ÖKÜZINI: THE COMPLEXITY AND VARIATION OF THE SYMBOLIC IMAGERY

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INTRODUCTION

The presence in the Near East of relatively rare but complex Paleolithic / Epipaleolithic modes of symboling, abstraction, and image-making thousands of years before the beginnings of agriculture raises questions concerning the significance of these traditions and their possible role in the conceptual preparation for agriculture, a cultural process which it is generally acknowledged represented a continuation and a change in more than material subsistence and technology (Cauvin 1994, 2000). The relatively rare, though widespread, early images and symbolic artifacts to be discussed in this chapter began to be published in the early twentieth century and thereafter usually site by site and artifact by artifact. There has not, as yet, been either a comparative analysis or a theoretical evaluation of these imaging traditions and artifacts, their possible use, or a study of their possible conceptual contribution to the subsequent beginnings of agriculture, as a cultural, rather than a mere material-subsistence manifest (but see Marshack 1997b, 1999).[1] An opportunity is offered by a preliminary internal and comparative analysis of certain Epipaleolithic images and compositions from the Anatolian site of Öküzini and its neighboring sister site of Karain, with an opportunity for comparison of these to other symbolic materials from this period in the Mediterranean area, extending interiorally beyond the Mediterranean rim. The Anatolian artifacts had been initially described as modes of "depiction," "art," or "decoration." Their recent analysis and a search for the cognitive and neuropsychological bases of their production and possible function indicate that they represent different symboling modes and pose analytical problems of extraordinary complexity for description, comparison, interpretation and inference. An analytical and theoretical attempt will be made to address these processes and problems.

In mid-century E.Y. Bostanci (1959) published the images of "Mesolithic" outline paintings of animals in the Anatolian cave of Beldibi near the Mediterranean coast, including a schematic horse and an antlered stag. A few years later, Kökten found the image of a bovid on the wall of the inland Anatolian cave shelter of Öküzini as well as an unusual set of engraved stone artifacts (Kökten 1961) excavated from a late "Mesolithic / Epipaleolithic" level (Phase 3, Layer IV).

Kökten also excavated images incised on stone from apparently the same period at the neighboring cave of Karain (Kökten 1963). For decades these remained among the few examples of early complex imagery known from this region. Other rare, often single examples of Paleolithic Near East imagery have also been recovered: a Levallois core from Qafzeh Cave with an intentional sequence of incised marks (Hovers *et al.* 1977); a lone incised Middle Paleolithic "abstraction" from Quneitra (c. 54,000 bp) excavated on the Golan Heights (Goren-Inbar 1990; Marshack 1996); an intentionally modified "figurine" of volcanic tuff excavated from the Acheulian site of Berekhat Ram (c. 254,000 bp) on the Golan Heights (Goren-Inbar 1986; Marshack 1997a; d'Errico and Nowell 2000); an incised Aurignacian bone (c. 29,000 bp) recovered from Ksar Akil (Tixier 1974); an incised single zigzag on a fragment of bone from a slightly later period at Jiita in Lebanon (Copeland and Hours 1977); a set of Aurignacian artifacts including animal tooth beads and an incised horse, apparently ritually used, on a stone pebble from the cave of Hayonim in Israel (Belfer -Cohen 1991b; Bar-Yosef and Belfer-Cohen 1999; Marshack 1995 a,b); incised fragments of bone from the early Epipaleolithic site of Ohalo II (c. 17,000 bp) (Nadel 1990, 1991); and, of particular interest, an extraordinarily complex composition incised on each face of a pebble from the late Kebaran site (c. 14,500, bp) of Urkan-e-Rub II in Israel (Hovers 1990). The sparsity of this early Paleolithic evidence (Cauvin 1994, 2000; Bar-Yosef 1996) contrasts strongly with its variability, suggesting that the sparsity may in large measure be due to a prior lack of widespread systematic Paleolithic excavation.

The complexity and quantity of the available evidence increases with the Epipaleolithic imagery from Öküzini and Karain. It is within this general period that one also finds the complex "geometric" composition from Urkan-e-Rub II in Israel, a composition that is conceptually and chronologically related to an incised composition from Öküzini. In the period that followed there is an explosion of symboling modes and forms of imagery in stone and bone in the Epipaleolithic culture of the Natufian (e.g. Belfer-Cohen 1991, Valla and Bar-Yosef 1997), again providing "geometric" compositions that are comparable to those earlier found at Öküzini and Urkan-e-Rub II.

It is not, however, the quantity but the *variability* and complexity of these early Paleolithic and later Epipaleolithic images that suggest a significant presence in the Near East of widespread and diverse modes of symboling, only a part of which has been recovered or fully described. Recent microscopic studies of the Near East Paleolithic symbolic materials and comparisons with symbolic materials and traditions in Europe suggest the presence of certain common symboling modes in both areas. The Anatolian Epipaleolithic artifacts from Öküzini and Karain can, for instance, be compared typologically and stylistically, as well as analytically and processually, to symbolic artifacts from the Geometric Kebaran and Natufian and contemporary modes found in Europe.

At Öküzini and Karain, Kökten found at least a half dozen different categories of incised image and symbol on stone which he categorized as "art" or "geometric decoration" (Kökten 1961; Anati 1968). Recent excavations at Öküzini have also produced an incised, apparently "ritual" geometric composition on a broken bone spatula, representing still another material and mode of incising (Leotard *et al.* 1998, and this volume), strongly suggesting the presence of other symboling modes and materials for this period and region.

A small pebble (4.2 cm) found at Öküzini is incised with the image of a wild aurochs (Fig. 1a). It was schematically published by Kökten (1961:Pl. 35,1) and later by Anati who depicted it as an aurochs that had apparently been overengraved with a female image in the profile "buttocks" style of the European Magdalenian. Anati presented the animal as a crude depiction with two horns and a "ladder-like" motif on its muzzle, apparently similar to the geometric ladder-like motifs incised on a pebble found at Öküzini (Anati 1968:26; Marshack 1995a,b, 1997b). Microscopic analysis revealed, however, that the human figure associated with the aurochs was a male with a bent arm holding a spear that was being thrust into the animal while the seeming protruding "buttocks" of the human figure was a crack in the stone. (Fig. 1b). Microscopy indicated that the bovid had a single front-facing horn produced by two strokes, and an anatomically correct, beautifully incised, muzzle that had been overmarked (or reused) a number of times (Marshack 1969, 1984, 1989, 1991b). The aurochs had a circular eye with an oval addition at the rear; the seeming horizontal ladder-like motif on the muzzle was the "tears" that often descend from a bovid eye (Fig. 1c). These details suggest a well-known tradition of depiction and a familiarity with the aurochs rather than an idiosyncratic and rare instance of crude engraving. Of particular interest, the pebble showed evidence of hand polish along its edges, suggesting possible long-term retention or curation.

The bovid pebble posed an interesting problem. Kökten had originally described the image of a wild aurochs on the wall at Öküzini ("Okuz" means "ox" in Turkish), but the remains of bovids were not found in the cave where the faunal remains were primarily of wild sheep and goat. It had been suggested that the aurochs may not have been an important animal in this group's subsistence. Wild aurochs were, however, present in the Taurus region and may have been seasonally hunted on the alluvial plain; or only major portions of the meat may have been carried to the cave. The presence of a bovid image on the cave wall and the pebble does suggest that the aurochs was a well-known symbolic animal. If so, it may have been killed, actually *or* ritually, by use of imagery, probably in a particular season.[2] Many of the large herbivores depicted on the walls of the Upper Paleolithic Franco-Cantabrian caves, often with indication of seasonal characteristics such as pelage, antlers, and moulting and an indication of symbolic "killing," were not the major species whose bones were found either at home sites or in the caves. At the early Neolithic site of Çatalhöyük, located in this Taurus region inhabited by wild aurochs, bovid heads were mounted on stands and painted on wall panels; the panels not only depicted bovids but also antlered stags surrounded by "dancing" or "hunting" males (Mellaart 1967). The human figures seem to have been made with different paints (Mellaart, personal communication) and may, therefore, have been added to the panels at different times, suggesting a periodic, perhaps seasonal, ritual of hunting and symbolic "killing." The wall paintings at Çatalhöyuk which depict fully antlered stags were patently seasonal. Could the earlier aurochs image on the Öküzini pebble have been *curated*, with the wild aurochs periodically or seasonally hunted or the image periodically renewed and ritually re-killed?[2] Would a seasonal *symbolic* killing of the aurochs have had a different valence than the quotidian or seasonal killing of sheep and goat? If so, could such early symboling traditions and seasonal concepts have persisted into the later Neolithic? Questions of this type, with possible relevance for later cultural developments, would appear often during the Öküzini and Karain studies.

THE "LADDER" PEBBLE

The possibility of long-term use and curation for some of the symbolic artifacts found at Öküzini was also raised by the flat pebble (12.22 cm in length) found in the cave (Kökten 1961:Pl 26,1; Anati 1968:26). The pebble is incised on each face with a different "geometric" composition, a composition that includes twenty-one ladder-like rows of tiny marks, representing more instances of the ladder motif than on any other artifact from this period (Fig. 2 a,b). Similar accumulations of ladder-like motifs have been found in the Geometric Kebaran at Urkan-e-Rub II in Israel as well as in the later Natufian at Hayonim cave, but similar motifs are also found in the late Gravettian and Epigravettian of Mediterranean Europe to the north. The sequence of changes in tool typology within this Mediterranean region indicates that Anatolia lay at a geographical crossroads for the dissemination of certain typological modes and perhaps also of certain generic cultural concepts.

The extraordinary complexity of the Öküzini pebble, its accumulation of "ladders" and its positional cueing "signs" (Marshack 1995a,b, 1997b, 1999), suggest that it was part of a well-known tradition rather than a unique and idiosyncratic artifact. Of particular interest, there is significant hand-polish along all edges of the stone, especially where it had been gripped while it was being incised and used, suggesting that the stone was curated and used for a considerable period. In places where an incised mark meets the pebble's edge, these marks often also show hand polish and wear.

It is likely that when this pebble was originally found, either in a wadi, a colluvial deposit, or at waterside on the alluvial plain, it was noticed that the stone consisted of a neck or handle and a wide trunk or body, with one face perfectly flat but the other divided into four distinct softly modulated water-worn planes (Fig 3). These planes are not indicated in the linear rendition of the incising (Fig. 2b), but they are clear in the side-lit photo. It became clear during the study that the unique shape and topography of the stone had influenced and constrained the mode and sequence of engraving on each face. The stone may have been retained because of this unusual topography and in recognition of its potential specialized use. In any case, the shape and the topography of the stone influenced and directed the analysis, as well as the inferences drawn from that analysis.[3] The blocks of "ladder-like" rows on the second face occur in three areas, each on a different plane and incised differently, having been constrained by the shape and size of the area. The reverse face of the stone is perfectly flat and, for reasons that will be explained, it was apparently the first face to be incised. It begins with a circular "design" in the wide area of the stone and has a ladder-like accumulation along the narrow handle (Fig. 2a). The analytical problem was to determine, if possible, the relevance of these structural and positional differences; the sequence of engraving; the differences within the rows including their anomalies, signs, cueing marks; and the hand-polish along the edges, all of which suggest long-term use and curation.

The initial microscopic study revealed anomalies or idiosyncratic additions within each of the twenty-one ladder-like rows (Fig. 4a-d) (Marshack 1995a:588, Fig. 3; and below). These anomalies suggested that different incising behaviors and positional decisions had occurred during the incising. The stone had also been reoriented and turned three times for incising the blocks of ladders in different areas. Each of the ladder-like rows begins at the left, usually with carefully aligned vertical strokes, but the incising then often grows more slanted and steeply angled as it moves towards the right and away from the center of stability offered by a presumably left hand grip on the stone and the changing angle of right-hand wrist action as the incising tool moves towards the right. These data suggest that the incising had not occurred with the stone resting on a solid surface, but while held in one hand, a process that involved persistent accommodations to the constraints of the space available in each area and the geometry and topography of the pebble. At the same time, the engraver was apparently evaluating and monitoring an original intent or plan. The process had not only involved changing orientations and grips on the stone and an incising tool, but also occasional changes of an incising tool.[4]

Because of this complexity, the analysis grew increasingly "cognitive," becoming an inquiry into the changing decisions, many conscious but some perhaps subconscious, made during the accumulation. The analysis also attempted to discern the possible relevance of the two differently incised faces and the positioning of the *three* major blocks of "ladders" on the second face. It was clear that the subsets constituting the rows as well as the rows themselves were of different length and had been incised with different rhythms of marking. In addition, though the rows and subsets had been accumulated sequentially, they had not been accumulated in either a regular or consistent manner. Why? Could these highly irregular rows, sets, and subsets have possibly been counted? There was also a broader question: what possible relevance could a curated artifact of this type have had within a hunting-and-gathering group that had maintained periods of seasonal mobility and occasional sedentism? The cave of Öküzini was apparently occupied primarily in the spring and early summer, that is, after the winter rains (Léotard *et al.* and Emery-Barbier this volume). The stone may therefore have been transported across these seasons and to different sites. There were also questions concerning the possible relation that this composition may have had to the other modes of symboling found at Öküzini, at the neighboring site of Karain, or at other sites within the Near East during this period.

Face two is assumed to be the main face, in part because it is the most complex and took the longest to accumulate (Fig. 2b). It was apparently also the second face to be incised. It contains the three blocks of "ladders" (A, B and C), each incised on a different plane and with a different "sign of closure." Block A ends with an inverted "Y" (Fig. 4a); Block B ends with an anomalous extension, consisting of two added small horizontal containing lines, inserted at an angle and then marked with additional strokes (Fig. 4b); this row and the block are finally "closed" by a small stroke over the edge of the pebble (Fig. 18 a,b). Block C ends with a deeply incised broad horizontal "bar of closure" (Fig. 4c). Row #6 of Block C ends with a cross (Fig. 4d). It was these carefully positioned anomalies or "signs of closure" that had initially suggested the presence of notation (Marshack 1995 a,b).

Direct microscopic studies of prehistoric compositions from different regions of the world had indicated that positional anomalies of this type did not occur in decorations or on artifacts that would considered "art." Such anomalies were usually intentional, positional, and apparently often *ad hoc*, determined by a decision made at that time and at this position, rather than being aspects of "style" or tradition. Positional anomalies of this *ad hoc* type are found often among the Paleolithic records or notations. Positional cues occur also in modes of ritual marking (e.g., Marshack 1977) and in simple forms of recording such as the message sticks used among certain preliterate hunting-gathering groups (Mountford 1938). Message-sticks, for instance, could be read primarily by the maker and the carrier since, like the early notations, they were neither a mode of formal "writing" nor intended as public documents. The far more complex information carried in the Paleolithic notations, e.g., *sets* and *subsets* accumulated over time, was also personal and not intended to be read by others; the encoded information would have had to be imparted by the engraver.

Since it apparently represented a widespread tradition, would the Öküzini accumulation and its signs and anomalies indicate a recognizable cultural pattern? Of particular interest was the fact that the single row with the greatest number of unit marks, row #6 of Block C, ended with its own "sign of closure" (Fig. 4d). This was considered to be unusual because this sign did not terminate block C but only that single row; Block C ends two rows below, with row #8, and its own more vigorous, "sign of closure" (Fig. 4c). The "cross" on row #6 may, therefore, have had a positional significance related to that row.

There were other findings of interest. Row #4 of Block C ends with a dramatic change of the point used to incise a subset of marks. The previous subset was incised with a sharp point, but the last stroke of that set is crossed over at a different angle by a flat point that was used to rhythmically incise a subset of 8 strokes (Fig. 5a,b). Such positional anomalies not only occurred at the end of a row or block, but also at the beginning of rows, within rows, and throughout the composition. Among the anomalous sets, for instance, were those that occurred at the beginning of row #3 of Block A and the beginning of Block B. These anomalies and variations included cueing marks and signs as well as differences in the length, angle, and pressure of single strokes and subsets and differences in the cross-section, spacing, and rhythm of marking sets and subsets.

Though discernable by microscopy, it was not clear whether these differences were always intended, were at times an epi-phenomenon of the accumulation process, had been incised at different times and under different conditions, or had meanings comparable to the terminal cueing marks or signs that were noted above. It seemed increasingly probable as these data accumulated that the composition represented a non-arithmetic, positional mode of notation or recording, a mode in which there was a certain level of short *subset* counting (as in the 8 flat strokes noted above), but that the notations did not involve a system of superordinate summing.

Considering the number of unit marks within the ladders (more than 800), the number of incised rows (21) and the hand polish along the edges, it seemed that the stone may have been incised or used for a period of more than two years. Öküzini's seasonal occupation suggests that the stone had been incised and used at the cave at least twice during this two year period, but at other times at other sites.

The First Face

On the first face (Fig. 2a) in the wide area at left, a set of sharply incised circles had been engraved. A large containing-circle was incised first, beginning with a line from the upper edge of the stone into this broad area.[5] Within the encompassing circle, 12 smaller irregular circles were incised, either at one time or in a sequence over a period of time. The incising is so thin and fine that one assumes that microliths had been used and, since such points were small and abundant in this period, they could have been curated for a period or be easily obtained at any site. The suggestion for a sequence of accumulating the small inner circles over time was strengthened by the microscopic evidence that at least a half dozen other small circles were later randomly incised within this wide area but outside of the encompassing circle. They were incised by points which created a flat, not easily seen, cross-section (Fig. 6 a, b), suggesting that these had been added at later times. The large encompassing circle ends before it has completed its arc. After the twelfth inner small circle had been incised (actually a half-circle), an arc was incised inward and upward, then turned 180° to meet the lower horizontal containing line of the "ladder-like" accumulation that extends from mid-stone towards the edge of the stone at far right. Though structurally distinct, these two motifs or images were apparently intended to be continuous, one running into the other. If, as seemed likely, the incising began on this face of the stone with the large circle and its smaller inner circles and was then continued into the ladder, the coalescence of imagery may have been significant. But how?

The First Ladder

Microscopic study indicated that the appended ladder consisted of subsets made by different points, pressures, rhythms, and angles of incising. Because of the small scale of the tiny strokes, roughly that of the unit marks on a centimeter or inch ruler (Fig. 7) I had expected to find a sustained and rhythmic incising of strokes.

Instead, there were persistent variations in the individual strokes and the subsets. The first four strokes are widely spaced (Fig.8a) but the fifth is incised at an abrupt angle. It has the appearance of a cueing mark, but microscopy indicated that the incising point had struck a fossil intrusion and was forced to follow it downward and towards the right (fossil intrusions occur elsewhere on the stone and were ignored or overengraved). An irregular thin line is lightly incised in front of this angled stroke, possibly indicating that this position now had a certain cueing relevance. The next six strokes (6-11) appear to be incised with a different tool, by a point that created an irregular wave-like, abraded edging. A cross-sectional study of the strokes could not be conducted because sand granules had accumulated, hardened, and encrusted within many of the strokes; some of the sand granules are red, the color of the soil in the cave (Emery-Barbier, this volume). The next two strokes (12 and 13) seem to represent a set, made with a different pressure and tool. Strokes 14-17 show a tendency to be more tightly spaced. Stroke 17 is perceptually arced, breaking the rhythm of essentially vertical marking. There is then a microscopically "wide" space and strokes 18 and 19 are incised at a different angle, apparently as a subset. Strokes 19 and 20 form a "Y," but it is difficult to tell whether this seeming "sign" actually is a short angular stroke made by one tool, followed by a long stroke made by a different tool, thus providing the appearance of a "Y." Whatever the case, for the engraver the "Y" would have provided a positional differentiation. Positional differentiations of one type or another appear throughout the composition. An apparent short stroke which follows the "Y" is, actually, a long stroke that was subsequently covered by a granular encrustation (Fig 8b). There then follows a group of subsets, two by two by two by two, and then a deeply incised long single stroke. Following this long stroke are seven short strokes followed again by a long stroke. As one proceeds to the right, the pressure of incising begins to diminish, the strokes become lighter and thinner, and the rhythm of marking is closer and tighter. This area increasingly shows deterioration, flaking, and granular encrustation. No other area of the stone is so heavily damaged. There is an implication in these data that, after the stone was discarded, it had lain on the ground with this face upward, so that water action, "weathering," and granular encrustation had occurred primarily on this portion of the upward face. Microscopy was able to determine most of the very fine, light strokes in this area, often a remnant stroke above or below a containing line or between the containing lines. There are approximately 20 exceedingly fine, light strokes in this area. A count of all the strokes in the "ladder" on this face is roughly 58±. It was of interest that the comparatively tightly packed 20 faint strokes at the end of the ladder encompass an area almost one half that of the initial 20-21 strokes, suggesting that the ladder had not been undertaken and maintained as a balanced design but as a process that involved the accumulation of an intended and monitored quantity of strokes.[6]

The tendency to incise lighter or slanted strokes as the sequence moved towards the right may be due to the fact that the stone had been gripped at the wide body of the stone, and the protruding neck upon which this first ladder was incised was less firmly held. This was one more indication that the incising had not occurred with the stone resting on a hard surface, as occurs when one is writing or incising on a table and is able to apply equal pressure for the length of a row. These variations in the rhythm, pressure and, occasionally, the angle of marking and the tool used, again raised the possibility that the incising may have occurred at different times or locations.

This preliminary study of the first face indicated different sequences of incising including, apparently, a later return to the first face to incise isolated small circles. With this evidence of prolonged use, the stone began to seem more like a periodically visited sanctuary wall than a "decorated" artifact. One cannot carry a rock wall during a seasonal round; one must visit the wall seasonally. One can, however, carry and mark a small symbolic surface over a period of time. Within the conceptual mode being proposed, one can suggest that the sequence of incising on the Öküzini pebble continues from the "ladder" on the first face to the accumulation of "ladders" on the second face, probably beginning with Block A, the area on the neck that is closest to the end of the "ladder" on the first face. The possibility of a continuity of action between the two faces had been raised by the occasional addition of small random circles to the first face, incised with entirely different tools from any other used on that face, possibly therefore during the accumulation of "ladders" on the second face. This suggestion for a continuity of different symboling actions within in a single composition has seldom been suggested in descriptions of Late Paleolithic "geometric designs" (e.g., Graziosi 1960; Villaverde 1994; d'Errico 1992). A discussion and comparative data are, therefore, needed (Marshack 1991a).

Every early notation published to date documents variable, non-standard, problem-solving strategies devised for maintaining a sequential accumulation of sets of marks (often with positional cueing marks and signs), upon the idiosyncratic space offered by a bone or stone surface. The Aurignacian notation (c. 28,000 BC) incised on a bone plaque from Blanchard, France, had involved a boustrophedon or serpentine mode, devised to sequence a linear notation of 69 marks in an area the approximate size of a man's wrist watch; the plaque had then been turned and completed on the other face with a subsidiary final accumulation (Marshack 1972/1991b:41). Similarly, the late Upper Paleolithic notation from the Grotte du Taï (c. 10-9,000 BC) had utilized a boustrophedon or serpentine mode for sequencing more than one thousand unit marks on a small surface. The engraver had solved the problem of a limitation in marking space differently in each area of the bone (Marshack 1991a,b, 1996, nd). The range of *ad hoc* strategies devised for solving the problem of a limitation in marking space at different positions was at first confusing (see appendix). Once the mode was understood, it was clear that these *ad hoc* decisions would not have been confusing to an engraver who was both the problem solver and the "reader." It was interesting also that both the Taï and the Blanchard plaques, separated by thousands of years, had each been turned over for the continuation and completion of a sequence of notation. In addition, the Taï plaque had opened with an abstract motif and had terminated on the reverse face with a set of signs and symbols (Marshack 1991a,b; 1996, nd).

On the Öküzini pebble, the initiating image of the encompassing circle and its smaller inner circles is clearly related to the appended ladder. The Grotte du Taï notation from Europe had been initiated with the motif of a right-angle "fret" or meander (Marshack 1991a,b), a motif that might represent a sign or symbol of periodic sequential time, in part because the fret was visually and kinesthetically repeated in the boustrophedon notation. The boustrophedon mode of sequencing a notation perceptually provides an abstracted image of the concept of periodicity and time.[7] It was with knowledge of the uses of the fret, meander, serpentine and zigzag within different cultures that this researcher had proposed that the right angle frets, meanders, and zigzag motifs incised on the ivory female figurines found at the Gravettian site of Mezin in Russia may have been motifs related to aspects of periodic time and process. One reason is that these figurines are not only profusely decorated with these motifs but they were also periodically and ritually overmarked in the vulva region (Marshack 1991c). The right-angle spiral motif was also incised on an ivory bracelet found at Mezin, a bracelet that is too narrow to have been worn by a man. Mezin also provides the instance of a right-angle spiral motif that is attached to a sequence of incised notation (Abramova 1967:Pl. XXXIV, #7). If such modes of metaphoric abstraction and association were present in the Paleolithic, it may be possible to suggest that the encompassing circle initiating the Öküzini composition is a motif related to periodic time. The twelve inner circles could, for instance, represent a schematic observational year, perhaps a sequence of moons or suns at different observational positions. The attached horizontal ladder, containing a sequence of two months, could then represent a period of observation that followed an incising of the initiating motif.

Face Two: Block A

A visual scan of Block A suggests an utterly random, inchoate accumulation (Fig. 9 a,b). The four rows and the horizontal containing lines of this block are unevenly aligned, and the rhythm and pressure of marking within each row is extremely variable. The first third of row #1 differs from the middle third of that row and the middle from the final third (Fig. 10 a,b) suggesting that the incising of this row had not been produced as a single rhythmic incising event. Between the 14th and 15th strokes on row #1 there are two faint double strokes (// //) angled in a different direction from the other strokes. They seem to represent cueing marks or a differentiated subset at this position.

Similarly, on row 3, the first group of strokes, representing almost one third of that row, is more complex and crowded than the rest of that row (Fig. 11 a-c) but this grouping is also more complex and crowded than on any other row of Block A or the Öküzini stone. By contrast, the rhythm of marking on the second row, the row above, is more spacious than for any in Block A. In the middle of this second row, there is a single deep stroke (|), incised at a slightly different angle; this stroke is followed by a short stroke and then by a "Y" image. There are other perceived differences. The first half of the bottom 4th row is incised more or less vertically, but the second half of that same row is incised at an angle that begins to slant towards the right, similar to the slanting at the end of row 1. Were these differences in the angle of incising due to the way the stone was held for different rows, or perhaps when incising at different times or in different locations? One garners no sense of a consistent or maintained rhythm, pressure, or angle of marking. This variability increases in a stroke-by-stroke analysis.

A line rendering of the first 17 strokes of row 3 indicates that the strokes were not incised with a single rhythm but as small subsets of one or two, made at different angles and with different pressures (Fig. 11 a-c). The fourth stroke has a terminal lower "branch" that may have been caused by the cross-section of the tool as the stroke arced. The last stroke in this group has two intentional strokes appended on its side, apparently indicating a differentiated meaning or reference at this position.[8] There is also a sign of "closing" at the end of row 4, a sign which terminates Block A (Fig. 12; Fig. 4a). The scale of marking within these four rows is, again, roughly equivalent to that found on a modern ruler. Because of this small scale, it is doubtful that the strokes, or the variations and anomalies among them, could have been arithmetically counted after they had been incised, though it is assumed that the subsets had been counte*d at the time* they were incised. Whether or not the sets and subsets could be counted, the rows and the position of subsets in a row could have been read positionally by the engraver, in much the manner that a viewer will increasingly be able to recognize many of these positional anomalies at a perceptual if not semantic level (Fig. 9 b). Human cultural vision functions at many levels of perception and reference, including those categorized in neuropsychology as "bottom up," "top down," "horizontal" and "bihemispheric," that is, as a process within a widely dispersed and complex network of feedback and reference. It is likely that the Öküzini variations could therefore have been read at different levels. Is it possible to attempt a contemporary reading or a tentative interpretation of the variations? Or determine the relevance of the blocks A-B-C or the still smaller perceptual "chunks" that they contain?

Beginning with the first row of Block A, the number of strokes from the beginning of that row to the stroke that comes immediately before the final set of eight long strokes is 31 (not counting the four lightly incised and slanted cueing marks preceding stroke 15) (Fig. 9b). Following these 31 strokes, the final set of 8 long strokes is clearly incised with a different point and rhythm (Fig. 10 b). These 8 terminal strokes have been differentiated by the incising of an upper containing line added to encompass them. Adding these terminal 8 strokes to the first 20 strokes of row 2, a group which ends at the "Y," provides a count of 30. Following this "Y," there are 12 strokes to complete row 2. Adding these 12 strokes to the first 17 strokes of row 3 takes us to the two cueing marks appended to the stroke at the end, for a total of 29 units. The initial surmise had been that the larger "periods" or groupings were lunar and that the two appended strokes may have been the days of last crescent or lunar invisibility. From these appended two strokes to the end of that row is 30 units. The fourth row contains 31 strokes. Each row in Block A is incised with a different pressure, rhythm of marking and spacing as well as a different breakdown of its subsets yet, in sum, we have a seeming record for five observational lunar months. The total of the four rows in Block A is 151±1, a few days more than five observational lunar months (151÷29.5=5.1 months). A tentative breakdown of these suggested "months" is indicated in the linear overmarking presented in Fig. 13. This overmarking suggests a perceptual non-arithmetical lunar breakdown by "chunking," that is, a breakdown that could have been read or evaluated by the engraver without this analytical overmarking. This is not the way one would construct or read a modern arithmetical record, but this mode of sequencing by sets and subsets has been documented in the Taï notation and in other Paleolithic notations within this geographical area (Marshack 1991a,b; 1997, 1999, nd; Riparo Tagliente and Kosslyn below).

Row 2 of Block A begins at left with a tiny stroke that was incised into the natural rise that surrounds the flaking that had spalled from the stone (Fig. 10a). This incised stroke and the edge of the flaking are polished and rounded from handling in the manner of the two opening strokes of row 1. A hand polishing of incised strokes occurs also at the end of certain rows along the stone's edge in Blocks B and C. This evidence of polishing can be added to the suggestion for an apparent periodic addition of small circles to the first face. We seem to have a stone that was in continuing use rather than a static composition, arguing against the possibility that the composition may have been produced at a single moment, or a single incising event, as argued for many Late Paleolithic "geometric" compositions and even notations by F.

d'Errico (d'Errico 1995; D'Errico and Cacho 1991).

Block B

Block B, in mid-stone, is incised at 90° to Block A, within a slight saucer-like concavity (Fig. 14 a.b). It differs from Block A structurally. The slanting that occurs at the end of each of the rows is *leftward*, as in Block C, not rightward as in Block A. It is likely that this change in slanting at the end of a row was due a change in the grip and orientation of the stone while incising. One is also struck by a major anomaly at the top, one that may help in an explanation of Block B. All the ladders in blocks A, B, and C are attached to one another, the lower horizontal of one row forming the upper horizontal of the next; as a result, strokes often cross over into the row above or below. Each of the eight rows of Block B varies as much as do the rows of Blocks A or C, that is, in their alignment, the length of the rows, their distribution of subsets, and their number of strokes. But the first row of Block B is separated from the others with a space between it and the second row (Fig. 14 a,b) It stands alone and has been intentionally separated as a "straggler." For many reasons, including the fact that some of the incising in the "straggler" crosses over and into block A, the "straggler" and Block B seemed to be a continuation of Block A. In part, because of this, the isolated "straggler" was considered to be a continuation from Block A and the row *below* the "straggler," i.e., the second row, was labeled during the analysis as "row 1" in the linear illustration of Block B (Fig. 14 b). Why, however, was a "straggler" at *this* position?

Row 1, the first row below the "straggler," is extremely narrow, almost tentative, and is incised with strokes that are shorter than on any other row on the Öküzini stone (Fig. 16). There is a strong sense that there were different mind sets in the incising and the rhythm of marking of the "straggler" and this second row (row 1) of Block B, perhaps indicating a difference either in the relevance or the moment of incising these two rows. Whatever the case, the evidence suggests a positional intent for the "straggler." There was, in fact, an increasing sense during the analysis that the "straggler" may have been a continuation of Block A, providing a sixth and final conceptual row for Block A which had, for the engraver, run out of space. The "straggler" of Block B also abuts Block A, its upper horizontal and some of its vertical marks cross over and into Block A, confirming the incising sequence: Block A then B then C. Like an isolated cartouche within a sequence of hieroglyphs, the "straggler" stood as a positional puzzle.

The odd nature of these positional anomalies again argues against the possibility that the Öküzini composition is a decoration. It was suggested earlier that there was a conceptual continuation from the ladder on the first face, to row 1 of Block A on the second face. It is now suggested that there is a continuation from the five rows of Block A to the "straggler" of Block B. This suggestion is based not only on its anomalous placement but on the assumption of a non-arithmetical, positional structuring and sequencing for the composition, a mode documented for many of the Paleolithic notations (e.g. Marshack 1991a,b, 1996a, 1997, 1999; and below), and on the assumption that the Öküzini composition is a notation.

If the ladder on the first face (Figs. 2a and 7) encompasses approximately two *observational* lunar months, and if a *solar observation* (solstitial or equinoctial) occurred within the second month of that appended ladder, then the *next* assumed comparable half-year solar observation would occur 182± days, or six months, later.[9] But the four rows of Block A contain only five months. A comparable solar observation should therefore have been expected approximately six months after the second month in the initial ladder on face one, that is, within the first row of Block B on the next face, or within the anomalously isolated "straggler."

Assuming that a sixth-month solar observation was to be expected within the "straggler" of Block B, it may be possible to search for a cueing mark that might indicate such an observed solstitial or equinoctial day (or period). The number of strokes in the "straggler" is 36. This sum is too long for an arithmetical or observational lunar month but it is adequate for an observed "short" month ("short" because the 31-32 day "month" that ended Block A apparently involved lunar observations that included the days of invisibility and the following first crescent). The "short" month of 26 that opens the "straggler" (i.e., minus the two or three days ending suggested for Block A) is followed by a subset of 10 which should continue on the following row until there is a sign or a perceptual break. This type of reading or continuation from one row to the next was demonstrated in Block A. There are two perceptually different strokes within the "straggler": stroke 14 is a long stroke that extends below the containing line, after which the pressure, rhythm of marking and incised cross sections change (Fig. 15). Stroke 22, eight days later, has a stroke or cueing mark added to it. There is no evidence that strokes 14 and 22/23 indicate a particular type of observation. Which of these strokes might, then, mark a surmised solar observation?

If stroke 14 of the "straggler" is the observed half-year solar day, then the previous comparable observation would have occurred 182± days earlier, that is, within the final month of the appended "ladder" on the reverse first face. Since Block A has only 151 strokes, the "straggler of Block B should contain the next half-year observation. If the cueing mark on stroke 22 indicates an observed solar day, then the prior 182± day solar observation would *also* have occurred in the second month of the appended ladder on the reverse face. We can thus conduct a number of tests: both for lunar periodicity and possible solar periodicity.

The subset of 10 days that follows the opening 26 of the "straggler" and that closes that row should continue below, on row 1 of Block B. The seven rows below the "straggler" are of uneven length (34-33-35-38-43-37, with a final 30+8 for 38). The bottom or concluding row is of particular interest. This row has 30 marks on its primary containing line, then two misaligned short horizontals were added at a steep angle. These added horizontals were incised with 6 supplementary strokes (2+2+2) plus a closing 2 below, providing a total of 38 for this final row (Fig. 18 a,b; Fig. 4b). This anomalous ending needs to be addressed because of the possible relevance of the sum or "count" for each block. Block A, as we have seen, has almost precisely five months. Block B, which is far more densely packed, has 293/294 units, or almost precisely ten lunar months: (294÷29.5= 9.96). The rows in these two blocks are not arithmetically "lunar," but the breakdown *within* and *among* the rows suggests an observational lunar sequencing. As noted for Block A, within a continuous cumulative notation, a sequence may be extended to continue into the next row. The fact that a row of notation can encompass more than one month, and extend to a second row, and that rows need not be divided into precise "lunar phrases" or periods, had been documented on the Taï plaque, whose primary structural divisions occurred at positions of "six-month" solar observation. Lunar observations had also occurred within the Taï notation, but they had not been as clearly differentiated as the solar divisions which completed the major rows. It is likely, then, that the misaligned, supplemental ending to Block B may have been intended as the completion of a lunar or awaited solar sequence.

This suggested mode of *ad hoc* record-keeping is different from the manner in which one produces and reads a standardized, arithmetically structured and cued contemporary notation or record. One reason for the probable efficacy of this early method was that these were personal rather than public documents. They were also intended primarily for the limited period of their production and use. Because they were unstandardized and *ad hoc*, they often solved positional problems by an insertion of cues.[10] A record-keeper could, as a result, read his own notation, not as an arithmetical record or calendar but as a private accumulation that encompassed a range of personal observations, knowledge of the sky and seasons, the tradition and the mode, the sequence of months and their relevance within that group's seasonal territory, as well as personal remembrance of the incising and problem-solving acts and decisions that had been made during that particular accumulation. It is not the present static "design" or "pattern" that would have been read but overlapping levels of reference within which that enculturated engraver functioned. Such a sequence would have served as an "aid to memory" at a number of cultural and psychological levels, though not in the manner that has been theorized and discussed on other grounds as a mode of shared *public* "information storage" by recent adherents to the concept of early notation (cf Donald 1991, 1999; D'Errico 1995). Though these early notations were quantitative in their underlying structure (Dehaene 1997, Butterworth 1999; and below), they were neither arithmetic nor syntactic. One could not, then or now, read such early modes in the manner in which one today reads a contemporary arithmetical, astronomical, or linguistic record.

The cumulative process being described had aspects that are not today visible. When incising on limestone, each stroke creates a white powdery line or chalking; each incised set and subset may have persisted in this state for weeks, even if the stone was curated and transported. Over time there would develop a difference in the chalking intensity between earlier and later incising. A prior incising could also be made relatively invisible by wiping a row, a month, or a set with a dampened finger. Pragmatically, this would be like turning a page in a book: the page or set being currently marked and read would then be highlighted with white powder. The process was tested by this researcher. *If* this process was used, it would have made the now static geometric composition one that could have been read as an ongoing, changing, inherently variable process rather than a mere accumulation of unit marks. The suggestion is an indication of the analytical problems involved.

An adequate analysis of these early accumulations requires investigation of processes occurring at many levels, with the most complex being those of contextual, cultural usage and cognitive, *ad hoc* problem-solving (see Appendix). The evidence of hand polish provides a certain low level of "time-factored" processual data; it can be read directly. The possibility that an engraver might be able to read a limestone slate at different levels, personal and cultural, incremental and positional, with attention to seasonal processes, as well as to the nature of a particular stone and its unique potential, requires levels of inquiry that are different from those used in traditional stylistic and typological studies or in structural studies of motifs and designs, or even the more specialized and limited studies of cross-sectional analyses.

The uses of limestone were highly variable, comparable in that sense to the use of clay tokens and clay envelopes as record-keeping devices in a region where clay was a primary available resource; the use of papyrus where that material was a primary resource; the use of cordage for quipu records in Peru where textiles, fabrics, and color dyes were abundant; or the uses of bone, ivory and antler in the European Upper Paleolithic. All such materials function and could be used differently with regionally devised strategies and modes of record-keeping or information storage. Limestone surfaces have their own properties and these would have been learned within any hunting-gathering culture using the material. Limestone was used for incising Late Paleolithic notations at Urkan-e-Rub II and Hayonim in Israel; and for incising both imagery and notations in Europe (see below).

Block B Continued

A first scan of block B (Fig. 9 b) indicates that the rows are as variable as those in Block A. Each row, and the subsets within them, contain different rhythms of marking. Each row begins at left with relatively evenly incised vertical marks, but the rows become increasingly slanted as they accumulate towards the right. The strokes at far right also become increasingly slanted as the rows descend, with the greatest angle of slanting occurring in the final bottom row, suggesting once again that the stone had been held in hand during the processes of incising. Though the slanting in Block B is towards the left, in Block A the slanting towards the end of a row tended towards the right, perhaps because of a different orientation and grip on the stone while incising. Some rows in Block B, as in Block A, have far more units than others, again arguing against a planned and monitored decoration.

The suggestion for non-arithmetical lunar observation presents a number of problems. If we assume that the "straggler" represents a *positional* sequence of relevance, and that the long 14th stroke within the "straggler" is a cueing mark for a possible solar observation, the next such solar observation (equinoctial or solstitial) would be approximately 91± and/or 182± days later. This assumes an observation of solar periodicity that is concurrent with, but different from, a lunar observation.

With this assumption, counting from the 15th stroke of the "straggler" to the end of that row, there are 22 strokes, 23 if the added stroke on the 22nd is considered to be a unit of notation and not a cueing mark (Fig. 14 b). Counting 91± strokes from this 15th stroke takes one to the 4th stroke of row 3: (22+34+33+4 = 91). This 4th stroke, which comes after an opening 3 strokes incised at a different angle, looks somewhat like a "Y." But this 4th stroke is a normal straight stroke that has had an arcing stroke attached to it, perhaps as a "cueing" mark or observational unit (Fig. 17) (this arcing stroke has red sand encrustation within it and so it has been lightened for the black-and-white photo). This 4th stroke is the 91st from the 15th stroke in the "straggler." But this 4th and 5th stroke is also part of a subset of 9 strokes that begins row #3, a group that is anomalous since it is produced with a variability and rhythm of marking that is different from that maintained for the rest of that row. In this sense the beginning group of 9 recalls the set of 17 strokes that began row 3 in Block A (Fig. 11 a-c). From the 6th stroke of this group, the stroke *following* the appended arc, there are 30 strokes to the end of that row. Counting 91 strokes from this 6th stroke (30+38+24=91) takes one to the 24th stroke of row 5. Row 5, containing 43 strokes, is the longest in Block B. The 24th and 25th strokes of this row constitute a subset made with a different point and pressure from the differentiated subset of 5 tightly packed strokes that follow; this tight subset of five suggests a discrete "period," perhaps an observational *lunar* period initiating a new sequence.

Counting 91 strokes from stroke 25 of row 5 brings one to the end of the last row of Block B: (19+37+38=94). This is the row that was extended after the 30th stroke by the addition of two short upward-angled horizontal containing lines marked with six strokes (2+2+2), with two lower closing strokes incised with a different tool, to give a sum of 94 (Fig. 4b, Fig. 18 a, b). A "91st" stroke would fall within these *added* marks of the last row. The anomalous ending appended to Block B may therefore have included an awaited solar observation and a period near the end of an observational lunar month, the last crescent, the days of invisibility, and the first crescent. If so, the first row of Block C, which follows, should begin with a "short" first month. It is assumed that the appended horizontals and the added strokes at the end of Block B were intentional and neither random nor decorative.

Block B is, therefore, bracketed with an isolated "straggler" at the top and a set of anomalous additions at the end, making it possible to assay a structural breakdown involving a presumed lunar and *concurrent solar* reading. A linear rendition of Block B with a horizontal overmarking indicates the suggested observational "lunar" periods (Fig. 19). A star sign is placed at the position of possible solar observations at 91± day intervals. In this assay, Block B begins and ends with a period of seasonal solar observation. It is assumed that the Epipaleolithic engraver would have been able to see and evaluate such periods as perceptual chunks without these analytical overlying lines or analytical cueing signs (cf Kosslyn 1988, and below; Marshack 1991a,b, 1997, 1999, nd) since the sequence of groupings had been personally incised and the observed phenomena were self-validating.

These accumulating analytical and inferential data, i.e., the hand-polish indicating long-term curation, the data found on the first face, the many anomalies and cueing indications throughout the composition, and the apparent match with a lunar and possible solar observation, seem to provide interlocking evidence for a "time-factored," *ad hoc* process and tradition of non-arithmetical accumulation and positional record-keeping.

Though these analyses and inferences are not a proof, the concepts and the postulated mode, if valid, may be crucial for understanding certain preparatory concepts that may have abetted the rise of agriculture and the subsequent development of the calendrical and record-keeping cultures of the Holocene (Marshack nd).

The terminal Upper Paleolithic notation from the Grotte du Taï in France (Marshack 1991a,b) had documented a process of set and subset record-keeping that involved non-arithmetical observations of lunar periods in apparent concurrence with solar observations marking "half year" periods (solstitial or equinoctial). This type of concurrence is common in "calendar-keeping" cultures. Almost all later traditions of "calendrics" involve the observation and coordination of concurrent sequences and periodicities. In a modern society these usually involve interlocking tapestries of religious, administrative, political, agricultural, manufacturing, aggregational, memorial, familial and personal, as well as debt, trade, and market sequences. The definition and description of an historical culture can, at this level, often be made in terms of the interlocking processes that occur within such calendrical tapestries. Every early agricultural society had its concurrent calendars of overlapping cultural sequences: Mesopotamia, Egypt, Mesoamerica, South America, China, Siberia, Africa, and such modes are still maintained among many indigenous cultures and peoples today. Of importance for the present analysis, the coordination and maintenance of such concurrent calendrical sequences is almost always assigned to an individual (or to a group of specialists), though the narrative and mythic structures and the pragmatic activities that are embodied in such tapestries are usually well known and often participated in throughout the culture (Marshack nd). That a sequence as *seemingly* "simple," but as analytically complex, as the Öküzini composition could function at different concurrent levels of observation and reference is consistent with a body of comparative ethnographic evidence and with theoretical models on the time-factoring of cultural tapestries (Bailey 1993), and it conforms to the analytical and discursive frameworks found in the developing subdisciplines of archaeoastronomy and ethnoastronomy (Aveni 1989a,b; Krupp 1996; Ruggles and Saunders 1994; Iwaniszewski 1999; and the journal *Archaeoastronomy*). If there existed early Paleolithic non-arithmetical modes of abstractly structuring cultural and subsistence time-and-periodicity, then we may have one specialized indication of some of the underlying cultural and conceptual processes that were involved in preparation for the more formally structured tapestries of the later farming cultures and, more basically, an indication of the fundamental, essentially time-factored nature of human cognition and culture itself. Every early agricultural society was faced with the fundamental problem of creating and maintaining a "time-factored" subsistence and cultural-social tapestry. But hunting-gathering cultures are also faced with this fundamental human problem, though at historically and developmentally different or simpler levels of practice, observation, and social/cultural maintenance (Marshack 1999).

Block C

Block C (Fig. 20 a,b) has 8 rows, the same number of rows as Block B, but the area is almost twice that of Block B and so the rhythm of marking and the spacing are different. A visual scan of the line rendition for Block C indicates that, once again, the ladder-like rows are neither symmetrically nor similarly incised. Some rows, such as 2, 3 and 4, are incised rather vertically, but other rows have a clear tendency to slant towards the left as they accumulate, again suggesting a hand-held incising, perhaps under different circumstances, a different grip, or at different times or locations. There is no sense that a rhythmic incising provided either coherence or uniformity to the eight rows. There is hand polish along the edge of the stone around Block C and on some of the strokes that impinge on the edge. Two vertical fossil intrusions at far right were ignored during the incising, particularly in rows 5 and 6; they were ignored because there was apparently a need for additional marking space after the fossils. Row 6, the longest of the rows, extends beyond both fossil intrusions and has a "sign of closing" after the second (Fig. 4d) created by a horizontal line that was incised over the final vertical to create a "cross" (Fig.21). Block C ends two rows below, with row 8, and this final row has its own far more dramatic "sign of closing," a broad wide band (Fig. 4c; Fig. 22). This sign essentially terminates the incising on the Öküzini stone. Even a cursory glance indicates that despite its differences, Block C documents the same type of variability present in Blocks A and B.

The most dramatic instance of a change within Block C, which was apparent before a row by row analysis had begun, occurs at the end of row 4 where the final stroke of a slanted sequence incised with a relatively sharp point is overcrossed by a flat point that was used to incise a subset of 8 flat vertical strokes. This row is then closed with two thin strokes made with a different rhythm and pressure (Fig. 5a,b). These eight flat strokes were apparently incised at one time, suggesting an arithmetical counting for this subset (Marshack nd). This subset of 8 uniform flat strokes contrasts strongly with the irregular accumulation of 17 strokes that begins row 3 of Block A (Fig. 11 a-c), a group of subsets that had apparently been incised at different times. These differences among sets and subsets would seem to be due to the different times of incising and to differences in the observations and record-keeping that had occurred at these positions.

A *preliminary* count of all the strokes in Block C is 308 (plus or minus one or two indeterminate strokes or edge marks); this is a possible 10½ month period of non-arithmetical lunar recording (308÷29.5=10.4). This sum is less than a lunar or solar year, but it is sufficient to have encompassed three solar (solstitial and/or equinoctial) seasonal observations within a sequence of lunar "month" observations.

If Block C continues from Block B, as the mode and evidence suggest, the first row should record a short month, i.e., minus the lunar days that were appended at the end of Block B. Row 1 of Block C has 23 strokes (Fig. 20 b), not enough for a full lunar month; however, the first three strokes of row 2, are made with an apparently different tool and end with a "cueing" mark (Fig. 23). After these four strokes the angle of marking and the cross-sections change. This opening set of four may thus be the completion of row 1, just as row 1 may be a continuation of row 8 of Block B.

Block C posed two analytical problems: the need for a row by row microscopic analysis and the challenge of demonstrating a possible concurrent lunar and solar observation. If, for instance, a solar observation was to be expected 91± days after the one assumed to have occurred within the appended end of Block B, it would have to occur in row 3, possibly in the subset near the small "v" sign that closes that row (Fig. 24). The next solar observation should then occur about 91± days later, within the 6th row, which has its own sign of closing at far right, the horizontal stroke forming a cross (Fig. 4 d, Fig. 21). Row 6 is the longest and the most densely packed row in Block C (compare it to row #1); it contains 60 to 61 strokes, possibly constituting an observational two month period. There was a question as to whether, and how, rows 6 and 8, with their different "signs of closure" might conform to the proposed model. The model suggests that there should be some indication of a *solar* observation in either row 6 or 8.

Not only do the rows in Block C vary in length and count but the strokes, sets and subsets also vary typically in their rhythm, spacing, and angle of marking. A few examples illustrate these differences.

In Block C there is again evidence demonstrating an incising sequence of A-B-C. Row 4 of Block C begins with a thin stroke that crosses over the lower horizontal line of Block B to the left, just as strokes from Block B crossed over into Block A. Row 4 of Block C consists of subsets incised at different angles and with different tools or cross-sections; this row changes its mode of incising in the middle, after a single long vertical (Fig. 25). This row ends with the subset of 10 in which the first 8 strokes are produced by a wide, flat point (Fig. 5a,b). Row 5 begins with 10 strokes before a wide space after which there is a change in the rhythm and angle of incising. With row 5 the incising on the stone becomes increasingly slanted as it accumulates towards the right.[11] Row 6, the longest in Block C, ends with the image of a cross. It begins with sharply incised vertical strokes but the 9th and 10 strokes represent a small subset, after which the incising point apparently changes. The 16th stroke has a cueing mark or a unit added to it. The 21st and 22nd strokes indicate that the incising point had broken, evidenced by the abrupt mid-stroke changes that occurs when a point breaks but the incising is continued. This is the only such instance of breakage found on the Öküzini stone.

Row 6 is the longest row in part because it extends into the wide space at the right after it has crossed beyond the two vertical fossil intrusions. The final stroke, incised after the second fossil intrusion, is overmarked with a horizontal to create the image of a "cross"(Fig. 4d; Fig. 21). It is possible that the terminal cross marked this row as one in which a solar observation had occurred or was expected. The bottom row, row 8, two rows below, begins like the others, with differentiated subsets: the 12th and 13th strokes, however, constitute a dramatic short subset incised at a sharp angle (Fig. 26). The strokes in rows 7 and 8 begin vertically but become increasingly slanted as they proceed to the right. The final three or four hesitant short strokes of row 8 are overmarked with the broad closing horizontal stroke (Fig. 4c; Fig. 22). As noted, there are 308 ± 1-2 strokes in Block C, or 10.4 lunar months, encompassing three to four solar observations if the assumed solar observation within the set of 8 added strokes at the end of Block B is included. The full sum of strokes on the stone, including the lone ladder of 58± on the reverse face, is 807 ± 1 or 2. The breakdown by blocks is: (Face #1) 58 + (A)159 + (B) 294+ (C) 308 = 807 or more than two years (365 X 2 =730), possibly encompassing 8 or 9 quarter-year solar observations 91± days apart, or 4 longer half-year solar observations 182± days apart. It is assumed that the hand polish along the edge of the stone represents a period of curation and use for at least these 807 days, a period that would have encompassed both group mobility and occasional sedentism.

Though the inferences drawn from these analyses are hypothetical, it should be clear that the complexity and persistent variability of the analytical data cannot be explained by any theory that suggests that the composition represents a decoration made with one point and at one time, as has been often suggested for early linear compositions (D'Errico 1989, 1991, 1992). Nor does the complexity and variability suggest a random marking or the presence of an entoptic image that was seen during a trance hallucination, as has been proposed for certain early "geometric" compositions (Lewis-Williams 1981; Lewis-Williams and Dowson 1988, 1989; Marshack 1989b; and Note 12).

The data that have been presented are adequately explained by the psychological and neuropsychological processes that are present in normal human vision, in visual problem-solving and abstraction, the acquisition of expertise, and by the nearly infinite variability that is found in human image and symbol production (See also Kosslyn below). It is interesting that these quite normative processes of cultural vision have never been applied to any of the "geometrically" structured Paleolithic compositions and artifacts by the proponents of the entoptic hypothesis (cf Marshack 1989b, and below).[12]

Having explored Block C at different levels of analysis and inference, a tentative analytical linear breakdown is presented (Fig. 27). A horizontal overmarking of the ladders suggests perceptually differentiated observational lunar periods; a star sign again indicates the position of possible solar observations at 91± day intervals. A visual scan indicates that the suggested lunar periods are, in fact, perceptually discrete, the breaks usually occur at a cueing mark or at a change in the rhythm and angle of marking. Within the process being suggested such groupings could probably have been read as discriminated periods by the engraver. Aspects of the basic visual-neurological mode by which one reads such differentiated perceptual chunks has been described by Kosslyn (1988; and below).

It should now be possible for a modern viewer to "see" the Öküzini composition, probably at first perceived as a static geometric pattern, as the product of a complex, time-factored process, a composition that had been incrementally accumulated within a seasonally mobile but occasionally sedentary hunting-gathering group, a composition that may have symbolically and practically helped to cohere its way of life (Emery-Barbier, this volume, on spring/summer vegetation at Öküzini). While these analyses and inferences reside outside of any current archeological paradigm, they conform to a number of recent theoretical and analytical models concerning the inherently variable and often uncertain seasonal hunting-gathering way of life (Rocek and Bar-Yosef 1998). It is apropos, then, to briefly present an analysis of comparable compositions found among certain mobile but at times more sedentary hunter-gatherers within this circum-Mediterranean area of Eurasia, and from this Late Paleolithic/Epipaleolithic period.

URKAN-E-RUB II AND HAYONIM, ISRAEL.

In 1990, E. Hovers published the report of an incised limestone pebble (9.2 cm long) excavated at the Geometric Kebaran site of Urkan-e-Rub IIa, situated on a terrace of the Wadi Ahmar whose winter run-off today flows through the Jordan Valley to the Jordan River (Hovers *et al.* 1988; Hovers 1990). The Hovers report was the first careful study of an incised geometric composition containing sets of ladders from the Levant, and it remains the type study for this class of Near East artifact. Because of the care taken by Hovers in addressing these processes it was these descriptions of the Urkan pebble that instigated this researcher's study of the Öküzini pebble in Anatolia and this class of imagery in Israel and Jordan.

Hovers noted a similarity of the Urkan composition to the Öküzini engraving, primarily because of their use of ladders but also noted that the compositions were structurally different.

However, there are similarities. The Urkan pebble, like the Öküzini pebble, documents significant hand polish along its edges, suggesting curation and long-term use; the Urkan pebble has a different composition on each face; it provides evidence for a use of "different tools" at different positions and, as suggested by Hovers, the possible incising of each face of the pebble by a different person. The two faces may, however, have been incised by one person at different times, at different locations, with other tools, and with different concepts.

Though there are ladders on each face of the Urkan pebble, the disposition of ladders is different than on the Öküzini pebble (Fig. 28 a,b). This is no surprise, since the early notations are unstandardized and largely *ad hoc* and therefore vary structurally. A microscopic analysis reveals that the Urkan engraving is, however, a variant of the Öküzini tradition, confirming and amending many of Hovers' findings. The Öküzini pebble, which is slightly larger than the Urkan pebble, has 22 ladders, while the smaller Urkan pebble has five isolated ladders plus a final melange or block of ladders on the second face. The Urkan composition, like the Öküzini composition, documents the presence of different *ad hoc* problem-solving decisions on each face and in each area, both in the positioning of the ladders and in a use of symbolic motifs in association with the ladders. Though the Öküzini and Urkan artifacts are visually and structurally different, they are analytically and functionally comparable. Of particular interest, the Urkan and Öküzini compositions represent a symboling mode that is also found in the later Natufian at Hayonim (Belfer-Cohen 1991b; Marshack 1997, 1991b, nd).

The analysis begins with Hovers' "Face B" (Fig. 28b) because it is the most complex and difficult and because it addresses a greater range of analytical problems. Hovers suggests that the incising began with the carefully incised grid or net motif at far right and that the two ladders along the sides which meet at the apex were the last items to be incised. This was interesting because a motif or symbol which either begins, ends, or accompanies a notation can be important in the attempt to understand its possible meaning. Hovers' line rendition indicates that one line of the net motif crosses into the upper ladder. Which, however, had been incised first, the net or this upper ladder? Microscopy reveals that the line from the net crosses *over* and into the upper ladder as well as over its lower containing line and some of its unit marks (Fig. 29 a,b). This evidence is comparable to the overcrossing lines from Block B into Block A and from Block C into Block B on the Öküzini pebble. A careful analysis of the incising on face B of the Urkan pebble indicates that the net motif represents the *terminal* incising on this face. The upper ladder was the first motif to be incised and it was incised like all sequences in this tradition, as sets and subsets made by different points or cross-sections with periodic changes in the angle, pressure, and rhythm of marking the subsets. The macrophoto (Fig. 29 b) also indicates that the lines from the net cross over and into the central melange above it. The melange, therefore, also precedes the net. A careful microscopic analysis indicates that the upper ladder (Fig. 28b, 29 b) was the first image to be incised on Face B; the narrower ladder at left, appended to the first at the apex, represents the second incising. The melange between these two ladders represents the third incising, while the net or grid motif terminates the engraving on this face. Establishing the sequence for these four elements was crucial in the attempt to understand the possible meaning or intent of the Urkan composition.

All the ladders on the Urkan pebble, as is apparent also in the schematic line renditions published by Hovers and by the close-up photos, were incised as subsets of different length, pressure, angle of marking, and with periodic changes in the cross-sections of the points used; at this level, therefore, the process is similar to the mode documented for the Öküzini pebble. The detail from the first ladder on Face B indicates these differences (Fig 29 b). This process of changing the angle of marking and the cross-section for different subsets had, in fact, been noted by Hovers in describing one of the vertical ladders on Face A: "The third ladder has 17 rungs of which the upper 4 and the 13th seem to have been made by a different point that produced a double line. The latter also has a different orientation than the rest..." (Hovers 1990:317). Figs. 30 a,b document the cross-sectional and angular differences within this "ladder" on Face A, variations of a type found among all the ladders on the Urkan pebble, as well as on the Öküzini pebble and other examples of early notation.

Microscopic analysis of face B reveals that the melange of lines in mid-composition consists of descending rows of ladders. These rows were produced by short horizontal containing lines that were appended to one another, each subsection then being marked with its own subset of strokes (Fig. 31), suggesting a periodic accumulation of highly variable subsets. The mode is conceptually, if not perceptually, similar to the more ordered accumulation of descending rows found on the Öküzini pebble. Unlike the ladders incised on face A of the Urkan pebble, or the ladders along the sides of face B, the ladders and their subsets within the melange were incised with exceedingly sharp, fine micropoints, in a manner that suggests that they may have been incised not only at different times, with different micro-points, but perhaps at different sites or locations and apparently without a stable or comfortable resting place for either the engraver or the pebble. It was these differences of incising that led Hovers to suggest that Face B may have been incised by a different person. Within the tradition being proposed, it may be more reasonable, however, to suggest that the incising occurred under different conditions. By contrast, great care and control is evident in the one-time, single-point incising of the terminal net motif. Great care had also been taken in the one-time, apparently single point incising of the initiating branching-band "design" on Face A. The care taken in incising these initiating and terminal motifs contrasts with the persistent variation that is found *within* the ladders. The motifs and ladders seem, in fact, to represent different symboling modes. The problem for the analysis, therefore, concerned the nature of the variations and the possibility for inference that this variability offered. There was also the obvious question: Was there a relation between the initiating branching band motif on Face A and the terminal net or grid motif on Face B?

Hovers had noted that the branching-bands on Face A had been incised first, beginning with the arcing multiple band at the top. The multiple bands below were then added as branches and appended outward to the right and left towards the edges and the corners. Three of these multiple bands were then marked internally to produce ladders. Hovers also noted that, though the branching bands may have been incised as a single event (and presumably, then, with a single point), the ladders within these bands had apparently been incised by different points (and perhaps, therefore, at different times). Hovers' line rendition indicates some of the variation within these ladders and the macrophotos document the nature of these subset variations.

The branching-band design on Face A and the net motif on Face B represent the only engravings on the Urkan pebble that were carefully incised, each apparently with a single tool and each apparently as a single marking event. Since they represent the initiating and closing motifs or symbols, they suggest a possible ritual or symbolic beginning and ending for the composition and the possibility that these motifs had particular relevance within this composition and for this engraver and that the two motifs had different meanings at the two positions.

A possible difference in the meaning of the two motifs was recognized by Hovers. In discussing the branching bands on Face A, Hovers noted that the present author had suggested that the branching band motif (including multiple zigzags, branching "comets," and "streams") is found in the Upper Paleolithic of Europe and may have been water-related (Marshack 1976, 1977, 1979, 1999). Hovers assumed that a water-related motif should be related to fishing and remarked that there is no evidence of fishing at Urkan. However, the water-related motif found among the riverine cultures of the European Upper Paleolithic, it had been argued, were more reasonably related to the spring thaw and floods of that region and the increasing seasonal flow of streams found within some of the Franco-Cantabrian caves. Fishing was also largely seasonal and often related to the appearance of certain anadromous fish within the network of European rivers. In the Levant the process was somewhat different, though the winter rains and the run-off within the wadis were equally strong seasonal markers for planning sequences of activity and mobility among regional groups of hunter-gatherers. Since Urkan-e-Rub IIa was located on a terrace of the Wadi Ahmar, whose run-off would have flowed eventually to the Jordan River, one may suggest that from the end of the winter rains to the growth of collectible cereals, legumes, tubers, fruits, and nuts and the seasonal presence or movement of animals would have encompassed a known sequence of months. The time from the winter rains run-off, perhaps symbolized by the motif of the branching streams, to the collection and storage of certain plants, perhaps symbolized by the motif of the net or basket, may have encompassed an observed period of both sedentary and mobile group behavior. Branching-bands, similarly constructed as flowing outward from a central stem or stream (as on the Urkan pebble), appear as a ritually incised motif at Karain, the site near Öküzini (Fig. 36 a,b). Branching-band motifs are incised on both faces of the Karain stone, and appear in variant form on another small stone from Karain (Marshack 1995a,b). The multiple band image of water, in its various manifests (i.e., multiple serpentine bands, multiple-zigzag bands, etc.) is an important motif in the later Natufian and in many of the agricultural societies that developed later among the Mediterranean cultures. The multiple zigzag image of water is also found at the Neolithic site of Çatalhöyük (Mellaart 1987).

Within the conceptual frame being posited, the three ladder sequences incised within the multiple bands on Face A of the Urkan pebble would represent an *ad hoc* problem-solving strategy, an incising of requisite ladders in the only space available after producing the branching-band motif. If so, the process would be comparable to the incising of an appended ladder to the large circle on the first face of the Öküzini pebble.

Hovers had, therefore, seen the Urkan composition correctly and had asked the proper questions. But within the tradition being described, the pebble clearly poses a set of interpretive problems. At the time of publication, the Öküzini data was not available. This limitation is evident in Hovers' general discussion of Paleolithic notation:

> "Marshack ...believes that... notations were accumulated sequentially over an extended period of time and hence imply a recurrent cultural activity that would have been of value to social units larger than the nuclear family.
>
> "The idea of notations accumulated over time has recently been criticized by d'Errico (1988, 1989)...On the basis of scanning-electron-microscopic examination of a large sample, he claims that the linear so-called notations were created in a short time and in many cases by one person with a single tool.[p.313]"

Hovers had recognized that different tools may have been used to incise the Urkan pebble and had surmised that each face may have been incised by a different person and therefore at a different time. The possibility that cross-sectional differences might indicate different periods of incising had been at the core of the notational debate for more than two decades. It is of interest, then, that a full year after publication of Hovers' report, D'Errico, having studied a different class of incised material than in his early arguments against notation (D'Errico 1985), announced that Upper Paleolithic notations did exist and consisted of sets incised by different tools (D'Errico and Cacho 1991). D'Errico had never investigated how a notation is structured or functions, or how a notation might be validated or be studied except at the level of cross-sectional analysis and had chosen his analytical sample simply because the artifacts were incised. After reporting that different tools had been used in incising these European Paleolithic notations, D'Errico continued to argue that all these notations were nevertheless incised "at one time" (D'Errico 1995; but see Marshack 1995). The possibility that a surface and a marking tool might be curated and be used for different marking events over a period of time, and that different tools could be used at different times for incising on a single surface, did not conform to d'Errico's "single event" hypothesis for early art and notation (D'Errico 1992). This researcher, and others, have voluminously demonstrated that symbolic artifacts could be curated and could be marked over a period of time (Marshack 1969a, 1972, 1979a, b, 1977, 1979).[13] It had also been demonstrated that notations and marking tools could be curated and that different tools could be used for separate marking events at different times (cf. Marshack 1972/1991b, 1974, nd, and the Appendix). Neither the Öküzini or Urkan compositions, both of which contain evidence for curation and a use of different tools, could have been incised as a single event or have been produced "at one time." Persisting uncertainty does point to a problem in the notational research that needs clarification (see Appendix). This researcher has repeatedly argued that notations cannot be determined or studied by mere cross-sectional analyses, any more than the processes of writing can be studied by an analysis of the inks or the changes in inks or pens that might be used in writing, or that cuneiform can be understood by a study of the cross-sections of the wedges used to mark the soft clay. Writing, notation, and record-keeping are extraordinarily complex neuropsychological, cognitive, visual, problem-solving modes of structuring and sequencing different classes of cultural data. They are processes that both function and need analysis at many levels (cf Marshack 1974, nd), the least of which is cross-sectional and the most important of which is cognitive and cultural. The Öküzini and Urkan artifacts had clearly been produced within a widely understood but highly variable, Epipaleolithic cultural tradition. I describe some comparable accumulations made within this region and within this Epipaleolithic tradition.

Belfer-Cohen and Bar-Yosef had already suggested that notations were present among the Natufian artifacts from Hayonim (Belfer-Cohen 1991a,b; Bar-Yosef and Belfer-Cohen 1999). In 1997, Bar-Yosef and Belfer-Cohen excavated a 55 cm long incised limestone block at Hayonim. The block, much too heavy to have been mobiliary, was incised along its entire length with an exceedingly faint, sharply incised, ladder (Fig. 32). Microscopy revealed that despite the seeming irregularity of marking, it consists of a linear sequence of long and short strokes grouped in discrete subsets incised at different angles and with different spacing or rhythm and that it was clearly interspersed with positional cueing marks making it a typical late Paleolithic ladder. As the sequence accumulated, the horizontal containing lines had also been lengthened and appended (Marshack 1997, 1999), a mode of extending current marking space that was documented on the Öküzini pebble as well as within the melange on face B of the Urkan pebble and the bone plaque from Taï in Europe. Though incised as a single ladder, it was possible to ascertain what seemed to be perceptual chunks or groupings within the accumulation, comparable in that sense to groupings perceived in the Öküzini, Urkan, and Taï compositions. Considering the size and weight of the stone and the length of the sequence, it is possible that an incising tool may have rested on the flat surface to be picked up as needed for incising a subset or, if the point broke, another micropoint could have been picked up in the debitage at the site. It was clearly not the tool but maintenance of the sequence that was important. A linear rendition (Fig. 33 a-d) indicates certain perceived and assumed major groupings; each apparently represents an approximate two-month observational period. Had these "ladders" and their subsets been incised as descending rows, their relation to the Öküzini stone would have been apparent. The full sequence seems to represent a seven month period; six primary months and a less strongly and less carefully incised final subsidiary seventh. When this breakdown was originally published, it was suggested that the sequence may have represented a period of at least seven months of occupation at Hayonim (Marshack 1997).

Other notations have been excavated at Hayonim (Belfer-Cohen 1991; Marshack 1997), the most complex being a recently excavated small block (Bar-Yosef, Belfer Cohen 1999; Marshack nd). This new stone is of particular interest since, like the Okuzini composition, each area of the stone is incised with a differentiated grouping of sets, subsets, and rows. After the main face had been filled, one of the flat edges was used for incising a final group of sets and subsets. There are other notations at Hayonim, each structurally different, some on stationary blocks and some on portable stones (Marshack 1997, 1999); each, however, conforms to the basic set-and-subset mode.

This researcher originally suggested that the long, linear, Hayonim composition had probably been incised and maintained by a specialist who kept track of the group's economic and ritual sequence, a sequence that would probably have involved observation of changes in nature and in the seasonal economic, ritual and social activities occurring during the period recorded (Marshack 1997:81-85). The suggestion has relevance beyond this single composition. There is archeological evidence for developing tendencies towards sedentation during the Epipaleolithic, including broad spectrum plant collection and processing, and even apparently the selective storage of certain plants. Incipient "mortars" and "pestles" were found in level IV at Öküzini, suggesting the presence of resources that could be processed and stored. Sickles are present in the later Natufian, again suggesting some means of portage, winnowing, and storage. Tchernov (1984, 1991) has documented the presence of commensals at Hayonim, suggesting a storage of plant resources, and Lieberman, (1991, 1993a,b) on the basis of cementum tooth studies, has suggested that at Hayonim gazelles were hunted in the Natufian during at least two seasons, April to October and November to March, suggesting an occupation at the cave for large parts of the year. A seven month block of continuous notation would, therefore, have theoretically had a viable economic and cultural context. The cueing marks and positional subsets may have marked differentiated aspects of the cultural sequence in that observed year.

Comparable modes of notation had developed among the hunter-gatherers of the European Upper Paleolithic. They appear first in the Aurignacian, becoming more complex during the Upper Paleolithic, the Mesolithic/Azilian, Epigravettian, Epipaleolithic, and Maglemosian, particularly in those periods and regions that began to show increasing trends towards local sedentary occupation (Marshack 1972/1991a,b, 1975, 1987; 1995, 1997, 1999; D'Errico and Cacho 1991). The widespread presence of these traditions in the Mediterranean and European area poses an interesting historical problem. According to the ethnographic record, the remnant, peripheral, and often isolated hunter-gatherer cultures of the historical period never developed or maintained record-keeping traditions of the type that have been described, though seasonal sequences and their human activities were carefully observed (Marshack 1991a; Orlova 1966, and below). Since notations, as highly specialized personal artifacts, perhaps "shamanistic," were not intended for display or for use in ritual and ceremony, they may not have been often discussed, sought, or collected ethnographically.[14] They have not been of general ethnographic interest and they have never been discussed in hunter-gatherer theory. The landscape, horizon, and celestial markers that are used for seasonal observation by almost all hunter-gatherers were seldom investigated by early ethnographers. That the landscape as well as the sky can, however, be an observational calendar has begun to be investigated theoretically and archeologically (Ingold 1993; see also Marshack 1972/1991b, 1975), and use of the sky and the landscape as a "calendar" has had broad investigation within the developing sub-disciplines of archaeoastronomy and ethnoastronomy (Aveni 1989 a,b; Ruggles and Saunders 1993; Ruggles 1995; Iwiniszewski 1999).

RIPARO TAGLIENTE

At the late Upper Paleolithic/Epigravettian Italian cave of Riparo Tagliente (Val Pantena), near Mont Cassini, Verona, a large incised block of granular limestone (25 X 17 cm) was excavated (Leonardi 1980, 1981, 1982, 1989). Dated to c. 11,000-10,000 BC, it comes from approximately the period of the Natufian notations excavated at Hayonim in Israel (Fig. 34). The block is too heavy to have been mobiliary and therefore represents an on-site sequence of sedentary incisings. The composition had been accumulated in the basic linear, variable, set-and-subset tradition. This accumulation could not have been read arithmetically, but it could have been "read" sequentially and positionally by the maker (Leonardi 1981,1982, 1989; Marshack 1995). Unfortunately, most of the incising had been overmarked with India ink for photography or exhibition purposes (Borsetti 1981).

The overmarking and the granular composition of the stone made cross-sectional microscopy impossible; but strong side-light and a slow, careful turning of the stone made it possible to recover all of the original incising. Because of the stone's size, the engraver had not found it necessary to incise horizontal containing lines to encompass and separate the rows, sets and subsets. If containing lines had been used, the accumulation would have been more formally structured and visually similar to the notations from Taï in France, Öküzini in Anatolia, and Urkan and Hayonim in Israel. Because of the size of the stone and the length and complexity of the accumulation, encompassing more than one year, it may again have been practical for an incising tool to have lain near the stone (see Appendix).

An overlining and a count of the major perceptual sets (Fig. 35) suggests the presence of observational lunar groupings but also indicates a variation in the tradition; there are anomalous subsets incised before and after the major sets as well as occasional cueing indications or strokes within a set. These modes of subsidiary marking represent an aspect of early notation that was first described in 1969 within a serpentine notation incised on a mammoth ivory tusk from the late Paleolithic site of Gontsy on the Russian plain (Marshack 1972/1991a). It was the evidence of this mode of subsidiary marking that had initiated the notational research. The Gontsy composition had documented cueing marks on different strokes, as well as subsidiary sets between and after the primary sets, subsidiary sets which had a different meaning or intent from the unit marks and subsets of the notation itself. Similar modes were subsequently documented in other notations from the Paleolithic (Le Placard, Taï, Raymonden, Cueto de la Mina, Zigeunerhöhle, Ferrovia) and in historical notations from the Nicobar Islands in the Indian Ocean (Marshack 1972/1991a,b, 1990, nd), Winnebego and Sioux calendar sticks from North America (Marshack 1972/1991a, 1985, 1988), calendar sticks from Siberia (Marshack 1991b) and the Chamula calendar board from Mesoamerica (Marshack 1974, nd, and Appendix).

THE NEUROLOGY AND CULTURE OF EARLY NOTATION

It is likely that this widespread tradition and the concepts and abstractive modes involved played a role in the subsequent development of Near Eastern agriculture and animal domestication, particularly since the region contained a diversity of ecotones supporting the seasonal growths of cereals, legumes, tubers, fruits, and nuts, resources that would have been available for storage under conditions of opportunity, climatic change, and stress (Marshack nd). North of the Mediterranean rim, the Upper Paleolithic and Epipaleolithic cultures of Europe developed their own subsistence, ritual, and networking calendars and their own symbolic tapestries. Although Europe did not possess a comparable range of storageable and processable vegetal resources, there is evidence for the seasonal harvesting and processing of plants for fiber weaving (Soffer *et al.* 2000) and there is an occasional grinding stone that may have been used for processing particular plants. It may be of interest that different plant images, marking the seasons of growth, flowering, or fruiting, are found in the Franco-Cantabrian caves and among the Upper Paleolithic mobiliary artifacts (Marshack 1970, 1972/1991b, 1975).

At a different level, but of importance in the study of early notation, are investigations into the cognitive processes involved in their production, i.e., into the neuropsychology of vision and imaging, visual abstraction, visual problem-solving, visual quantification, and perceptual and conceptual "time-binding" and "time-factoring." I touch briefly on a few of these processes.

Two decades after the accumulation and sequencing of non-arithmetical sets and subsets had been documented for the European Paleolithic materials, S. Kosslyn, a neuropsychologist of vision and imaging, wrote that "...principles of perceptual organization ... determine the part structure of images... it has been known since the early part of this century that we see lines and regions as being organized into perceptual units. For example, the pattern '------' is seen as a line (grouped by the 'law of good continuation'), not six isolated dashes; 'XXX XXX' is seen as two units (grouped by the 'law of proximity'), not six solitary X's; and 'XXXooo' is seen as two units (grouped by the 'law of similarity') not simply three X's and three o's. Similarly, lines that form a symmetrical pattern or that form enclosed areas tend to be grouped as units...There is good evidence that these sorts of units are not only perceived but are stored in memory" (Kosslyn 1988:1622).

These are among the capacities that had years before been inferred from an internal analysis of the Paleolithic notations. But in that research it was not alone this capacity to visually discriminate sets and subsets that had been found to be important but the fact that the capacity could be *enculturated* and become part of a widespread skilled, if variable, cultural tradition.

A dozen years after he had described the presence of perceptual chunks or sets, Kosslyn and his colleagues (Mellet *et al.* 2000), investigated another of the specialized processes found in the early notations, the capacity to differentiate and remember short subsets by the "length, width, orientation, and the amount of space between the bars" [or strokes] which had been presented to subjects as differentiated sets in a printed display; the subjects were then asked to remember and report on these perceived differences (Mellet *et al.* 2000:Fig. 1). The results documented another of the capacities that had been inferred from the notational research, the ability to both perceive and to remember such differences. Brain-imaging tests have also documented dispersal of this capacity for perceptual discrimination and recall through a network of cortical and subcortical areas of both the right and left hemispheres.

The specialized visual capacities investigated by Kosslyn and his colleagues clearly represent capacities that, during the Late Paleolithic, were being utilized by certain groups of regional hunter-gatherers in a highly specialized and regional cultural development. But the notations also suggested other capacities. The small *subsets* that were being incised had probably been counted, though not within a formal system of arithmetic or subset summing. Accumulations of subsets, sets, and superordinate sets (or rows), had been evaluated and read as relevant non-arithmetical *quantities*. The notational inquiry had early surmised that the capacity to evaluate a sequence of sets and subsets, quantitatively and positionally, would have depended on a capacity for non-arithmetical quantification, termed in contemporary psychology as a capacity for "numerosity." The neuropsychologist S. Dehaene has described these neurological processes and the structures of the brain that are involved in such evaluations via experiments conducted into the human capacity for *non-arithmetical* numerosity, a capacity which includes not only estimations of set size but *also* of time duration and time length (Dehaene 1997, 2000).

Dehaene indicates that such numerosity "can be extracted from a spatial representation of sets of items" (Dehaene 1997:96). Dehaene cites the Taï notation (Marshack 1991a) as a Paleolithic example of this capacity for non-arithmetical "numerosity" (Dehaene 1997:96). The human capacity for "numerosity," observationally demonstrated in children in mid-twentieth century by Piaget (1952), has since become a major subject of neuropsychological and brain function research (Dehaene 1997, 2000; Butterworth 1999; and the citations in each), producing a significant body of data that may be considered as concomitant with and supplemental to studies of the neurology and capacity for language.

Numerosity studies have tracked the presence of this capacity and its ontogentic development not only within pre-linguistic human infants (Wynn 1990, 1992, 1995) but also in other primates and the great apes (Woodruff and Premack 1981; Premack 1988, Rumbaugh and Rumbaugh 1987; Brannon and Terrace 1998; Hauser *et al.* 1996). On purely a priori and logical grounds there should have been a significant level of such capacity in early and later hominids, and the Neanderthals. This would have been an aspect of the evolving and developing hominid capacity that cannot be determined from studies of morphology, cranial volume, lithic typology, subsistence strategies, or site structures. Despite its absence from the material record, this generic and evolving capacity is important for understanding the appearance of Paleolithic notations as well as the development of later more variable and sophisticated modes of record-keeping. It had for long been argued in the notational research that the cultural "suddenlies" which appear in the archeological record (e.g., in technology, subsistence strategies, symboling and image-making, or even the Paleolithic notations) were incipient and prepared for by far earlier capacities and behavioral manifests (Marshack 1972, 1976, 1989, 1990, 1996b, 2000).

Dehaene and his colleagues also published the results of brain-imaging and psychological experiments (Dehaene *et al.* 1999) demonstrating that the processes of "non-arithmetical" quantification, described as "approximate arithmetic," reside in particular structures and areas of the brain, topographically and functionally distinct from those involved in language and true arithmetic. The capacity is localized in the parietal lobes of the right and left hemisphere, particularly in those areas concerned with processing visual spatial information and tasks, in guiding hand and eye movements, and in orienting and rotating objects (conceptually via attention and manipulatively by hand). These processes had been both demonstrated and inferred in the notational research. Dehaene also found that the capacity for numerosity involves "a representation of numerical quantities analogous to a *spatial number line*" [my italics. AM], a capacity that relies on the "visuo-spatial circuits" of the dorsal parietal pathway (Dehaene *et al.* 1999:970). This metaphorical "spatial number line" is materially manifest in many of the early notations as the horizontal "containing" line or the ladder-like structures that encompass a linear sequence of sets and subsets. Though these neurological processes are specialized to particular structures and pathways of the visual brain, they are integrated within a wider, whole-brain network of memories, references, and evaluations, including linguistic and other cultural inputs.

While these visual capacities are important for understanding the early notations, a more generic human capacity is apparent in the notations, the capacity for visual, manipulative, *ad hoc* problem-solving, and the development of expertise within a particular cultural context or conceptual frame. This capacity is at the core of much human culture. It is a capacity that has been generally assumed but has seldom been defined or specifically addressed within the fields of evolutionary anthropology or archeology, except perhaps in the limited sense of *tool* production, craft specialization, and general adaptation. An evolutionary increase in the two-handed capacity for visually mediated variable modes of problem-solving would clearly have been crucial in the development of hominid subsistence technologies and cultural tapestries and their diverse material manifests (Marshack 1984, 1985b). Two-handed skills are, in this restricted sense, always *contextual* skills and largely "time-factored" and as such they would be under frontal and prefrontal lobe evaluation and mediation. The Paleolithic notations represent a rather late, specialized aspect and cultural use of this human capacity (Marshack 1976). Two-handed skills are learned experientially and so tend toward varying degrees of enculturated expertise. The notations represent one such exceedingly specialized, expert, cultural skill. Visually mediated cultural skills may, in this sense, be like the "infinite" variability that is argued for language, an "infinite" variability that is constrained by the mode and yet is "infinitely" open and *ad hoc*. Within the realm of our present discourse, it is argued that this capacity for visually mediated two-handed expertise and skill and *ad hoc* problem solving is present in all the early notations. Within the discipline of psychology the human capacity for expertise in context specific modes of problem-solving has had extensive study (Shallice 1982; Cohen et al 1985; Ericsson and Smith 1991; Ericsson 1996) It is suggested that it is largely this human capacity for the perception and abstraction of "equations of process," and for the perception of their persistent variation, coupled with the capacity for visually mediated modes of contextual problem solving, that were vital in the development of notations and, later, of agriculture (Marshack nd).

CONCLUDING REMARKS

The early notations were, of necessity, also narrative frames. The observed periodicities and variations in nature would have been cross-referenced by story and explanation. The presence of story and narrativity in the early notations and in Paleolithic symbol and imagery had been argued in *The Roots of Civilization* (Marshack 1972/1991b:). The inferable complexity of the early notations would always, therefore, contain far more than meets the eye or can be described analytically.

Part of that complexity derives from the nature of human cultural vision (Eccles 1989:131-139). The adaptive organismic visual capacity to see differences in motion, shapes and forms, and to judge distance, had evolved among diverse life forms, and then among vertebrates, and finally within humans to the point that complex processes and periodicities, or equations, could be perceived as highly abstracted, static images, forms, and structures. Referential variations could be cued, encoded, and read within a diversity of static and changing culturally devised frames. It is from this evolved capacity for higher visual perception, abstraction, and problem-solving that notation, writing, arithmetic and the variability of the abstractions and structures that are embodied in the sciences would develop. Given this capacity, it would have required no great evolutionary step or cultural revolution to go from the non-arithmetic, linear, visuo-spatial records of the Paleolithic to arithmeticized modes of record-keeping a short time later. That step would have required, at most, a cultural preparation of the type that has been described, an incremental accumulation of relevant cultural data, an increase in social/cultural complexity and recognition, therefore, of a contextual need.

The human capacity for time perception, time-binding and time parsing has had wide interdisciplinary study. The development of "event knowledge" in the human child, with its correlate capacity for story and narrative, has been studied (Nelson 1986, 1996; Pouthas *et al.* 1993). A child's development of language in terms of its growing perception of available equations of process and relation, with a lexicon of verbs (in contrast to a naming lexicon of nouns and objects) has been investigated by Tomasello (1992, 1993). At a higher level, the capacity to read a changing landscape in terms of its time-factored seasonal and human activities has been described (Ingold 1993). For the Upper Paleolithic, K. Gibson, investigating the evolutionary development of human capacity, has written: "One cultural behavior of great benefit to a migratory style and well-developed by Aurignacian times, involved the practice of inscribing records on stone, bone, and other materials... The recording of absolute time would have facilitated the advanced prediction of seasonal events such as caribou and avian migrations, salmon spawns, the beaching of seals, the birth of animals, the ripening of plant foods, and the advent of hazardous weather. In addition, a proto-calendrical system would have enabled dispersed sub-groups to meet at pre-arranged times and locations for festivals, marriage and initiation ceremonies, group hunting expeditions, and trade, thereby facilitating behaviors which sustain kinship bonds and tribal affiliations...Upper Paleolithic peoples would have found themselves far more prepared to exploit the seasonally harsh environments than any predecessor population..." (Gibson 1996:42). Comparable models involving hominization have proposed the development of a capacity to adapt conceptually and pragmatically, or "culturally," to major variations in climate and ecology, or to essentially unexpected and random periodic changes in nature (Vrba 1985, 1986; Potts 1996, 1998; and Marshack 1976b). The limitation in this human capacity has been addressed in hypotheses dealing with the collapse of cultures, including even of the Natufian and later agricultural societies, in the face of unexpected, drastic, often rapid, climatic and ecological change (Weiss and Bradley 2001). It is possible to suggest that a conceptual and cultural effort to monitor and deal with such periodic changes, even on the small scale of seasonal and generational variation, may have been present in the early notations.

The above formulation raises a "species" question. It had been often argued as an aspect of the notational research that one of the differences between Neanderthal culture and anatomically modern human culture lay not merely in a *capacity* for language, image and symbol making, tool technology, or more efficient hunting, but also in a qualitative difference in the development of symbolically marked, "time-factored, " cultural tapestries and networks. It was argued that a capacity for cultural planning was present among the Neanderthals (cf Marshack 2000) despite differences in language, symboling, tool technology and subsistence strategies. The Upper Paleolithic cultures developed more complex, widely shared time-and-space cultural tapestries, more extensive culturally coded intergroup networks, and more complex time-factored conceptual maps and myths. These entailed shared linguistic concepts, modes of image-making and ritual, and schedules of aggregation and exchange (Marshack 1999). Within Europe, these observational calendars and cultural tapestries were devised in response to major oscillations and variations in the seasons and climate of a late Paleolithic mid-latitude four-season ecology. In the Near East, different but cognitively comparable regional cultural tapestries were woven in response to a two-season ecology of rain, plant growth, animal behavior, and no rain. The creation and maintenance of such variable regional tapestries by anatomically modern humans would have required far more than material adjustments and changes in group mobility and technology. It would have required the ability to create a wide and variable range of *ad hoc* alternative subsistence strategies and adjustable cultural tapestries with adjustable explanatory narratives, myths and rituals.

At some level, cultural processes of this type would have occurred wherever anatomically modern humans located. Within the core Mediterranean area under discussion, these processes led to the late Paleolithic development and maintenance of a certain symbolic mode of referencing and record-keeping. Within Europe a different seasonal round involved winter frost, ice, the thaw and floods, caribou and avian migrations, salmon runs, the arrival of coastal seals, complex periods of rutting, the birthing of animals, the ripening of regional plants and always, and of equal importance, the persistent uncertainties of mid-latitude Pleistocene climate and weather. A shared time frame, and proto-calendrical observation or recording, would have enabled dispersed Upper Paleolithic groups in Europe to meet at pre-arranged times and locations for marriage and initiation ceremonies, group hunting and trade, and the exchange of information, behaviors which would have sustained kinship bonds and tribal affiliations (Gibson 1996:42; Marshack 1999). In the Near East, the use of that capacity in a different regional ecology devised other but comparable variable tapestries. At some level, this process extends backward to earlier hominid adaptations. A number of evolutionary models have, in fact, strongly argued for a developing hominid capacity to perceive and adjust "culturally" to major variations in climate and ecology (Vrba 1985, 1986; Potts 1996, 1998).

An entirely different evolutionary scenario for the development of hominid capacity has been proposed by the psychologist M. Donald (1991; 1998a,b). Donald suggests that the highly evolved visuo-spatial capacity of humans, manifest among hominids in modes of "mimesis," evolved in stages so that in the Late Paleolithic and Holocene it led to "external" record-keeping. Donald assumes that this late development occurred primarily among the agricultural societies of the Holocene, with an apparent earlier but relatively unimportant incipience in the Paleolithic as evident in the notations that have been discussed. The *capacity* for "external information storage," however, clearly precedes the notations. A complex visuo-spatial problem-solving capacity is present in all Paleolithic cultures, and all hunter-gatherers are dependent on a structuring of time and seasonal periodicity. Donald, for instance, cites the presence of an indigenous aboriginal Australian capacity for "visuo-spatial" and "visuo-graphic" modes of imaging information, but he notes these as a *psychological* process evidenced in certain ethnographically described imaging behaviors (e.g Munn 1973), without noting far more important and perhaps ethnographically less well known visuo-graphic and visuo-spatial aboriginal modes of structuring and imaging time-and-space (Mountford 1976; Haynes 1990; Johnson 1990; Clarke 1998). Even Australian aboriginal message sticks, which were not modes of cumulative record-keeping, represented visuo-spatial and visuo-graphic quantifying modes of structuring and abstracting relations in time-and-space. The Australian landscape and sky were also read as forms of "external information storage," and Australian rock art and rituals marked an extraordinarily complex time-factored, visuo-spatial and visuo-graphic cultural tapestry. One can amend Donald's model of Paleolithic and hunter-gatherer visuo-spatial cognition and problem-solving.

Donald, for instance, asserts that "the earliest move [in the development of 'external symbol storage'] was apparently a form of visual thinking, especially in the construction of analog models of time and space" that occurred among the farming cultures of the Holocene (1991:35). However, the Paleolithic/ Epipaleolithic notations from Öküzini, Urkan-e-Rub, Riparo Tagliente and Hayonim represent pre-Holocene, non-arithmetical, non-public, unstandardized, visuo-spatial and visuo-graphic modes of "external information storage" that are clearly incipient to and preparatory to the more standardized, arithmeticized, often administrative, record-keeping modes that developed among the farming cultures (Marshack 1997, 1999).

ART, IMAGERY, AND TIME

On the assumption that the notations, and probably the Öküzini bovid, the incised composition on a bone spatula found at Öküzini (Léotard this volume), and the images incised on stone from Karain (Kökten 1963; Marshack 1995a,b) were not idiosyncratic efforts but were images produced at a proper "cultural time," it may be possible to describe them as having been produced within a time-factored cultural tapestry.

I discuss one example from Karain. The fragment of a flat stone was incised with three different types of imagery: two anthropomorphic figures, probably made by the same hand at different times, an abstract schematic hand, and a "branching-band" motif incised along different edges (Fig. 36 a,b). The fragment of another branching-band motif is found on the reverse face. Conceptually these images do not seem to be related, yet they appear on the same stone. They are, in this sense, like our hypothesized ritual wall, a curated surface able to take a sequence of images at different times.

The two humans seem to be male; they lack sexual attributes and have short hair; there is a suggestive "nose," but no mouth or ears. Their distinguishing feature is a large oval eye (Fig. 37). Large eyes, and a stress on the eyes, are well-known on human and anthropomorphic images both in the Natufian and in later periods of the Near East. The human figures do not seem to be realistic portraits; by their similarity and repetition they seem to be symbols or "spirit" images. The conjunction of two large-eyed humans with two "branching-band" motifs suggests a relation between the images. Repetition of these motifs may have had ritual or symbolic relevance; if so, the schematic "hand" may have been an addendum to an equation involving the two motifs. If the male figures were related to the branching-band motif of "flowing waters," and if the hand was a sign of participation in an equation involving these images, we may have a sequence of related ritual behaviors. Such a relation may have existed even if our suggested explanations are inadequate. If the argument for "time-factored" notation and "time-factored" imagery is valid, it may be possible to hypothesize a complex tapestry of "time-factored" ritual and symbolic behaviors within Anatolian and other Epipaleolithic cultures of the Near East. Such interacting modes may together have been incipient and preparatory to modes of symboling and time-factoring which abetted the development of agriculture and its accompanying conceptual tapestries (cf. Stordeur *et al.* 1995, 1996; Cauvin 1994, 2000; Marshack 1997b, 1999, nd).[15]

NOTES

1. Cauvin (1994, 2000) has provided an excellent description and interpretation of certain images and concepts that are found in the late Epipaleolithic preparation for agriculture within the Near East (Cauvin 1994, 2000), but he has done so primarily in what might be termed the traditional categories of imagery that are of archeological concern and discourse; the images of females, males, animals and particularly the bull, and certain geometric motifs. Cauvin does not discuss the classes of imagery, or the symboling processes or modes of conceptual problem-solving that are discussed in the present paper.
2. The sacrificial seasonal killing of a bull is, of course, well known in many of the later agricultural cultures of the circum-Mediterranean area.
3. Even among the notations of the European Paleolithic, the geometry, topography, and nature of the materials always constrained and shaped a particular notational structure. One reason is that these early traditions were never standardized, either in terms of a marking surface or a marking style or mode. Though the underlying concepts and the tradition were apparently widely known, each notation always involved the individual, often *ad hoc*, problem-solving effort of a particular record-keeper faced with the material at hand. Standardized surfaces, standardized marking tools and materials, and standardized modes of recording would develop only later among the centralized temple and administrative polities of the agricultural societies. It was one of the early findings of the Paleolithic notational research that *ad hoc* adjustments to the variations and limitations of a marking surface and marking space were inherent aspects of the tradition. The process was documented in the Aurignacian notation from the Abri Blanchard (Marshack 1972/1991a), in the later Upper Paleolithic notation from the Grotte du Taï (Marshack 1991b), and in the Epipaleolithic accumulations from Öküzini, and Urkan-e-Rub II and Hayonim in Israel (see below); the process is found also in historical notations as widely separated as those from the southeast Asian Nicobar Islands to those in Mesoamerica (Marshack 1972/1991a, 1974, nd).
4. See Appendix and Fig. 38 for a contemporary illustration.
5. Bar-Yosef (1996) has noted that this encompassing circle with its smaller interior circles and an upper path leading into the circle is reminiscent of the "kites," or animal enclosures, that are known from later desert cultures in the Levant. A similar "corralling" interpretation had been given to a post-Paleolithic European (perhaps Neolithic) group of large red circles which enclose many small double strokes suggestive of "hoof prints" (cf Mithen 1988; Bradley 1997) in the cave of La Pileta, Spain (Breuil, Obermaier, Verner 1915). This mountain cave looks down on a small hill-enclosed

valley that could easily have been modified to serve as a corral. While such similarities in imagery are interesting, they pose their own problems. Similar small double strokes have been considered to be "wound" marks when found *within* Upper Paleolithic animal images, (they are also found within animal images at La Pileta), and they have been considered to be ritual participatory marks when found on a cave wall as at Cougnac. Encompassing circles are a generic motif of "enclosure" in many human cultures; in this regard they are comparable to the horizontal containing lines of the Epipaleolithic "ladders" which, in the context of notations, are also an image of containment or enclosure. The Öküzini circle, therefore, poses the ever-present problem of *context.* Even the later desert "kites" that were used for corralling herds, as suggested by Bar-Yosef, were probably used seasonally, perhaps to corral aggregating or migrating groups of animals; they would in that sense have also represented a "time-factored" motif. Anati, without the help of microscopy, saw the small circles in the Öküzini composition as animal or anthropomorphic heads (Anati 1968).

6. Analysis of the Taï notation from France had demonstrated comparable problem solving strategies for limitations of marking space at different positions; the endings of some rows were extremely crowded, with subsets and strokes incised over each other; for other rows, the containing lines had been extended vertically downward to take a required or estimated quantity of marks; in other areas of the plaque, apparently needed later strokes had been attached immediately below a containing line, not representing a separate row but a continuation of the horizontal row to which they were now attached. Such *ad hoc* solutions to a local limitation of marking space are often encountered in a notational accumulation. A comparable process was documented on a modern Chamula, Mayan, calendar board (see Appendix). The Öküzini accumulation provides many instances in which the structure of the composition, the topography of the stone, or a lack of local space led to an *ad hoc* positional solution.

7. The perception of a linear serpentine or boustrophedon sequence as an abstraction of process and periodicity is found among widely separated cultures and periods, including the intertwined Celtic knot as a symbol of recurrent eternal life and the Japanese solar "year knot" which similarly symbolizes recurrence and periodicity. The spiral, fret, and maze as abstractions or symbols of process and recurrence are, in this sense, easily perceived kinesthetic and visual "descriptions."

8. The use of cueing signs on particular strokes within a notation had been first noted decades earlier in the study of an incised composition on a small mammoth ivory tusk from the Russian site of Gontsy. This composition possessed different types of "cueing" marks or "signs" at different positions, within a set, on particular strokes, between sets, and at the end of sets (Marshack 1964, 1972/1991a; nd).

9. The possibility of concurrent types of observation was not recognized during the earlier notational analyses. It was within the Taï plaque, which took twenty years to unravel and within which non-arithmetical sequences of both lunar and seasonal or solar observations were found, that the possibility of such concurrent observations in the Paleolithic became apparent (Marshack 1991a,b). Though they were unexpected for the Upper Paleolithic, such conjunct modes of observation and recording are abundantly documented historically and in ethnography and archaeoastronomy.

10. This is the way, of course, that one marks and reads any short-term *ad hoc* notation or set of personal, abstracted, or schematic notes.

11. Because of the exceedingly fine incising and the wish to create discernable photos, a single strong side light, with a less powerful fill light, was used to make many of the photos. Occasionally, because of differences in the angle of incising, some of the strokes would be lit along their length making them appear flat. A comparison of these macrophoto details with the same strokes in the larger photos often shows this difference.

12. The entoptic hypothesis was proposed by D. Lewis-Williams before he had studied any of the Upper Paleolithic symbolic materials or cultures or had investigated their development over time. The theory was argued on the basis of ethnographic evidence for the induction of states of trance and hallucination in certain "shamanistic" cultures, and the psychological evidence for the induction of such imagery by drugs, stress or migraine. The voluminous evidence for the creation of comparable images and abstractions in a wide range of human, cultural, modes of abstraction and image-making, particularly in the Paleolithic period, was never addressed (cf Lewis-Williams 1985; but see Marshack 1985). The entoptic or phosphene hypothesis as an explanation of early "geometric" motifs, and of trance as an explanation even of realistic animal images has nevertheless had wide support, but it has had equally strong criticism from within psychology and by researchers who are familiar at firsthand with the range and complexity of Upper Paleolithic imagery. It is interesting in this regard that when F. d'Errico announced in 1991 that he had been in error and had unexpectedly "validated" the presence of Upper Paleolithic notation, which had been argued by Lewis-Williams as supposed "entoptic" forms, Lewis-Willliams, wrote to this researcher:

> "If some (many?) of the Upper Palaeolithic non-representational markings are indeed notations, I am not in any way dismayed. I'm sure that people of that period had the mental ability to make notations. What I argue is that when we find a whole set of images (a clear range of geometric forms, construed geometrics, iconic images, iconic combined with geometrics, therianthropes, etc.) then, and only then, do we have a strong case that the set of images was associated in some way with altered states of consciousness. An isolated geometric form does not constitute evidence... If the UP `religion' was in a broad sense shamanistic, then it seems highly probable that notation would have played some part in that 'religion'." (Lewis-Willilams 1994)

While this may be self evident, it should be also evident that one can not go developmentally (or "neuropsychologically") from San trance-hallucination and its entoptic imagery, or from the drug induced hallucinations or imagery induced ritually among some indigenous American cultures, to the development of complex, innovative, time-factored and time-binding, problem-solving cultures and societies. One can, however, go developmentally from normal visual, cognitive modes of symbolic and pragmatic problem-solving, and normal modes of abstraction, to the development of complex human informational cultures and their functional tapestries. Within such cultural developments, subsidiary, transient and occasionally induced hallucinations would, at most, serve as a peripheral and mythic cultural accompaniment. It is important in the study of early cultures that the differences between these diverse modes of conceptualization and "imaging" be clearly distinguished. For Lewis-Williams, and probably for many of his followers, the Öküzini, Urkan, Hayonim, Taï, and Riparo Tagliente compositions would have been considered, on simple a priori, non-analytical grounds, to be hallucinatory or "entoptic" geometric structures.

13. In the Franco-Cantabrian caves there is abundant evidence that surfaces and images have been added to, revised and, at times, even erased to make room for a new image. The surface and the prior image were not, in this sense "sacred" after they had been made or used. It was the act of production and use that was apparently symbolic. There is evidence for the periodic accumulation of signs, dots, and sequences of such images in the caves (Niaux, Trois Frères, Cougnac, Castillo, Altamira, etc.) though these modes represented entirely different types of symboling, structuring, and reference than are found in the mobiliary notations. There is also a large body of mobiliary material documenting the accumulation over a period of time of motifs and images on a single artifact or surface (La Marche, Lalinde, Limeuil, Gönnersdorf, Cavallo, Romanelli, etc.).

14. They would not or could not be easily explained to an ethnographer. Reichel-Dolmatoff, who studied shamanic practices in Colombia, informed this researcher that the calendar sticks and symbolic constructs kept by shamans in that area were "secret" and would not be discussed. Australian aboriginal observational astronomical lore and their accompanying explanatory myths are also usually a carefully taught secret male lore, rather than a "public" or display lore. Though extraordinarily complex, these aboriginal data are not found archeologically, nor have they been normally sought ethnographically (but see Mountford 1976; Haynes 1990. Clark 1998, Johnson 1998). Additionally, with the historical destruction or disruption of hunter-gatherer cultural tapestries and the destruction or disruption of their intergroup networks, any artifactual modes of record-keeping that may have existed would have been discontinued. Indigenous North American "winter-count" records, painted on perishable buffalo skins, were discontinued by the tribes making them for precisely that reason. None of the indigenous traditions of American or Siberian notation that I, and others, have published are currently practiced. The few incised ethnographic calendrical artifacts that have entered museums, and the few that have been studied and published by this researcher and other researchers, had all been collected or obtained rather serendipitously. The archeological record is equally rare. In the Levant, the earliest artifact documenting a tradition of linear sets and subsets incised by different tools is an Aurignacian bone (c. 29,000 BC) at Ksar 'Akil, Lebanon (Tixier 1974). The earliest African example of an incised accumulation of sets and subsets comes from Ishango (Marshack 1972/1991a); a recent dating at Ishango suggests that it may have come from approximately the same period as the Ksar 'Akil engraving from Lebanon (A. Brooks, personal communication) and the Aurignacian notation from Blanchard, France (Marshack 1972/1991a, 1975).

15. Cauvin has discussed the early symbolic significance of the "bull" or wild aurochs in the non-agricultural Khiamian culture, as well as its increasing significance in Neolithic and later agricultural societies of the Near East [Cauvin 1994, 2000]. Cauvin indicates that the anthropomorphic "god" that was associated with the bull was apparently a male weather or storm god. In such a metaphorical equation, the "seminal" male storm or rains would then fertilize the fecund earth. Within a developmental cultural/equational process such as that being proposed in the present paper, the concurrent presence of a ritually killed wild aurochs, a branching-band "water" motif, the association of a water motif with a male anthropomorphic "spirit," the net or grid motif as possibly related to plant storage, and the presence of notation could all have been encompassed within a set of explanatory ritual and mythic equations and practices, and have functioned as concepts that would have culturally supported or abetted the later regional development of agriculture and its necessary, mediating, time-factored tapestries.

APPENDIX

There have been various criticisms of the notational hypothesis. First, it was argued on a priori grounds that record-keeping began in the agricultural societies of the Holocene; second, that the early notations do not tally with what is known ethnographically among the world's remnant historical hunter-gatherers; third, the notations do not correlate with any modern arithmetical mode of record-keeping; and finally, that a single tool (or even a surface) could not, or would not, have been retained for marking events over different days. In none of these arguments was there any indication that there had been any analytical effort to study either the nature of notation, the human capacity for notation, or the variability found among different documented notational traditions and artifacts.

Because of these early arguments and controversies, the American ethnographer, G. Gossens, wrote in 1973 to ask whether it would be possible to subject the "cognitive" method of internal analysis to a blind test. A recently acquired Mayan calendar board kept by a shaman of the Chamula people of Chiapas, Mexico, would be sent for analysis in order to determine whether a "cognitive" analysis could derive information about the record-keeping process that had not, or could not, have been obtained by the ethnographer. This blind analysis would be published simultaneously with an ethnographic report on the Chamula culture and the calendar board and an evaluation and comparison could be made of the "cognitive" method. Such a comparative test could not be conducted for any Paleolithic materials, so the challenge was accepted.

The "cognitive" analysis that was conducted unexpectedly made it also possible to reevaluate the Paleolithic notational materials and to aid in subsequent studies, including analysis of the Taï plaque and the compositions from Öküzini, Urkan-e-Rub II, Hayonim, and other prehistoric and historic notations.

The Chamula calendar board (Fig. 38), part of what had been a burned wooden door, is a one year accumulation that had been periodically marked with charcoal. Infra-red photography revealed that each of the 18 Mayan months in the 365 day year had been accumulated by marking short subsets of one to three or four days at a time. A different rhythm of marking and a different piece of charcoal had often been used for each "set" or month. A single piece of charcoal had been curated, perhaps on a shelf, for marking each month. Significantly, the rhythm of marking for each month was unconsciously established by the first subset marked for the new month. A new piece of charcoal was then obtained for the next month and a new rhythm of marking was established by the first subset and retained for that one month. Since the rhythm of marking varied with each "set" or month, the amount of space that became available at the end of each row varied. Evaluations and adjustments had to be made as a row accumulated; some rows, as a result, become extremely crowded at the right. Each month was terminated with a cueing sign or symbol representing the twentieth day. As a result, though the shaman could count, one did not have to count the marks in the accumulating sets but only the month signs and the few subsets of the particular month that was being marked. Usually there were three months to a row but because the first two rows and the last row on the board contained only two months, the shaman had, perhaps unconsciously, provided them with the widest spacing of any of the rows on the calendar board. On the second row, between the fourth and fifth months, an anomalous subset of five marks had been intruded without any sign of closure. This was clearly an intercalary period that had been inserted to complete a solar year of 365 days (18 X 20 + 5 = 365), but it had been inserted within a cultural, ritual, and mythological year frame of arithmetical non-lunar months comprising an observational solar year. Significantly, these five intercalary days did not occur where they would have originally occurred, at the end of the 365 day year. It was thus clear that the 365 day year frame had apparently shifted over the years.

Infra-red photography revealed that the calendar board had been wiped clean each year, but each year had been accumulated in the same inherently variable and *ad hoc* manner. The analytical variations were not part of the calendar tradition but an aspect of the marking mode and of the ongoing visual evaluations and adjustments that were made during the accumulation. The most unexpected finding was that one piece of charcoal had been curated, usually for a period of one month, and for a number of marking events. Gossens later confirmed that the shaman had indeed marked the board with short subsets that represented the number of days that had elapsed after she returned home from her shamanistic practice (Marshack 1974; Gossens 1974a,b).

The Chamula analysis documented the long-term retention of a marking surface, a retention and a change in marking tools, an accumulation of short subsets to form larger sets, a use of positional signs and the insertion of a symbolic subset at a particular position in the year. The analysis revealed that a cumulative notation might involve ongoing evaluations of the amount of space that was available as a row accumulated. These were pragmatic aspects of the process of accumulating a notation, whether it was arithmetical or non-arithmetical. In one form or another each of these processes is found in the Öküzini composition. If one should conceive of the Chamula rows as being constrained within ladders or as having been incised with a series of stone tools, the comparison would be even stronger.

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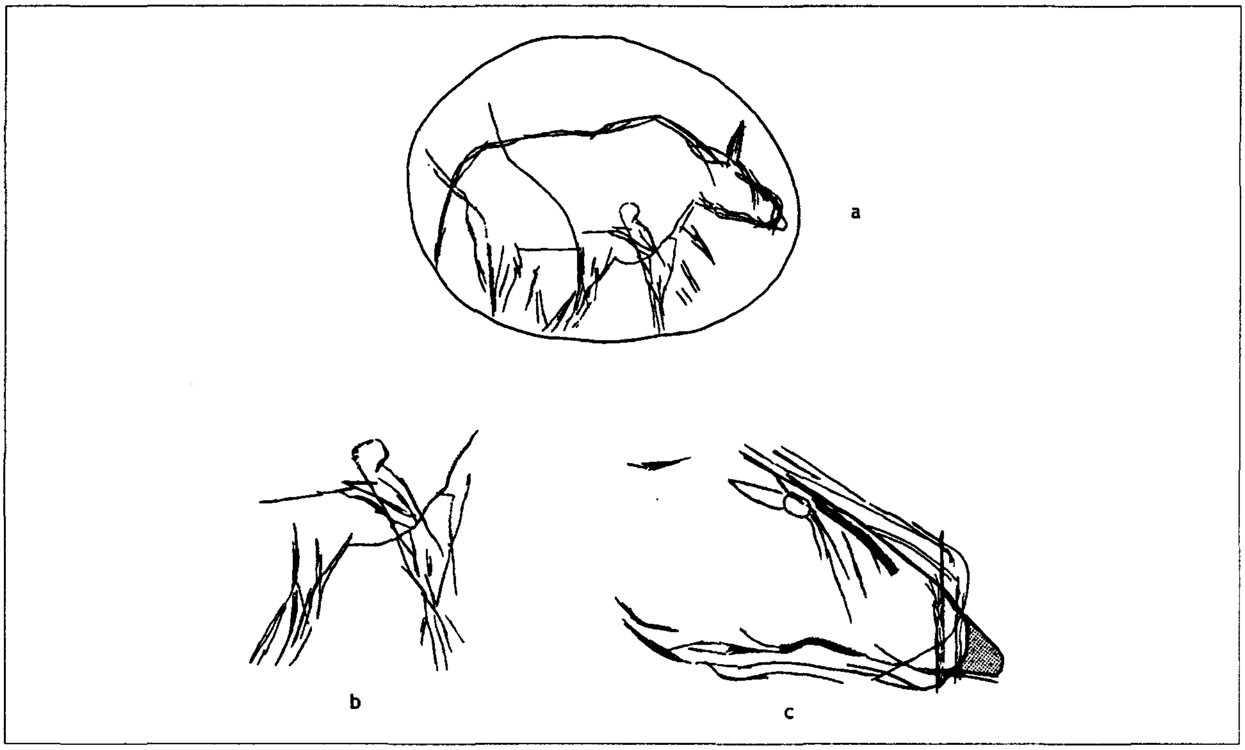


Figure 1 a-c.

a. Öküzini pebble (4,2cm) incised with a bovid and a human.
b. Detail of the human with a bent arm thrusting a spear into the bovid.
c. Detail of near circular bovid eye with a rear tear duct and tears descending from eye. The well-drawn muzzle seems to have been reused and renewed by overengraving.

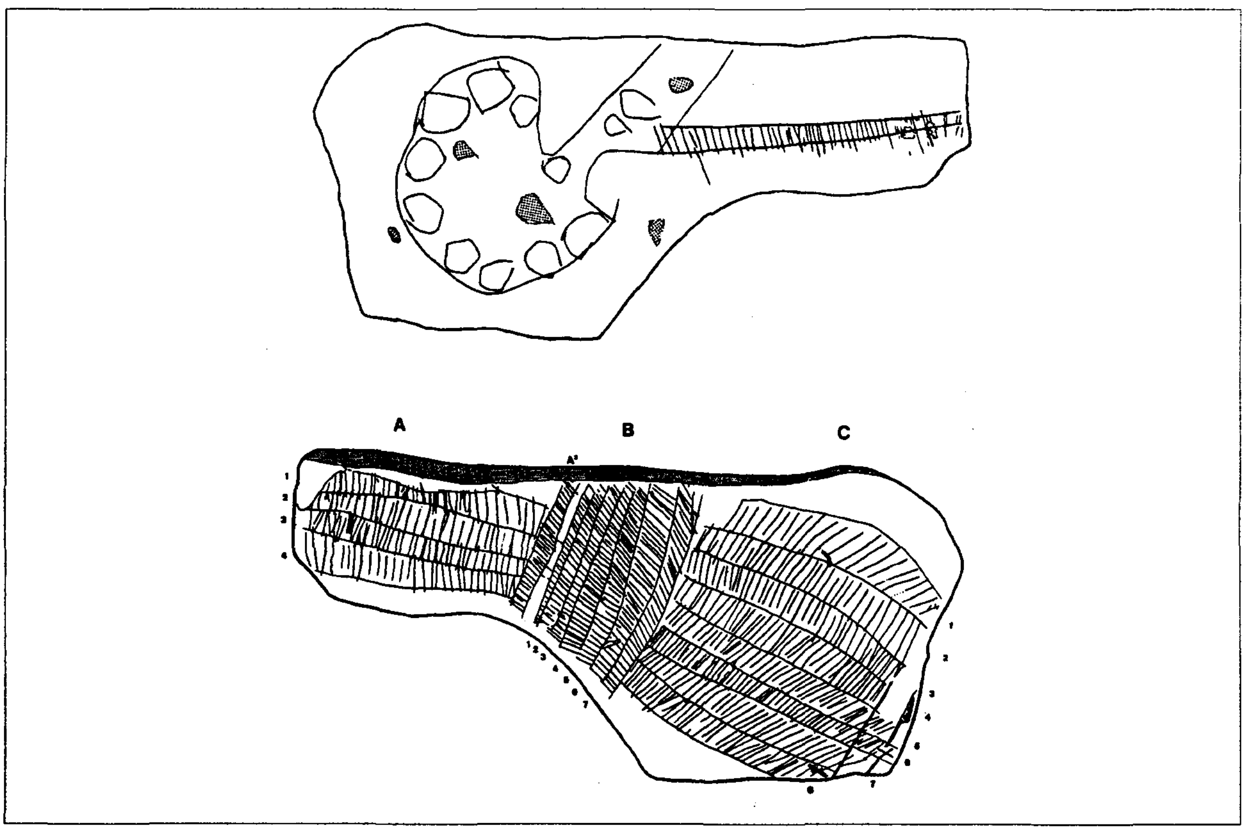


Figure 2 a et b.

A line rendering of the incised compositions on the two faces of the Öküzini pebble.

Figure 3.
A side-lit photo of the secobd face of the Öküzini pebble indicating the different planes wich were used to accomodate the three blocks of ladder-like accumulations, A-B-C. An original flaking in the upper left croner was later incised along its edge (Figure 10a).

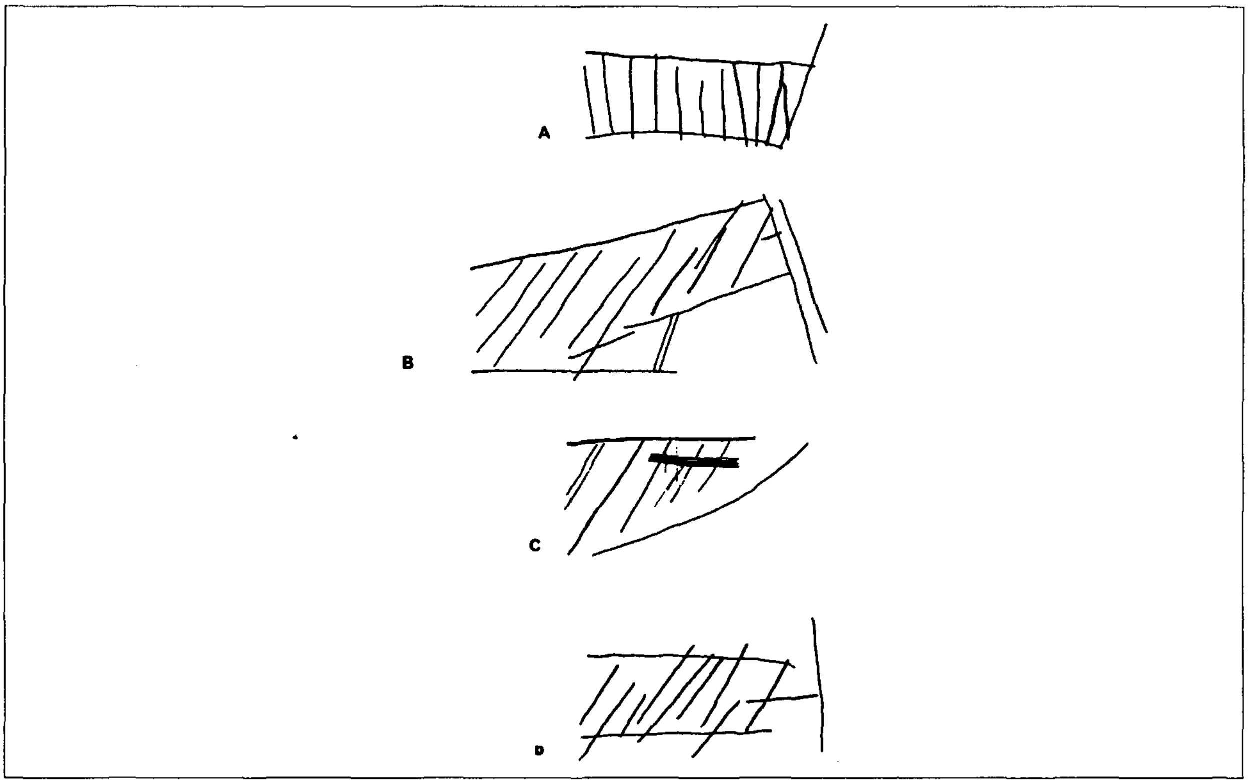


Figure 4 a-d.
A linear rendition of the cueing signs or indications of closure that terminate blocks A-B-C, and one row, on the Öküzini pebble.
a) The last row, row 4, of Block A ends with an inverted "Y".
b) The last row of Block B, row 7, ends with two added short horizontals and 8 added strokes.
c) The last row of Block C, row 8, ends with a deep bar closure.
d) Row 6 of Block C, ends with the sign of a cross; the longest row, row 6 of Block C, ends with a cross.

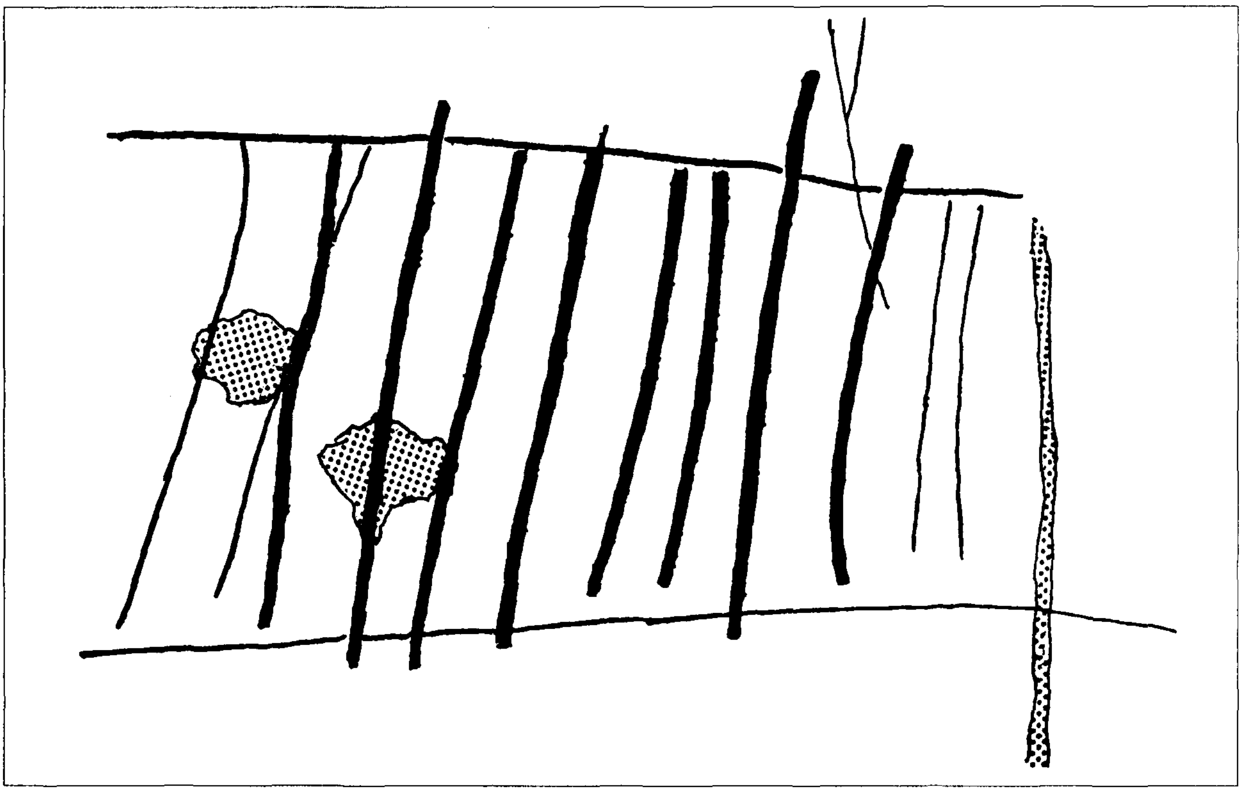


Figure 5 a et b.
The final set of marks on row #4 of Block C. A set of 8 strokes made with a flat point begins by crossing over a prior set incised by a sharp point and at a different angle. The 8 are followed by two more lightly incised strokes. Note the differences in the pressure and angle of marking in the rows above and below.

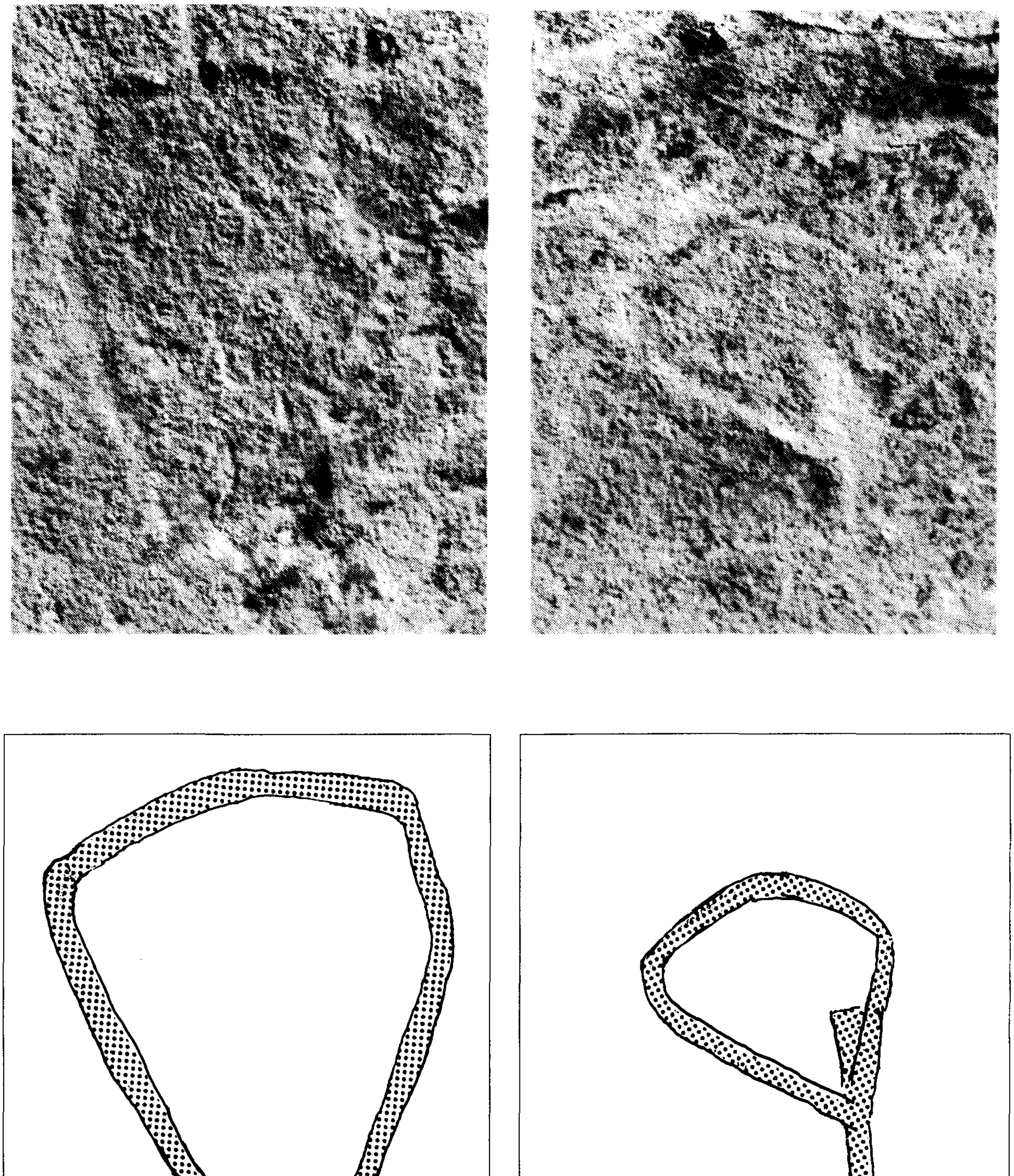


Figure 6 a-d.
Photos and drawings of two of the small circles added to the area around the large circle on face one. The small circles within the encompassing circle were also made by incising short arced strokes.

Figure 7. The finely incised ladder that is appended to the large circle at far left. The sequence is 5,5 cm long and its 58 strokes, though varying in length, are incised at the approximate scale of a centimeter ruler, too fine to be summed after the subsets were incised. The pressure of incising and spacing diminishes as the row accumulates towards the right. Encrustation and flaking begin to occur at right. The edge of the stone is polished from handling.

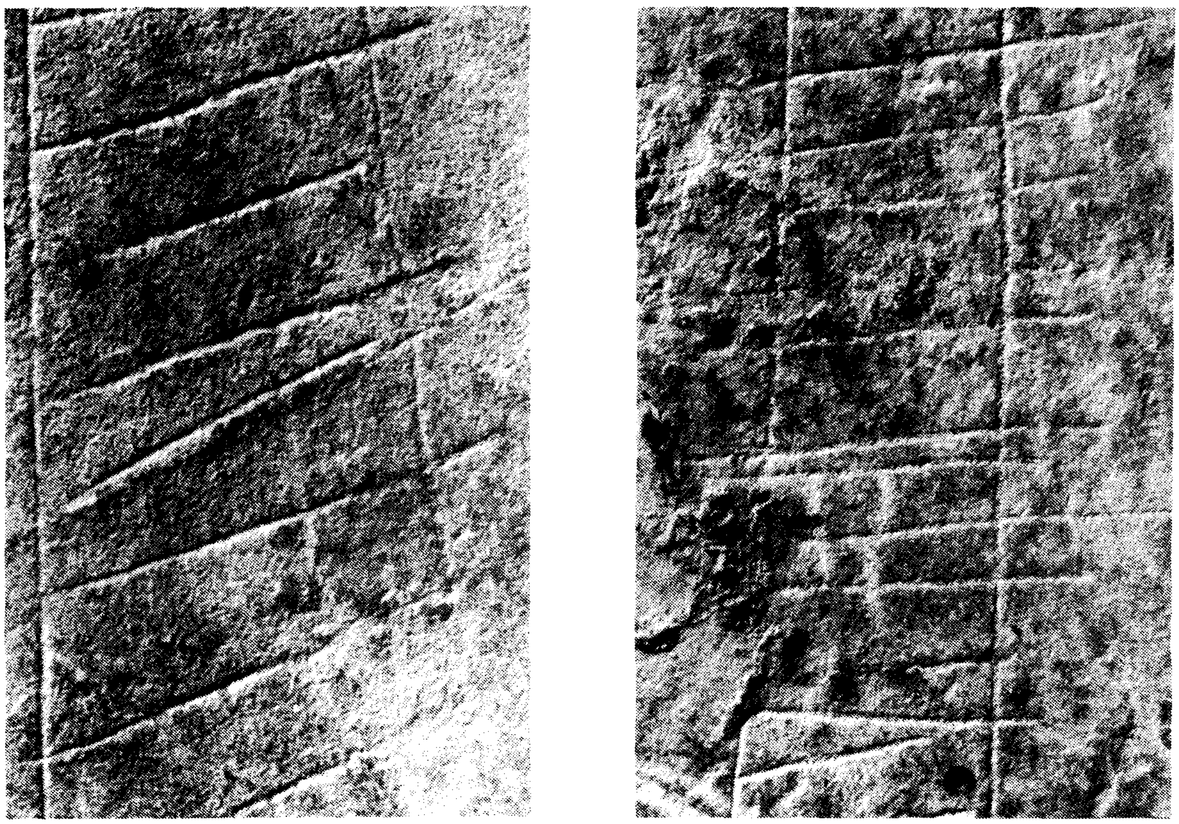


Figure 8 a et b. a) The opening strokes of the first ladder indicating the wide spacing and strong pressure of incising. The 4th stroke struck a fossil intrusion and was forced to follow it downward at an angle. b) Detail from the middle of the ladder. The apparent "Y" results from the series slanted strokes that are followed by a subset of more vertical strokes. Half of stroke after "Y" is masked by encrustation. The 7th stroke after the "Y" is entirely hidden by encrustation, but remnants of this stroke are still visible above and below the horizontals. Photos a and b are at the same scale.

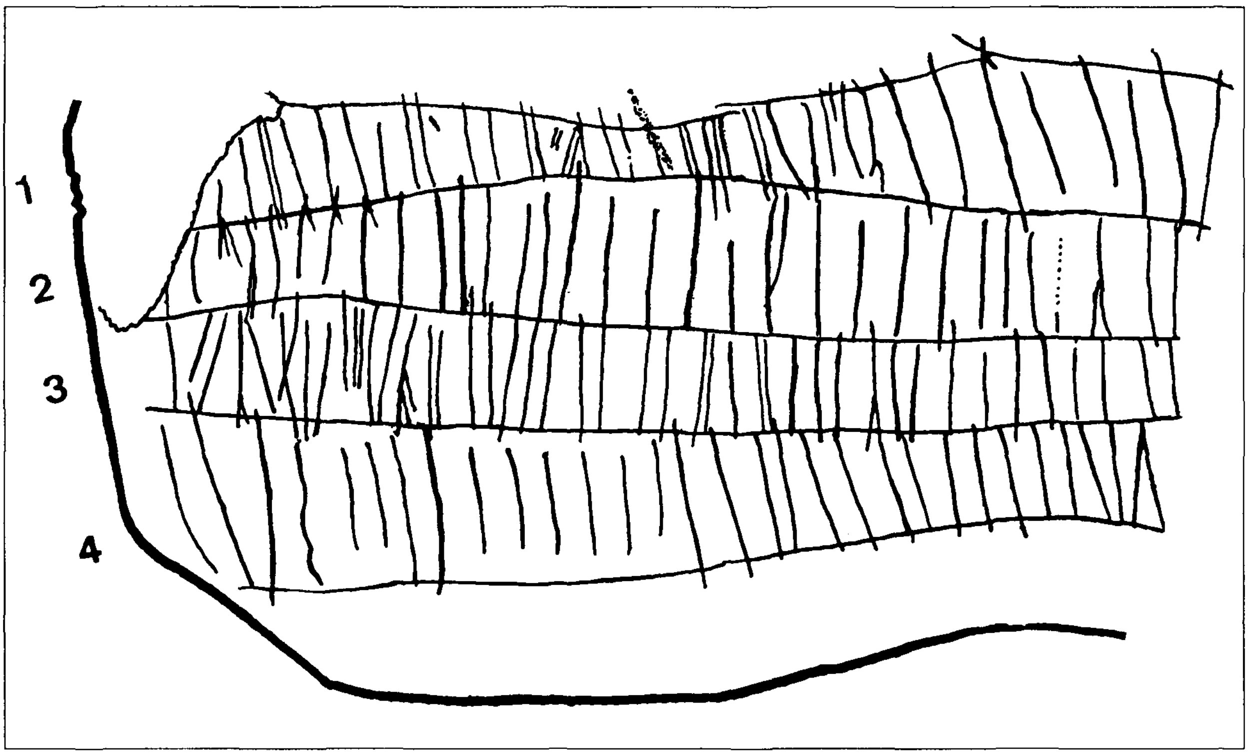


Figure 9 a et b. a) Öküzini. The four rows of Block A on face #2. The pressure, angle, of marking and spacing vary in each row. The flaking at the left corner has two strokes from row #1 incised into its edge. Both the edge of the flaking and the incised marks indicate hand polish. At far right one sees the vertical marking of the first ladder of Block B. b) Linear rendition of the marks in Block A indicating the variations in each of the four rows. Note that row #1 begins at left with a very light marking but ends at right with long marks incised with strong pressure, a reversal of the process in the ladder on face I. Note that row # 3 begins at left with a complex set of irregular subsets (figure 11 a-c). Block A ends et bottom right with an angle sign (figures 4a and 12).

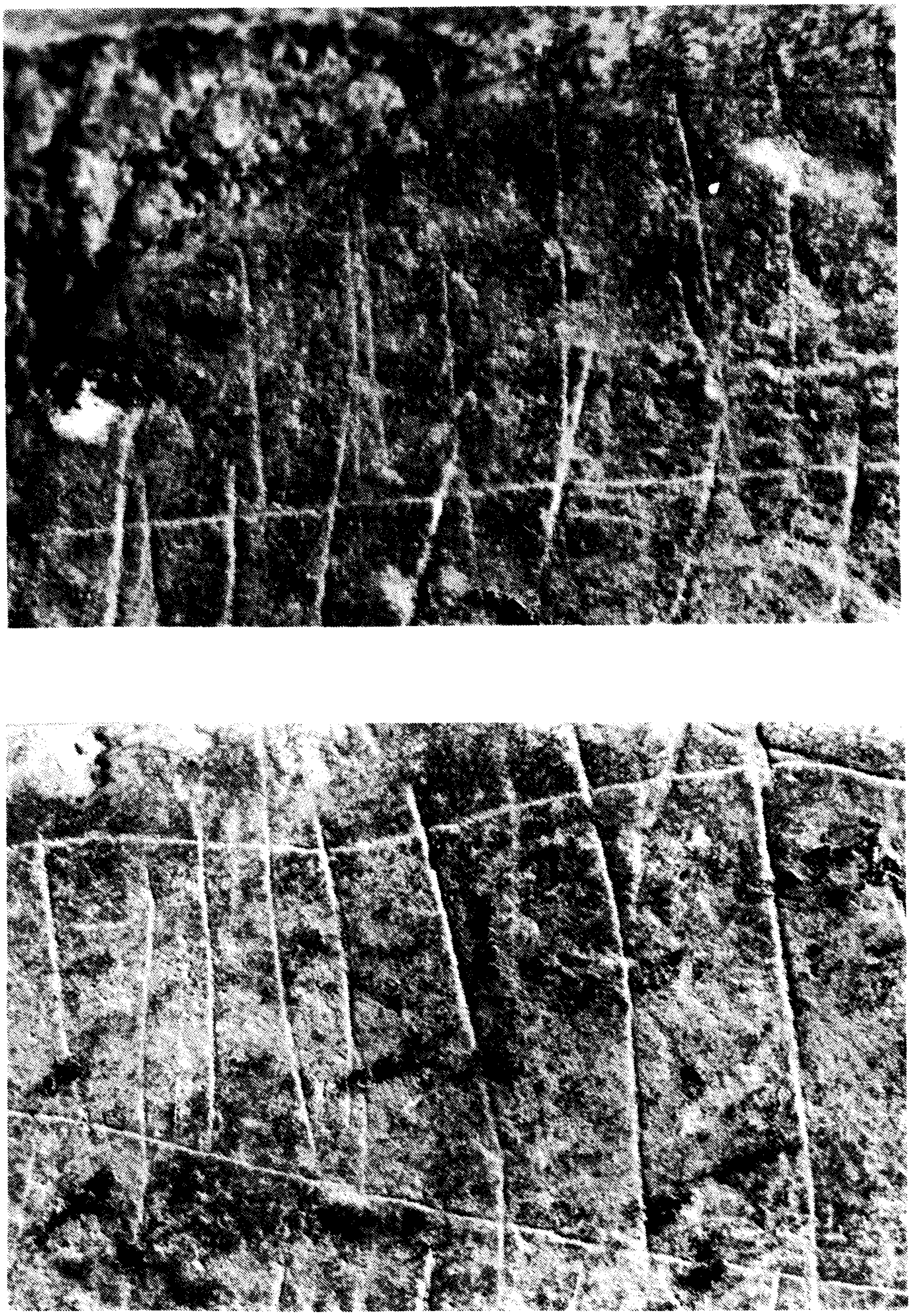


Figure 10 a et b. a) The lightly incised opening strokes of row # 1 of Block A, indicating the two tiny strokes that cross into the edge of the flaking at left. The rim of the spalled area and the two strokes crossing it are polished, as is the upper edge of the stone along the top. Note the difference in the pressure and angle of incising between rows #1 and #2. b) At left in the photo are the last four strokes of the lightly incised sequence of 31 marks that begin row #1 of Block A, followed by four at the 8 deeply incised longer strokes that close that row. The photo is made to the same scale and with the same angle of lighting as the opening sequence in figure 10a. Compare the angle and pressure od these terminating strokes of Row #1 with the first strokes of row #1 and those of row #2 in figure 9b.

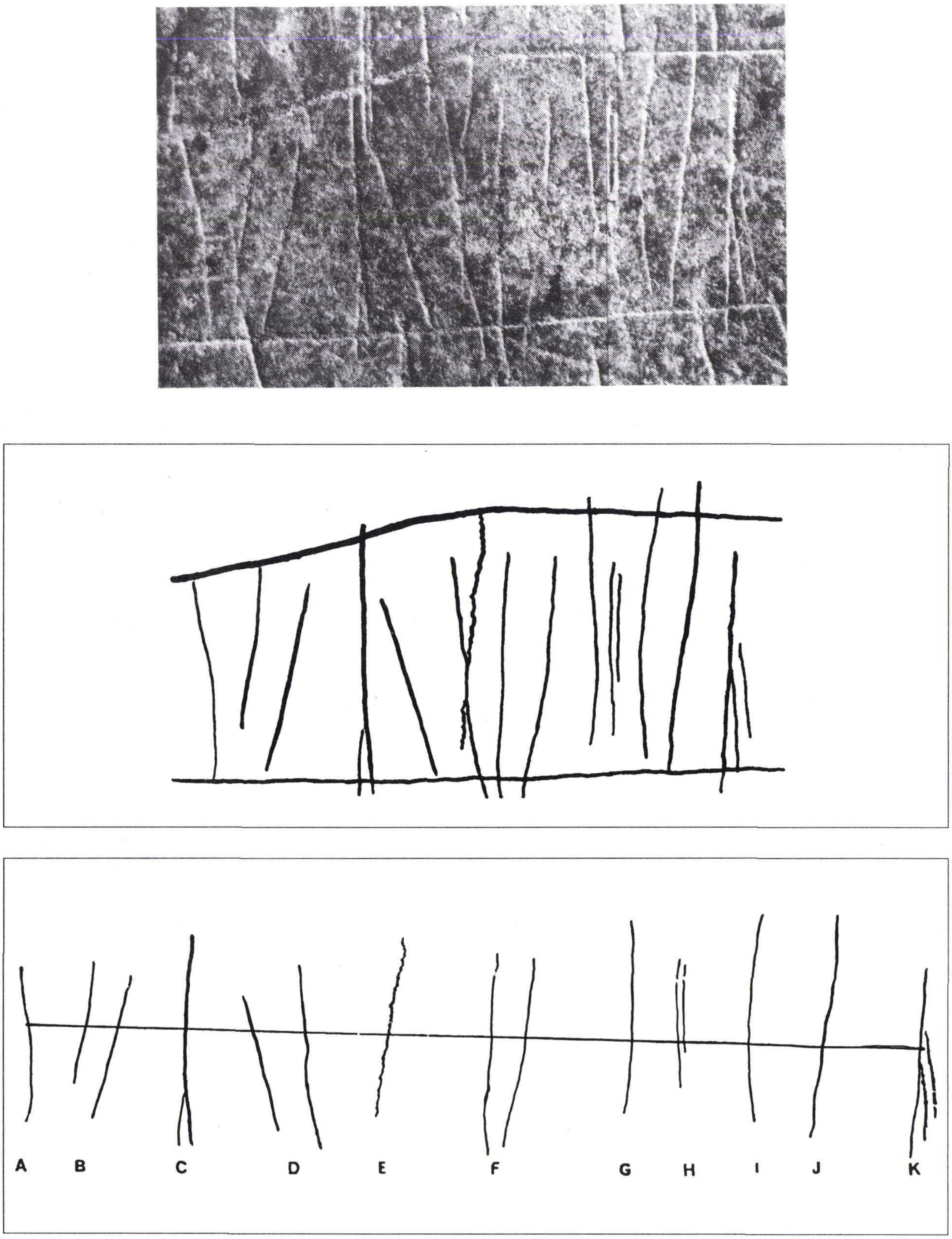


Figure 11 a-c. a) Photo of the beginning of row #3 of Block A indicating an irregular accumulation of subsets consisting of one or two marks incised at different angles and with different pressures. b) A linear rendition of the 17 marks at the beginning of row #3 indicating the differences among the subsets. Some subsets and strokes are slanted or arced to the right or the left. The final stroke has two appended cueing marks. c) An exploded rendition of the 17 marks indicating the different angle of incising the subsets. This type of subset variation would not occur in rythmic marking.

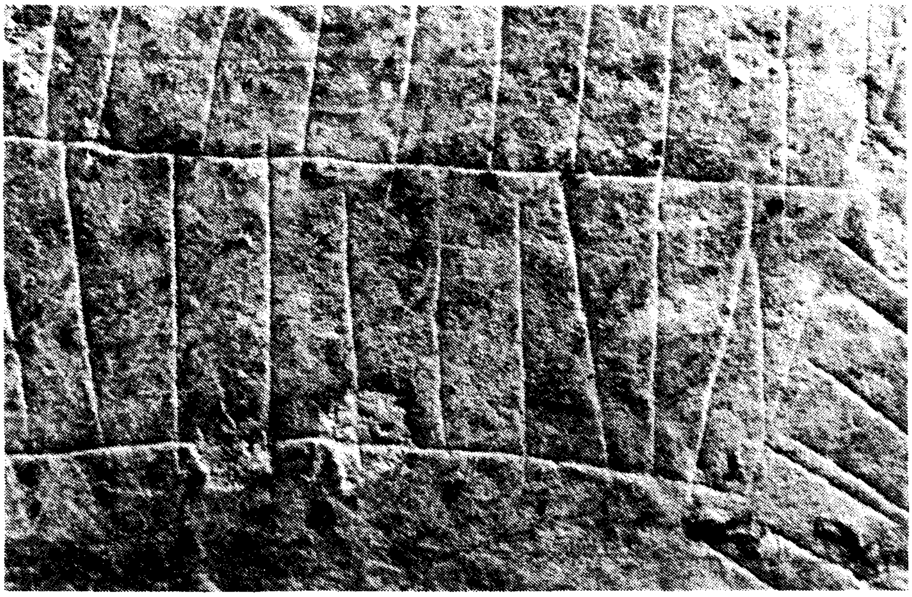


Figure 12.
The ending sequence at right of row #4 of Block A, indicating the inverted angle sign of closing. The last five strokes vary in their angle of marking. The first row of Block B, incised at 90°, in visible at right.

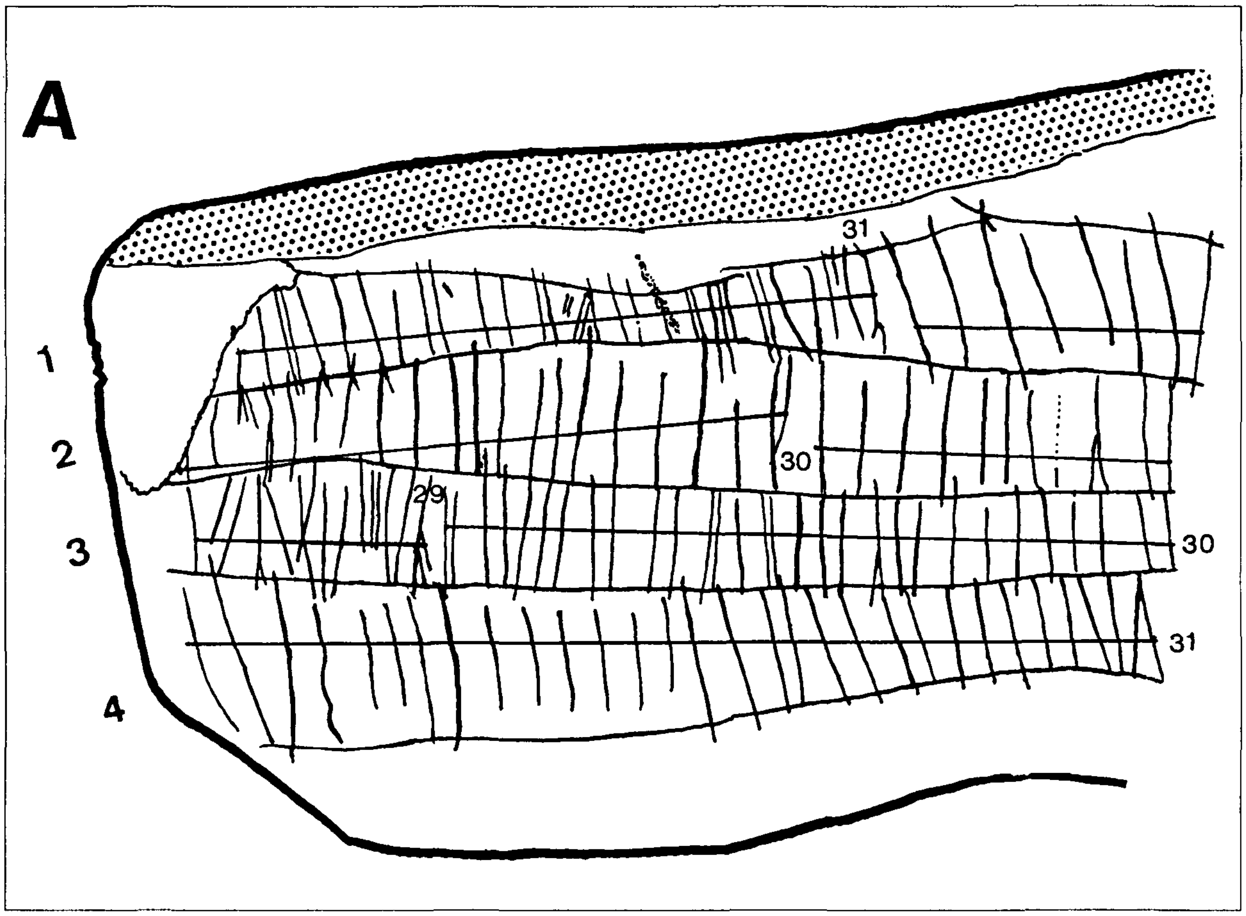


Figure 13.
A linear rendition of Block A overlined to indicate some of the apparent changes in the rythm, angle of marking, and cueing signs found within and between groupings of sets. The breaks in this overlining usually occur at signs or cueing marks or at a change of point. These long groupings or presumed superordinate sets have been counted as part of the analysis, though they may not have counted the engraver. The overlined groupings are comprised of smaller subsets wich, however, were probably counted (See Appendix).

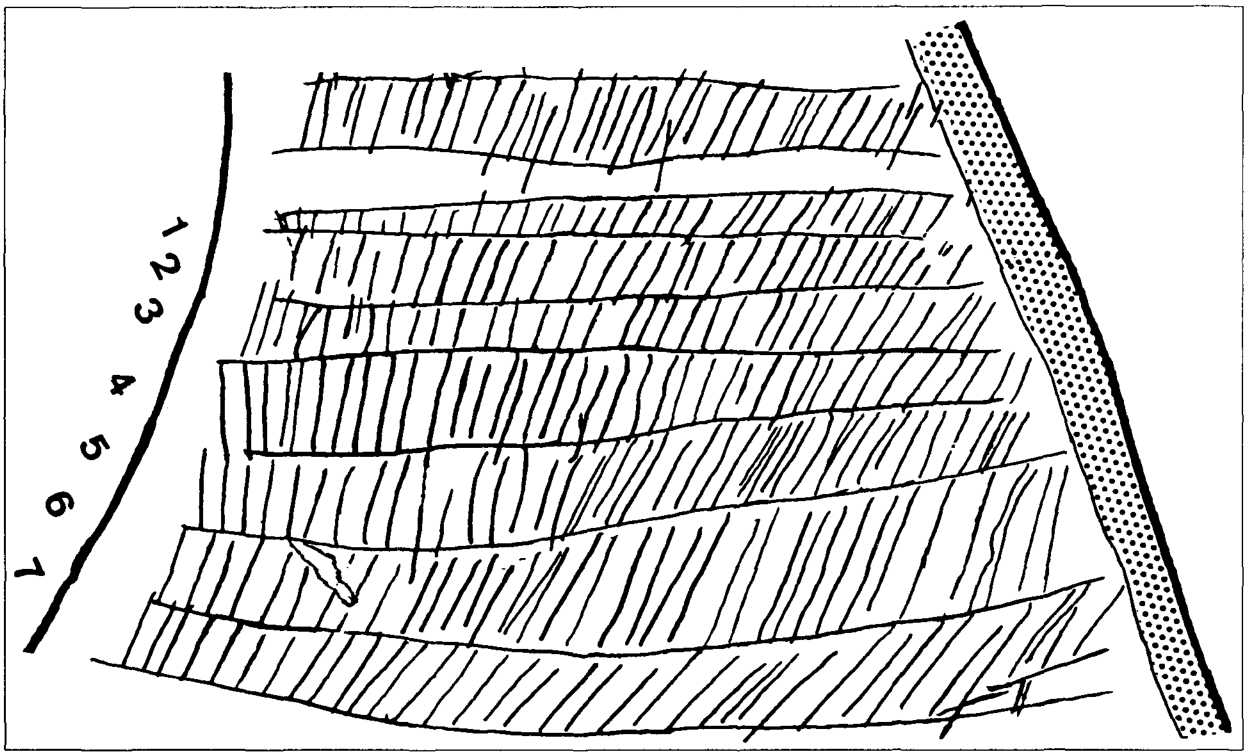


Figure 14 a and b. a) The eight rows of Block B wich are incised at 90° to Blocks A and C. Each row varies in its number of units and the rythm, pressure and the angle of its subsets. b) Line rendition of the marking in Block B. The upper row, here termed the "straggler", is separated by a space from the rows below. The first row below the "staggler" is incised in a different manner from the "staggler" or any other row on the stone. There is a tendency for the incising to begin to slant towards the right as a row proceeds even though the row may have begun vertically. Block B ends with the addition of two short containing lines and added strokes (figures 4b, 18 a-b and 19).

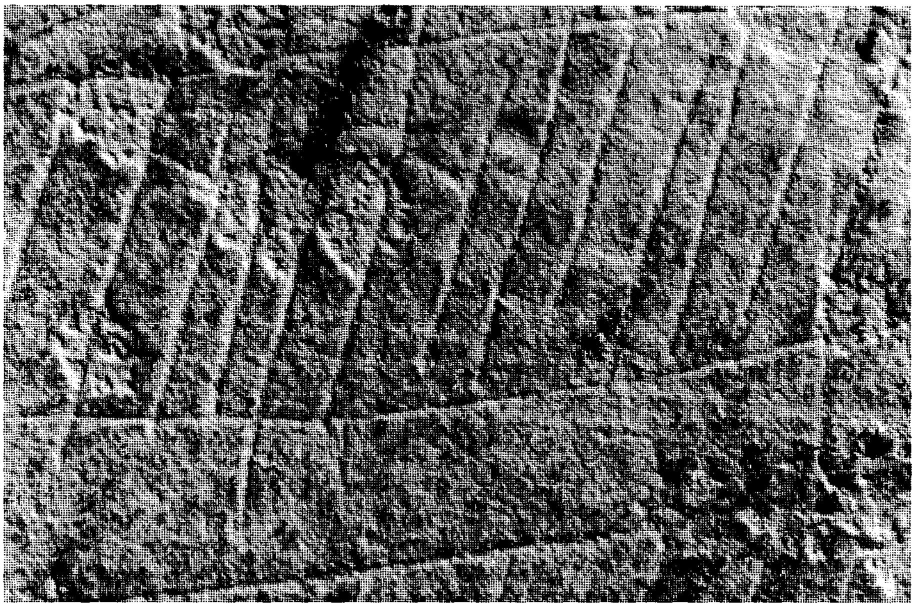


Figure 15.
A section within the "staggler". The long 14th stroke (at the dark encrustation) crosses the lower horizontal. The strokes to the left and to the right of this 14th stroke are incised with different pressures and cross-sections. The encrusted 22nd stroke is marked with cueing stroke at its base. There is a space between this typical ladder and the very lightly incised first row below the "staggler"

Figure 16.
The beginning of Rows #1 and #2, and some of row #3, of Block B, indicating the differences in the angle, pressure, these rows and the "staggler" above. The differences strongly suggest separate periods of incising.

Figure 17. The opening verticals of row #3 of Block B indicating the addition of an arced cueing mark on stroke #4. The arced stroke is filled with red sand and so was lightened.

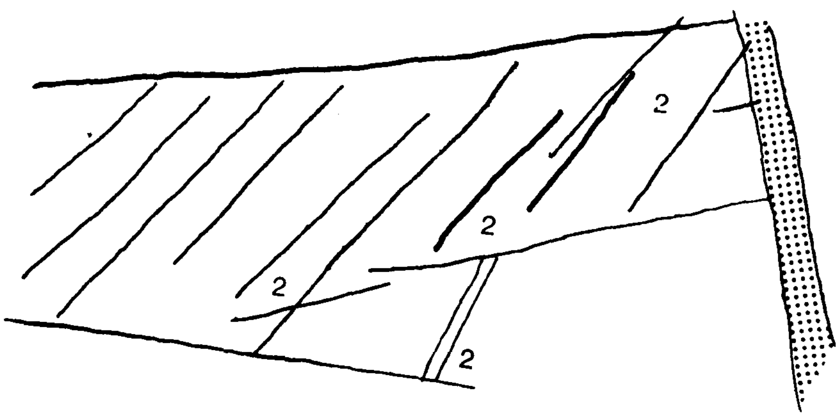


Figure 18 a and b. Detail of the ending of Block B on row #8, bottom right. Two short containning lines were incised at an upward angle following the petering out of the lower horizontal. Two strokes were added above the first short horizontal, then a second angled horizontal was incised and four (2+2) strokes were added above it. Fanally, to close #8, two strokes were added below the added six strokes and a tick was incised over the edge. In the photo, the long original lower containing line is visible at bottom left as it thins out. The upper containing line continues to the edge of the stone. The photo was been pieced together from two macrophotos.

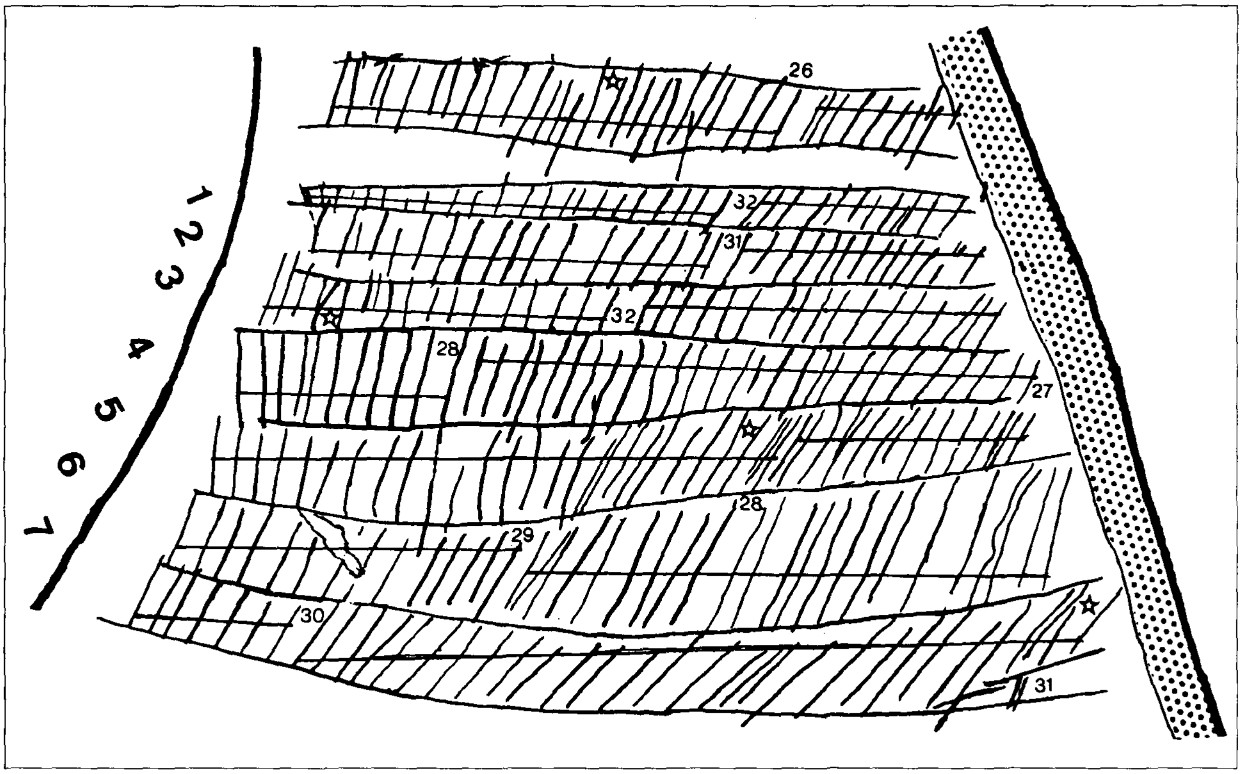


Figure 19. Linear rendition of Block B of the Öküzini pebble over-marked with horizontal lines to indicate the apparent observational lunar periods that are differentiated visually either by a space, a change in the rhythm, angle or pressure of marking, or a cueing sign. The numbers at these positions are the analyst' s, they do not represent an arithmetical count by the engraver. A "star" is placed at possible positions of a solar observation at approximate 91± day intervals.

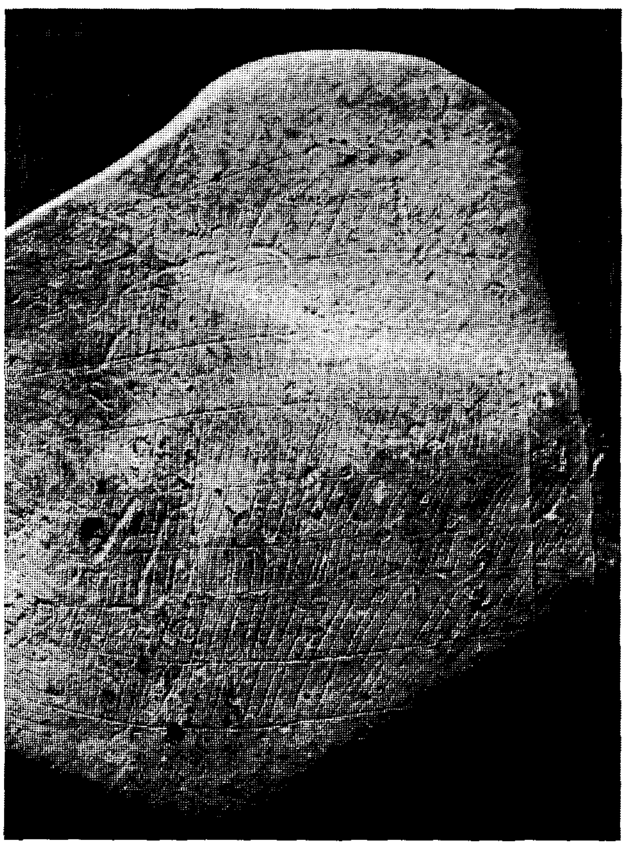


Figure 20a. Block C, indicating the two planes that were incised with 8 rows of ladders.

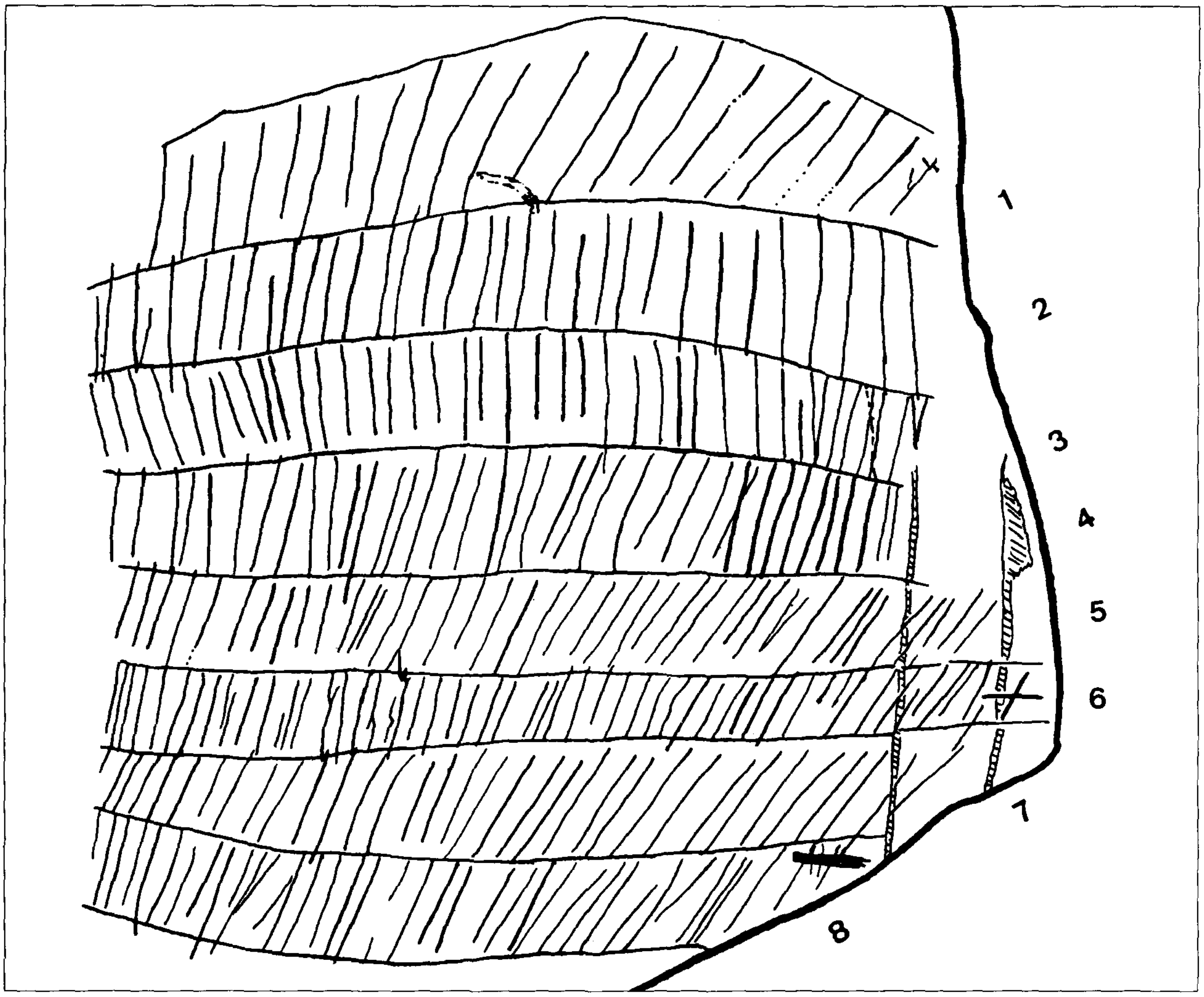


Figure 20 b. Line rendition of all the marks in the 8 rows of Block C. Each of the rows is incised with a different pressure and rhythm of marking or spacing. Row #6 extends beyond the two vertical fossil inclusions and ends with a cross. The eighth row, #7, ends with a sign of closing at far right (Fig. 4c, Fig. 22). The top row, #1, seems like the "straggler" of Block B, an addendum that was incised before the more regular marking that begins with row #2. Row 3 ends with a small "v" sign, row 4 ends with a subset of 8+2/3 and row 7 ends with the "sign of closing" that terminates the incising.

Figure 21. The end of row #6 of Block C indicating the line that crosses the last vertical stroke. At right, the polish and discoloration along the edge of the stone are apparent.

Figure 22. The end of row #8 indicating the broad horizontal stroke that crosses over the final three of four short hesitant strokes. The polish and discoloration along the edge of the stone is again apparent.

Figure 23.
The first four strokes of row #2 indicating the cueing sign after the third stroke. The cross sections change after the cueing mark.

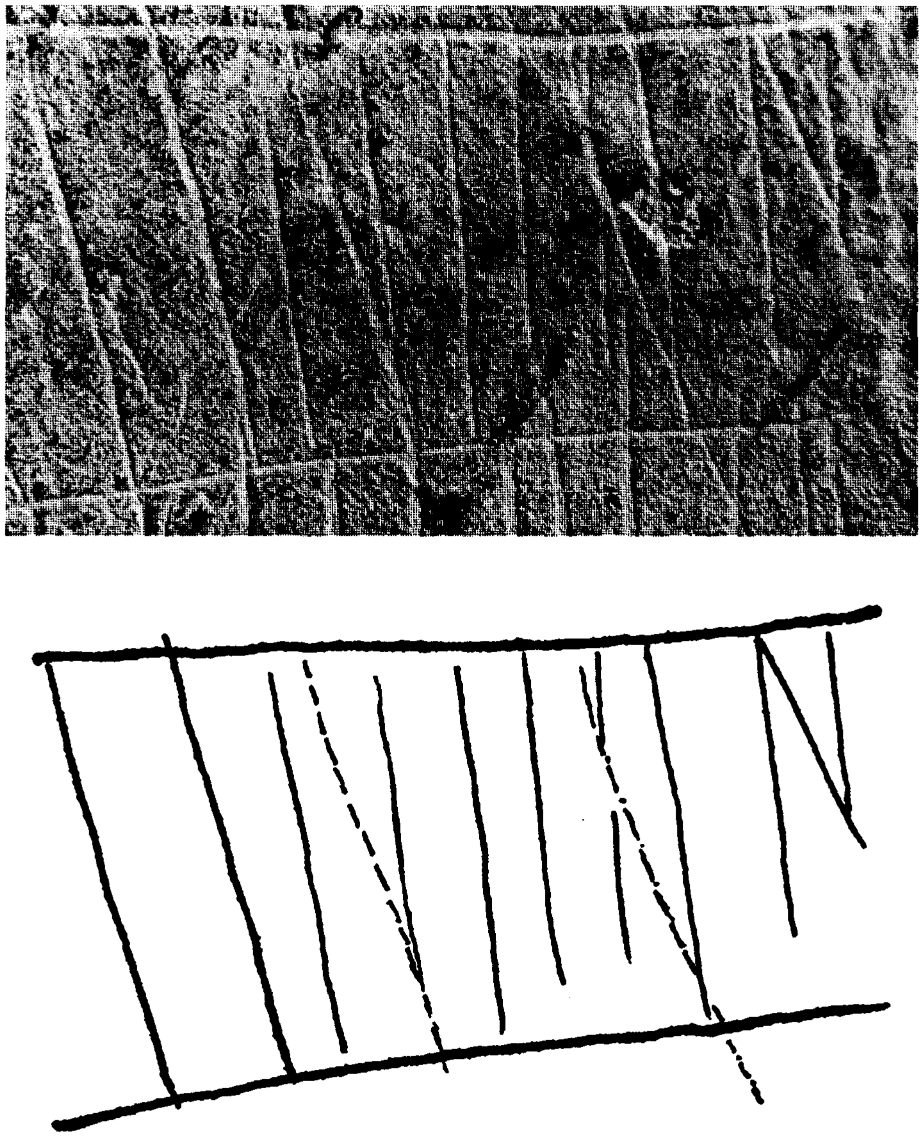


Figure 24.

The ending at right of row #3 of Block C, indicating the set of strokes that was incised after the two deeply angled strokes at left. This final set ends with a small "v" sign. There are 8 vertical strokes in this group, but the group also includes three strokes that are angled to the right. It is possible that these three strokes were added after the 8 vertical strokes, with one of these forming the small "v." There are only a few places within the Öküzini composition where such seemingly extraneous marks occur within a set or on a stroke and in each instance their appearance suggests some positional relevance.

Figure 25. Detail within row #4 of Block C indicating the variable marking before a long line in mid-photo, stroke # 12, after which the angle and rhythm of marking changes. Following the five strokes to the right of the long vertical, there is another long vertical and the angles of incising again change until the terminal 8+2 verticals of figure 5 a,b. (See Fig. 20 b).

Figure 26. The beginning of row # 8 of Block C. The first stroke of this group, at left, crosses the bottom horizontal of Block B at left. Strokes 1-2-3 are a subset; 4-5 and 6-7-8 are subsets; as are 9 and 10. The 12th and 13th strokes are a subset incised at a sharp angle. This subset terminates this beginning group of 13 strokes.

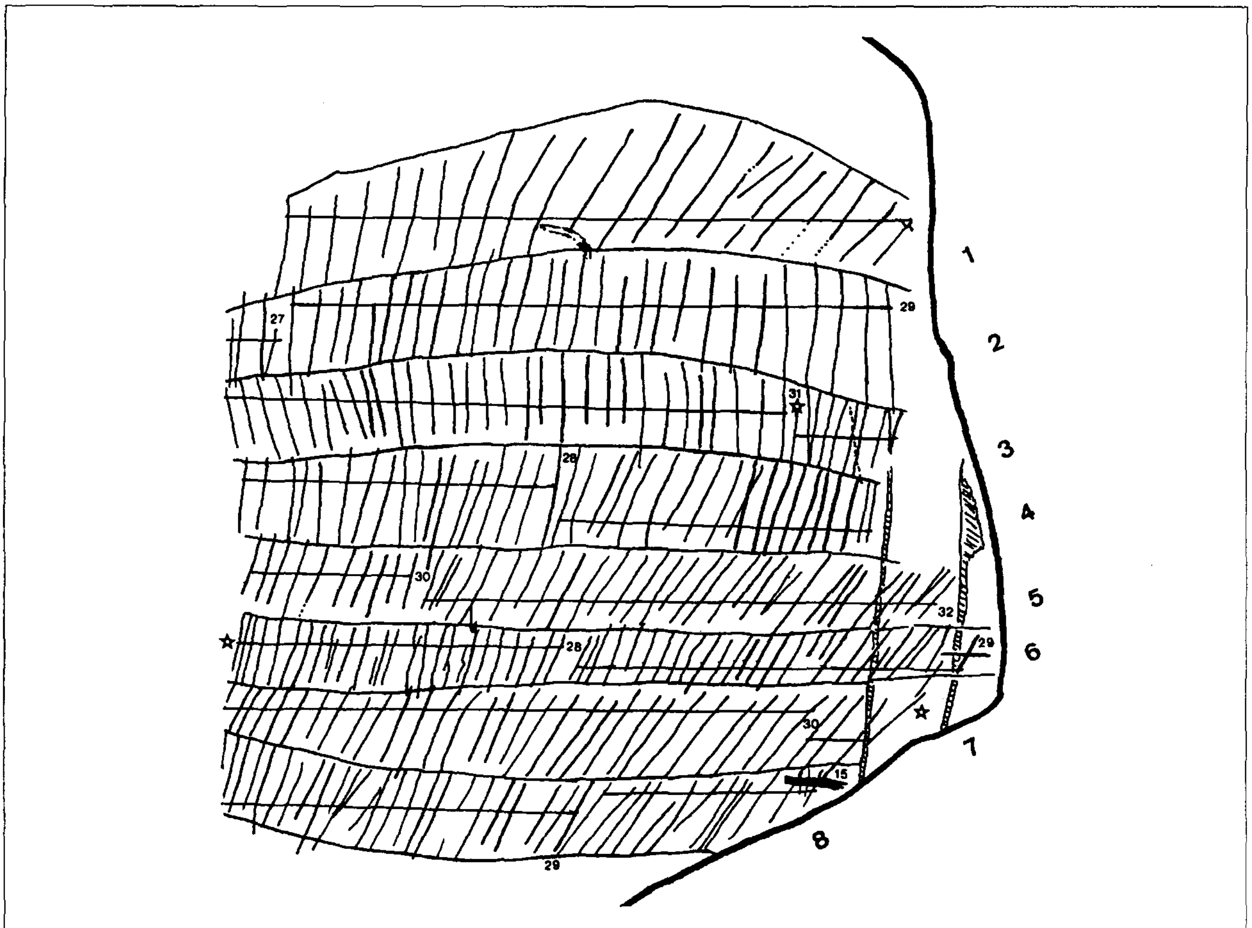
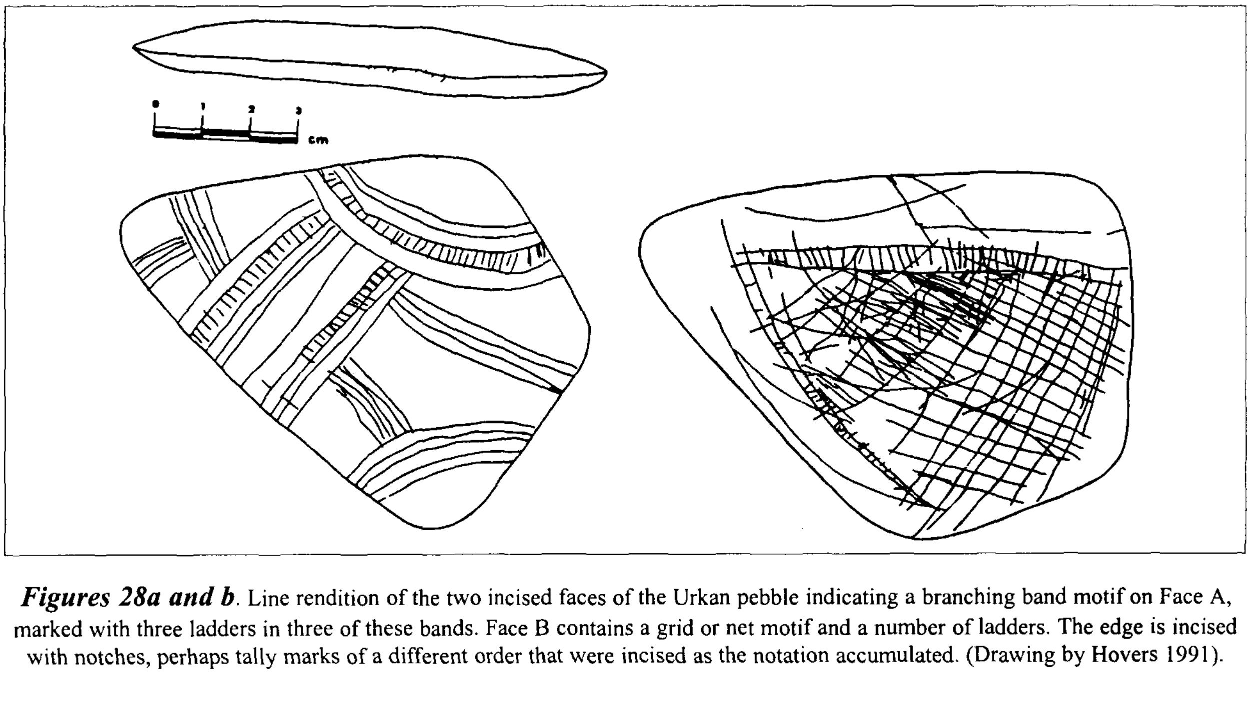


Figure 27. A line rendition of Block C that has been overlined with horizontal lines to indicate what seem to be recognizable changes either in the angle or rhythm of marking, or the presence of a "sign" or cueing indication. The overlining seems to encompass non-numerical observational lunar periods, indicated by the numbers appended at the end of each grouping. If the assumption is valid, it would have been possible for the engraver to perceive these groupings without the analytical overlining. The many "anomalies" would have aided in such a reading. A possible conjunctive solar reading has been noted by placing star symbols at approximate 91 day intervals, assuming that there had been a solar observation within the 8 added strokes at the end of Block B and adding 3 days to row 1.



Figures 28a and b. Line rendition of the two incised faces of the Urkan pebble indicating a branching band motif on Face A, marked with three ladders in three of these bands. Face B contains a grid or net motif and a number of ladders. The edge is incised with notches, perhaps tally marks of a different order that were incised as the notation accumulated. (Drawing by Hovers 1991).

Figure 29a.

Figure 29b.

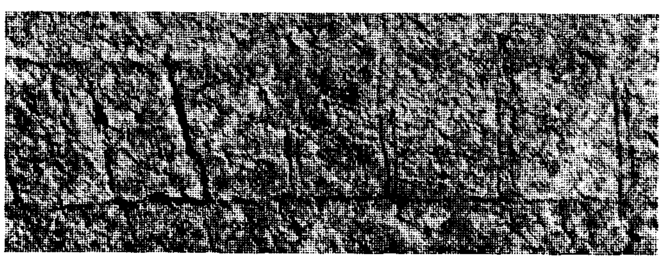


Figure 30a.

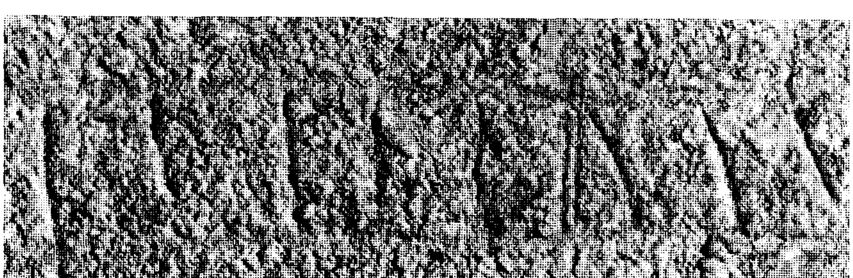


Figure 30b.

Figures 29 a and b.

a) Close-up photo of part of the net or grid motif as it crosses over the upper ladder. The fine incising and regularity of the net motif contrasts with the typical subset variability in the ladder.

b) Close-up detail of the ladder indicating the short subsets that were incised with different points, pressures, and at different angles.

Figures 30a and b.

a) The beginning of one of the vertical ladders within a branching band on Face A of the Urkan pebble. The sequence opens with four finely incised strokes made by a point with a double track. These are followed by more deeply incised strokes made at an angle.

b) The ending group of this first vertical ladder documenting subsets incised by different tools and angles of marking. The fourth stroke is incised by a point with a double track. The sequence ends with a long stroke. This type of subset variability is round within all the ladders on the Urkan pebble.

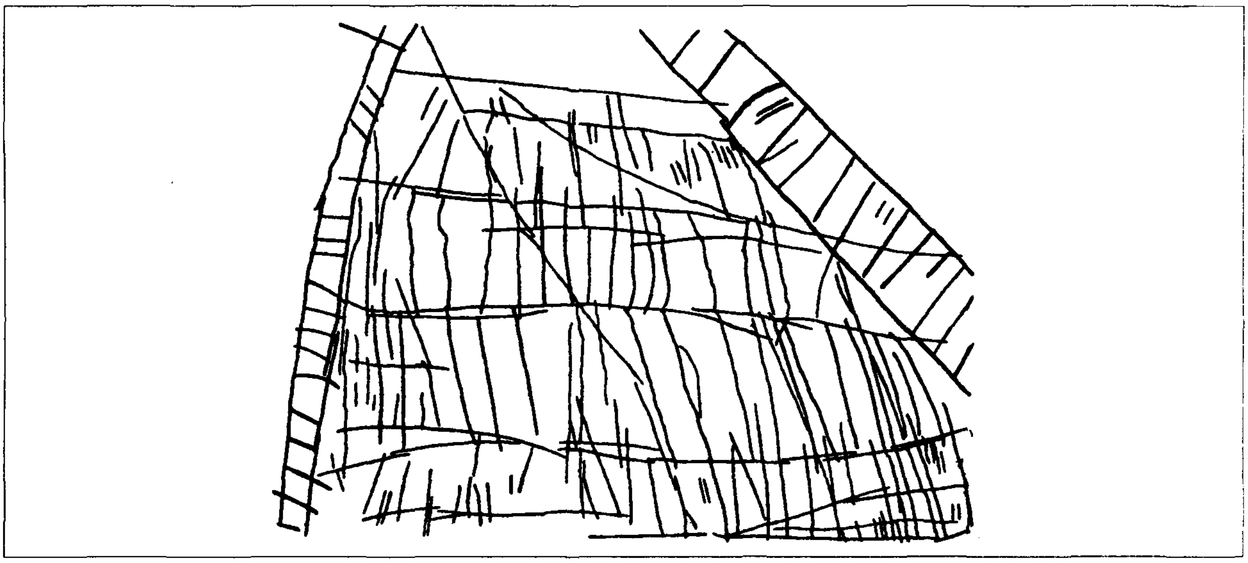


Figure 31.

Linear rendition of the central melange on Face B of the Urkan pebble. It is composed of four rows of subsets made at different angles and different rhythms of marking and by adding short appended horizontals to contain these subsets. The drawing illustrates three different groups of ladder-like accumulations, each accumulated in the subset mode. The net or grid below the melange is not illustrated.

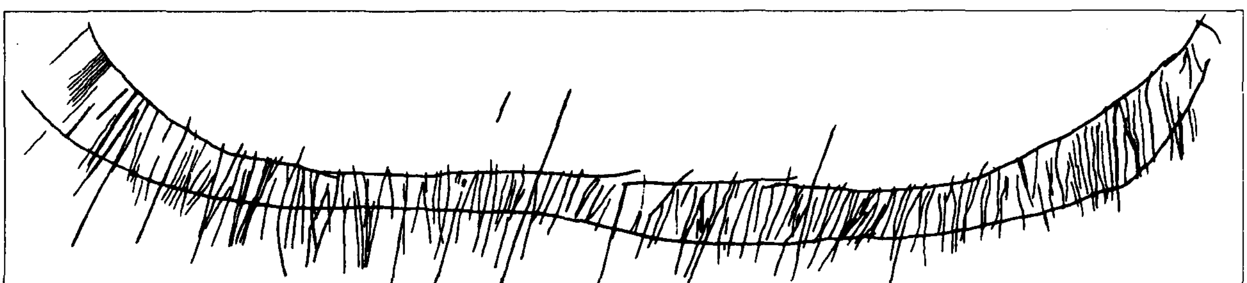


Figure 32. Linear rendition of the finely incised ladder on a block from Hayonim cave.

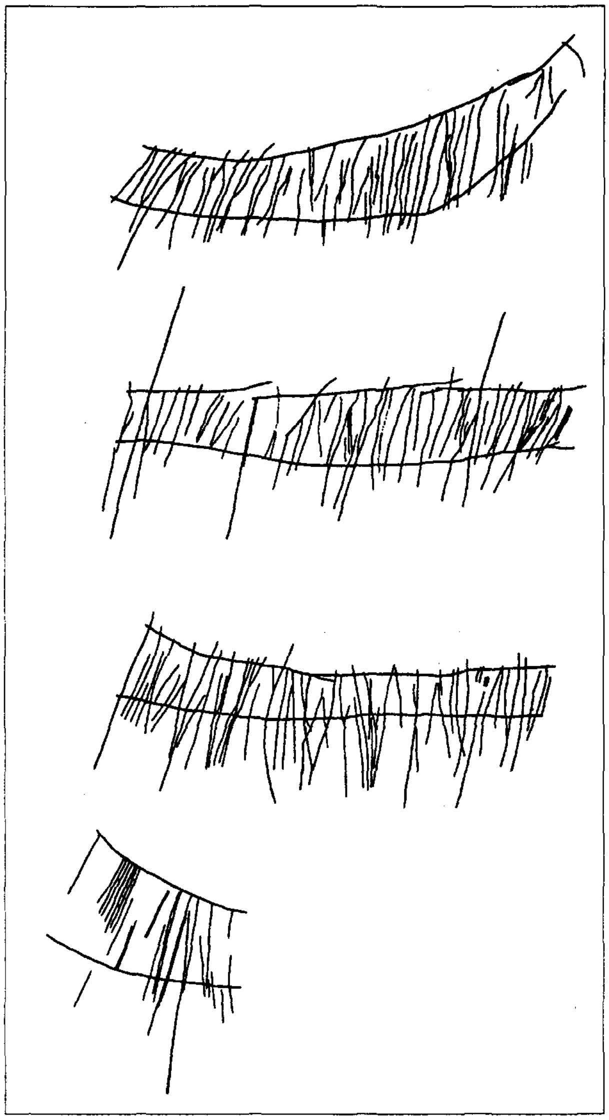


Figure 33 a-d. A breakdown of the Hayonim sequence indicating the four groups of approximately two months each and a last smaller group, each set containing its own distinctive subsets and positional cueing marks.

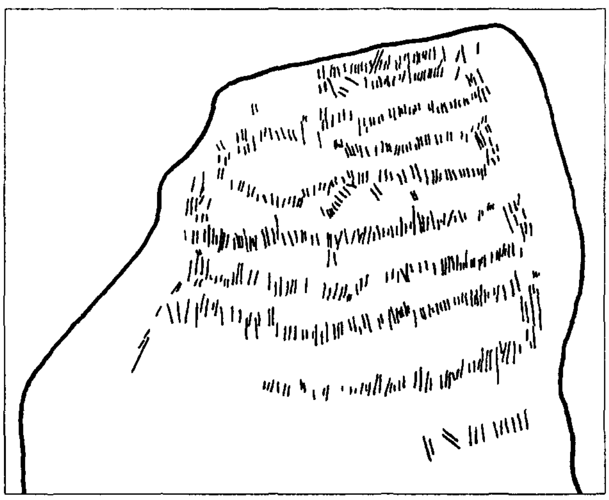


Figure 34. The incised composition on a limestone block from Riparo Tagliente.

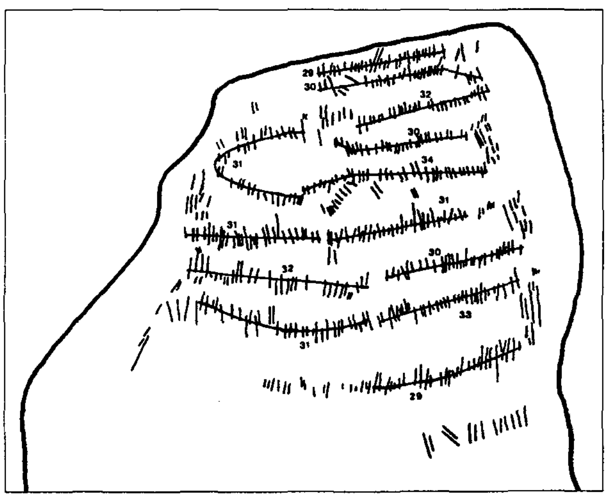


Figure 35. The Riparo Tagliente composition overmarked and numbered to indicate the major sequences and perceptual groupings, each of which seems to represent an approximate observational lunar period but with occasional cueing marks. Smaller subsidiary subsets are present before and after these groupings and may represent other forms of reference.

Figure 36 a. Karain, Anatolya. One face of an incised flat stone containing three types of imagery, two anthropomorphs, a schematic hand, and a multiple band motif. There is a remnant branching band motif on the other face.

Figure 36 b. Line rendition of the incised images on one face of the Karain stone

Figure 37. Karain. Close-up of one of the human figures incised above one edge of the stone, indicating the large oval eye. A schematic hand with four fingers and a possible fifth finger line, is incised along a different edge.

Figure 38. Chamula, Chiapas, Mexico. The wooden calendar board kept by a shaman and marked with different charcoal crayons at different times and with different rhythms of marking for different months.