polish has survived almost completely intact and there is a shimmering effect as one moves about in the cave.

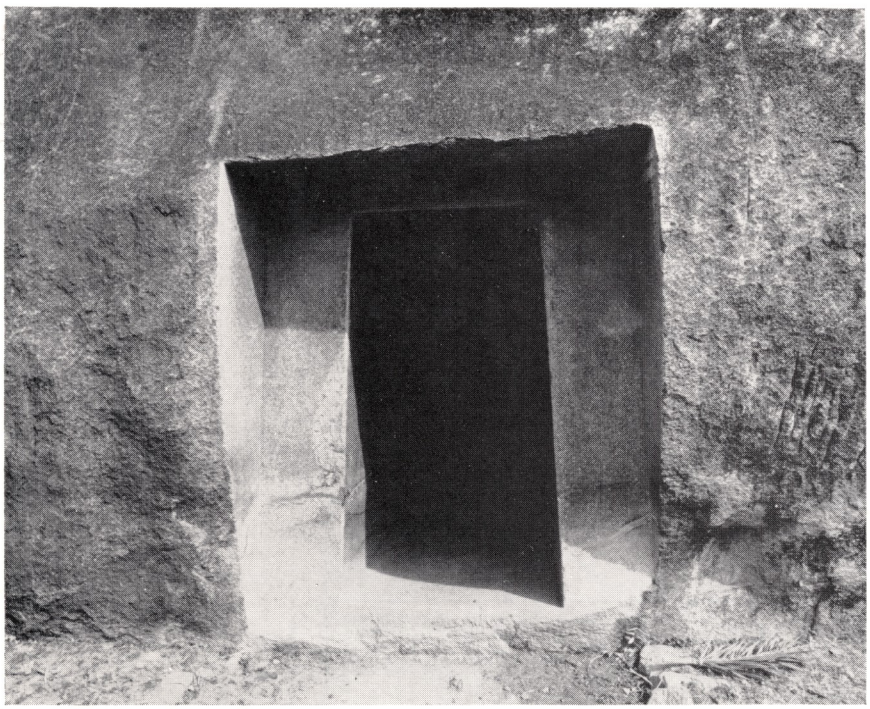

Fig. 4. Sudāma's cave, entrance.

Fig. 6. Sudāma's cave, interior of the hut looking west.

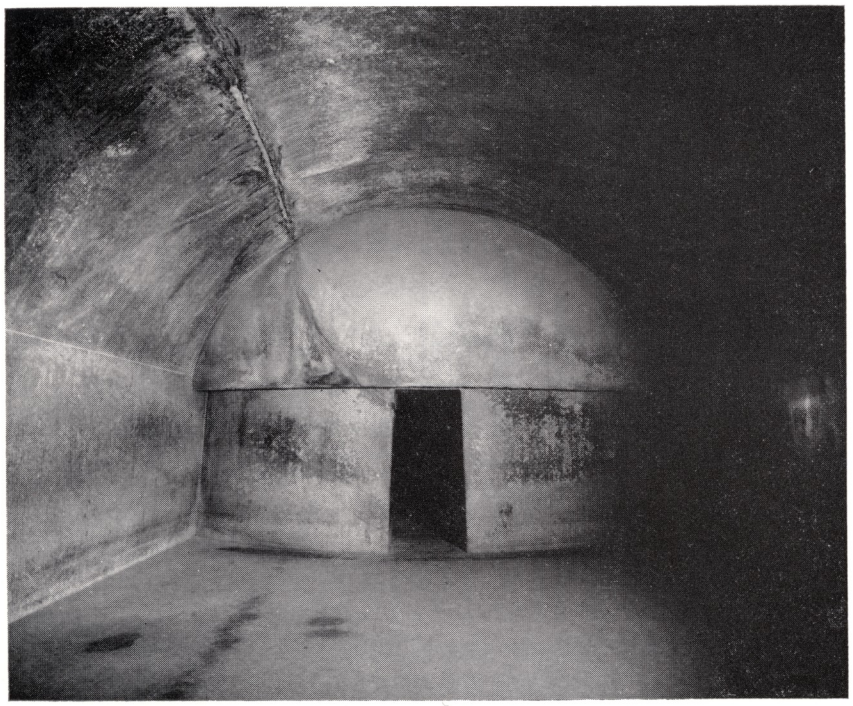

Fig. 5. Sudāma's cave, hut in west end.

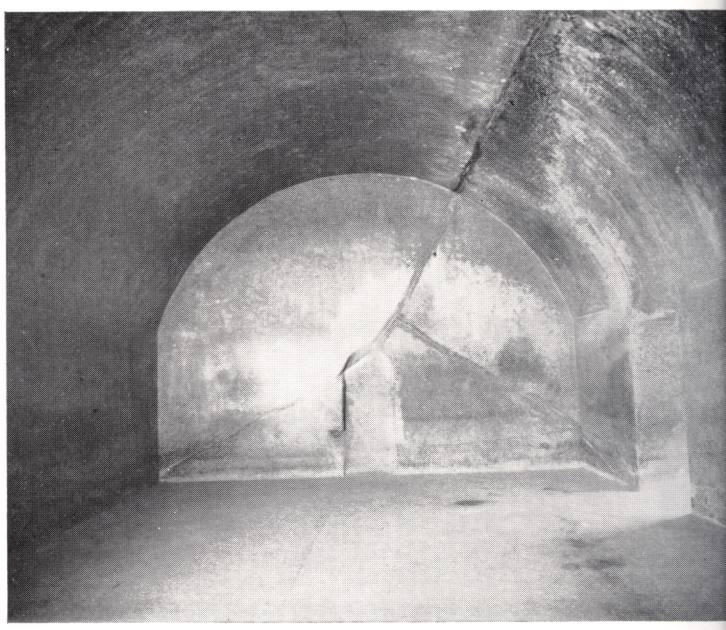

Fig. 7. Sudāma's cave, east wall.

The low stone platform or bench on the west wall of the cave may have supported an image at one time. A close examination of the wall behind it reveals the outline of a triangle against which the shape of a human figure seems to have been superimposed. The lower half of this "ghost" is unclear, although it seems to me that the figure must have been standing directly on the bench with the triangle generating out of the juncture of the corners of the bench and the wall (see drawing in Fig. 8). If so, one may suggest that the bench may well have been the pedestal for an image and that the triangular form on the wall was the surrounding element, more or less like a *prabhāmaṇḍala*. It is impossible to determine the date of the "ghost." Since it occurs on the west wall of the cave, it may be taken as evidence that this was the sacred area, as appears to have been the case in the Lomās Ṛṣi and the Sudāma caves, making a

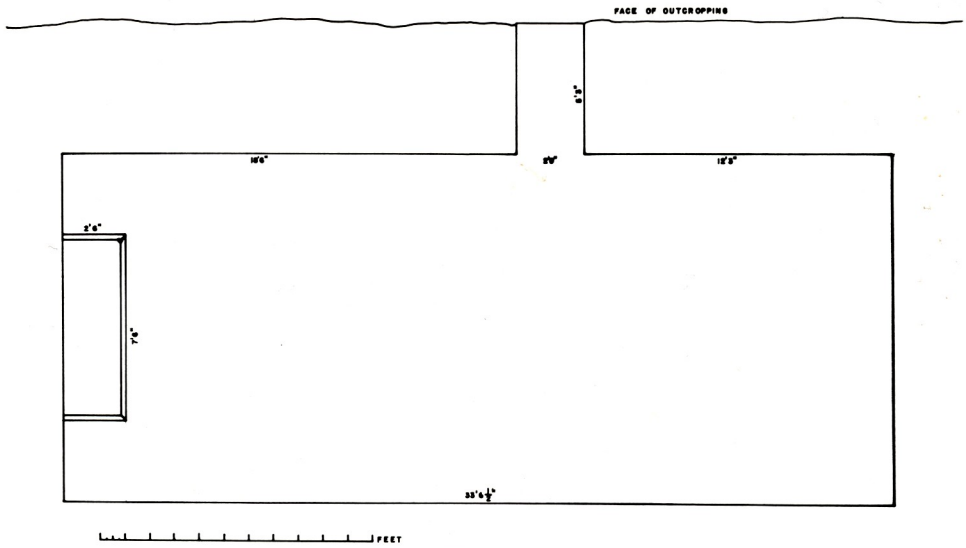

Fig. 8a

Fig. 8. *Plan and elevations of the Karṇa Chopār.*

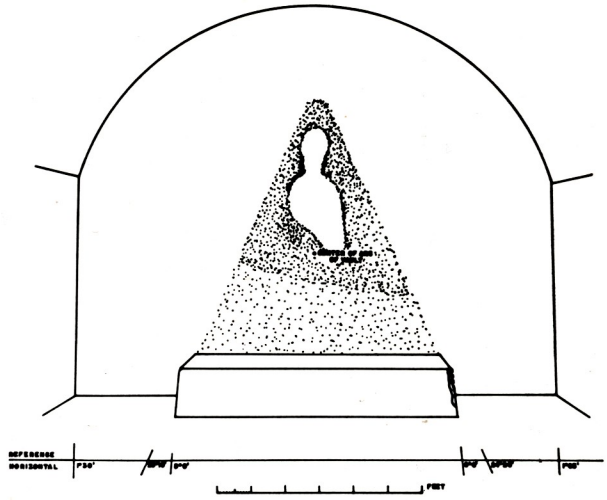

Fig. 8b

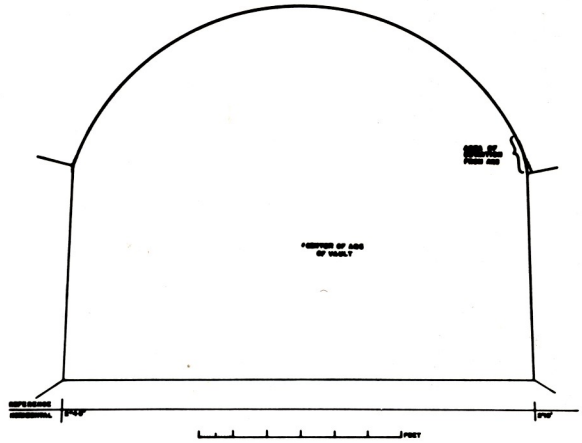

Fig. 8c

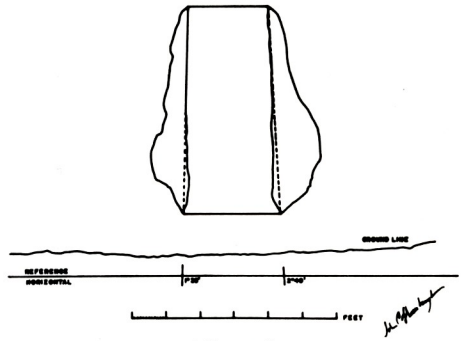

Fig. 8d

Mauryan date possible. However, it is known from Buddhist inscriptions over the door that the caves were used by Buddhists during the Gupta period and, during the fifth century, Anantavarman installed images of Krishna and other brahmanical deities in some of the Barābar hill caves. Further, it is not certain that the Ājīvikas even used images. Generally, they are associated with aniconic tendencies. The only shred of evidence is the "ghost" and it has only two features that seem pertinent. The triangular form is unlike any parallel convention in early Buddhist, Jain or Brahmanical art forms.[5] Thus, it may be that the "triangular *prabhāmaṇḍala*" indicates a vestige of another tradition, that of the Ājīvikas, and therefore may be of the period of the initial excavation. Another feature of the triangle is that it is discernable only because of the lesser degree of polish on the surface of its area. It could be construed that the surface had been left unpolished because it was known at the time of excavation that something was going to be placed over it. Thus, while in the light of these two features I favor a Mauryan date for the "ghost," I concede that there are a number of possible alternatives.

The side walls of the cave are excavated in an identical manner to those of the Sudāma cave with a one and a half degree angle rather than two and a half degrees and a slightly lower hall elevation and rise to the vault, but this latter is a proportional function of the width of the cave. The juncture line where the vault springs from the walls is very easily visible because, as chance would have it, the specular highlights from the electronic flash are cut by the change in angle of the reflective surface (Figs. 10, 11).

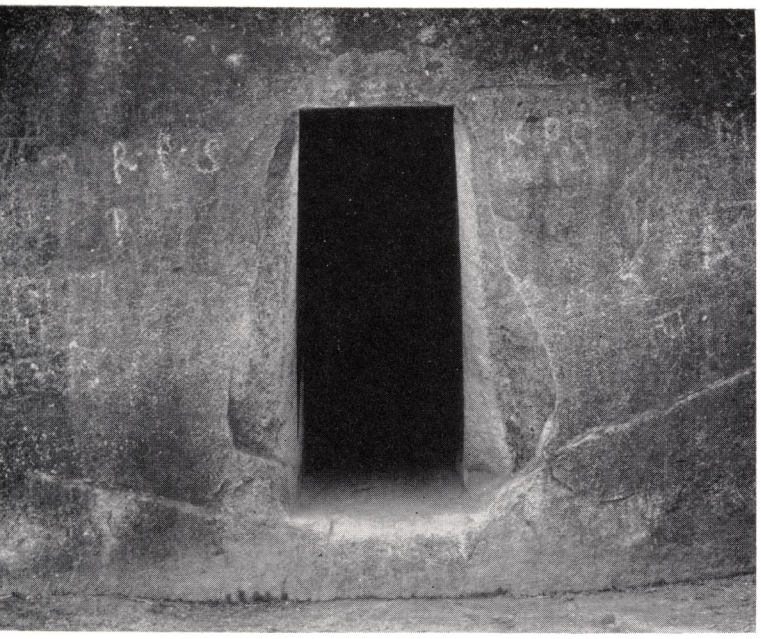

Fig. 9. Karṇa Chopār cave, entrance.

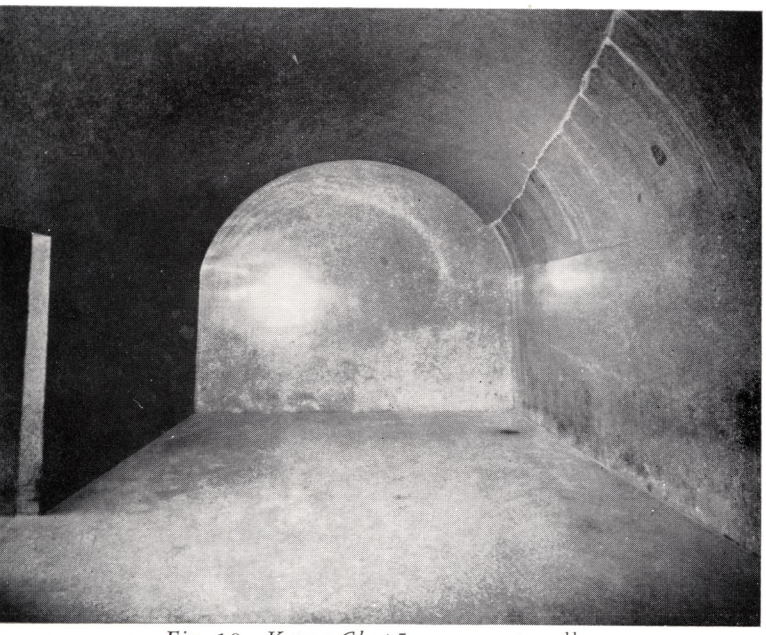

Fig. 10. Karṇa Chopār cave, east wall.

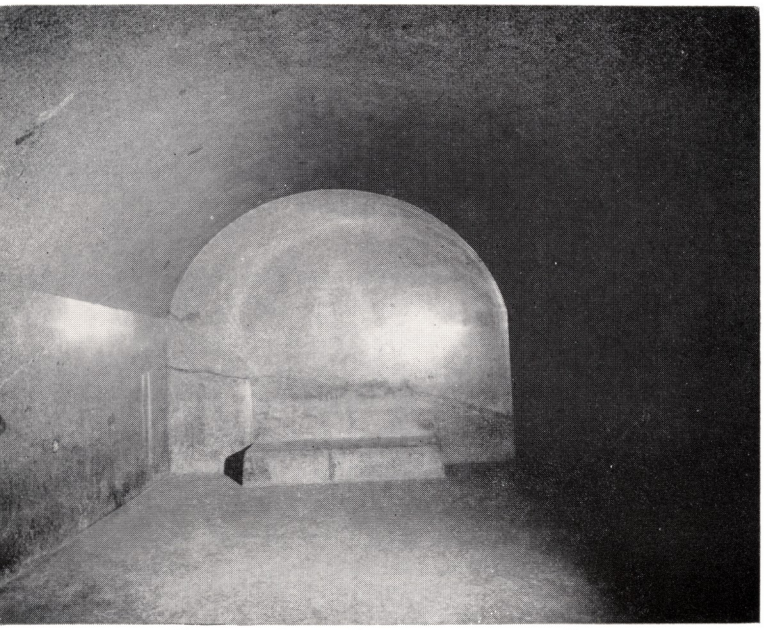

Fig. 11. Karṇa Chopār cave, west wall.

The Lomās Ṛṣi Cave

The Lomās Ṛṣi cave compares so closely in plan to the dated Sudāma cave that there can be no doubt the excavators intended to make a near duplicate (Fig. 12). However, the caves differ in two significant aspects: the presence of the *dvāratoraṇa* on the façade of the Lomās Ṛṣi (Figs. 13 and 14) and the fact that the Lomās Ṛṣi is unfinished (Figs. 15 and 16). This latter condition has led to a considerable amount of speculation and, in my opinion, confusion as to the nature of several features of the cave.

The problem of the grooves on the wall of the hut:

Grooving on the outer walls of the hut in the west end of the Lomās Ṛṣi cave has been described as a representation of wooden boards or giving the appearance of architecture in wood (Figs. 15, 17, 18). I believe, however, that the grooves are surviving elements of a finish cutting operation, preparatory to the smoothing process. If the wall of the hut is studied in detail the process becomes readily discernible. In Fig. 17 we can see that the vertical grooves were apparently cut in the wall surface both as depth guides and linear demarcations of work units. These were presumably cut into areas which had been excavated to an approximation of the surface level but which had not been taken to the final depth. In the corner, however, there is a wide space, three to four units in breadth, which has no vertical lines. The second step in the finishing process was to make fine cuts across the vertical units in order to bring the surface nearer to the desired level. These cuts may be seen in the lower portion of the wall shown in Fig. 17. There is a question in my mind whether or not there may have been an intermediate stage in which relatively rough vertical cutting was done along the units to further the removal of matrix. Some coarser vertical cutting may be seen in the lower left portion of the wall and along the bottom of the wall of the hut. Wherever the vertical cutting occurs, it is rougher than the horizontal cutting and is apparently done with coarser tools, but there does not seem to be any real evidence as to whether the grooves were made before or after the vertical cuts. It should be noted that the force a mason could use in making a vertical cut is greater than that used in a horizontal cut because of the gravity-

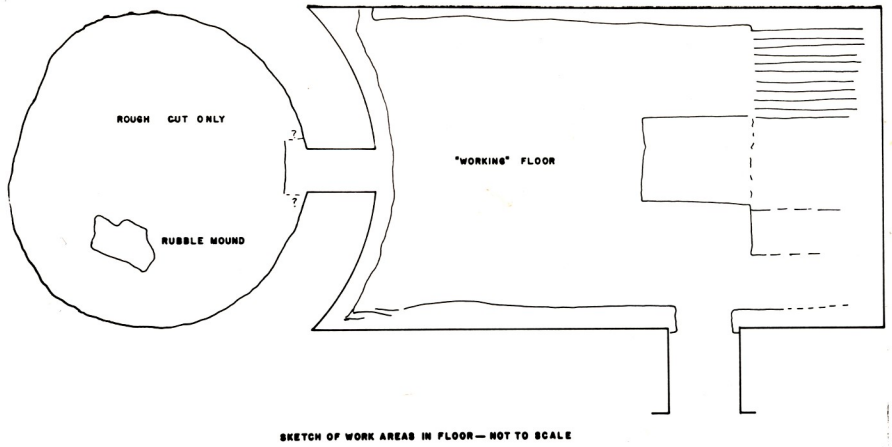

Fig. 12A

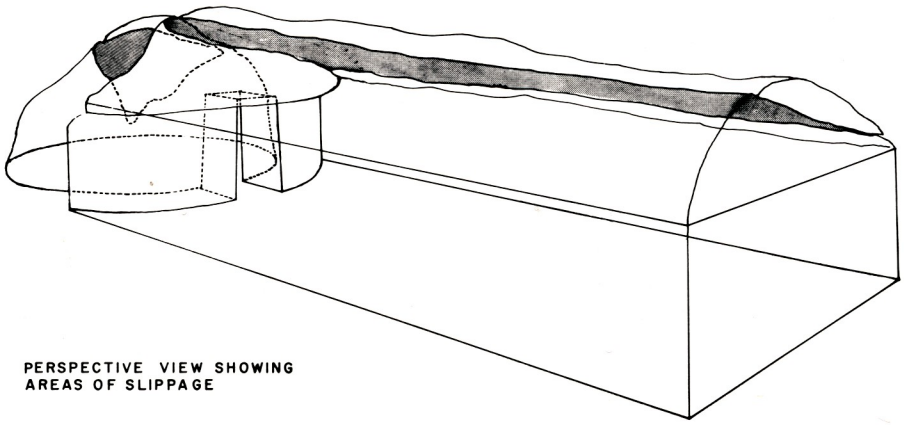

Fig. 12B

Fig. 12. *Detailed drawings of the Lomāś Ṛṣi cave.*

enhanced force of the downward motion of the driving implement. It is only natural that the closest finishing work would be done with horizontal cuts, since there is more control over a less forceful stroke.

After the horizontal cutting had been completed in a sufficiently large area, the smoothing process could have begun. It is not possible to determine exactly what process was used: simply rubbing blocks of similar stone over the rough matrix would have given the desired effect, with the craftsmen smoothing out rectangular areas (Figs. 17 and 18). Further, the vertical work area nearest the door has been left unsmoothed, a protective measure against the damage that might occur while excavation was still in progress in the interior of the hut (Fig. 18). If there had been any intention to indicate boards by the grooved lines on the surface of the hut, it may be assumed that the central portions of the walls would not have been ground smooth nor would the grooves have been left in highest relief along the juncture of the hut and the floor and in other less accessible places. It was probably the universal human attitude of doing the easy portions of a job first, which dictated the smoothing of the central portions of the wall prior to the other more inaccessible areas.

If my analysis of the technique is valid, traces of these methods would be found in other portions of the cave. The left portion of the north wall, adjacent to the hut, has virtually identical grooving; and the floor in the north-east corner has similar although more crudely executed grooving (Figs. 18 and 16 respectively). The presence of the grooving in the walls other than on the hut is quite significant. Since these are mostly smoothed (see Figs. 12 and 16) there can be no doubt that the grooves are only a stage on the way to a smooth and ultimately polished surface. If the floor is examined closely it will be seen that there is a shallow channel around most of the juncture of the floor and the walls (see Figs. 12 and 15, lower left). This was evidently cut to allow the walls to be finished to the final intended level of the floor. Most of the rest of the floor is about one and a half inches above the level of this channel, but in the north-eastern corner of the cave it seems that the intermediate stage of removing the last of the matrix had begun. This is where the grooving occurs, thus providing a clear demonstration of the grooving technique. Further, the use of the grooving technique in some of the lowest level work stages of the floor demonstrates that it was not intended to represent the wooden walls of a building. Its use in the floor leaves no doubt

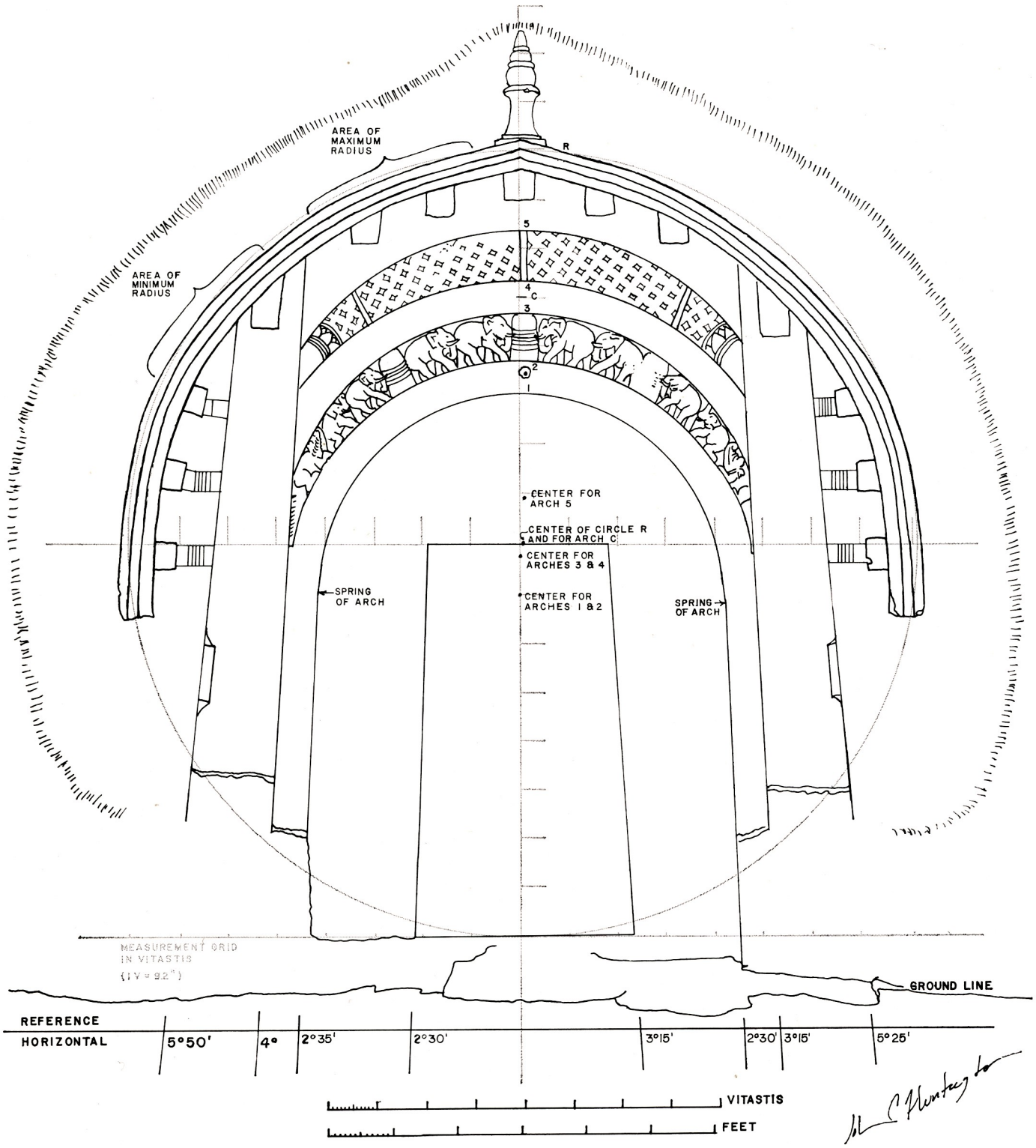

Fig. 13. Detailed drawing of the dvāratoraṇa of the Lomāś Ṛṣi cave.

that it was an intermediate step in the progress of the excavation. It should be noted that the matrix left on the floor was probably considered a "working floor" which would protect the main floor level as pieces were cut loose from the ceiling.

Some scholars have seen grooves in the hut in the Sudāma cave.[6] A photographic detail demonstrates that such an opinion has no basis in fact (Fig. 19), as does a careful first-hand examination of the hut itself. The detail of the right corner of the hut in the Sudāma cave also pro-

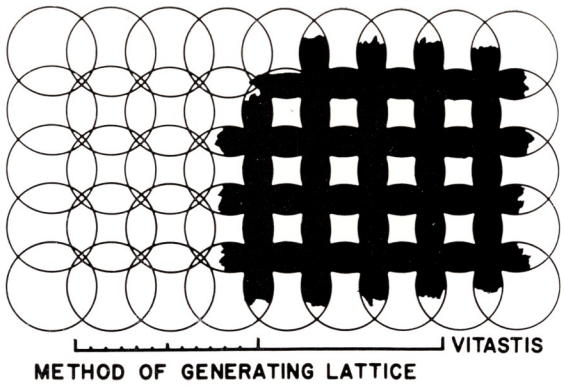

Fig. 13A

vides considerable insight into the precision with which these caves were excavated and finished. Every line runs exactly straight, there are no uneven portions of the walls and even the roof line is sharp and accurate along its unbroken section. Finally, I will point out that the two comparison caves, Sudāma and Karṇa Chopār, are finished with similar exactitude (Figs. 5, 7, 10, 11). If, as all available evidence would seem to indicate, the Lomās Ṛṣi was intended to be part of this group, then we would expect that it would be finished in a similar manner. As a result of the foregoing evidence, I must conclude that the excavators did not intend to portray wooden planking on the sides of the hut and that the linear grooving is simply an incidental survival from the work stoppage.

The Interior of the Hut:

The interior of the hut (Fig. 20) in the Lomās Ṛṣi cave, although quite unprepossessing, has been the center of considerable speculation. Its unfinished condition has been neglected in previous elevation drawings which do not show the mass of rock left unexcavated in the rear of the ceiling (Figs. 20 and 12). Like the main chamber, the excavation was done in several stages at once. The north and portions of the west ceiling areas are still in the roughest coarse cutting stage while the south wall and the lower portion of the west wall are in an intermediate stage of rough cutting used when the wall surface is being reached through the matrix. The line of demarcation is a fissure which obviously caused the excavators considerable concern since they have done little secondary cutting above it throughout the cave. All ground plans show the cell to be oval and, at floor level, it comes close to being so, but it is evident that the excavation was incomplete so that any ground plan based on the present dimensions is not likely to reflect the intended concept. The hut in the Sudāma cave technically has an oval plan as well, but the difference in the length of the

Fig. 14. *Lomāś Ṛṣi cave, dvāratoraṇa.*

axes is only six inches, and in a chamber where the minimum dimension is nineteen feet across, I feel that this difference is hardly significant. Accordingly, it should be assumed that the intention of the excavators was to produce a round floor plan for the hut in both caves.

Another feature of the interior of the hut is the so-called "altar," which I assume refers to the low pile of rubble from the cuttings of the excavation which have been compacted with mud, possibly deliberately (?), off to the left of center (*cf.* Figs. 12, 20 and 21). This pile is not aligned with the rest of the cave in any manner (Fig. 20 faces exactly along the central axis of the cave looking west), and, if anything, it may have been a temporary mound set up to receive the image of Krishna installed by Anantavarman. However, I do not intend to suggest even that as a serious possibility. Given the architectural conventions current in India in the mid-fifth century, it is impossible to believe that Anantavarman or any of his ministers would have been so insensitive to the arrangement of the cave as to place the pedestal of an image that far out of alignment. Rather, I feel that the mound must be either the survival of the original excavation waste products, or an addition by some unknown individual who inhabited the

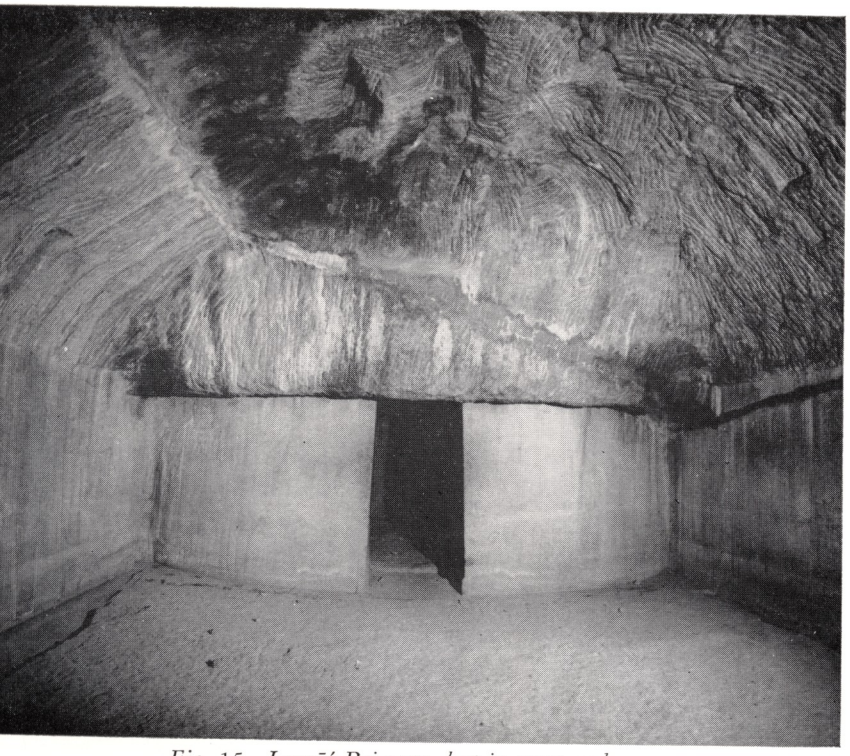

Fig. 15. *Lomāś Ṛṣi cave, hut in west end.*

cave in the two millenia since its excavation. Simply, I do not believe that the suggestion that an altar had a role in the concept of the cave has any basis in fact.

The floor of the hut is in a much less finished condition than the floor of the main hall and some of the areas of excavation may have led to speculation on the possibility of an altar but, as the photograph demonstrates, these are

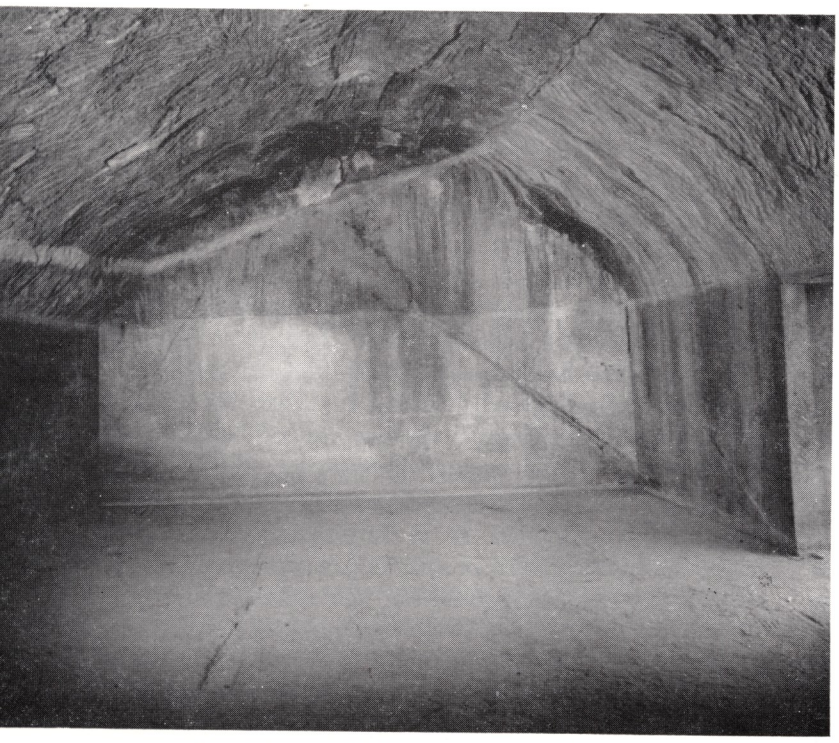

Fig. 16. *Lomāś Ṛṣi cave, east wall.*

simply roughed out areas and not the remains of a purposive architectural form. The technique of excavating the floor in rectangular areas may be examined in the main hall (Fig. 16), which was divided into rectangular sections as work stages. Further, the final depth of the hut floor and that of the main hall may be seen in the area of the entrance to the hut seen in Fig. 15. No area of the hut floor is as low as the section in the entrance and, based on a comparison with the other two caves described in this article, it must be assumed that the intended depth of the floor is represented by this, the lowest area.

Why did the work stop on the cave?

There have been several suggestions to explain why work stopped in the Lomās Ṛṣi cave, and I doubt if it is possible to come to a positive answer. The simplest, and to me one of the most logical, is that with the end of the reign of Aśoka, patronage at the site ceased and work stopped. Given the present state of our knowledge about Mauryan history, there is no way of determining whether this is the actual case or not. However, internal evidence seems to point in another direction. As was first noticed by Cunningham, a fissure in the granite rock into which the cave has been excavated may have had some bearing on the cessation of work. In the northern portion of the ceiling there is a large mass of stone that has only been cut in a crude manner. With a slight exception along the top of the northern wall, the boundaries of this section are provided by a fissure that extends the length of the cave and into the hut. This may be seen easily in Figs. 15, 16, and 20, as well as Fig. 12. The displacement along the fissure makes it appear as if the ceiling portion of the cave has moved some three to four inches to the north; but geologically, it would be impossible to determine the motion relative to the surrounding area without extensive surveys of the region. Since much of the rest of the cave is near completion, it must be assumed that there was some reason for not working on the section bounded by the fissure. One obvious answer would have been the movement of the rock mass during the course of the excavations. Such movement is not unexpected where large masses of rock are removed from the internal structure of an outcropping. With two other caves carved into the same mass of rock within the same few years, there could well have been releases of tensions in the outcropping during the period of

excavation. One may note that all of the caves exhibit some cracking, but that only the Lomās Ṛṣi shows signs of significant movement along the fissure line.

Because the more careful rough cutting comes to the edge of the fissure and stops, it is reasonable to assume that the workmen were cognizant of the fissure and its potential danger. This suggests that work continued after the slippage although with apparently less than the original enthusiasm for work on the ceiling area bounded by the fissure. There is evidence that a slippage occurred during the active work on the cave, and it is conceivable that work was abandoned when a second movement occurred; in the upper portion of the east wall near the juncture of the wall and the ceiling there was apparently an attempt to "try it again," since it is at this point that the cave reaches its full height.

As interesting as this hypothesis may be, it must be remembered that there are only two incontrovertible facts contained in it: that the workmen were aware of the fissure, demonstrated by their working around it, and that there has been some slippage of the ceiling mass since the excavation of the cave, demonstrated by the lateral offset of the surface (one must realize that the Archaeological survey of India has filled the fissure with concrete in its conservation program) best seen in Fig. 16. Thus, the foregoing must remain a tentative suggestion.

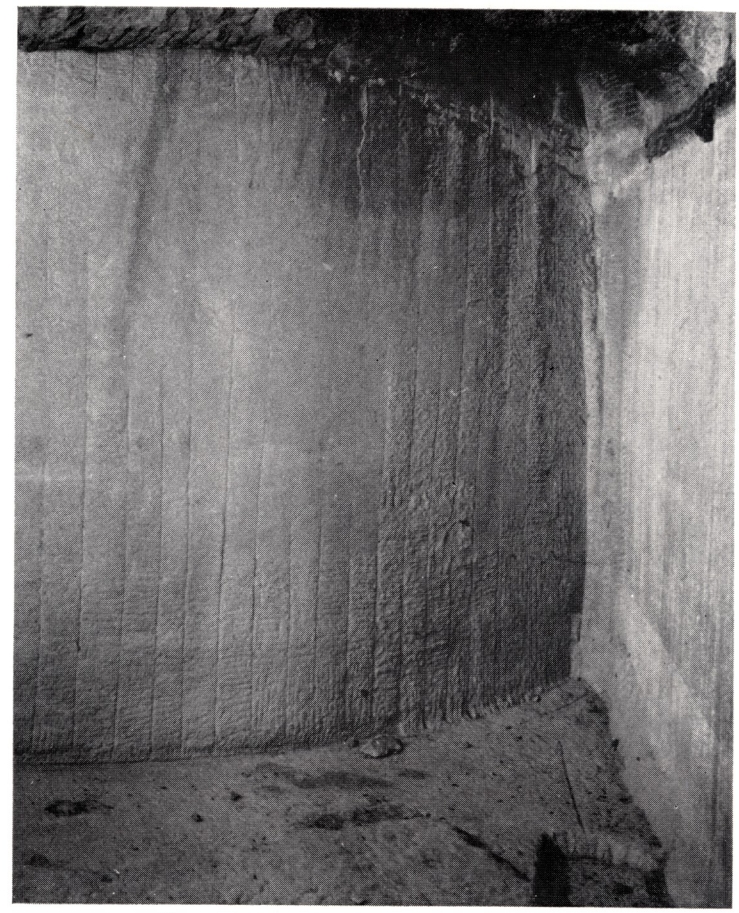

Fig. 17. Lomāś Ṛṣi cave, detail of Fig. 18.

Mauryan Excavation Techniques

As a by-product of this study, it has become possible to discern a general pattern of excavation techniques used during the Maurya period. Since these are at some variance from the better known techniques of the western caves, I shall briefly recount them at this point, unhampered by other concerns. I shall also disregard the problem of the façade *dvāratoraṇa* for the moment as it forms the last portion of this study.

1. Working into the face of the matrix and using the crudest cutting possible, the volume of the cave is roughed out to within a foot or so of the intended surface. This work is done at a work face roughly the height of a man and apparently continues into the full extent of the cave as a continuous progression.

2. Following closely behind the front face workers are masons charged with cutting upward to the intended limits of the ceiling. (It may be seen in Figs. 15 and 16 that the walls of the chamber are almost finished while portions of the ceiling remain unexcavated.)

3. Finishing the surface after the crude cutting follows five steps:

a. Rough cutting to a near approximation of the intended surface (Figs. 16, top right, and 20, lower left and center of wall area).

b. Finish cutting (first phase) long vertical cut closely approximating the intended surface to within the last one and a half inches (Fig. 17, lower right corner of hut wall).

c. Grooving and cross cutting with carefully controlled fine cutting tools to within less than one inch of the intended surface (Figs. 17 and 18).

d. Smoothing by grinding the surface to the intended depth (Figs. 17 and 18).

e. Polishing, technique uncertain. (The suggested burnishing with an agate would not produce the desired results, but there must have been some sort of polishing compound in use: fine quartz sand or possibly some metal oxide?)

Fig. 18

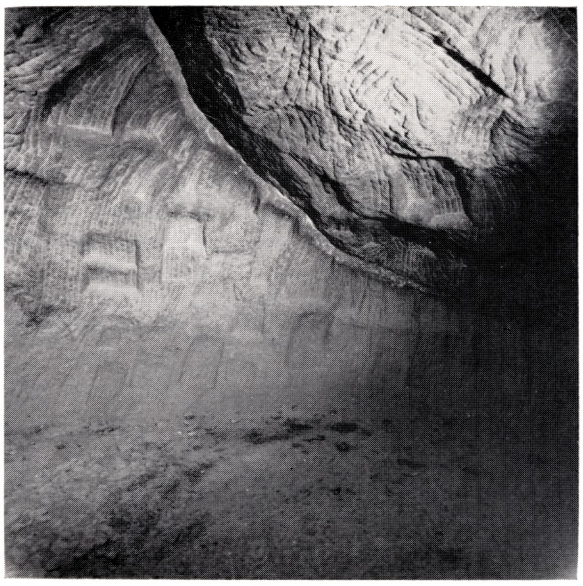

Fig. 20

Fig. 18. *Lomāś Ṛṣi cave, right side of hut.*
Fig. 19. *Sudāma's cave, detail of the right side of the hut.*
Fig. 20. *Lomāś Ṛṣi cave, interior of hut looking west.*
Fig. 21. *Lomāś Ṛṣi cave, rubble in interior of hut.*
Fig. 22. *Lomāś Ṛṣi cave, arch inside of dvāratoraṇa.*

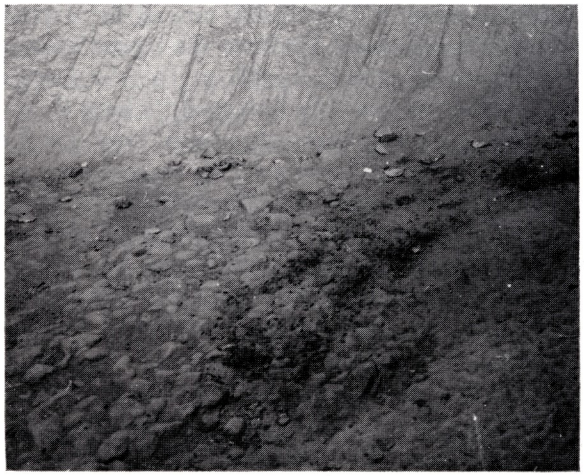

Fig. 21

Fig. 19

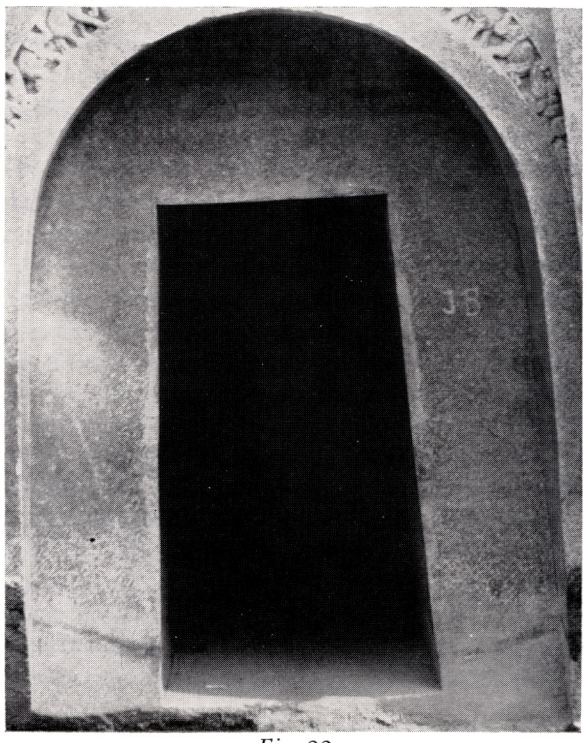

Fig. 22

4. These various procedures follow each other in simple sequence more or less as there is room to work. This means that the areas nearer the entrance are finished prior to the completion of the initial excavation.

5. Two special techniques may be discerned:

a. the provision for a "work floor" which serves as a protective surface while the excavation of the ceiling is in progress and which is progressively removed in two stages:

(1) around the walls as it becomes necessary to finish portions of the wall down to the floor level (Figs. 12, 15, 16).

(2) the main removal is done in large rectangular sections (Figs. 12 and 16).

b. the provision of protective "work areas" adjacent to doors protecting against chipping during work in process (Fig. 18).

Two major differences may be discerned between the excavation techniques of the Mauryan period Barābar caves and those used in the western Indian caves. The first is the progress of the excavation of the interior of the cave. In the Barābar caves, it seems to have been the practice to excavate the upper portions and ceiling after the lower portions of the chamber, probably necessitating the use of scaffolding to support the workers while working on the upper levels. In the western caves all evidence points to the use of the matrix left in place in the lower portion of the cave to allow the carvers access to the top. Thus, the western caves were effectively carved from the top down. The second operational difference is the provision at Lomās Ṛṣi of protective working surfaces such as the floor or door jambs of the hut (Fig. 18) to safeguard the intended surface. However, the appearance of progressive finishing from the exterior of the cave toward the presumed sanctum of the hut at Lomās Ṛṣi exactly parallels procedures in the western caves as they are presently known.

One point of human interest is that the sound of chiseling must have deafened the workmen with uncovered ears in a very short period of time. Voices or even the sound of the shutter on a large camera reverberate unpleasantly through the chamber—twenty or so men pounding chisels at the rock faces must have raised the sound level to a point where it could have become destructive to human hearing.

The Problem of the Dvāratoraṇa

Part I, Physical Considerations:

One of the most disputed elements of the Lomās Ṛṣi cave is the sculpture of the *dvāratoraṇa* carved around the entrance to the cave. It has been identified variously as being Mauryan, as a Gupta addition of the same period as the Anantavarman inscription which occurs directly under the arch just above the actual entrance, and as belonging to several periods in between, mostly within a century of the beginning of the Christian era. It is my opinion that the *dvāratoraṇa* is Mauryan in date and, further, that the most significant evidence is internal to the *dvāratoraṇa* itself, thereby removing "soft" or speculative forms of analysis from the proof.

The *dvāratoraṇa* around the entrance is the only feature of the cave that does not invite direct comparison with the Sudāma cave, a factor for which there is no satisfactory explanation. If one considers the façade to be Mauryan in date, the difference between the two caves must be explained, but if the date of the façade is presumed to be post-Mauryan then comparable recarvings of unfinished caves in *retardataire* styles must be found elsewhere in India to provide a basis for comparison. To my knowledge such a parallel has not been found.

Comparison to Sudāma cave provides a number of significant insights into how the *dvāratoraṇa* fits the Lomās Ṛṣi cave. The Sudāma cave entrance (Fig. 4) is set back from the face of the outcropping into a rectangular niche and the Lomās Ṛṣi entrance is set back to an almost identical depth in the arch of the *dvāratoraṇa*. If the two had originally been identical, *i.e.*, Lomās Ṛṣi without the *dvāratoraṇa*, one would presume that the face of the recess around the entrance would have been altered in shape from a rectangle to an arch. One would expect some signs of reworking on the face of the recess (Fig. 22), but careful examination of the surface reveals no sign of a recess resembling that of the Sudāma. Further, one might hope that there would have been traces of "Mauryan" polish surviving on either the Lomās Ṛṣi or the Sudāma cave. But here again, the investigator is out of luck. Both caves have much the same finish on the face of the recess, a very smooth and even treatment of the stone, but no sign of polish or reworking.

Given the precision of the measurements of the two caves and their almost exact parallels, it should be possible to determine if dimensions of the recess of the Lomās Ṛṣi entrance were enlarged in order to clear away the old appearance. A point that would seem most likely to be altered is the distance from the top corners of the entrance to the sides of the recess. Yet a comparison based on our photographs determines that the variance is less than one per cent between the Lomās Ṛṣi and Sudāma caves. It is very hard to believe that persons who were in charge of recutting the door frame would be so concerned for the Mauryan measurements that they avoided changing the dimensions of the arch width at this particular point while undertaking the difficult task of altering a rectangular form to an arch. The story is quite different at the bottom of the entrance. In the distance from the bottom corners of the door opening to the side of the recess, the difference is on the order of twenty per cent, fully enough to allow the expansion of the width of the recess to accommodate the inward curve to the point at the top where the measurement is so close. This would seem to effectively negate the above consideration since, while it seems unlikely that such care would be taken in the removal of stone, it must be acknowledged that the most efficient way would be to remove as little stone as possible to achieve the arch and this would mean literally keeping the distance at the top the same as the original. This situation is further confused by the geometry of the arch itself. It is formed in such a way that the two measurements that I have used for comparison could not both be the same as in the Sudāma cave. The arch begins to spring toward the center at a point approximately three-fourths of the elevation of the entrance. This feature necessitates that the width of the base be wider in relation to the level of the top of the entrance to allow for the space necessary to develop the curve of the arch.

But, the *dvāratoraṇa* seems to hold its own solution to the problem. Two other measurements conform very significantly to the rest of the cave. The first is that the height of the lower surface of the roof at the center is just over twelve feet one inch, measured from the level of the floor of the cave as seen in the entrance way. This is within two inches of the ceiling height of the cave's interior, and within a one and a half per cent margin of error. Second, the inside angle of inclination of the battered pillars is very close to two and a half degrees, virtually the same as that of the interior walls. Given these close parallels to the internal measurements of the accepted Mauryan portion of the excavation, it is possible to suggest that, in fact, the comparison measurement of the upper level of the entrance of the Sudāma cave and Lomās Ṛṣi is also significant. But, what about the lower level of the door? It must be assumed that while the carving on the façade of the cave is a representation in stone of a wooden architectural form, this, in fact, has no real structural purpose in relation to the cave behind it. It may therefore be stated that the *dvāratoraṇa* is an arbitrary form copied from wooden models. Given the relative precision of the measurements and the accuracy of excavation in the interior of the caves in general, it would be natural to assume that the carvers simply copied the wooden model as accurately as possible, including the proportions of its parts. If this was done, it would naturally follow that if the proportions did not conform to the measurements of the Sudāma cave, allowances would have been made. I find the coincidence of the three corresponding measurements to be much more significant than non-corresponding measurements. Indeed, given the proportions of the *dvāratoraṇa,* these are the only measurements that could correspond to other aspects of the cave complex. Therefore, in the event that the façade was a later addition, one would have to state that the individuals who did the work measured carefully both the Sudāma cave and the interior of the Lomās Ṛṣi to determine the measurements of the façade. I simply do not believe this to be the case.

In the analysis of the physical aspects of the façade, a significant feature came to light that is not directly related to the problem of chronology but which is an interesting aside. The pillars of the façade were never finished to the ground. In Fig. 14, we see them virtually as they were carved. This is determined by the fact that there is a small ledge at the bottom of the finished portion of both of the pillars and, if the pillars had continued beyond, the ledge would not have been present. The one on the left is slightly higher than the one on the right, a one and one-fourth per cent variation when measured from the apparent ends of the longitudinal beams at the top of the pillars, illustrating again the very limited margin of error in the whole excavation.

Judging from the near perfection with which the rest of the façade is done, it is impossible that the lack of the lower portion of the pillars was an error. I have no evidence to explain this curious feature, but it seems possible that something may have been placed in front of the pillars in such a way that the excavators were relieved of the necessity of carving the lower portions. Certainly supporting figures were present in later doorways, but this must remain only speculation.

It has been suggested that the entire face of the rock outcrop had been reshaped, from a rather steep slope to its present undercut form during the period of "recarving" the entrance to the cave. A quick glance at Fig. 1 will demonstrate that this suggestion is not realistic since the overhang follows the entire length of the outcrop from the right of the Lomās Ṛṣi to a point well past the opening to the Sudāma cave. Further, if such massive reworking of the natural form were done, why would the designers of the project have been content with recreating the natural appearance of the rock? It may be noted that in isolated patches along the face of the rock there are tool marks, usually consisting of six or seven nearly vertical lines next to each other (see the right side of Fig. 4). When these are compared to the tool marks surviving in the Lomās Ṛṣi cave (Fig. 20 for example), their origin is easily determined: these areas are trials of newly sharpened or newly made tools. The grooves are always very sharp and seldom very deep while the grooves in the Lomās Ṛṣi cave are frequently made with much blunter implements and are invariably deeper. It would be reasonable to assume that tool makers were present at the site and that they tested their tools in order to determine if the correct temper had been reached. Further evidence for this assumption may be found in the fact that the test marks are concentrated near the entrances to the caves and are relatively scarce along the rest of the rock face.

One argument against the carving around the doorway being a latter addition is the fact that such an addition would run counter to the usual excavation process. It is well known that the façades of caves in western India were finished in complete detail as work still progressed in the interior. Cave 24 at Ajaṇṭā, for example, is apparently finished when seen from the outside but the interior is only partially excavated. It has been shown that exactly the same progression occurred at Barābar and in the Lomās Ṛṣi cave in particular. We have seen that in the interior of the hut there are two types of roughing out, one area having large coarse cutting, yet another area, closer to the presumed limits of the excavation, which is much more controlled and careful. Outside the hut and on the side walls, both finish cutting and polishing appeared while the roof area of the hut had yet to be fully excavated. This would seem to be a progression in the work that conforms to later excavation practices. It is only logical to assume that the façade would have been finished first, probably long before the interior was completely excavated. Further, the finished façade on an otherwise unfinished cave raises a number of problematic questions. If it was added later, why would the interior not have been finished? Or, why was the façade put on the Lomās Ṛṣi cave rather than the finished Sudāma cave? One explanation is that some holy man had lived in the cave and there was a desire to enhance his residence, but there is no evidence of this connected with any of the caves. It seems much more likely that the progress of the excavation simply followed the normal pattern, with the *dvāratoraṇa* finished first.

Part II, The Design Characteristics of the Façade:

Cunningham first noticed the circular appearance of the outer portion of the Lomās Ṛṣi façade and rendered his elevation of the entrance of the cave within a circular recess. But this was an entirely subjective view and his treatment of the actual sculpture of the architectural elements was somewhat in error due to his elongation of the roof and the misunderstanding of the shape of the sides of the roof.[7] In the photogrammetric analysis on which the technical side of this study is based, several features came to light that are worthy of bringing to the attention of individuals concerned with early Indian architecture. While making a tracing of the cave façades, Fig. 13) in order to check out some alignments which I thought might have some bearing on the problem (they did not) I began to speculate on the position of the various centers for the curves of the different arches above the entrance. As expected, these fell in a straight line along the central vertical axis of the cave. Up to this time I had assumed that the curve

of the two halves of the roof would, like Cunningham's drawing, require two centers, one to the right of center for the left half and a left counterpart for the right. But the roof line is not geometrically regular since it is an accurate representation of a wooden structure, and it reflects where there would have been greater stress and thereby decreased radii to certain sections of the curve. By an averaging process, I constructed an "apparent center" of the roof by using the junction of the roof line as its meets the lateral beams from which to construct the cords. The result was startling. The center fell exactly on the line of the upper edge of the entrance and exactly in its center. With the equipment in use to do this work, the probable error is only one-tenth of a per cent, literally only the width of a pencil line.

A circle drawn from this center using the actual elevation of the entrance opening as a radius produces a circle that encompasses the entire façade. There are slight variations in the degree of accuracy by which the line of the outer edge of the roof follows the circumference of the circle, but the variation is so slight that there can be no doubt that the intention of the architect was to follow the circle thus produced. One problematic point is that the lower extension of the pillars terminates so that almost all of the carved portion falls within the circle. There are five points on the diagram which fall outside of the circle, the small peak of the roof (the finial rises above the entire circle), the two eaves of the roof which extend one thickness of the roof layers beyond, and the two outer corners of the pillars. As these all extend an equal amount, about one and a half inches, it would seem that there would be a logical explanation. If one examines the entrance closely (Fig. 13) it may be seen that the "working floor" has not yet been removed from the passageway into the cave. By constructing the intended level of the floor and using the revised elevation of the door for the radius of the circle we find that all of the points that formerly lay outside the circle are now exactly on the circumference. However, there are two factors that lead to the conclusion that this later circle is an artificial construction and was not the one intended by the architects. The first of these is that to have intended the outer circle as the basic design unit would force the allowance of a much greater margin of error on the façade than is present anywhere else in the three caves; that is, almost six per cent. Second is the fact that the upper portion of the façade is easily divisible into multiples of nine and two-tenths inches, a unit of measure called a *vitasti,* when the smaller circle is used (see Fig. 13). Therefore, in spite of the presence of the outer circle and the inclusion of the protruding features within its circumference, it seems that the circle generated by the radius of the actual elevation of the door is the one that was used for the development of the façade.

I have not been able to use a circle to generate a *dvāratoraṇa* in any other similar structure. There are two problems in attempting to locate them: the first is that few other *dvāratoraṇas* have the same type of trapezoidal entrance in the arch of the door, thus making any measurements only an approximation; and second, those that do have a limited vertical area in the center of the arch tend to be in elongated versions. The problem probably lies in the fact that there had been an evolution of the form between the time of the carving of the Lomās Ṛṣi façade and any other surviving example. The closest example that I have found is the architectural façade in the interior of the *vihāra* at Bhājā (see Part III and Fig. 28), in which the elevation of the whole approximates twice the apparent height of the entrance and the pillars are slightly battered. However, the overall configuration is much more vertical and the eaves of the roof do not extend below the top level of the opening of the entrance. This may be because it is part of a system of ornament rather than an actual work of architecture, but I do not think this to be the case. It is my opinion that the apparent increase of verticality and the change in the proportions of the relationship of the roof to the rest of the façade is part of the time-factored evolutionary process. Whether the technique of generating a design from a circle in the manner I have suggested was "lost" or simply abandoned is impossible to determine, but the fact that the Lomās Ṛṣi façade alone has this unique feature distinctly sets it apart from any other similar configuration.

Part III, Stylistic Considerations:

There have been a number of discussions, both published and privately, among scholars on the relative merits of various stylistic associations of the Lomās Ṛṣi *dvāratoraṇa* with material from Bhājā, Bhārhut, Sāñchī, and the ivories from

Begrām. From the foregoing analysis of physical aspects, the evidence would favor a Mauryan date for the façade. Yet, based on stylistic grounds, many scholars hold to a date either in the first century B.C., or just after the beginning of the Christian era. There is some irony in comparing the *dvāratoraṇa* of Lomās Ṛṣi, a cave whose date is relatively secure, with monuments of Indian art whose dates are often uncertain in order to determine whether, in fact, that ornamental façade belongs to the datable portion of the cave.

Philippe Stern, in one of the most important recent essays on the subject, compared the façade of the Lomās Ṛṣi to architectural elements depicted in the Begrām ivories.[8] As illustrated here in Comparison I (Fig. 23), the ivories and the façade share one basic element in common. Figure 23A shows a door frame and roof arch of the Lomās Ṛṣi type, the closest resemblance of any of the Begrām material to the façade. Further, the relative scale in proportion to the human form is approximately correct (assuming that the height of the door is about the same as a man but that the Begrām piece has been reduced in scale to accommodate the composition of the frieze in which it occurs). In this comparison, the generic similarity is quite close, but there are specific features that are significantly different, such as the overall design concept, the shape of the roof and the relative verticality of the pillars.

We have seen that the roof line of the Lomās Ṛṣi is part of the circle centered at the top of the entrance, in which the whole design is generated, while the centers for the lower edges of the arch beams are aligned vertically along the central axis of the façade. When the façade is viewed from a distance the curves of the roof seem to have been generated from the same center as the arches above the entrance. The sense of concentricity is further enhanced by the fact that the center line of the middle arch (the one above the line of elephants) has the same center as the roof line. This illusion reiterates the fact that the basic design unit of the whole façade had been a circle with its center on a line with the top of the entrance. This is hardly the situation with the façade depicted in the ivory. The door is far larger in proportion than is the archway of the Lomās Ṛṣi, and there is no circle or circular design that predominates in the composition. The overall impression is one of greater unity for the façade of the Lomās Ṛṣi while the ivory seems much less integrated.

Besides the basic design differences, the roof line and the verticality of the pillars are also quite different. The roof of the ivory representation consists of a double compound curve formed relative to four centers, not one as in the Lomās Ṛṣi. This is a function of the ever increasing elaboration of this type of roof in its treatment in Indian architecture. Each change and degree of increased curvature is generally accepted as a sign of relative lateness when compared to simpler forms. The same is true of the vertical pillars in the ivory representation. Slanting pillars are usually considered to be earlier than the vertical ones, and the ivory exhibits simple, untapered, vertical pillars. In spite of the generic relationship of the two façades, it is clear that there are major differences between the two, certainly, more than enough to negate the idea that there *has* to be close temporal proximity between the two as is the implication in Stern's study.

Another comparison from the same material is that of the elephant motif occurring in the space between the lower two arches in the Lomās Ṛṣi façade with several examples of the same motif occurring in the Begrām hoard (Fig. 23 B-C and D-E). It has been argued, because of the similarities of the two bands of elephants, that there cannot be very much difference in date between the Lomās Ṛṣi and the Begrām ivories. In this motif, the two are closely related, but in other respects the two *dvāratoraṇas* are only remotely so. The vertical pillars and the curve to the roof must sustain the same objections as did the previous example. In addition, the capitals, bracket figures, carved floral motifs and figures on the pillars, and figures riding leogryphs are more advanced chronologically than the simple Lomās Ṛṣi façade.

That a motif could survive almost intact for a period of several hundred years is not surprising in a culture as conservative as that of India. Elephants, as either directional indicators or symbols of well-being and prosperity, have been used in Indian art since the Harappā civilization. But a close comparison (Fig. 23 D-E) of the anatomical structure of the elephants in the two examples reveals a marked difference in style. Those on the Lomās Ṛṣi are more slender and long bodied, essentially more naturalistic than those on the ivory, which are much more animated, have shorter bodies, and fuller proportions, and

Fig. 23. Comparison.

Fig. 23A. Begrām Ivories, Kabul Museum.

Fig. 23B. Lomāś Ṛṣi cave, dvāratoraṇa.

Fig. 23C. Begrām Ivories, Kabul Museum.

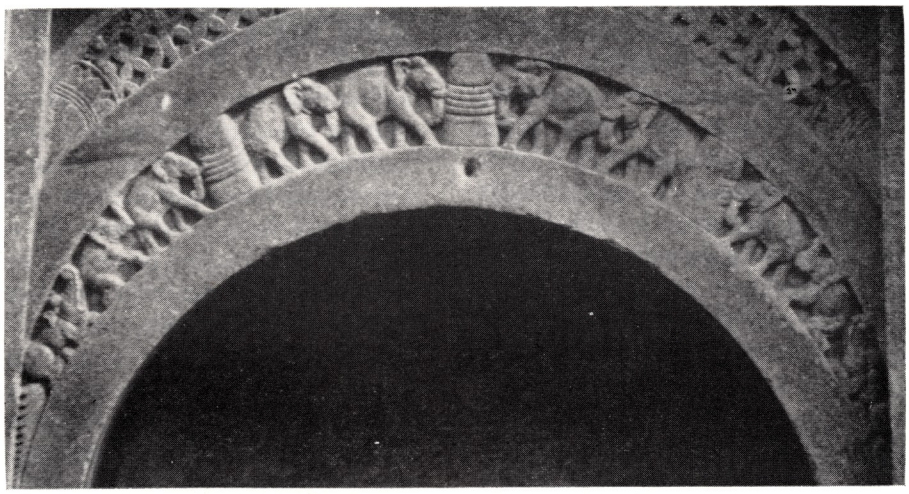

Fig. 23D. Lomāś Ṛṣi cave, elephant procession.

Fig. 23E. Begrām Ivories, (detail figure 23c), Kabul Museum.

each has at least one leg raised from the ground. Those on the Lomās Ṛṣi façade have all four legs firmly planted on the ground and appear to move in a much more sedate manner. Comparing the elephants on the two *dvāratoraṇas* and the elephant on the Mauryan period lion capital at Sārnāth (Fig. 24), we find that those on the Lomās Ṛṣi façade more closely correspond in the degree of movement, relative anatomical structure and position to the Sārnāth elephant (for a comparison to a Śunga representation, see Fig. 27). It is important to realize that the motif of elephants buttressing the spindles separating the arches was of considerable antiquity by the time of the Begrām ivories and it helps put them in their proper art historical perspective. However, because of the considerable difference between them, it is impossible to use the Begrām material to determine much about the date of the Lomās Ṛṣi façade, especially since the Begrām material itself is so highly controversial in date.

There are several other sources of comparative material which could be used to demonstrate the relationship of the Lomās Ṛṣi façade to the general development of Indian architecture, but in the interest of brevity, I shall limit myself to three of the more significant ones—Sāñchī, Bhārhut and Bhājā. It will be noted that no material from the early large *caitya* halls is used. This is because I feel that the scale of the architectural concept is so different that there is a strong possibility of different traditions in use which could lead to false comparisons. The main difference is that the use of battering in smaller structures seems to have diminished greatly prior to the excavation of the big *caitya* halls at Pitalkhorā and Bhājā, which have battered pillars. This is only a general observation and would take substantial investigation to verify in detail. However, even if the opposite proves to be true, the objections to the developments in the roof line and generation of the design on the basis of a circle still hold true for the larger halls as well.

There are several reliefs on the *toraṇas* at Sāñchī that illustrate small huts and shrines similar in concept to the Lomās Ṛṣi cave (Fig. 25). The Sāñchī *toraṇas* are usually considered to date from the last quarter of the first century B.C. and provide a good basis for comparison to the Lomāś Ṛṣi façade. In the panel illustrated, from the north *toraṇa*, three small huts may be seen, all of which bear a close relationship to the

Fig. 24. Sarnath Lion Capital, elephant on drum. Sarnath Museum.

Barābar excavations. In the lower right of the composition is a hut similar to the ones excavated inside the Sudāma and Lomās Ṛṣi caves. It is plain, with straight walls and a hemispheric overhanging roof. On top of the roof is a finial very like the one on the façade of the Lomās Ṛṣi cave. However, it is clearly not in a cave but surrounded by a fence, standing in a forest amid worshippers and a variety of trees. The other two buildings in the scene have *dvāratoraṇas* of the same generic type as the Lomās Ṛṣi cave but here again there is a considerable difference in the specifics of the structures. The designs are not based on a circular configuration, the edges of the roof are much thicker, the peak is much higher and is an integral part of the overall outline rather than an added finial. In addition, the pillars are vertical and the feeling of concentricity is completely absent. Across the middle of the arch is what some have called a "tie rod" but what, in this particular case, seems more like a rolled shade of some sort. (I read the suspended elements at either end of the horizontal member as ties.) Whatever the case, the element is not present on the Lomās Ṛṣi façade and represents an innovation.

As in the Begrām ivories, the features of these façades that differ from those of the Lomās Ṛṣi are usually deemed to be of later date than the simpler configuration. This is particularly true for the little wings at the lower ends of the roof, the vertical pillars and the horizontal device, "sunshade," in the middle of the arch. If we consider Sāñchī as representative of this type of architecture in central India during the last part

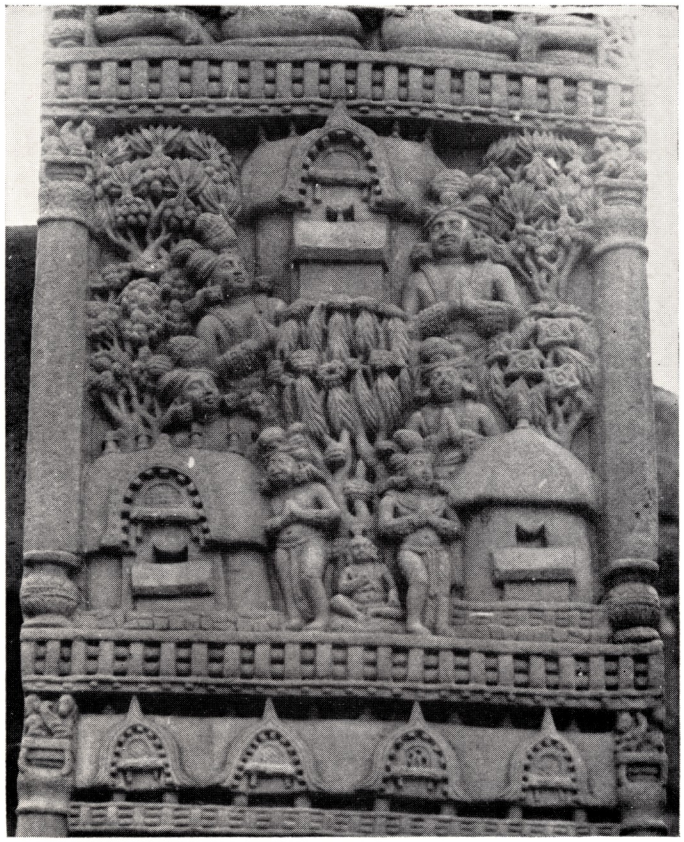

Fig. 25. Sāñchī, scene from north toraṇa.

Fig. 26. Bhārhut, scene from railing. Indian Museum.

of the first century B.C., it would have to be argued that the Lomās Ṛṣi façade must predate it as well.

In the material surviving from Bhārhut, usually dated to *ca.* 80 B.C., there is nothing that allows quite so close a comparison. The related forms occur as the upper stories of larger buildings or in some other more complex architectural context. However there is a feature in the Bhārhut material that is worthy of attention. Two closely related treatments of the roof arch are current in the same monument (Figs. 26, 27). In Fig. 26 both the entrances on the upper level of the building enclosing the *dharmacakra* and the façade of the gate to the compound have *dvāratoraṇas* of the same generic type as that of the Lomās Ṛṣi. The same basic objections apply to these as to those represented at Sāñchī, that is, the development of the overall form on some other basis than the circle, the verticality of the pillars and the increased peak in the center of the roof. But two features present at Sāñchī are lacking in this formulation, the wings at the lower edges of the roof and the horizontal member or "sunshade" across the center of the opening. Morphologically, this configuration appears closer to the Lomās Ṛṣi form, but it has one added variance in that the lower line of the roof does not come to the top line of the arch of the entrance. This materially changes the proportions very greatly and sets this particular representation apart from the Lomās Ṛṣi façade.

In Fig. 27 the entrances to the upper level of the shrine of the *Vajrāsaṇa* at Bodhgayā have been developed in a substantially different manner. The roof has a much higher peak and accented wings at the lower edges, yet the line of the lower edge of the roof comes well below the top of the entrance. The fact that these two very different treatments occur simultaneously at the same site would seem to indicate that the formal convention was undergoing a series of changes during the period in which Bhārhut was being constructed. I do not mean to imply that these two configurations represent a chronological separation of the two reliefs in question, but only that both of the forms were in the architectural vocabulary at the time. Both are well removed from the Lomās Ṛṣi treatment but are more similar than previously compared examples.

In this exercise, working back in time from the Begrām ivories, the appearance of the various examples becomes more and more like that of the Lomās Ṛṣi façade, but in the final comparison, to the Bhājā material, I wish to stress that availability of related examples ceases *ca.* 100 B.C. The architectural façade in the *vihāra* at the far right of the Bhājā site (which contains the well-known veranda reliefs) comes as close to the Lomās Ṛṣi façade as any that I have found (Fig. 28). The guardian figures in the *dvāra-toraṇas* give a clear indication of the intended scale and relative proportions of the *dvāratoraṇa*. These resemble those of the second Bhārhut type discussed but with one added relationship to the Lomās Ṛṣi—the pillars are slightly tapered and inclined toward the center of the arch. However, the proportions are not those of the circle-generated design nor does the line of the lower edges of the roof come below the top of the entranceway. In short, there is still considerable morphological separation from the Lomās Ṛṣi façade, even at *ca.* 100 B.C.

One final consideration is that by the beginning of the first century B.C., there was very widespread use of the arch roof motif. It is possible to trace this theme rather extensively in excavated caves and reliefs from the period and later. To have been so popular and stable a theme requires an already long tradition. When the use of the form might have begun and how old the tradition really is can only be speculated about, but the stability of its continued use and the widespread occurrence by the time that it becomes known points to a very long tradition, probably much antedating the excavation of the Barābar caves.

In conclusion, let me state that I came to the problem of the date of the Lomās Ṛṣi without bias of any sort. My original concern was to determine if the builders really intended to portray wooden planking on the sides of the hut. This concern was part of an iconographic problem that I had been working on in relation to the meaning of shrines and had nothing to do with chronology *per se*. Accordingly, I have tried to discover whatever reasoning lay behind the various theories presented. I was particularly concerned about the Begrām comparison since it seemed by far the most cogent argument for a later date. But, the trend of the evidence far outweighs the single "continued motif" theory on which the arguments are based. In summary, it may be suggested that the excavation of Lomās

Fig. 27. Bhārhut, scene from railing. Indian Museum.

Fig. 28. Bhājā, interior of far right vihāra.

Ṛṣi probably commenced after the completion of the Sudāma cave, that is, the year 19 of Aśoka's era, and that the façade was finished well before work on the cave was stopped. Further, I assume that work at the site was not continued past the end of Aśoka's reign, whatever the actual cause of the stoppage.

A Note on the Use of Photogrammetry

In discussions with some of my colleagues, I have discovered that the idea of measuring from a photograph is greeted with a certain skepticism. It will be noted that throughout the foregoing article I have dealt mostly with proportional measurements and relationships. These are quite easy to do if two conditions are met when taking the initial photograph (old photographs *may not* be reprinted in an adjusted manner to compensate for having been taken at incorrect angles). The first is that the photograph must be taken very close to dead center in front of the object that one wishes to measure. Second, the camera must be aligned so that the film plane is parallel to the plane being measured, thus negating perspective distortion. If these conditions are met and a sufficiently large print is made, one may literally measure to within thousandths of inches. One aid, which we did not use, and one which is frequently misleading because of problems in perspective alignment, is a measuring device included in the composition of the picture at exactly the plane that one wishes to measure. This would allow printing to a specific scale and precise measurements of distances across the surface being measured. For further information on the technique and its uses see the bibliography in K. B. Atkinson and I. Newton, "Photogrammetry," *Photography for the Scientist,* edited by Charles E. Engel, Academic Press, London and New York, 1968, 273-298.

NOTES

1. This article is entirely based on photographs taken by my wife and myself during our visit to the Barābar hills caves in winter of 1969-70. We are most indebted to the late Dr. Saksena of the Bodhgayā museum who accompanied us to the site and who, with his wife, made our visit to the Gayā district a most pleasant experience. This article is respectfully dedicated to his memory. I also gratefully acknowledge the National Endowment for the Humanities which supported my work in Asia and the American Council of Learned Societies which contributed towards photographic expenses on my return.
2. It is not my intention in this article to "attack" the ideas of any scholar or group of scholars. Therefore, since I assume that the reader will be familiar with the general literature on the cave I shall not annotate the sources of the various theories but shall refer to them in a general manner. However, for those who wish a summary of current ideas combined with several new interpretations I refer them to Jeannine Auboyer's, "The Cavern of Lomāś Ṛṣi, Barābar Hills, Bihār," in *Journal of the Indian Socoiety of Oriental Art,* New Series, Vol. IV, Calcutta, 1971-1972, pp. 38-43. To avoid confusion, one must note that Madame Auboyer illustrates the entrance of Vahiyakā or Vapiya cave in the Nāgārjunī hills (printed in reverse) as the entrance to Sudāma cave.
3. A. L. Basham, *History and Doctrine of the Ājīvikas,* London, 1951, p. 154.
4. All angular measurements are approximations with a tolerance of 0°30′. Because of the use of large scale (one inch to one foot) photographs and modern measuring equipment, it has been possible to measure the caves with a margin of error less than 5′ of an arc. Such accuracy is meaningless when measuring an object made to much broader tolerances. For example, the inside edge of the right pillar of the Lomāś Ṛṣi façade curves inward almost 20′ of an arc and the top edge of the entrance dips some three-eighths of an inch in the center. These "errors" are virtually invisible and such precision would only serve to complicate any discussion of the measurements. Therefore, I have attempted to make averaging estimates of all angular measurements and many linear measurements. Even with this adjustment, it will be found that the dimensions and angles of the caves all fall within, and mostly substantially under, a one and a half per cent margin of error—truly, a remarkable achievement. For detailed measurements see drawings.
5. A triangular *"prabhāmandala"* does occur in Buddhist art by the seventh century for certain secondary figures of the esoteric tradition, but the difference in time and the fact that it is for a secondary figure makes the relationship tentative in the extreme.
6. This view seems to originate with a mislabelled photograph in Percy Brown's *Indian Architecture: Buddhist and Hindu Periods,* Bombay, 1956, pl. IX, Fig. 2. He has illustrated the Lomāś Ṛṣi cave but labelled it the Sudāma cave.
7. A. Cunningham, *Archaeological Survey of India,* Vol. 1, "Four Reports made during the Years 1862-63-64-65," Simla, 1871. "Barabar," pp. 40-53.
8. Ph. Stern, "Les ivories et os découverts à Begram—Leur place dans l'évolution de l'art de l'Inde," in *Nouvelles recherches archéologiques à Begram,* Paris, 1954, pp. 38-41.