THE BUILDING OF SACSAHUAMAN

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BACKGROUND

The Inca ruin of Sacsahuaman, located in the heights above Cuzco, Peru, is probably the most impressive example of megalithic architecture in the New World. The precision with which the gigantic, irregular boulders of its outer terrace walls have been fitted has astounded observers since the conquest (fig. 1). How, exactly, those stones were set so perfectly in place has remained one of the great mysteries of Andean archaeology. The work had apparently been completed or abandoned prior to the arrival of the Spaniards and the Incas neither reported nor left records of their methods.

In the absence of any evidence other than the structure itself, numerous theories have been advanced to account for the construction of this enigmatic monument, though none have been sufficiently detailed or convincing to achieve widespread or serious acceptance among scholars and scientists. Exotic explanations involving laser beams (Fawcett, 1953), liquid stone solvents (Däniken, 1970), and giant builders have been advanced, presumably on the assumption that the work was otherwise beyond the means of "primitive" people. In rejecting such fanciful theories, most opinion has gravitated instead to some sort of trial and error approach involving multiple movements of each stone, as first proposed by Garcilaso in 1604 (Garcilaso de la Vega, 1961, bk. 7). Support of such a method nevertheless stems largely from the lack, to date, of any plausible alternative, since no studies have yet been published suggesting precisely how a trial and error system might have worked on such large stones.

INTRODUCTION

In this paper I present an alternative technique by which Sacsahuaman could have been built. This scribing and coping technique is the precise opposite of the trial and error approach in that it achieves the desired fit in one operation, and thus requires only a single lowering of each stone into place. The scribing and coping technique is characterized by several features that recommend it as worthy of serious analysis:

1. It is far more efficient in its use of time, manpower, construction materials, and work space than any trial and error method.
2. It involves tools, technology, and science apparently available to the Incas, and relies solely on materials of which little or no trace would remain today.
3. It is not contradicted by any physical evidence yet found at the site of Sacsahuaman and tends to be confirmed by some.
4. It appears to explain many seemingly illogical aspects of Inca stonemasonry.
5. The same technique, or one involving identical principles, continues in use today, and may be observed and studied in the work of traditional log cabin builders.

Perhaps the best introduction to the scribing and coping technique proposed here is a review of the process by which builders of traditional log cabins fit logs together.

Log Construction

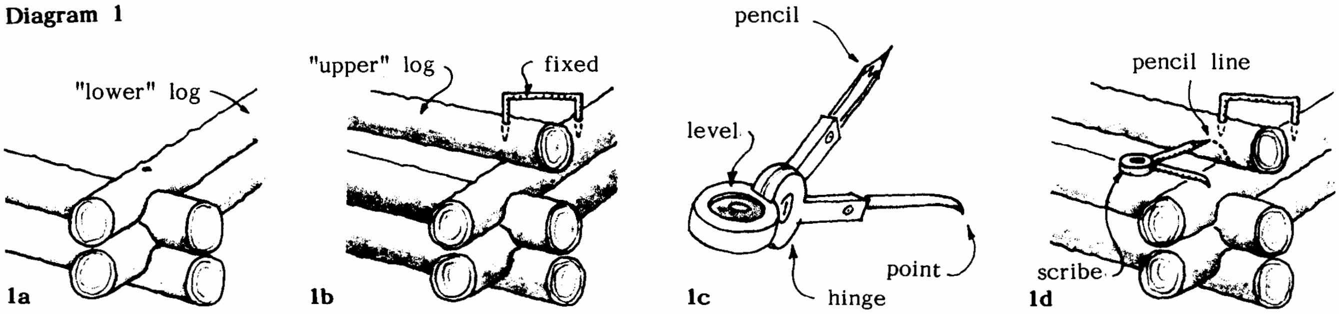
Traditional log structures are defined as those utilizing natural tree trunks as they come from the forest. While the bark is generally removed, the irregular shape of the tree is retained in the finished work. Diagram 1 shows the manner in which such logs are typically notched over one another where they cross at the corners of log structures. The object is to achieve an exact, tight fit.

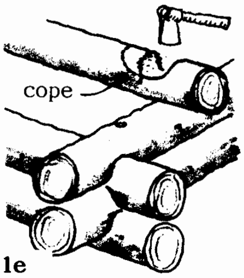
First, the lower log is fixed in place, anchored to the log beneath it or to the foundation. The upper log is typically notched to fit over the lower log so that the resulting joint will not collect water and eventually rot out (diag. 1a).

Next, the upper log is rolled into place directly above its intended final position. It is then immobilized with respect to the lower log by temporarily nailing the two logs together so that their relationship remains constant during the next operation (diag. 1b).

The irregular shape of the lower log may now be transferred onto the irregular underside of the upper log by means of a special tool called a scribe, similar to a draftsman's compass but fitted with leveling bubbles and a locking device to prevent movement of the hinge once the ends are set the desired distance apart (diag. 1c). As long as the bubble is kept centered, it is evident that the locus of all points visited by the

Diagram 1





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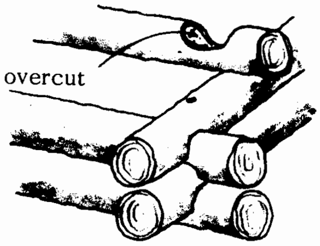

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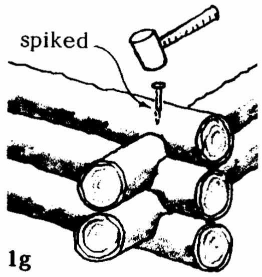


1g

pointed lower end is exactly duplicated by the pencil attached to the upper end. With the ends of the scribe set a bit less than half a log diameter apart and the bubble maintained level, the pointed end is moved along the face of the lower log, and its profile is marked onto the face of the upper log by the pencil (diag. 1d). This process, called scribing, must be done with great care and precision since the eventual fit depends entirely upon its accuracy.

Once scribing is complete, the upper log is freed from the lower log, rolled 180° so that the scribed line points up, and the cutting or coping of the notch may be done easily, working from above (diag. 1e). The edge of the notch, or cope, is cut precisely to the scribed line, but the interior of the cope must be slightly overcut to avoid any unwanted high spots inside the joint, which would hold the logs apart and spoil the visible fit (diag. 1f).

The coped upper log may now be rolled back onto the lower log directly below the position in which it was scribed, and spiked in place (diag. 1g). In theory, an imperfect fit may be improved by rolling the upper log back out of the joint prior to spiking, and refining the cope by trial and error, though in practice this is neither easily nor often done. In fact, it is a matter of pride among expert log men that the fit should be perfect the first time so that no such tactics are needed.

STONES VS. LOGS

Before we proceed to apply the principles of logwork to the fitting of the huge stones at Sacsahuaman, close examination of the walls themselves (fig. 2) reveals a number of characteristic details apparently related to the nature of large stones, as opposed to logs. Analysis of these details against the background of log fitting provides the basis for the scribing and coping method proposed in this paper:

1. Unlike logs, neither side of the stone joints is formed by an unworked, natural surface. All joining faces of the stones appear to have been cut to their finished shapes.
2. In contrast to the ease with which logs can be worked, Inca masons apparently used hammerstones of hard rock to shape building blocks (Protzen, 1985), a tedious but highly precise technique capable of producing extremely close tolerances.
3. The typical stone joint appears to have been formed by the simultaneous fitting of the bottom, or bedding, face and one adjacent vertical, or rising, face. As with logs, no part of the fit can be achieved independent of the whole. Thus, the two adjacent faces are effectively one L-shaped joint (fig. 2).
4. Occasional exceptions to the above rule are found where the bedding face appears to have been fitted simultaneously with both adjacent rising faces in the form of a U-shaped joint (fig. 2). Such stones were necessary in filling the last space in each course of the wall, assuming that masons then, as now, worked inward from the corners. Called keystones (Protzen, 1985, p. 195), these stones are not, however, structurally significant.
5. In nearly every case, the upper stones appear to have been cut, or let, into the stones beneath and adjacent to them, the opposite of the typical procedure with logs. Recalling that, unlike logs, both stones were worked to achieve the fit, and assuming that neither stone was easily moved nor likely to rot once in place, the reasons for letting the upper stones into the lower ones become clear. As with logs, the coping of the material was most conveniently done working from above so that gravity worked for, rather than against, the mason, and dust and chips fell away from, rather than into, his eyes. It is evident that the lower stones could be worked from above once in place, but the upper stones must have been worked elsewhere and on their sides to achieve the same advantage (fig. 3). This consideration, in turn, suggests the sequence of the scribing and coping technique as applied to very large stones.

The stone to be placed was selected from the quarry or onsite staging area to be slightly larger than the next space in the wall. It was then laid on its side and preshaped by masons working only those faces necessary to fit the next joint. Ideally, this preshaping removed as little material as possible from the stone, abstracting its natural form to a smooth shape easily transferred onto the stones already in place, against which it was to bear. When finished, the preshaped upper stone was moved into position above its intended resting place and supported in such a manner as to permit the scribing of its shape onto the surfaces below, which could then be worked conveniently from above and coped to provide a perfectly shaped seat for it.

MOVEMENT AND SUPPORT OF LARGE STONES

Any system of construction at Sacsahuaman presumes some means of moving and handling large stones. Though the precise technique utilized by the Incas is not known, various alternatives ranging from dragging directly on the ground to sleds pulled across log rollers have been proposed. Many such methods are theoretically possible, and more than one was likely employed at Sacsahuaman. Of more importance to the subject of this paper is the sequence of movements implied by the scribing and coping technique and the means by which such movements might most efficiently have been done. In order to position each successive upper stone above the surfaces into which its shape was to be coped, it was first necessary to transport all stones arriving from the quarry to a platform above the top of the wall under construction. This move could easily have been done by leveling a portion of the hillside behind and above the retaining wall as a staging area, and backfilling against the rear of the wall as its height increased. Access to this staging area could have been by low-angle ramps.

Once each stone reached the staging area, only two relatively simple movements remained. After preshaping, it would have to be slid, probably still on its side, onto a scaffold above the space it was intended to fill. Then it would have been tipped up onto its bedding face and immobilized precisely above the positon it would occupy when set into the wall.

Aside from the final lowering, discussed later, no further movement of the stones would be required. Indeed, as with logs, it would be important that the surfaces to be scribed and coped remain absolutely motionless with respect to each other until final lowering.

One further problem remained to be resolved before scribing could begin. In order for the scribers to have unobstructed access to the precut bedding face of the upper stone, it would have been necessary to provide some alternative support so that the scaffolding could be removed from underneath. It is this aspect of the scribing and coping technique for which the most tangible evidence is found.

Many observers have noted the ubiquitous indentations, grooves, and bulges found along the lower edges of most of the largest stones at Sacsahuaman (figs. 4-7), including even those which now bear at or below grade (fig. 8). Such indentations would provide the perfect means to accomplish the alternative support required by the system proposed here. By inserting posts into these pockets, anchoring their butt ends firmly in the ground, and bracing and lashing them together, the weight of even the largest stones could readily be borne without obstruction of the bedding face for the scribers working underneath. A single twelve-inch diameter log will easily bear a vertical load of fifty tons or more.

Diagram 2 summarizes the preshaping of the next stone to be fitted, its movement into position above its final resting place, and the substitution of alternative supports for the scaffolding in anticipation of scribing and coping. In diag. 2, this alternative support system has been abstracted for clarity, and is shown in the form of upright posts beneath each indentation. In practice, a much more complicated bracing and shoring would have been required to provide a stable structure capable of carrying the enormous loads involved.

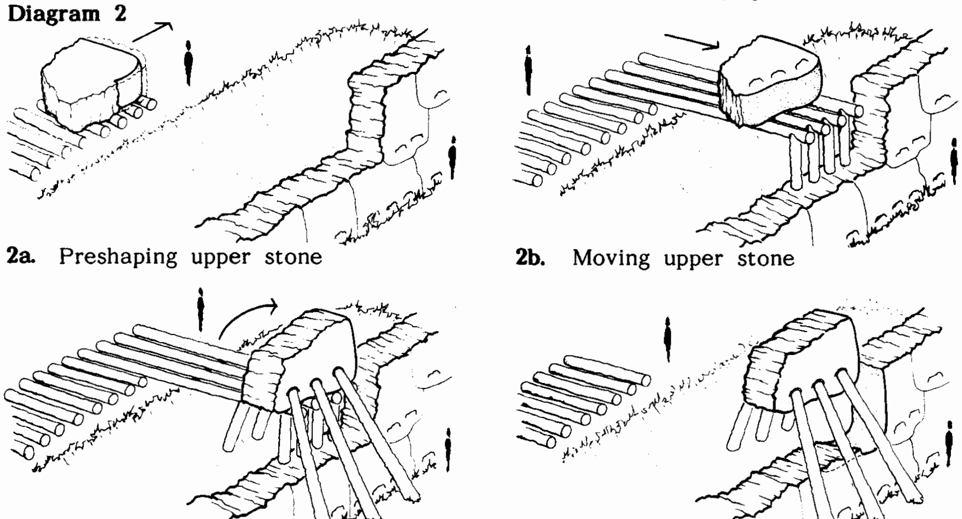
Though seldom found at Sacsahuaman, the protuberances commonly found elsewhere (e.g., fig. 9) were probably used to provide the same alternative means of support as the indentations noted above. Protuberances are generally found on smaller stones, which may have been supported on horizontal, rather than vertical, logs (diag. 9), and are fairly well located for that purpose. It is likely that some protuberances were removed after the stones were in place, making analysis of their original function more difficult. They do not, however, seem to provide good anchor points for ropes or logical leverage points.

SCRIBING AND COPING OF LARGE STONES

The next step in the process proposed here would have been the transferral of the precut shape of the upper stone into the stones already in place beneath it. As with logs, this would require a scribe of some sort, but in scribing huge stones it would be necessary to transfer the entire surface, rather than just the perimeter of the joint. Also, where the log scribe must span a gap of only a few inches, the stone scribe would need to be long enough to permit a crew of scribers and copers to work comfortably and efficiently between the stones. Finally, unlike working with logs, it would have been necessary for stone scribers and copers to work simultaneously, with the former constantly checking and rechecking the work of the latter.

A tool meeting all of the above requirements, involving concepts known to the Incas and utilizing only perishable materials (with the possible exception

Diagram 2



2a. Preshaping upper stone

2b. Moving upper stone

2c. Immobilizing upper stone

2d. Scribing and cutting lower stone

Diagram 3

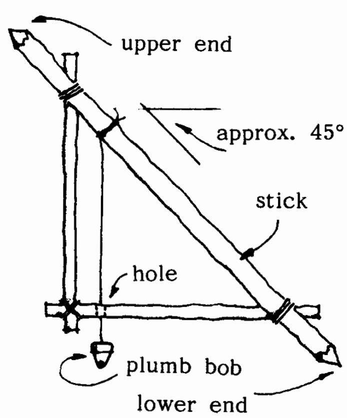
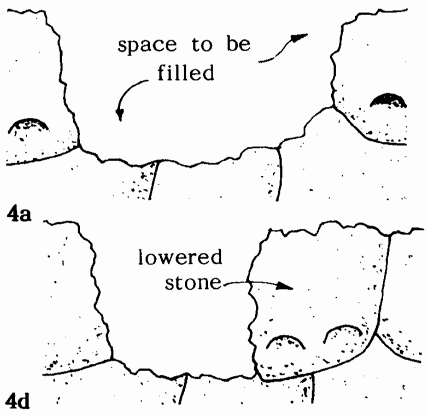
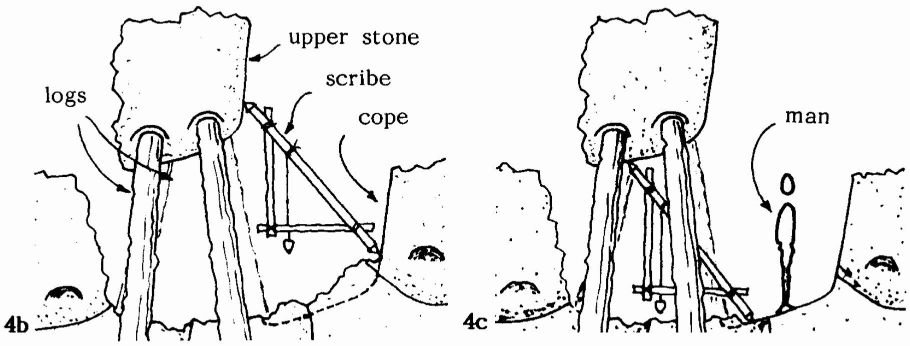


Diagram 4





of plumb bobs such as those found at Machu Picchu and Ollantaytambo) might have been no more than a measuring stick fitted with a plumb line hanging through a hole in a second stick (diag. 3). By moving the upper end of the stick along the precut face of the upper stone and keeping the plumb line centered in its hole, the lower end of the stick would precisely duplicate the profile of the upper stone. Stone masons, by chipping away the lower stones to accept the scribe exactly, would thereby create the required cope. The function of the plumb bob could be performed by any weighty object, which may explain why few plumb bobs have been found. A small error would result if the scribe were allowed to rotate significantly about the axis of the plumb line (the yaw axis) during scribing, and care would be required to avoid this. A length adjustment designed into the measuring stick would permit its reuse for scribing stones of various sizes.

The scribe shown in diag. 3 is designed to transfer the typical L-shaped joint discussed earlier. The measuring stick is oriented approximately 45° off the vertical so that it works equally well for both the bedding face and adjacent rising face. The upper stone must therefore be immobilized approximately 45° above and to the open side of the space it is intended to fill. Keystones, on the other hand, would have to be scribed directly above the U-shaped notch into which they were to be placed, a situation for which the scribe design above would not work. Various alternative designs are possible for this and other circumstances, as will be discussed later.

Diagrams 4-6 illustrate how the walls of Sacsahuaman might have been assembled: diag. 4 shows the typical L-shaped joint, diag. 5 the setting of a keystone, and diag. 6 the placement of the first stone of a new course. The procedures involved have been tested by the author using actual scribes to fit large blocks of styrofoam together in the same sequence as shown. The method worked to achieve joints accurate to within several millimeters, the difficulty of working with foam being the limiting factor. Using stone, even closer tolerances could easily result.

A different scribe design is required for the placement of keystones as noted earlier. The tool shown in diag. 8 works on the same principle as the scribe already detailed but can be rotated 180° on the axis of the plumb line to work equally well for the bedding face and both of the adjacent rising faces. The two ends must be vertically aligned so that their relative positions remain unchanged despite the rotation, and must be rigidly attached to the diagonal stick so that the distance between them cannot change accidentally.

As noted in diag. 5b, it is necessary that a keystone be supported at least its own height above the opening it is intended to fill. Otherwise, as suggested in diag. 5a, the tops of the stones already in place will interfere with the scribe as it is moved deeper into the cope. Such interference is further avoided by sloping the rising faces of the keystone well away from the vertical, so that the scribe moves laterally as well as vertically into the joint.

The first stone of each new course would have been the easiest to place since only its bedding face

Diagram 5

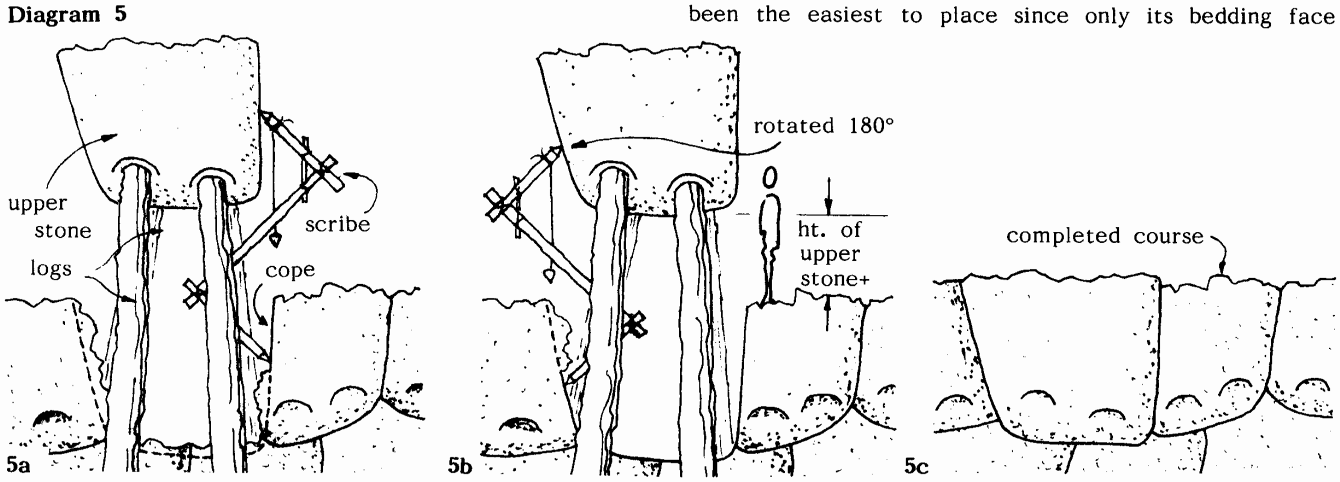
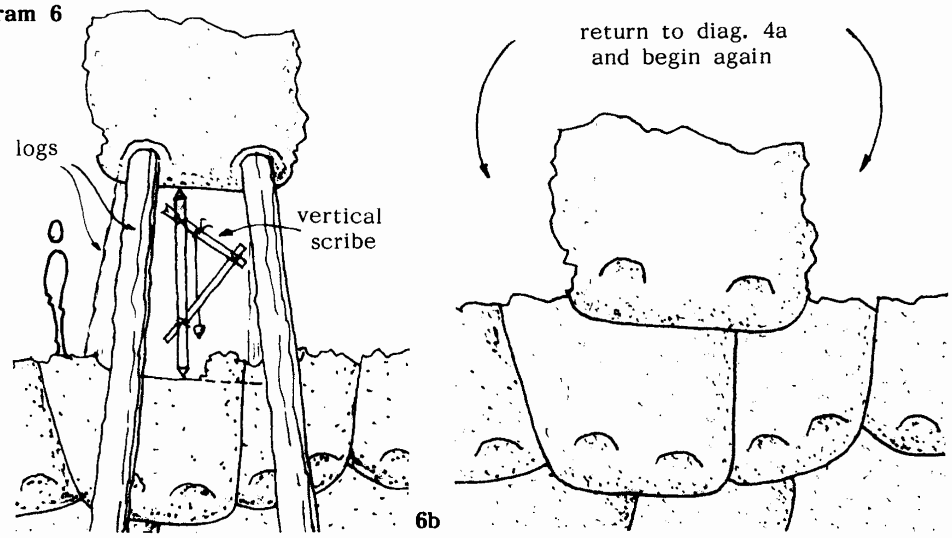
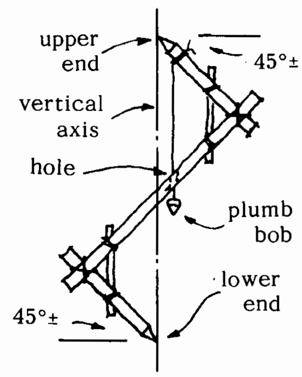


Diagram 6



6a

Diagram 7



would have to be fitted, there being no adjacent stones at either side. To accomplish the fitting, only a roughly vertical measuring stick would be needed. Keeping this tool more or less vertical might or might not have required some sort of plumb line, since the error introduced by slight changes in the alignment would be very small. The scribe used for typical L-shaped joints could easily have been modified for the purpose by rerigging the plumb line (diag. 6a).

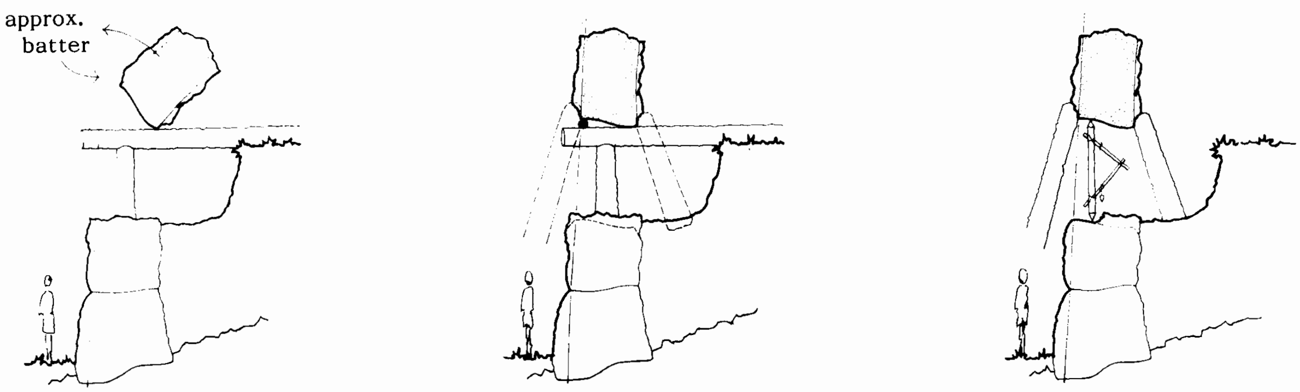
It seems likely that, in practice, several stones, rather than just one, might have been placed at intervals along the top of each finished course. In this manner, a number of crews could have worked the new course simultaneously, greatly expediting the work. Next to each "first" stone would be L-shaped spaces opening to each side, which could then be filled until crews working towards one another met at keystones, several of which could then be fitted at the same time, completing the new course. Such a procedure might explain why it is difficult to determine the numerical order in which the stones of Sacsahuaman were assembled by studying the pattern of joints (Protzen, 1985, p. 195). Small groupings are relatively easy to decipher, but over large areas the sequence becomes less clear, suggesting that the work may have progressed in several directions at once.

ANALYSIS OF CHARACTERISTIC DETAILS

The scribing and coping technique proposed here not only is capable of dealing with the irregular shapes found at Sacsahuaman (and elsewhere), but also almost necessarily produces such shapes. This system of construction is fundamentally unlike our own in that it does not involve the concepts of straight lines, uniform vertical and horizontal planes, truly right angles and square corners; each individual building block is a unique form. These factors, combined with the practice of setting such blocks tightly together without mortar, totally preclude the kinds of prefabrication inherent in most other known building techniques. It is no accident that scribing and coping survives today in Western culture only in the fitting of irregular shapes such as natural tree trunks, an arcane and seldom-used skill.

Understanding the radically alien nature of the technique that created them, it is possible to see the simple logic of various characteristic details of Inca stonemasonry commonly observed at Sacsahuaman. Wall slope, or batter, for example, is not only advantageous structurally, but also is the only plane

Diagram 8

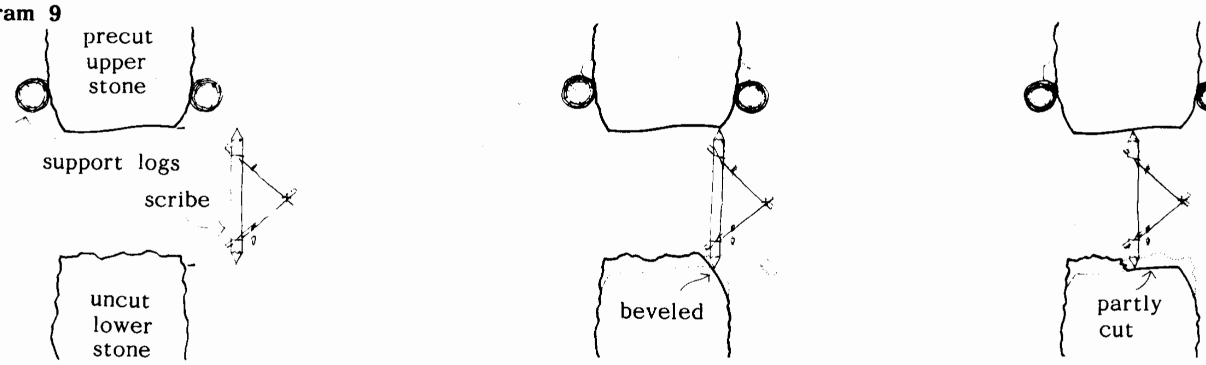


8a. Irregular precut upper stone tipped up.

8b. Front edge of rising joint set to batter.

8c. All other cuts determined by angle of batter.

Diagram 9



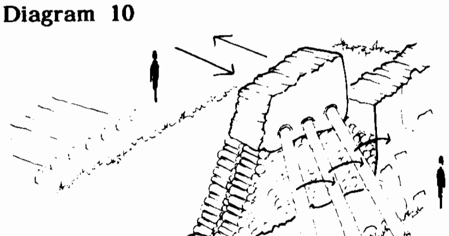
9a. Scribe blocked by uncut edge. **9b.** Bevel allows scribe into position. **9c.** Scribe part way into cut.

common to all stones in the wall. Thus, it was the only reference available in determining the position in which to immobilize each successive stone prior to scribing (diag. 8).

Similarly, the bulging profile of the stones beyond deeply recessed joints, which we find so aesthetically appealing, has distinct practical advantages for the stone cutters as well (Protzen, 1985) and, in some cases, provides purchase for the support of the stones during scribing. In addition, some degree of bulge appears necessary in order to move the scribe into position for beginning the cope since, at the outset, the scribe is longer than the space between the stones (in diag. 9, shown with alternative support by protuberances bearing on horizontal logs).

Where stones have been removed from their original positions at Sacsahuaman (fig. 10), it is often observed that the interior of the joint was slightly overcut so that only the visible edges fit perfectly, likely for the same reason that log copers overcut today. Such a procedure would have greatly simplified coping the joint, since only a small percentage of the surface would require careful scribing. The rest would simply be chipped so that the scribe fit loosely between the finished surfaces.

Diagram 10



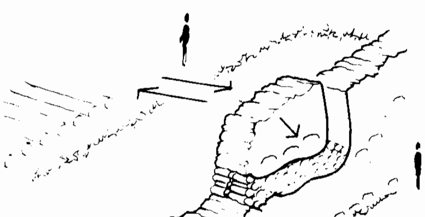
10a.
Packing and removing poles.

LOWERING (OR RAISING) OF VERY LARGE STONES

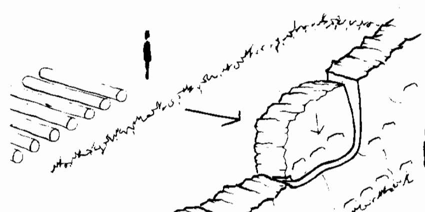
The final problem of the technique proposed here is the means used to lower the upper stone into place once the scribing and coping was completed. Were the trial and error technique to have been used, it would presumably have required massive amounts of manpower, but used in what way is unclear. Even with steel cables and large cranes, the load of a 50-100 ton stone would be controlled from below, by means of a sling beneath the stone. It is a truism of construction that, except for magnetism, there is no way to pull anything. All load handling is a matter of pushing, regardless of how the force is applied.

In the absence of high-strength cables of manageable size (Inca suspension bridge lines were reportedly about a foot in diameter [Garcilaso de la Vega, 1961, bk. 3]), huge loads could be controlled from below by manipulating materials carrying the weight in simple compression. In Egypt, sand was the perfect such material. Plentiful, cheap, enormously strong yet soft enough to avoid damage to the load, it was nevertheless easily manipulated (Englebach, 1924). While no trace of any such material has ever been identified at Sacsahuaman, it is nevertheless possible that a similar approach was used by the Incas.

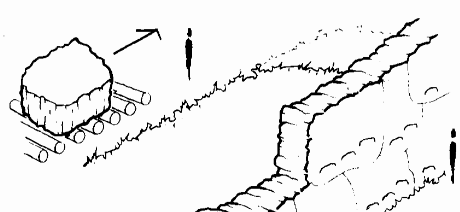
Diagram 10 summarizes a system involving back-to-back stacks of cordwood packed beneath the stone to be lowered. By tipping the stone from side, it would have been possible to remove the supporting logs from the indentations, shifting the weight to the cordwood. Continued tipping would then permit the removal of a few sticks from each side in turn so that the stone would settle slowly into place. The full weight of the stone would bear continuously on the wood, no doubt crushing and splintering many of the sticks, but no damage would be done to the cut faces of any of the stones. Meanwhile, the amount of force needed to



10b.
Tipping and lowering.



10c.
Cleaning and setting.



10d.
Backfill and start again.

tip the stone back and forth would be a small fraction of its full weight. Removal, or even addition, of sticks would allow for lateral as well as vertical movement as needed to manipulate the stone into position.

As the stone neared its seat, the last sticks would probably have been removed from beneath the unseen, back edge first. The final movement into place would pivot the stone on this edge, and with the last of the wood gone, chipping might occur. The last sticks could then be removed from beneath the front edge, and the joint swept clean before lowering the stone. At this point, it might have been possible to make minor adjustments to the fit of the front edge, if necessary, and the visible face of the joint could also be dressed by masons working from the front.

FITTING LARGE STONES BY TRIAL AND ERROR

The same technique could be reversed in order to raise a stone out of its seat, thus providing a way to accomplish the multiple movements inherent in a trial and error system. In order to work the faces, however, it would be necessary to remove all the wood, and re-establish some alternative support each time the stone was raised. While theoretically possible, it would be a horrendously tedious and inefficient process. Worse, it is not clear exactly how the masons would know what to do to improve the fit once the stone was raised. Scribing would be of no help, since the stone could never be restored to precisely the same position each time it was raised. In discussing logs, it was noted that trial and error could be used to improve a poor fit, but that it was not as easy as it might seem. Once the log is moved from the position in which it was scribed, all reference is lost, and the process becomes largely guesswork. The same lack of reference would plague the masons in a trial and error stone-fitting operation, and necessitate many movements of each stone in order to achieve the results seen at Sacsahuaman.

A trial and error technique would make sense only if moving the stones were easier, or at least less tedious than scribing and coping. With huge stones, such is clearly not the case, since scribing requires only a small crew whereas moving the stones calls for a very large gang of laborers, and multiple movements would commit such gangs to each stone for very long periods of time. It does not seem likely that a people as well organized, efficient, and clever as the Incas would use such cumbersome methods unless there were no alternative.

A simple exercise is recommended to those wishing to compare the trial and error and scribing and coping techniques by some means less onerous than wrestling with huge stones. First, cut one edge off a sheet of typing paper in a gentle, but irregular, curved pattern. Next, attempt to match exactly the edge of a second sheet of paper to the first by alternately trimming it with scissors and fitting the two together (no fair tracing or overlaying the two sheets). As you will see, the curse of the trial and error technique is accidental overcutting of some small portion of an otherwise good fit, all of which must then be recut to correct the problem. Now, tape the first sheet to a table, and tape an uncut sheet down next to it several inches from the irregular edge. Take a dime-store compass, opened to the necessary spacing, and carefully move the point along the cut edge, meanwhile marking the blank paper with the pencil. Cut along this pencil line, and you should easily match the shapes in one, simple operation.

IMPLICATIONS OF THE SCRIBING AND COPING TECHNIQUE

Many observers, contrasting the irregular warped planes often found between the stones of Sacsahuaman (fig. 11) with the more visually regular joint patterns found elsewhere (fig. 12), have assumed that the latter must have been easier to do (Cobo, lib. 14, cap. XII; 1956, tomo 92, p. 261). Why, then, is the most regular work often found in especially important buildings such as the Coricancha?

As noted earlier, the scribing and coping technique does not favor regularity, it simply duplicates the shape of the stone being scribed, whatever that may be. Thus, the warped surfaces of Sacsahuaman present no problem and, to the extent that the stones there resemble their original shapes, might have required removal of relatively little material. In contrast, regular stones had first to be broken into like-sized blocks and then trimmed to shape by removal of much greater amounts of material. Since the stones shaped in this way are generally much smaller than those at Sacsahuaman, many more of them are required within a given wall area, and the length of joints needing to be fitted is greatly increased.

Careful examination, moreover, shows that the apparent regularity of these walls is an illusion. The stones are only approximately regular, and the apparent horizontal and vertical joints between them are seldom geometrically true, so that there is no essential difference between regular and irregular work except that the former required much more labor. Viewed in this way, it is clear that apparently regular stone masonry was actually quite difficult to achieve, given the tools and techniques used, and was thus highly appropriate for particularly important structures.

CONCLUSION

In asserting that the scribing and coping technique described herein was the method used by the Inca builders of Sacsahuaman, it should be noted that this system is most appropriate to the assembly of large, heavy stones. It is likely that small (1- or 2-man) stones were fitted either by trial and error, as suggested by at least one chronicler (Acosta, 1962), or by some combination of the two techniques. The break-point beyond which scribing and coping became the technique of choice would have occurred where the number of laborers required to move the stone exceeded the number necessary to the scribing operation, since the number of masons involved in dressing the material would have presumably been the same in either case for a given stone size.

The evidence for the procedure postulated here is almost entirely circumstantial, and falls well short of proof positive. Indeed, barring revelation of some yet unfound artifact or document, proof of the use of any such technique seems unlikely. Excavation behind a section of the lower terrace wall might indicate whether the evidence of alternative support, so apparent on the visible faces, is duplicated there as well. The likelihood of such evidence may be seen in fig. 13, where the removal of an adjacent stone has exposed indentations on a previously hidden face of a large corner stone. Also, numerous examples of rear-face indentations are seen among the apparently unfinished parapet stones (fig. 14). Careful study of the unseen rear bedding joints might also show evidence of chipping and suggest that the load had once been pivoted on that surface. Perhaps the most telling test of the scribing and coping annd cordwood lowering systems would be to attempt to duplicate the work found at Sacsahuaman today, using stones. Even success in such an enterprise might not settle the issue, but it would certainly be interesting to try.

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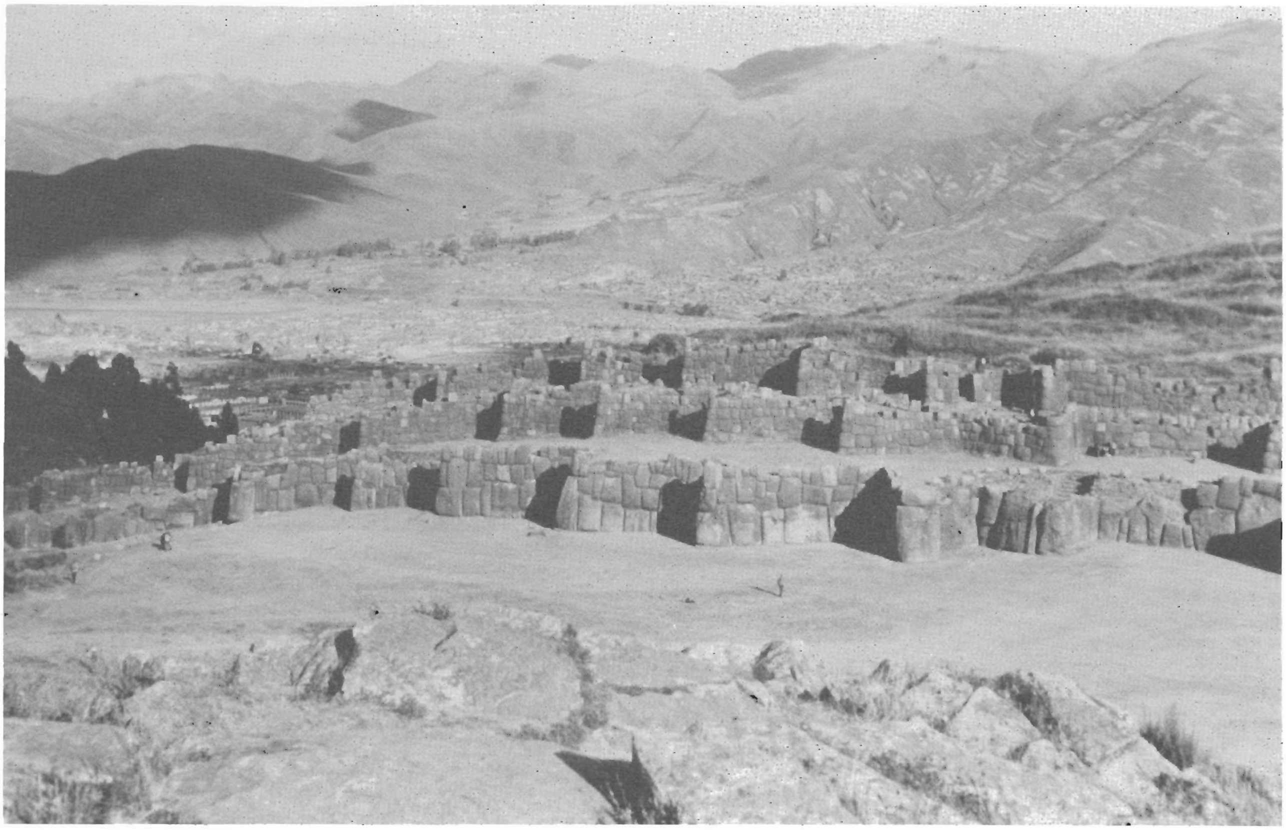

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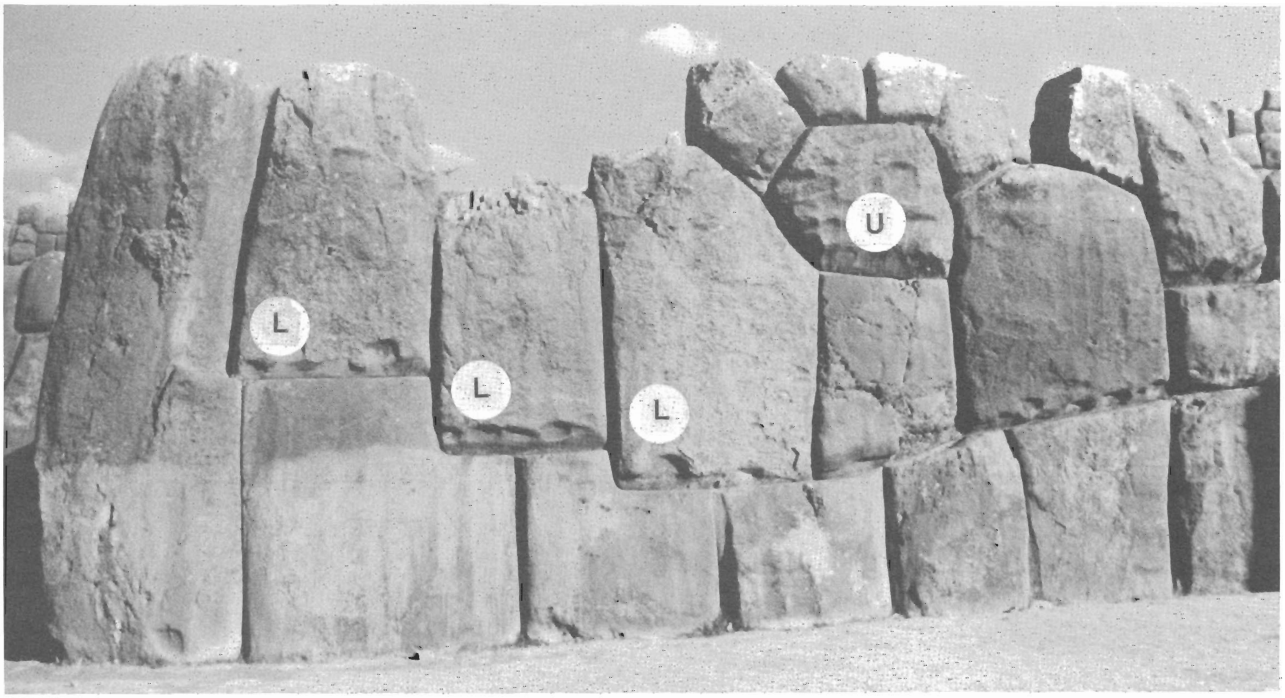

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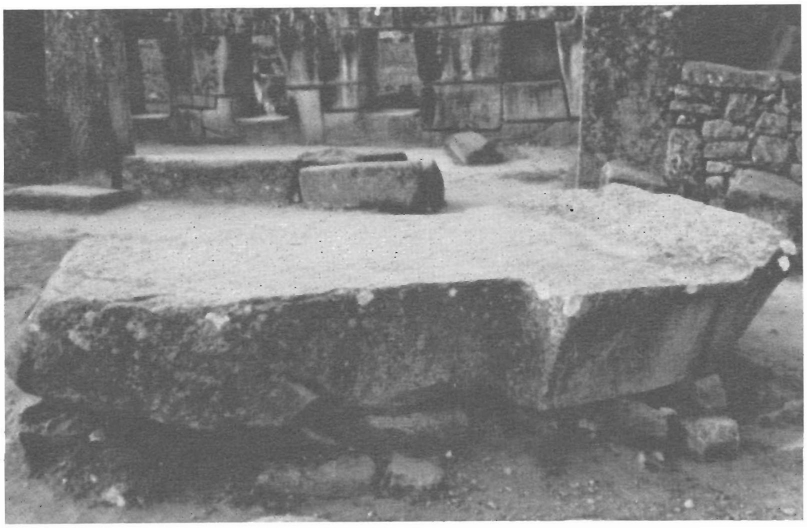
Sacsahuaman in the heights above Cuzco, Peru. **Fig. 1.** Outer terrace walls. **Fig. 2.** Lower terrace wall showing typical L-shaped joints (marked L) and keystone (marked U).



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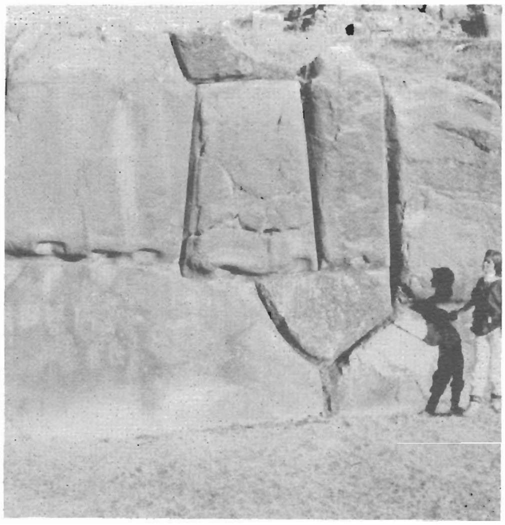

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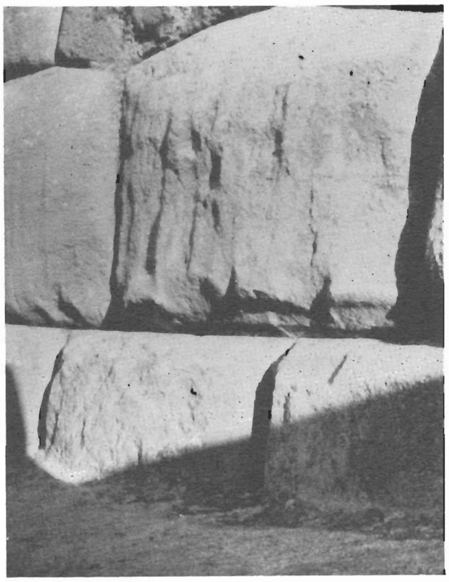
Fig. 3. Machu Picchu, stone apparently being worked at time of abandonment. **Fig. 4.** Sacsahuaman, indentations on lower terrace wall. **Fig. 5.** Sacsahuaman, detail of typical indentations near lower edge of stones. **Fig. 6.** Sacsahuaman, detail of indentations combined with continuous grooves along lower edge of stones.



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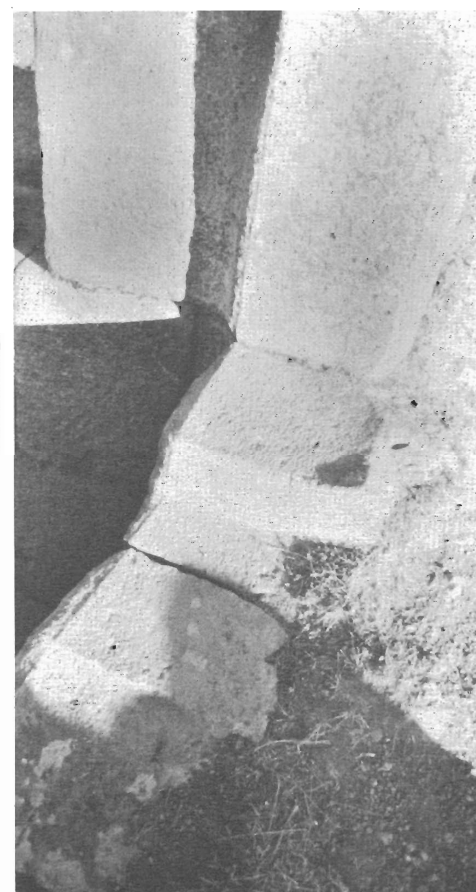

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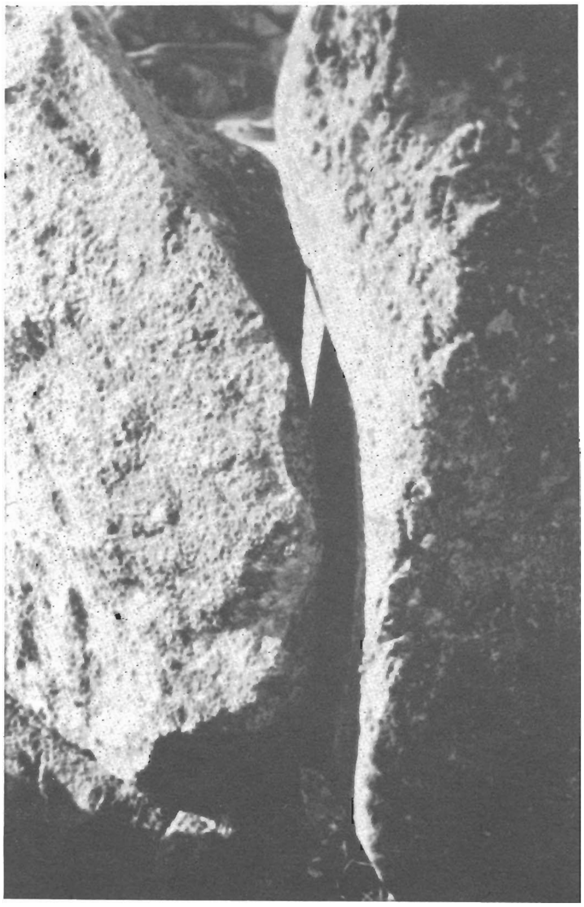
Fig. 7. Sacsahuaman detail, bulges in lieu of indentations and/or grooves. **Fig. 8.** Sacsahuaman lower terrace wall, indentations and grooves at or near grade suggest that stones may have been supported above their present positions. **Fig. 9.** Hatun Rumiyoc, Cuzco, protuberances along lower edges of upper stones in wall; any protuberances on lower stones may have been removed to ease traffic in the narrow street. **Fig. 10.** Sacsahuaman, detail under missing stones shows attention to fit at visible face and slight overcut inside joint.



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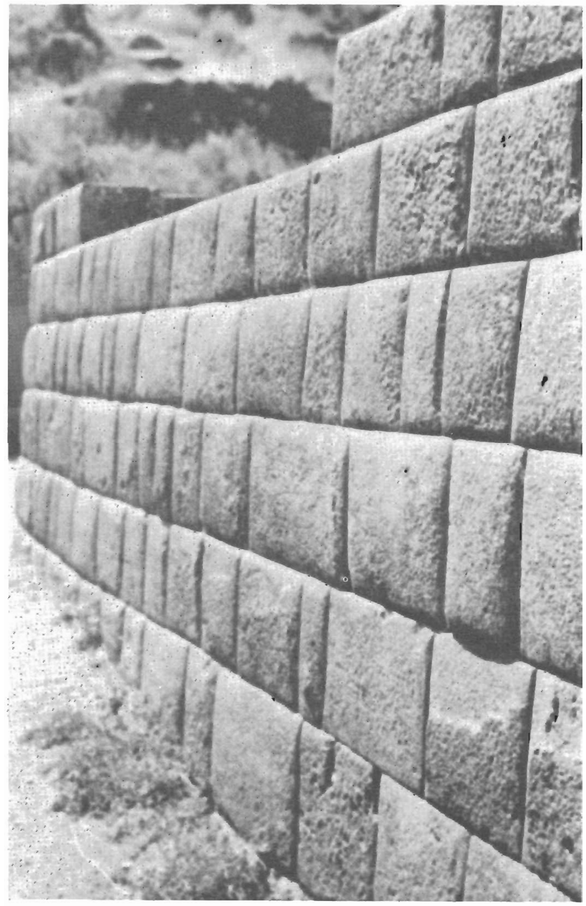

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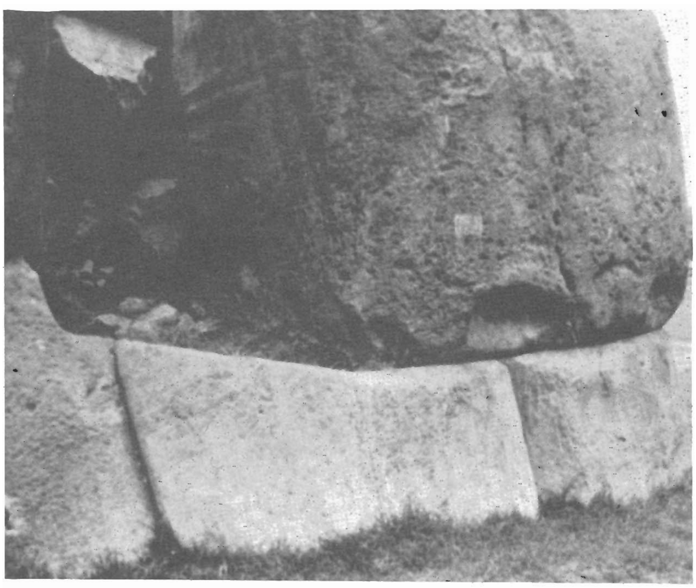

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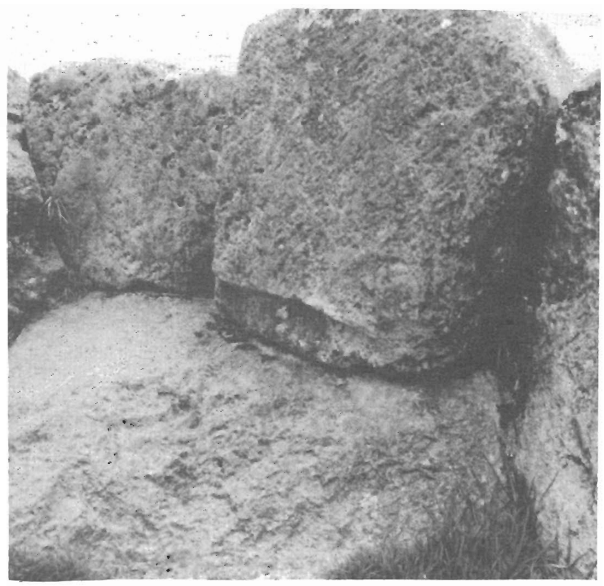

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Fig. 11. Sacsahuaman, detail of open joint shows warped plain along which stones originally met. **Fig. 12.** Pisac wall, slight irregularities in superficially rectilinear stonework. **Fig. 13.** Sacsahuaman, indentations in originally hidden inner face of large corner stone; indentations also occur in third exposed face around corner to right (not shown). **Fig. 14.** Sacsahuaman, groove in rear face of stone in parapet of lower terrace wall. Opposite, front, face (not shown) contains matching groove of similar size.