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GEOARCHAEOLOGY OF THE PLEISTOCENE OCCUPATION OF WESTERN CANADA

ABSTRACT: Recognition of Palaeo-American sites in Pleistocene geological settings is rather problematic for most American archaeologists as no consensus has been reached yet about the timing of the initial Palaeo-American migration from eastern Asia, the level of technology and the associated typological variety of stone tools that the early inhabitants of the continent might have brought with them. One of the principal problems concerns the recognition of artifactually flaked lithics and associated cultural remains deeply buried under or within glacial and glacigenic deposits in Eastern Beringia and adjacent areas. This fact largely reflects the lack of adequate geomorphological, sedimentological and rock-mechanical studies, combining field observations and analytical laboratory expertise (including cultural and natural stone flaking) in the current archaeological studies. Introduction of geoarchaeological research strategies incorporating glacial geology and palaeolithic archaeology, and a more active role of other natural sciences may significantly contribute to elucidation of the earliest New World prehistory, particularly in the formerly glaciated areas of North America. Pioneering investigations in western Alberta at palaeolithic sites sealed by thick (10+m) surficial deposits formed under or close to the continental ice-sheet or the Cordilleran valley glaciers during the last glacial stage have provided the first definite evidence that early people occupied foothills and the plains east of the Canadian Rocky Mountains prior to the last glacial maximum.

KEY WORDS: Western Canada – Pleistocene glaciations – Quaternary geology – Glacigenic deposits – Palaeolithic archaeology – Palaeo-American occupation – Lithic industry

INTRODUCTION

The conditions, routes and timing of human colonization of the New World until now remain unresolved problems, despite the fact that there have been many attempts to cope with these issues – on the basis of field data, as well as theoretically by providing various explanatory models. Although a certain progress in the intellectual reasoning on the initial peopling of the Americas and a shift from the traditional "Clovis-first" paradigm has been recently observed due to the acceptance of a 13,000 year-old cultural horizon at the Monte Verde Site in southern Chile (Dillehay 1997), the question of the initial peopling the New World is far from being resolved. Critical assessment of any potential archaeological record older than *ca* 12,000 years, i.e. the time horizon which marks the appearance of bifacially shaped stone projectile points, follows three lines of evidence :1) the cultural character of the record, 2) its primary context, and 3) the chronological assignment. Nevertheless, the need for unequivocal proof of cultural status and original geological context of any claimed Pleistocene-age site or lithic sample is probably the most frequently raised argument of opponents of an earlier pre-Palaeoindian occupation of the New World. Currently there is no pre-12,000 year-old site in the Americas whose evidence has been accepted without reservation.

Despite my original professional specialisation in the European Palaeolithic studies, I have become genuinely interested in the earliest American prehistory after coming to Canada in 1988. At the beginning, I did not fully realise how controversial the intriguing question of when the first prehistoric people arrived to North America and settled the rest of the continent is for the American scientific community. After my move to Calgary in August 1990, my interest increased significantly after finding several flaked quartzite cobbles and retouched flakes eroding from a deep geological context (presumably glacial deposits) about 20–25 m below the present land surface on the western periphery of the city during a casual visit in early October of the same year. The apparent similarity of those specimens with palaeolithic industries I had previously collected in large numbers on high river terraces and other places in southern Moravia, the Czech Republic (e.g. Chlachula 1993), was astonishing, and I could not persuade myself after a close and repeated examination that they were naturally flaked rocks. The realisation that they are, indeed, prehistoric artifacts, was the initial impetus to visit on a regular basis naturally exposed Pleistocene sections along the Bow River on the western periphery of the city of Calgary and to search more systematically for the cultural record and determine its original geological provenience. As the size of the lithic artifact assemblage expanded, I soon realised – to my surprise – that the collected material includes virtually all principal tool types characteristic for the Central European Lower, Middle and in part also the Upper Palaeolithic, that under normal circumstances would not occur together at any of the sites I previously investigated even where identical raw material was used for stone tool production. Uniform textural traits, including degree of abrasion and mineral staining, made me conclude that all quartzite artifacts found associated with each other represent a single and rather specific lithic industry. This conclusion was verified when other "typologically" variable pieces were recovered together in the identical geological context. It was the overall archaic appearance of the assemblage, including many very rudimentarily modified artifacts, which inspired so much of my personal interest – much more than if those finds were perfectly shaped projectile points made on exotic raw materials.

Although the first reactions from most North American archaeologists working on the Western Plains in respect to the Calgary lithic record were overwhelmingly negative or at least taken with much reservation because of the rather unusual geological context producing the alleged artifacts (which would normally be accepted as humanly made if found in a setting on or close to the present surface, as it is the case with most post-glacial prehistoric sites in western Canada), the research continued and gradually developed in a multidisciplinary long-term project. Because of the nature of the record, the methodological and intellectual background for the investigations became inevitably based on combining the Old World Palaeolithic archaeology and North American, specifically western Alberta, Quaternary geology. Particular attention has been paid to geological (stratigraphic and sedimentological), palaeoenvironmental, and clast modification aspects of investigation. Already in the course of the initial studies, the primary research objectives gradually shifted from archaeological to purely geological ones because of the key issues related to the stone industry provenience, site stratigraphy, Quaternary environments, contextual chronology and human palaeoecology. The geoarchaeological studies were structured to demonstrate, in a logical sequence, the cultural authenticity of the claimed Pleistocene-age cultural record, to secure its geological context, and to establish a supporting geochronological framework for Late Pleistocene occupation of the western Canadian prairies. Eventually, the 1990–1997 research has repeatedly produced clear evidence of early human presence in this part of North America long before the appearance of the Palaeoindian cultures on the Plains, which are traditionally regarded as the earliest cultural manifestations of the prehistoric peopling of the New World. These pioneering, Pleistocene-oriented geoarchaeological investigations, opening a completely new niche of future archaeological research in the areas formerly affected by glaciations, show the necessity of implementing flexible methological approaches and research techniques into the current early prehistoric studies in the formerly glaciated parts of western Canada, and North America in general.

PLEISTOCENE GEOARCHAEOLOGY IN ALBERTA: A STUDY CASE – THE BOW VALLEY SITES

At the present time, there are several sites in the province of Alberta that have repeatedly produced clear evidence of an early (pre-last glacial) occupation of this part of western Canada. The sites are distributed in the present and former river valleys east of the Rocky Mountains over a territory of 1,500 km from north to south (*Figure 1*). Geologically, the sites show a patterned contextual situation with archaeological finds under last glacial deposits (glacial diamictons) related to the Cordilleran glaciation (Calgary 1–3) or the Laurentide glaciation (Grimshaw, Villeneuve, Edmonton) (Chlachula, Leslie 1998, Chlachula, unpublished data). Except for the open-air sites, there is one potential cave site with early human evidence in the Crowsnest Pass in the SW Alberta Rocky Mountain Foothills (Eagle Cave). The Calgary sites are, at the present time, the most significant and best studied palaeolithic sites in Alberta.

Geomorphological setting

The sites (114°10'00" W; 51°05'30" N) are located in the Bow River valley on the south-western margin of the Interior Canadian Plains in the western part of the city of Calgary, south-western Alberta. The surrounding landscape of a 1000–1200 m altitude is characterised by a rolling prairie. The locality comprises a series of natural exposures along the NW-SE oriented northern side of the Bow River, with surface altitude of 1070–1084 m. Two principal places

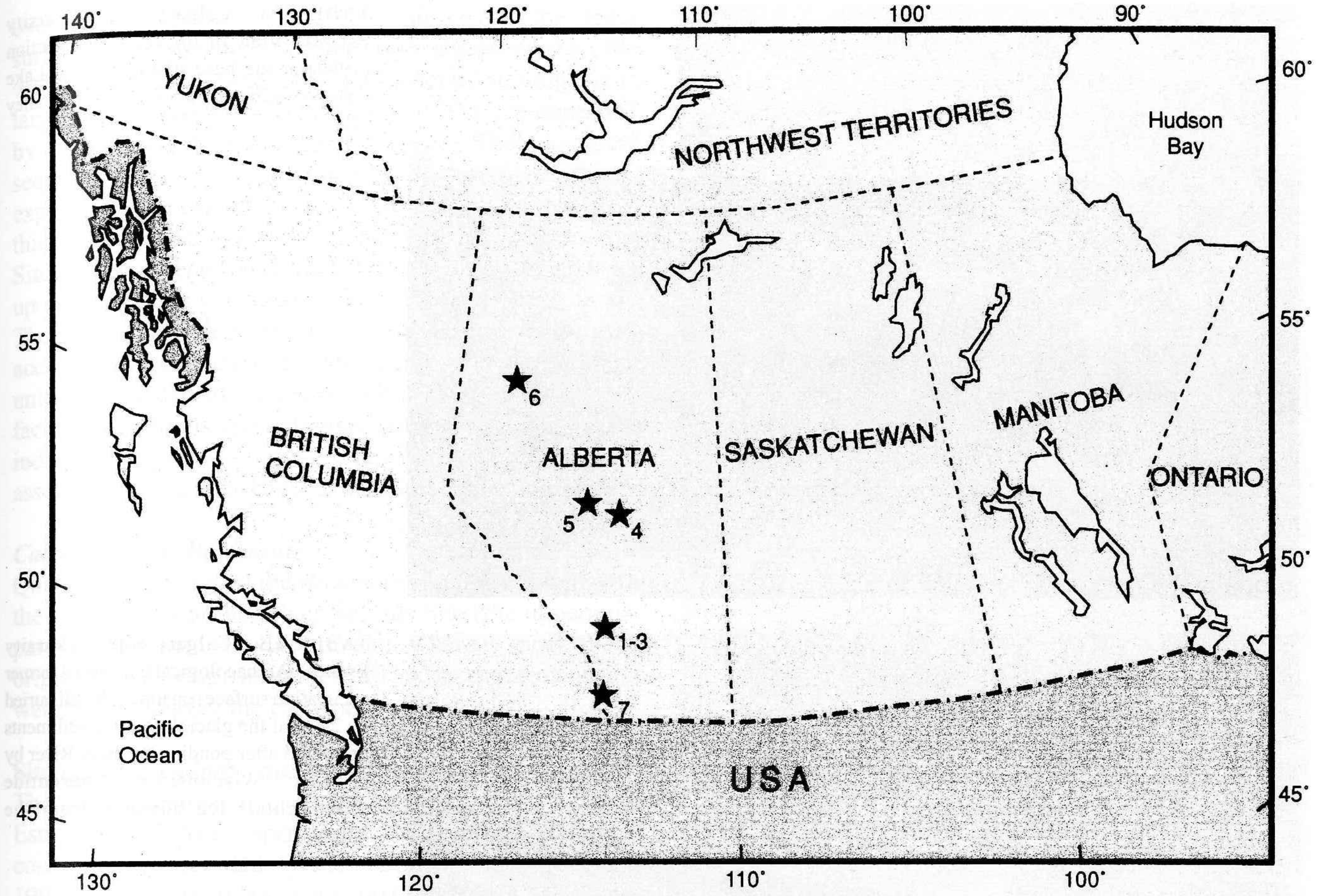

FIGURE 1. Geographical distribution of investigated palaeolithic (palaeo-American) sites in Alberta. Legend: 1–3 Calgary (Varsity Estates, Silver Springs, Bowmont), 4 Edmonton (Riverside), 5 Villeneuve, 6 Grimshaw, 7 Eagle Cave.

with actively eroding Quaternary sections, formally referred to as Site 1 (Varsity Estates) and Site 2 (Silver Springs) are located 2.5 km apart (with the latter site being farther upstream) (*Tables 1A, 3B*). A third, most recently studied location (Bowmont), situated farther west, is *de facto* a continuum of the Silver Springs sections which are here much less preserved and exposed only in a recent road cut. The steep northern wall along the river valley is about 35–51 m high, in places deeply dissected by gullies and intensively modified by slope gravity processes. Beyond the cliff-forming upper margin of the NW-SE oriented "inner valley", forming the top surface of both exposures, a broader and shallower "outer valley" opens, which is bordered by a rolling upland prairie. The relief gradually rises into the foothills area to the front range of the Cordilleras about 100 km west of Calgary (*Table 4A*).

A variety of glacial, glacio-lacustrine, glaciofluvial, alluvial and colluvial deposits form the local Quaternary geological record overlying the Palaeocene sandstone of the Paskapoo Formation, superimposed over Cretaceous sedimentary rocks. Most of the surficial materials distributed on the present surface are geologically young, being largely derived during the last glacial (Late Wisconsinan) mountain and continental ice advances. The lithology of clastic deposits throughout the study area is fairly uniform. In general, rocks derived by fluvial and glacial processes from the Rocky Mountains region prevail, particularly towards the west, whereas igneous and metamorphic rocks from the Canadian Shield are more widely distributed in the east.

Site stratigraphy

The general stratigraphy at the Bow Valley sites is established from several large scale natural sections at each site. The exposed Quaternary deposits can be traced intermittently for a distance of *ca* 300 m at the first site, located about 100–200 m north of the present Bow River, and approximately 500 m directly alongside the river at the second site. The site stratigraphy at the third location is rather limited due to limited thickness of the sediments (0.5–1 m) directly overlying the archaeological horizon as well as the spatial extent of the lithic industry occurrences (*ca* 50 m). In addition to places with stone industry-bearing deposits, peripheral parts were studied at all locations. Specifically, these include lowermost stratigraphic sequences resting on bedrock at Site 2 (*Table 4B*), and the

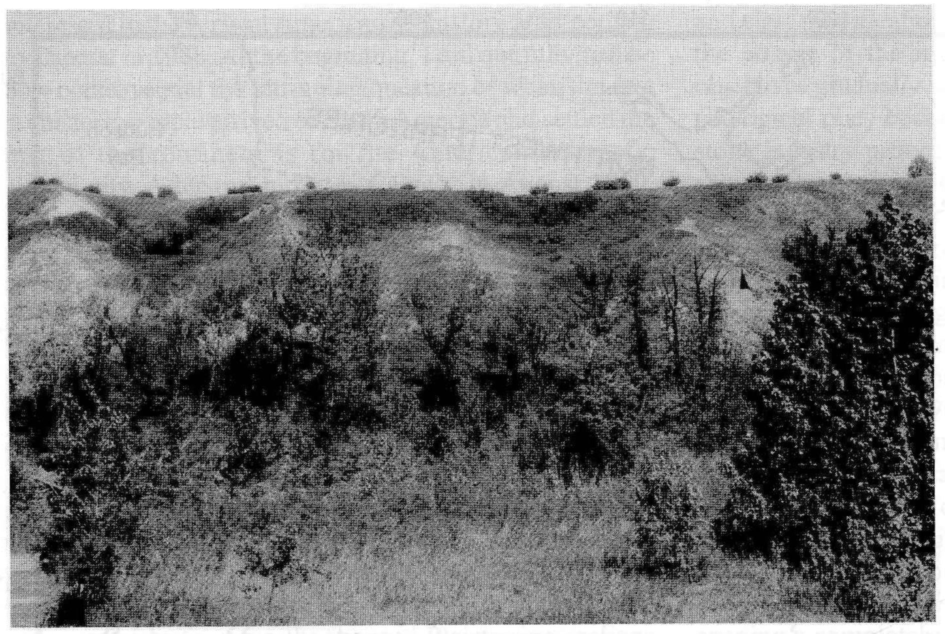

TABLE 1A. Calgary Site 1 (Varsity Estates). View of the excavated section (1993) at the base of the Glacial Lake Calgary sediments above the Bow valley till.

TABLE 1B. Calgary Site 1 (Varsity Estates). Archaeological horizon (a former occupation surface) on top of the till buried by 24 m of the glaciolacustrine sediments deposited after ponding the Bow River by a Late Wisconsinan Laurentide (continental) ice advance from the northeast.

best preserved upper bluff section at Site 1 (*Table 1A*), which together provided data for establishment of a general chronostratigraphic framework of the locality. The spatial distribution of individual sedimentary units at the Silver Springs and Varsity Estates Sites, grouped into facies and facies associations, was *a priori* determined by visual field observation, on the basis of which a sedimentary model and palaeoenvironmental reconstruction were derived.

Calgary Site 1 (Varsity Estates)

At the Varsity Estates sections, a complete documentation of the Quaternary record is prevented by lack of exposures. The lower part of the site is largely covered by slope deposits and a tree-shrub vegetation (*Table 1A-B*). Only locally and partly exposed sections reveal the geological structure of the middle part of the slopes. The upper part of the bluff-forming, gullied slope becomes semi-recessive to recessive and is largely covered by grassy vegetation. It is only locally exposed in a deeply incised, 20–25 m high ravine in the western part of the site. Most of the middle and upper section at the site can be stratigraphically documented only from a series of small spatially limited profiles. The general sequence, 25–30 m high, was derived from two larger exposures located about 200 m from each other (VEe and VEw). It was divided according to genetic depositional criteria into 8 stratigraphic units representing 6 different facies, which are grouped into 4 facies sequences, specifying particular sedimentary environments.

Calgary Site 2 (Silver Springs)

The Quaternary record at Silver Springs sections comprises up to 35 m of deposits studied in a series of stratigraphically

overlapping exposures (1072–1084 m a.s.l. at the upper surface). The upper portion of the original geological profile was eroded during the early postglacial, although it is largely preserved in the western part of the site separated by a deep gully from the eastern portion. The geological sequence above the Tertiary bedrock at the Silver Springs exposure in the eastern part of the site (SSE) is about 23 m thick (*Table 4B*). The western part of the Silver Springs Site (SSW) extends over a distance of about 200 m with up to 34 m thick Quaternary deposits above the bedrock. The Quaternary deposits were described and classified according to genetic criteria into 21 (resp. 19) stratigraphic units represented by 10 facies, which are grouped into 4 facies associations. Stratigraphic correlation between the individual sites as well as sections is based on the facies associations, related to specific depositional settings.

Calgary Site 3 (Bowmont)

Quaternary geology of the Bowmont site is consistent with the stratigraphy at the Silver Springs Site (the uppermost part of pre-glacial fluvial gravels), whereas most of the originally overlying overburden (till and lacustrine deposits) were eroded during the early post-glacial.

Site geoarchaeology: methods and approaches

The three investigated sites, designated as Site 1 (Varsity Estates), Site 2 (Silver Springs) and Site 3 (Bowmont), were consecutively recorded by the author in 1990, 1991 and 1992, respectively (Chlachula 1991, 1992, 1994a, 1994b, 1994c, 1996a, 1996b). Although these locations are referred to as sites, this is meant from a geological point of view and they are not explicitly considered to be archaeological sites *sensu stricto,* as most of the lithic material is redeposited, thus implying a secondary context. As documented below, only part of the cultural record from

TABLE 2A. Calgary Site 1 (Varsity Estates). Excavation *prior* to exposure of the till surface formed after retreat of the Cordilleran (mountain) valley glacier subsequently inundated by the glacial lake. A certain time hiatus between the two events is evidenced by a sharp disconformity between the two geological formations, as well as archaeologically by the presence of the early cultural record.

TABLE 2B. Calgary Site 1 (Varsity Estates). The exposed former occupation surface incorporating stone artifacts distributed on top of till, some of them *in situ,* other locally transported by fluvial processes. More abraded and spatially widely distributed artifacts found in the till were secondarily derived from an earlier cultural context that was disturbed by the valley ice advance.

TABLE 3A. Calgary Site 1 (Varsity Estates). Frontal part of the quartzite cobble *(Figure 5)* buried in an originally highly saturated till surface.

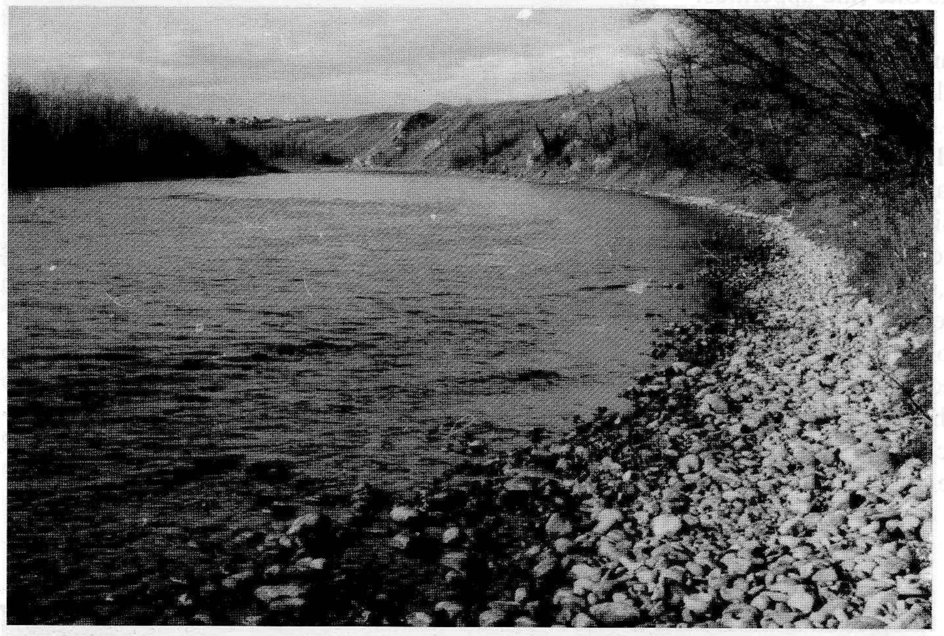

TABLE 3B. Calgary Site 2 (Silver Springs). View of the exposed Late Pleistocene sections on the left bank of the Bow River.

the first location (Varsity Estates) found *in situ* can be considered to fulfil the specific requirement of being a largely undisturbed archaeological site.

The initial archaeological and geological investigations primarily focused on the establishment of a chronostratigraphic framework at the particular sites in terms of sedimentary environments, occurrences of the stone industry, and relative chronology of the artifact-bearing deposits. This approach was largely predetermined by the character of the local physiographic and contextual setting. Detailed geological studies have been carried out in places where the sediments are well exposed in several sections, varying horizontally and vertically according to the stability of the slope and the composition of the bluff-forming deposits. Stratigraphic studies and sedimentological interpretation of palaeoenvironmental settings at the Bow Valley locality have provided crucial information on the nature, context, and approximate age of the flaked lithic assemblages. They also provide basic information about the character and configuration of natural forces which acted during the formation of these processes of the industry-bearing deposits; and the background to assess the natural potential to mimic cultural flaking patterns in the lithic collections. Specific methodological procedures were applied at individual stages of the field research. Stratigraphic sequences, reconstructed geological processes, and Pleistocene palaeoecology inferred in the study area have been the building blocks of the following archaeological studies. Without describing the geo-contextual background, basic information about the spatial distribution and stratigraphic position of the lithic record cannot be assessed, neither the cultural status of the stone assemblages demonstrated.

TABLE 4A. Calgary Site 2 (Silver Springs). View of the Bow River valley with the Rocky Mountains on the horizon, *ca* 100 km in the west.

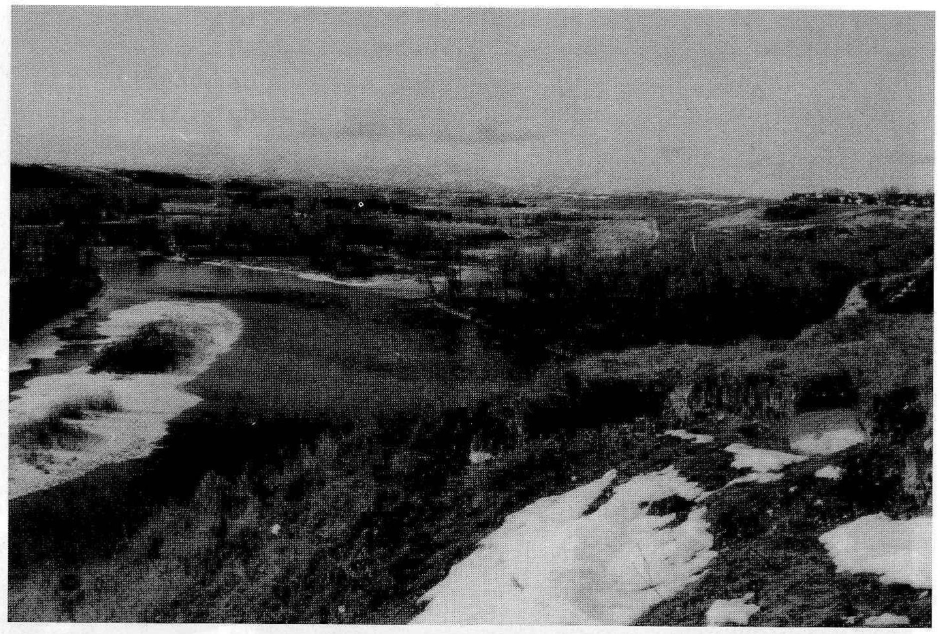

TABLE 4B. Calgary Site 2 (Silver Springs – SSE sections). Mid-Wisconsinan alluvial gravels superimposed by the early Late Wisconsinan Bow Valley till in the eastern part of the site.

For the field documentation of sedimentary structures, several criteria were applied to differentiate between various deposits on a broader spatial scale, specify their origin and palaeocurrent direction, and provide stratigraphic control. Specifically, the particle size analysis describing the shape, size and specific lithological composition of clasts was applied for a lithostratigraphic correlation of deposits and to study the dominant mechanism of sedimentary transport and deposition (Gale, Hoare 1991). Eventually, the data were used to reconstruct palaeoenvironmental conditions during the time of accumulation of these sediments, as well as their subsequent erosion. Both the primary and secondary texture of deposits were investigated and related to the syndepositional and secondary (post-depositional) particle arrangement (fabric and packing), respectively. Recorded characteristics of each particle (in the pebble and cobble group) include form (measured in three orthogonal axes), sphericity, roundness, and surface texture (presence of striation, percussion and chatter marks, degree of weathering, mineral staining and calcium carbonate incrustation).

Directional measurement of current flow in both the clast-supported and fine-grained laminated sedimentary structures (strike and dip) within particular units was used for the palaeocurrent analysis (Selby 1976, Potter, Pettijohn 1977, Gale, Hoare 1991). The recorded orientation of elongate clasts in gravel units and cross-bedding structures in sandy, silty and clayey deposits (i.e. bedding inclined to the principal surface of accumulation) includes the azimuth angle and the angle of inclination in respect to the horizontal plane. The fabric analysis, i.e. the study of orientation of particles in a sediment as referred above, comprised

TABLE 5A. Calgary Site 2 (Silver Springs). A poorly stratified sub-glacial melt-out till formed during *in-situ* ablation of a stationary or retreating valley ice.

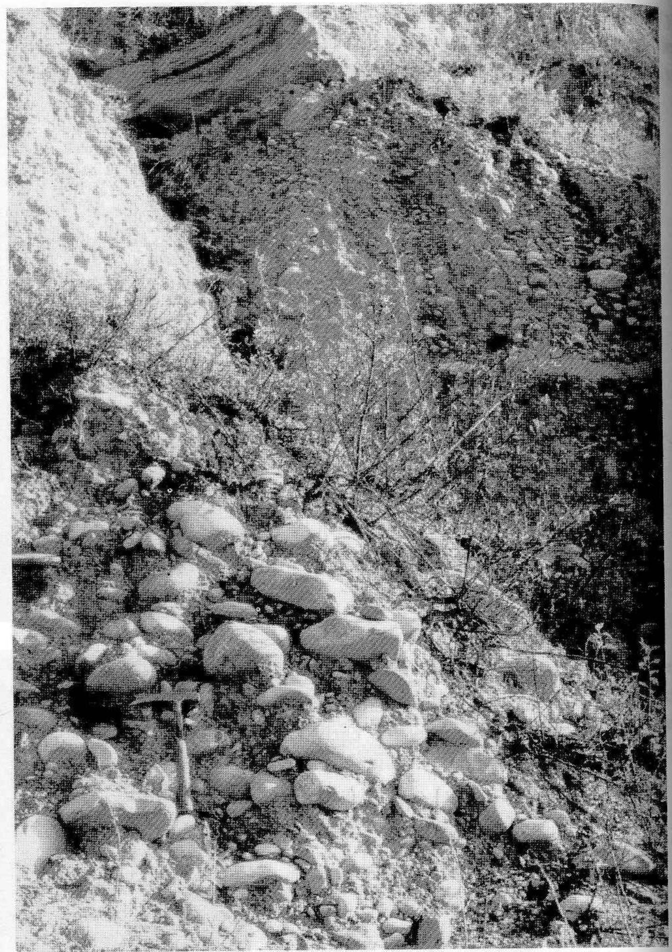

TABLE 5B. Calgary Site 2 (Silver Springs). A massive gravelly alluvium with lithic artifacts incorporated in the upper part and on top of the pre-glacial (presumably Mid-Wisconsinan) gravels beneath the Late Wisconsinan Bow Valley till.

50–100 gravel clasts from each investigated unit collected within a spatially confined area to satisfy the minimal requirements of objectivity of the sampling. Finally, other sedimentary directional features differentially recorded in coarse – and fine-grained sedimentary units were attended to (i.e. gravel imbrication, flute marks, mud ripples, grooves and parting lineation). Association of these features provided a useful means of stratigraphic correlation and control.

Except for determination of the flow direction during the time of deposit accumulations, the derived data were applied to study facies distribution and their thickness variability within the exposures, as well as their relation between facies boundaries and secondarily palaeocurrent deformations. Despite generally well recognisable strata defined by specific texture, colour, thickness and petrographic composition, a certain difficulty has been encountered in the tentative correlation between some site sections with less distinctive sandy/loamy gravel beds, primarily in the middle slope exposures. The characteristics of individual strata refer to a descriptive concept of facies specifying qualitative and quantitative variables for a certain volume of sediment (Anderton 1985). Individual strata are defined on the basis of their physical integrity, including lateral continuity and geometry of the surfaces bounding the units, vertical-stacking patterns, and lateral geometry within the units (Van Wagoner *et al.* 1992).

Petrographic analysis of larger (pebble and cobble) clasts and mineralogy of the coarse sand fraction (0.5–1.0 mm) from the matrix of these deposits was used to specify the provenance of clastic materials within particular sedimentary units. Lithology was used to assess the energy level during the depositional process and to provide information about the rate of reworking and the degree of sorting of gravel clasts in respect to transport distance. Two to five hundred clasts of various mineralogical composition were collected for the lithological analysis from each unit. The mineralogical analysis of matrix from gravelly units was performed microscopically after separation of the coarse sand fraction from a sample by sieve analysis; a sedigraph analysis was used for a genetic assessment and correlation of glacial diamicton facies.

Quaternary environments

The interpretation of Quaternary deposits is based on contextual (i.e. sedimentological, mineralogical and petrographic) data and their laboratory analysis. Palaeocurrent data were collected from all gravelly beds in the investigated sections to display a central tendency and degree of dispersion of individual clasts, defining the prevailing flow orientation in respect to the cardinal points (trend), as well as to the vertical and horizontal variation of clast orientation angles (i.e. dip and roll, respectively). The palaeogeographical setting at all sites is reconstructed from the geological record and from studies of actual sedimentary (fluvial, colluvial and glacial / glacio- fluvial) processes and their facies in various sedimentary environments throughout western Alberta.

Reconstruction of the past sedimentary environments from the investigated sections is a crucial component for elucidating the nature of flaking of the lithic assemblages. Application of the general concept of sedimentary facies models is prerequisite in order to understand the dynamics and overall configuration of natural forces acting during the deposition of these sediments, and their kinetic potential for simulating cultural flaking patterns. It is also significant to follow the rationale of the applied methodology. The sedimentary units and reconstructed sedimentary environments provide the principal information about the palaeoecology of the area.

Interpretation of the local Quaternary history is based on interpretation of individual sedimentary strata and their relationship through facies models (Harms *et al.* 1982, Reading 1989, Walker 1986). The concept of a (litho)facies (i.e. body of a lithified rock or an unconsolidated deposit with specific characteristics defined on the basis of colour, bedding, composition, texture, fossils and sedimentary structures) was used to refer to an individual sedimentary stratigraphic unit. Both quantitative and qualitative parameters were applied to define the nature of each facies. Single facies, occurring together and considered to be environmentally and genetically related, were grouped into facies associations, eventually forming in the stratigraphic column a facies sequence, being a series of individual facies which pass gradually one into another and are bound by gradational, sharp, or erosional surfaces. Internal textural and structural changes within the facies sequence are controlled by shifts of the local sedimentary environment, as manifested in grain size distribution, thickness of individual deposits and variability in mineral composition. These are governed by external environmental factors, including climatic shift, subsidence, change in vegetational cover, etc., all largely influencing the rate of input, transport and deposition of a sediment. Accordingly, a facies model was used as a general summary of specific properties within a sedimentary environment. Its formulation is inferred from the description and classification of any body of sediment in terms of interpretation of processes and environments of deposition (Anderton 1985, Walker 1986, Brodzikowski, van Loon 1991).

Archaeological record

Palaeolithic industry assemblages have been recorded at all localities from the eroded exposures, where flaked quartzite and carbonate cobbles and flakes have been collected on the slope below, as well as identified in several levels within natural sections and subsequently exposed archaeological excavation sections. At Site 1 (Varsity Estates), culturally modified lithics originate as being secondarily redeposited from a Late Pleistocene Bow Valley till, but also from its gravelly surface from a more intact buried context under 24 m of glaciolacustrine sediments of Glacial Lake Calgary (*Figures 2–3; Tables 1B, 2A–B, 3A*); at Site 2 (Silver Springs), identical flaked artifacts are distributed, largely in a secondary position, in the upper part of pre-glacial fluvial gravels (*Figure 9; Tables 4B, 5A*), and the basal part of the overlying glacial diamicton which is correlated with the till at Site 1; at Site 3 (Bowmont), the lithic artifacts have a similar contextual position as at Site 2, with a stratigraphic provenience on top of the alluvial gravels. Archaeological excavations were conducted at all three sites, exposing 55 m², 6 m² and 4 m², respectively.

Only local clastic raw materials derived from the Rocky Mountains area and forming the Quaternary glaciofluvial deposits at the site sections were used for stone tool flaking. The lithic assemblages were separated into two groups: Group A, which includes specimens with demonstrable diagnostic cultural flaking attributes specified in the previous comparative analysis, while Group B are specimens which are likely to have been artifactually modified, but which cannot be indisputably considered as artifactual because of imperfect and simple modification patterns, and/or due to partial reworking. Both groups were qualitatively subdivided into two subgroups in order to provide more detailed qualitative discrimination among individual specimens.

The group of core tools is dominated by various choppers, with rudimentarily modified unifacial types prevailing (*Figures 6–7, 10–11*), followed by distinctive side scrapers on cobbles produced by an anvil percussion technique (*Figure 12:1*). Other tool types are much less represented (rabots, picks, unifaces, bifaces, etc.) (*Figure 17*). The group of flake tools consist largely of morphologically variable side scrapers (*Figures 4:2, 8:2, 12:2, 13*). Burins and end scrapers, the next most numerous categories, occur much less frequently (*Figures 4:1, 14, 15:2–4*). Other, sporadically present types include notched and denticulated artifacts, distally pointed tools and retouched flakes. Tool combinations on individual specimens are relatively common. Utilized flakes (*Figures 8:1, 15:6*), numerous lithic waste and various cores form the remainder of the collection (*Figures 4–8, 10–18*).

Geological and occupation history

The sequence of deposits from the investigated sites is interpreted as a succession of alluvial (fluvial) facies in the lower part of the composite stratigraphic profile into glacial and glaciofluvial facies in the middle sections, as a result of a gradual establishment of full glacial conditions in the former Bow Valley. The reconstructed general sedimentary facies model, based largely on the geological record from Silver Springs, is believed to represent one glacial cycle with ice advance and retreat (Brodzikowski, van Loon 1991:94, fig. 94A). The basal fluvial or proglacial complexes *(Facies Association 1)* were formed during the advance stage; the glacial deposits *(Facies Association 2)* during maximum glaciation, while the overlain proglacial sands and gravels *(Facies Association 3)* were deposited during the retreat phase. *Disconformity I* relates to the time interval elapsed between the accumulation of the uppermost (glacio)fluvial gravels and their burial by the Cordilleran till during the Bow Valley ice advance. Deposition of the glaciolacustrine sediments in the upper part of the exposures *(Facies Association 4)* occurred later during a subsequent Laurentide glaciation of the NE Calgary area. *Disconformity II* relates to the temporal hiatus elapsed between the two glacial events. Both disconformities are manifested by the corresponding stratigraphic distribution of two lithic artifact assemblages, implying two episodes of the pre-Palaeoindian occupation of the upper Bow River valley, with the earlier at the Silver Springs and Bowmont sites, and later at the Varsity Estates site.

As no datable macro-organic material was found at either site, the approximate age of the early American

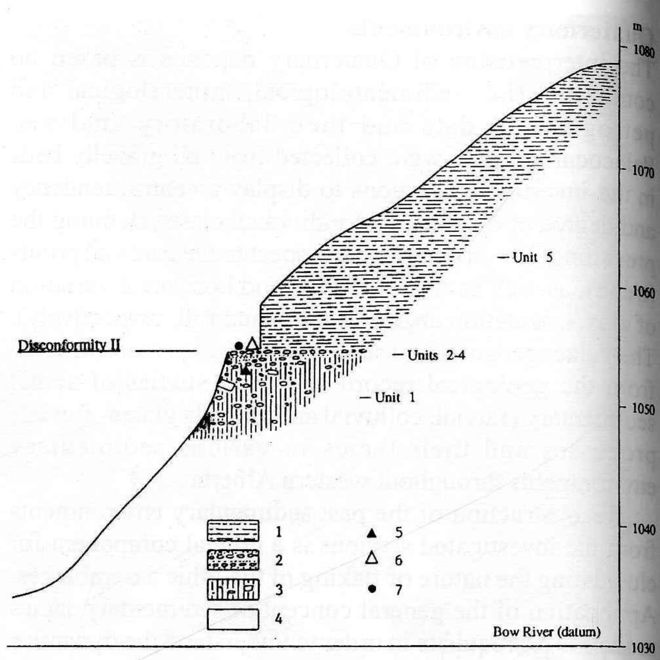

FIGURE 2. Calgary Site 1 (Varsity Estates). General stratigraphic scheme of the site geology with the excavated section. Legend: 1 glaciolacustrine sediments of Glacial Lake Calgary, 2 outwash sands and gravels / gravelly, fluvially presorted till surface, 3 the Bow Valley till, 4 covered, 5 artifacts redeposited within the till, 6 artifacts *in situ* on the till surface, 7 pollen *(Cyperaceae, Pinus, Picea)*.

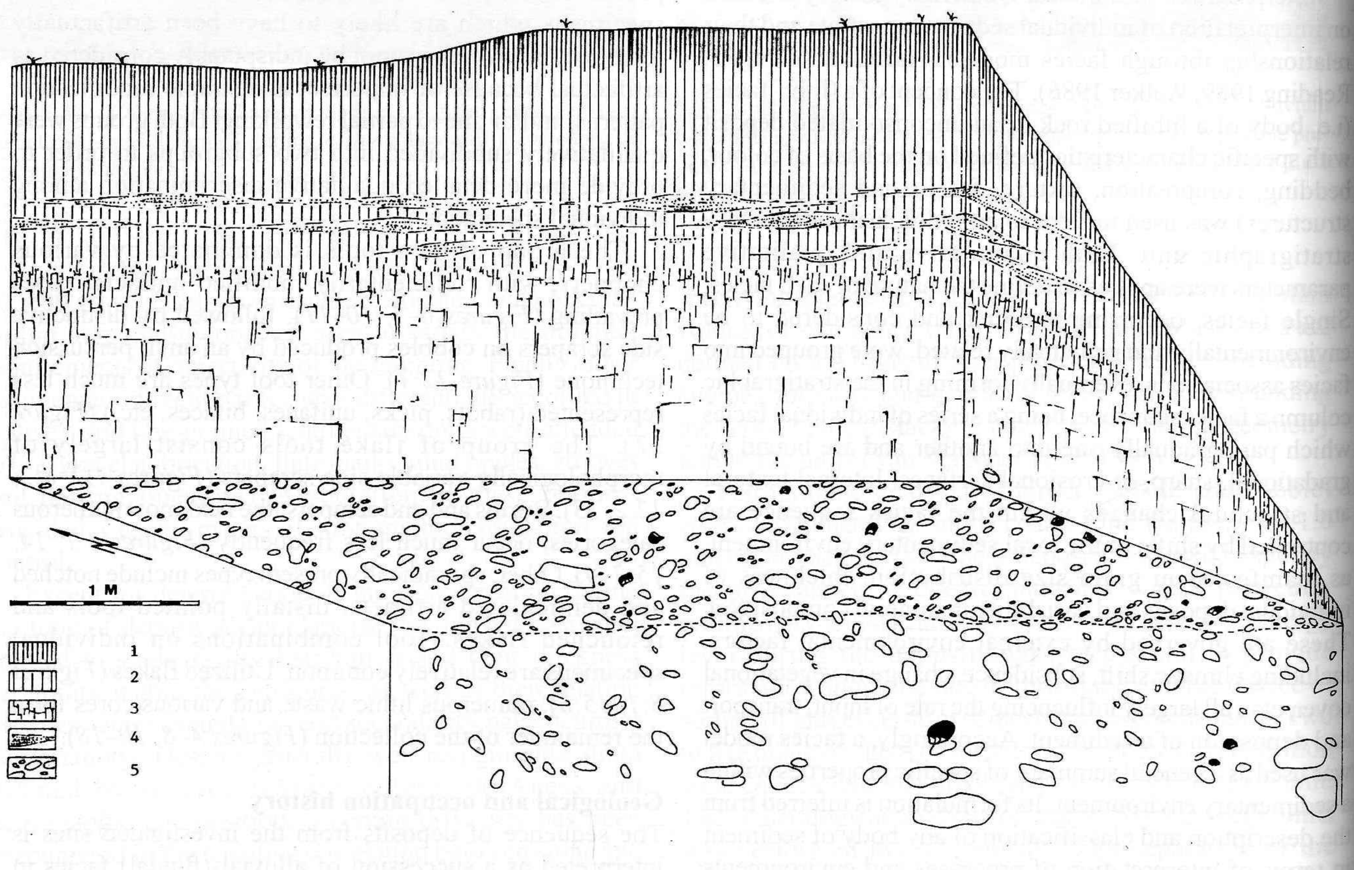

FIGURE 3. Calgary Site 1 (Varsity Estates). Block diagram of the excavation (1993) with the lithic industry distribution on the exposed Bow valley till surface buried by Glacial Lake Calgary clays. Legend: 1 recent chernozemic Ah horizon, 2 recent chernozemic Bmk horizon, 3 unweathered glaciolacustrine silts and clays (Ck horizon), 4 lenses of sands formed near the bottom of the glacial lake, 5 gravelly surface of the till.

occupation in the Bow Valley is based on the chronostratigraphic correlation of the industry-bearing deposits with the existing Late Quaternary geological framework of the region. The relative age of the lithic artifact assemblages recorded within the geological contexts at the Calgary sites is indirectly, but logistically assessed. As stated above, the till incorporating the artifacts is related to a Cordilleran Bow Valley ice advance; the overlying lake sediments to Glacial Lake Calgary formed during the maximum of the subsequent Laurentide glaciation (*ca* 20 ka.). It is assumed that only a relatively short time span separated the two glacial events.

PLEISTOCENE GEOARCHAEOLOGY IN ALBERTA: GEOLOGICAL CONTEXT

Because of the time focus, geoarchaeological contextual investigations are crucial to demonstrate the chronological and cultural authenticity of any particular archaeological record, especially if this is represented only by rudimentarily flaked lithics. Specific characteristics of local depositional environments, associated with occurrences of early lithic industries, which are the most likely archaeological inventories to be anticipated, must be addressed in terms of their natural potential for production of pseudoartifacts. The most frequent geological settings in a larger area of Western Canada, which are likely to include buried early cultural record, are old river channels and related fluvial deposits, alluvial fan, slopewash and other gravity flow settings, glacial and glacigenic (glaciofluvial, glaciocolluvial, ice-contact, etc.) depositional environments, lacustrine and glaciolacustrine settings, sea-shore areas and raised beaches (along the Pacific coast), and caves (in the Rocky Mountains).

Fluvial settings

Recognition of roughly modified stone tools in a fluvial setting may be rather problematic, particularly if they are found within thick sedimentary units composed of heavy-load clasts (e.g. Tricart, Vogt 1967). On the contrary, flaked artifacts in fine-grained interchannel and overbank deposits should be identifiable without major difficulties even if produced on local raw materials.

Evaluation of the possible human character of flaking of a lithic assemblage should take into consideration the following aspects: determination of sedimentary dynamics, including energy level, periodicity and palaeocurrent direction; density of the fluid, and the amount and composition of the saturated matrix; velocity of the current and rate of sedimentation; structural disconformities and depositional irregularities in sedimentary units; secondary post-depositional disturbances; assessment of the mechanical potential of the present high-energy natural factors in the vicinity of a site and the surrounding area to imitate cultural flaking patterns on local rocks and clastic minerals, identification of natural stone-modification factors in the same geo-context, etc. Understanding of the basic principles of fluvial processes is therefore essential for critical assessment of the source of modification of flaked lithics in a buried context, as well as for interpretation of the existing palaeoenvironment and its human inhabitation potential in the vicinity during the time of deposit formation.

Patterned spatial distribution of the flaked lithics is one of the most important aspects which may support, although not conclusively establish, the cultural nature of flaking of a lithic assemblage enclosed in a geological context. However, a more or less homogeneous dispersal of flaked lithics within a deposit does not *a priori* exclude their artifactual origin. The degree of spatial compactness is governed by several factors, including the distance of redeposition, velocity and density of the fluid, character of the local topographic setting, etc., all of which can significantly contribute to a high mixing of the original cultural sample with the derived sediment. Under favourable circumstances, the archaeological material may be horizontally dispersed within a small area on top of the subaerially exposed deposits (e.g. a river bank), and subsequently buried by fine sediments without any major reworking and redeposition (*Table 7B*). Such occupation surfaces, defined as spatially limited places of association of cultural remains (lithic and other artifacts, patterned cultural material accumulation, etc.) may be expected to occur in low energy fluvial and lacustrine sedimentary settings potentially sealing many early Palaeo-American sites. Distribution of the cultural record at the Calgary sites confirms the fact that artifacts and other cultural remains are likely to be largely dispersed by high energy streams flowing across the braided periglacial flood-plains. At the present time, the Varsity Estates site (the uppermost cultural level on top of the till) is currently the only palaeolithic site in western Canada with a clearly defined early prehistoric occupation area (*Table 2B*).

Alluvial fan settings

Alluvial fans deposited near mountain fronts are likely to incorporate early cultural records within thick sequences of sandy-gravelly strata. Alluvial fan and related deposits have proved to be a rich source of Early Palaeolithic sites in the Old World (e.g. Isaac 1977, Clark *et al.* 1984, Bar Yosef 1988, Chlachula 1993). Climate and tectonics are, among other factors, the most important agents affecting alluvial fan formation, especially if acting concomitantly. Periods of intensive debris accumulation usually coincide with accelerated erosion in the source area as a result of disturbance of vegetational cover, change in precipitation patterns, subsidence and orogenic activity, or simply as a result of more effective weathering due to increased insulation and/or frost action. Differences in clast composition and varying amounts of fractured rocks in a vertical profile in the deposit have a direct bearing to all the above factors. Debris flow deposits frequently occur in semiarid and periglacial zones in North America. The

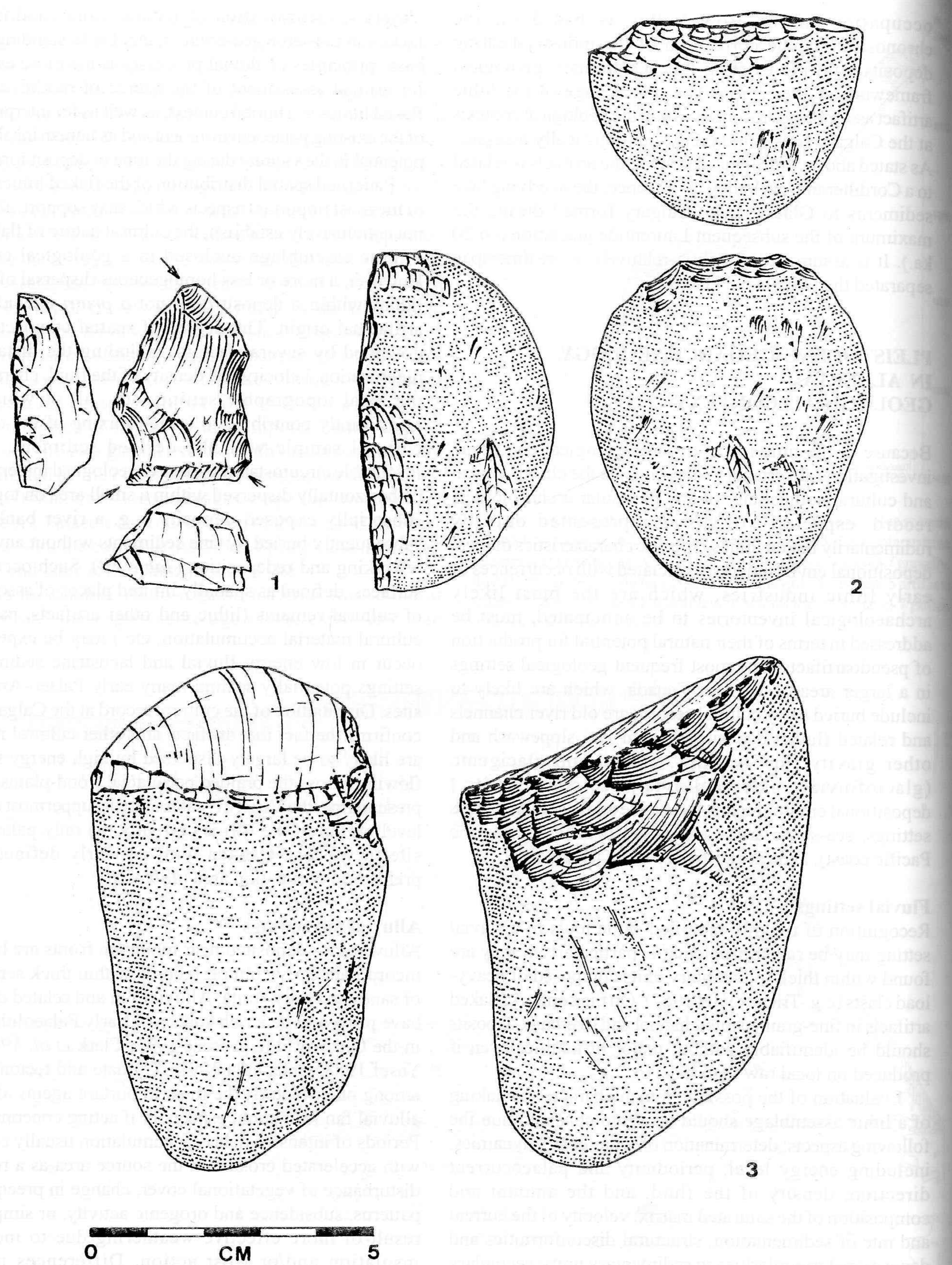

FIGURE 4. Calgary Site 1 (Varsity Estates). Lithic industry (redeposited in the till): 1 multiple burin, 2 retouched cobble fragment (scraper), 3 cobble core with one flaking platform (quartzite). (All drawings by the author.)

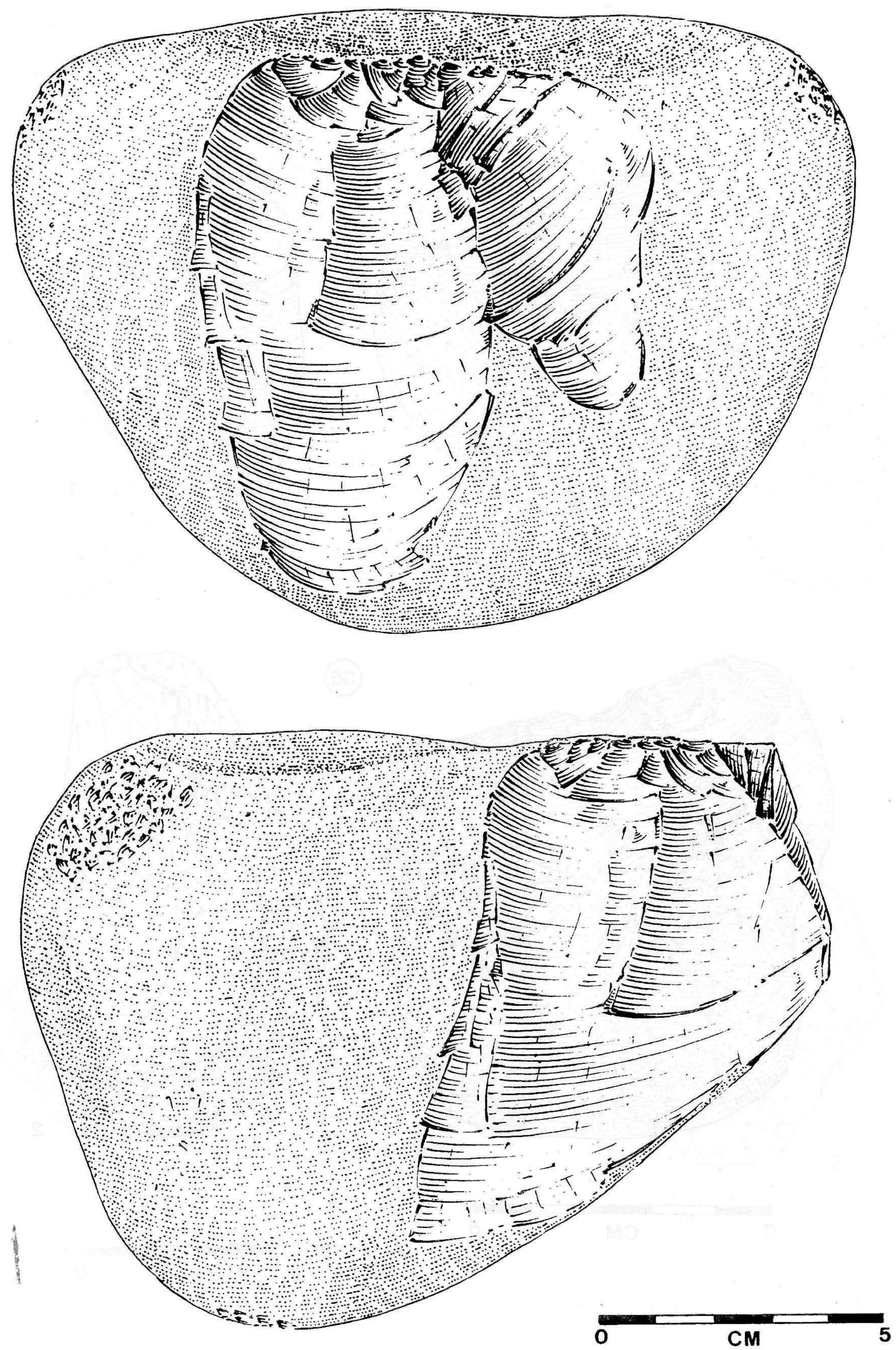

FIGURE 5. Calgary Site 1 (Varsity Estates). Lithic industry (1993 excavation): Cobble core with a cortical flaking platform also used as a hammerstone as evidenced by concentrated percussion marks on the exposed cobble edges. The core was found *in situ* with other artifacts (*Figures 6–8*) on the till surface sealed by 24 m of the Glacial Lake Calgary clays.

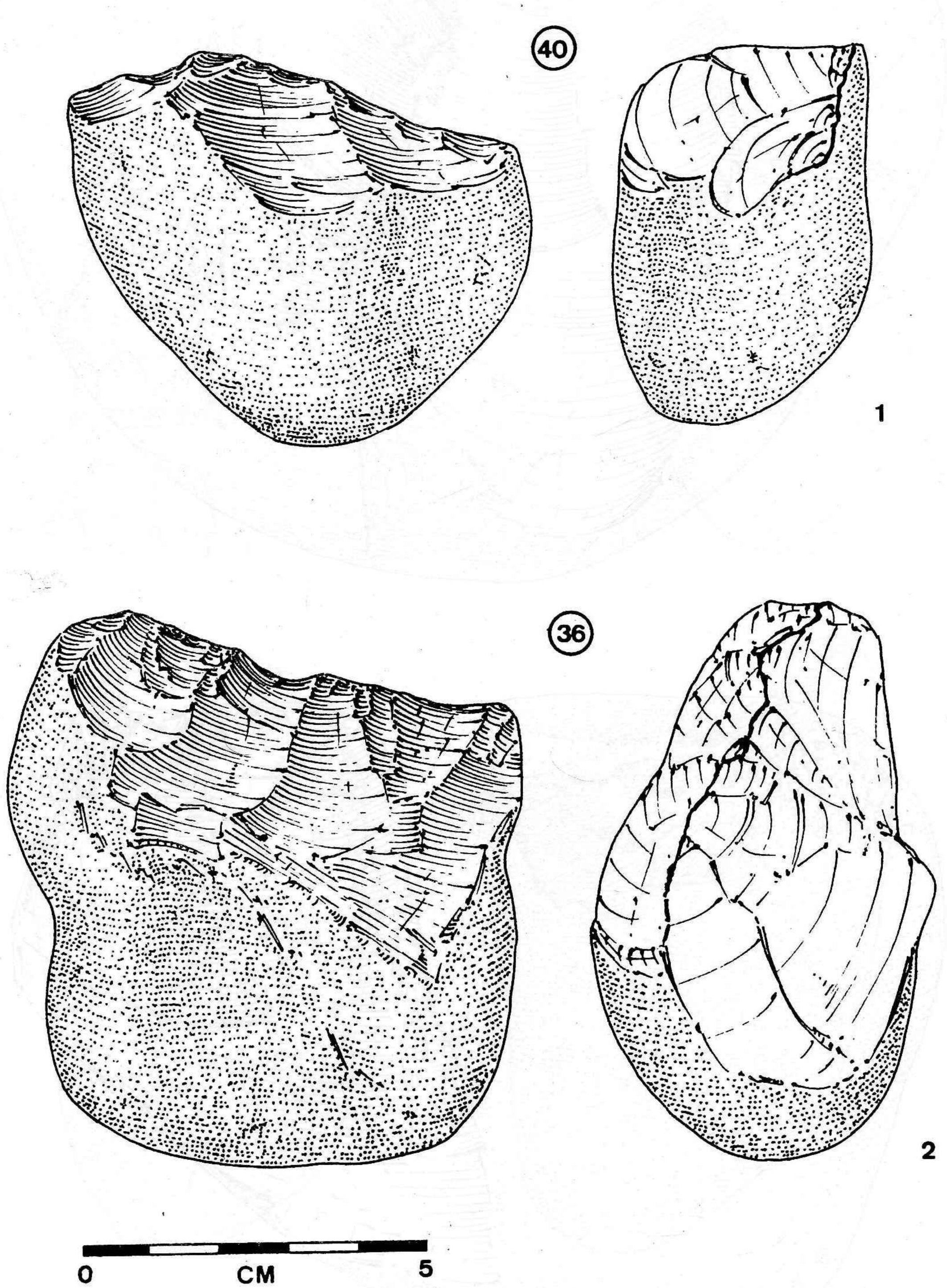

FIGURE 6. Calgary Site 1 (Varsity Estates). Lithic industry (1993 excavation): 1 cobble core / unifacial chopper (quartzite), 2 bifacial chopper (limestone).

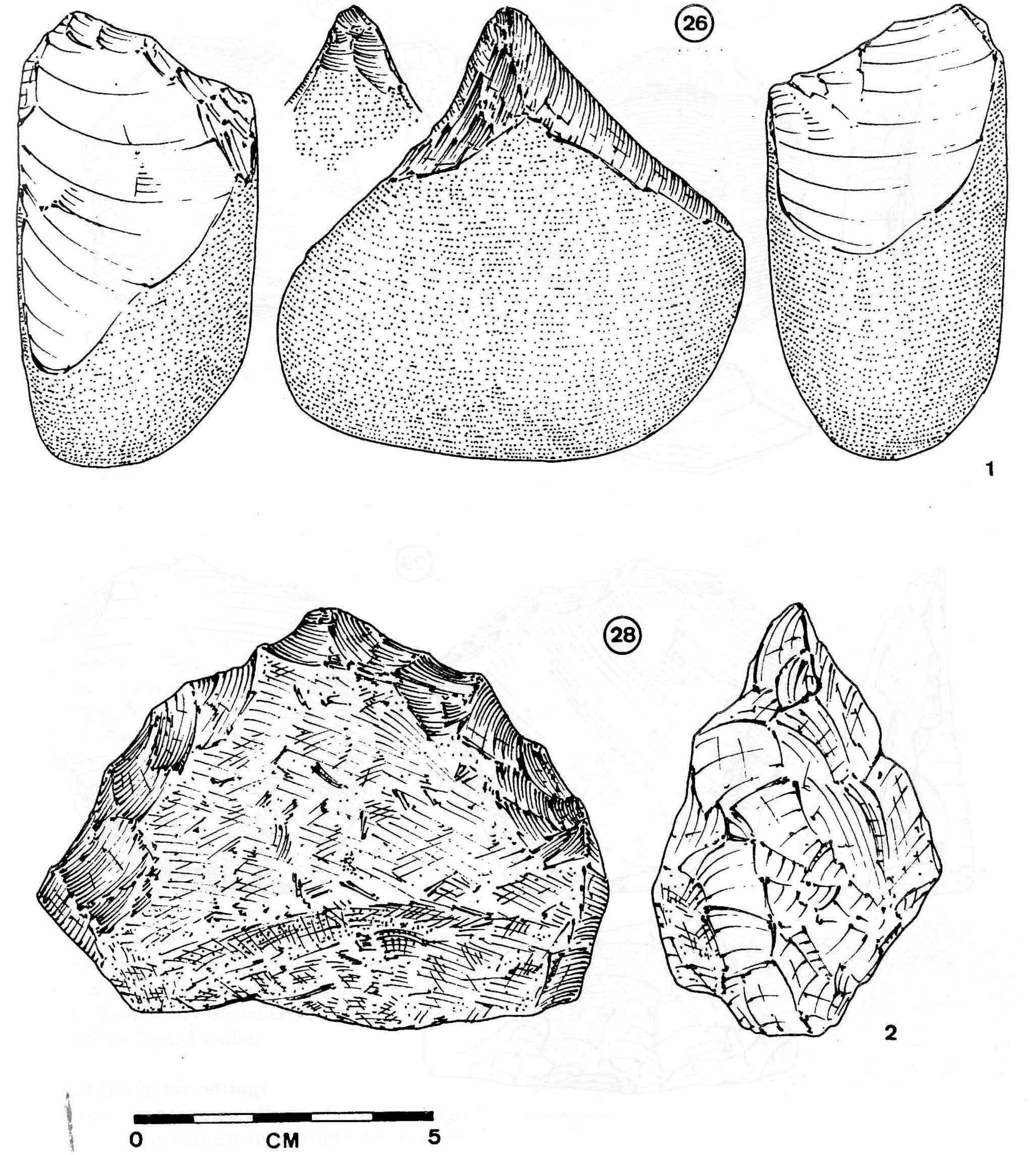

FIGURE 7. Calgary Site 1 (Varsity Estates). Lithic industry (1993 excavation): 1 pointed chopper (quartzite), 2 bifacially flaked rock fragments (sandstone).

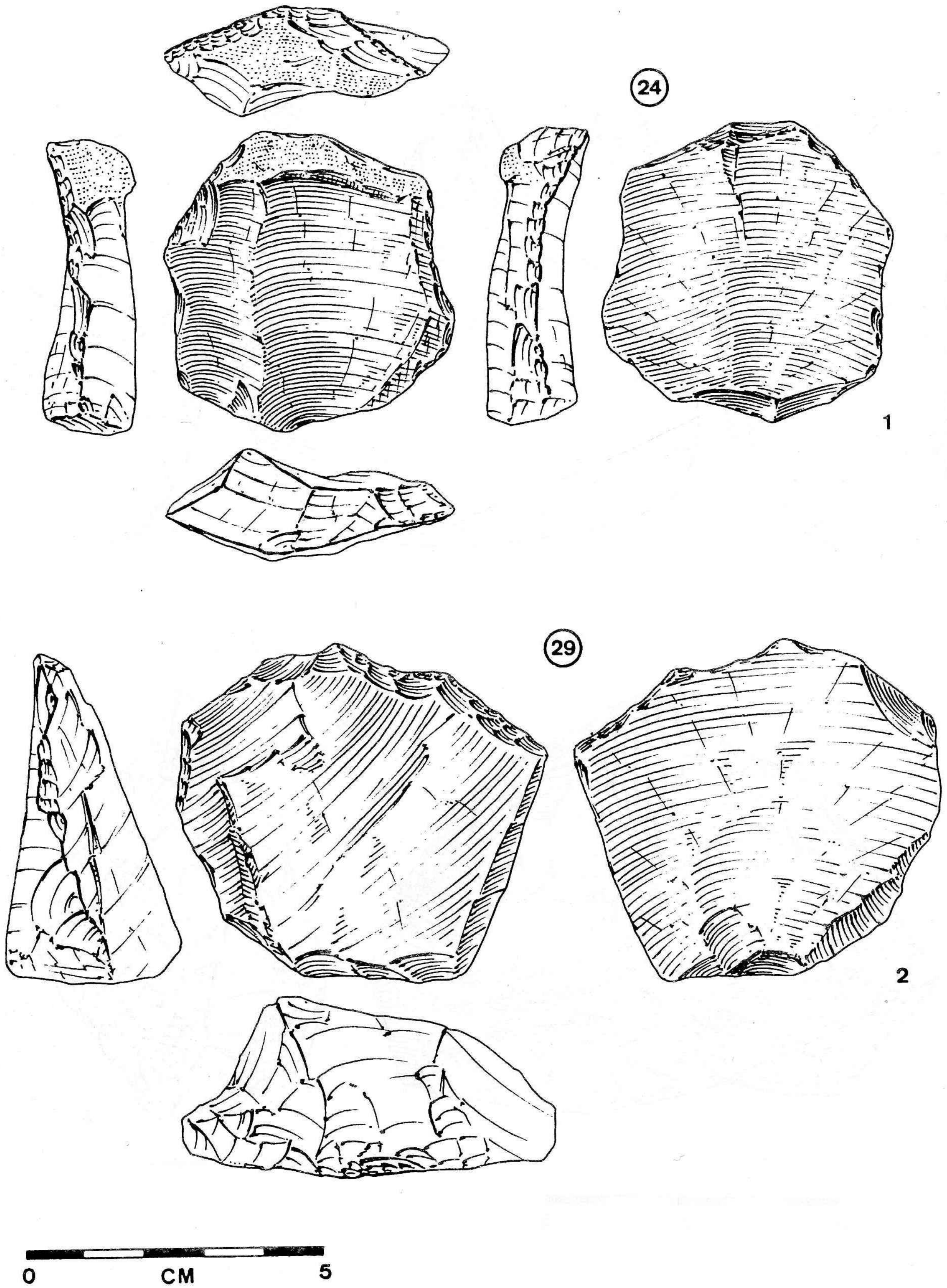

FIGURE 8. Calgary Site 1 (Varsity Estates). Lithic industry (1993 excavation): 1 retouched flake, 2 scraper on a flake (quartzite).

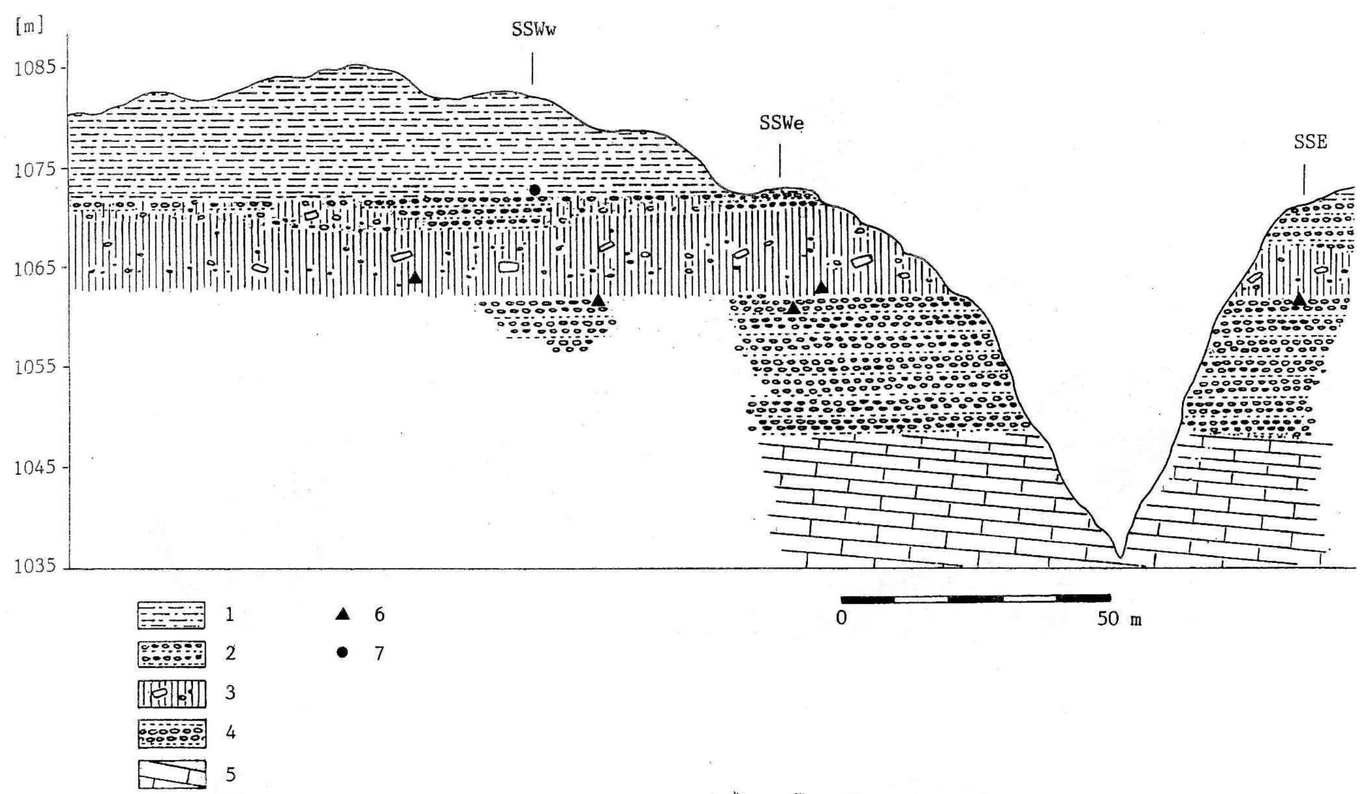

FIGURE 9A. Calgary Site 2 (Silver Springs). General statigraphic scheme of the site geology. Legend: 1 glaciolacustrine sediments of Glacial Lake Calgary, 2 proglacial sands and gravels, 3 the Bow Valley till, 4 pre-glacial fluvial sands and gravels (Mid-Visconsinan), 5 bedrock, 6 distribution of artifacts, 7 pollen (*Pinus, Picea*).

character and intensity of these phenomena and physical properties of incorporated clastics have a direct bearing on assessment of the potential of an early stone industry distribution in the deposit.

The resulting alluvial fan facies can be highly variable, depending on several variables, including the amount of saturated debris introduced to the site, their lithology, periodicity of deposition, stability of the local bedrock, etc. Accordingly, alluvial fan deposits can occur as chaotically supported paraconglomerates formed by mud-flow activity, or orthoconglomerates with interbedded fine sandy and gravelly strata periodically laid down by sheet-flows and perennially active braided streams (Reading 1989, Nemec, Steel 1984). Particularly the latter should be a subject of close geoarchaeological studies.

Glacial and glacigenic settings

Glacial processes are the most effective high-energy agents in a terrestrial environment responsible for erosion of quantities of surficial materials, their large-scale and long-distance transport, subsequent reworking, and final distribution over large areas. Eroded rock debris of varying form and size are secondarily transported by melt-water or in the form of saturated deposits as gravity (mass)flows, all significantly contributing to progressive modification

FIGURE 9B. Calgary Site 2 (Silver Springs, section SSWe). Stratigraphic position of artifacts (marked in black) on top of fluvial gravels beneath glacigenic deposits (the Bow Valley till) of an early Late Wisconsinan Cordilleran glaciation. Some isolated artifacts also occur in the basal part of the till as a result of glacial erosion of the former occupation surface.

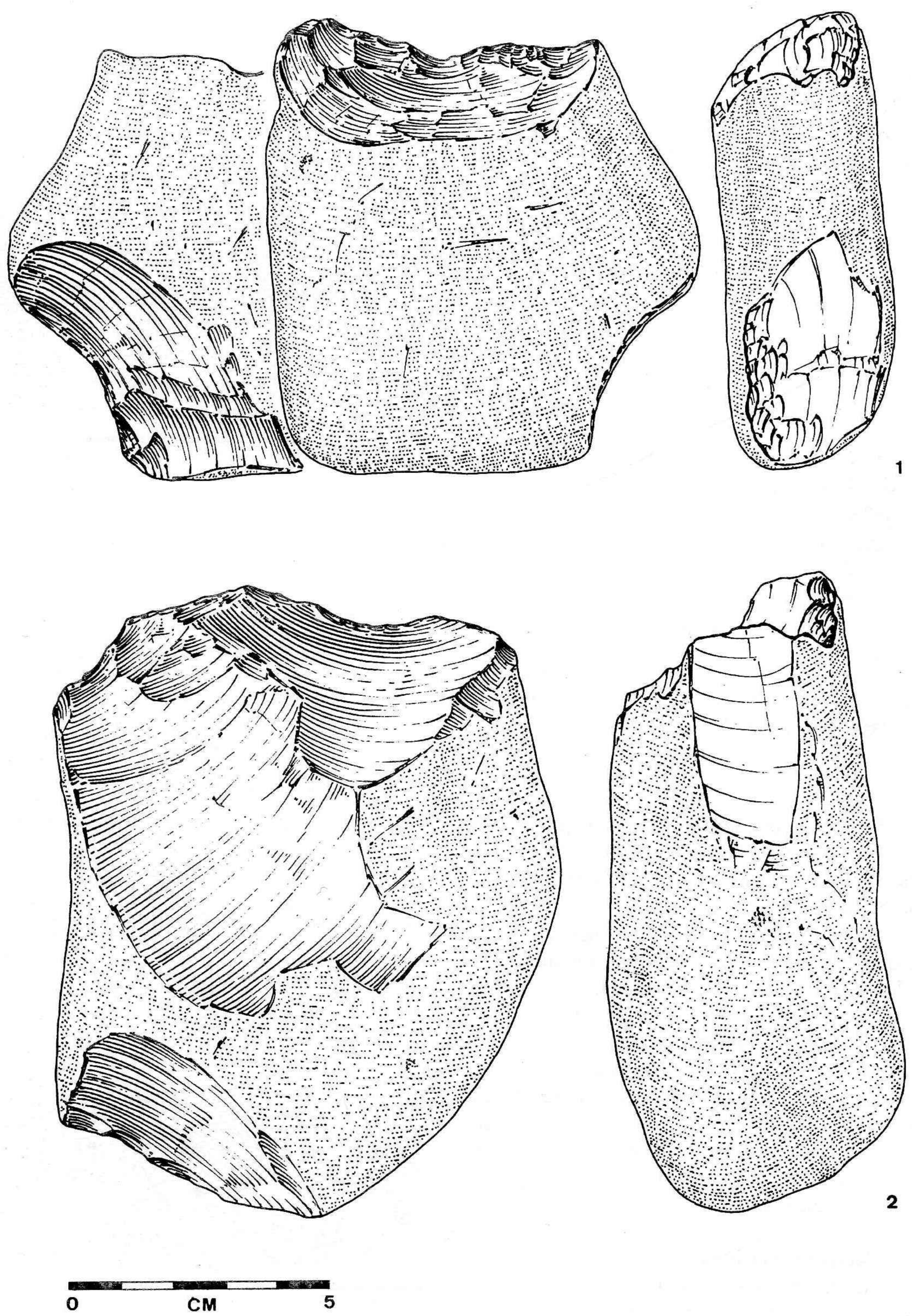

FIGURE 10. Calgary Site 2 (Silver Springs). Lithic industry: 1–2 unifacial choppers (quartzite).

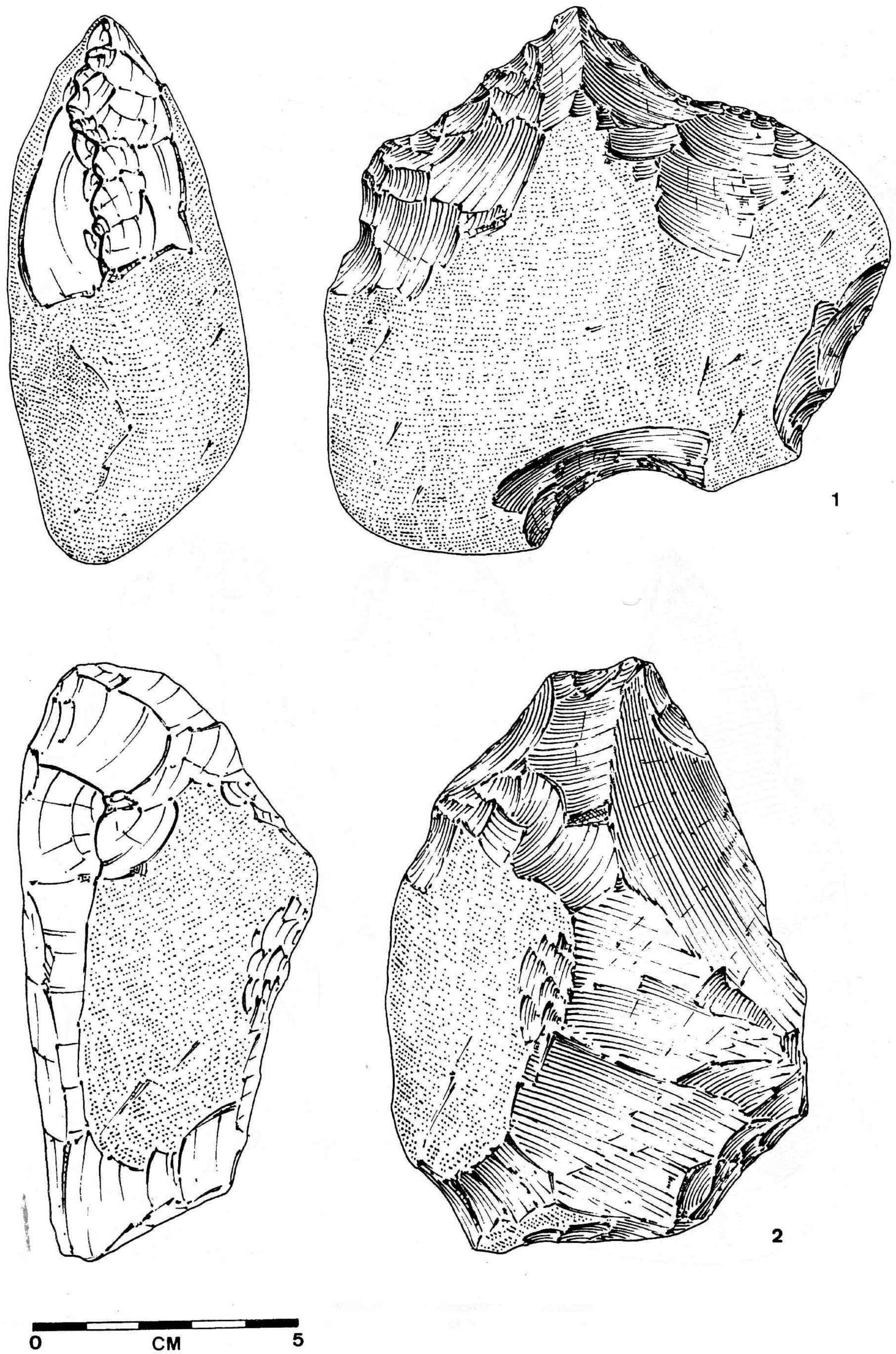

FIGURE 11. Calgary Site 2 (Silver Springs). Lithic industry: 1 pointed chopper (siltstone), 2 bifacial core (quartzite).

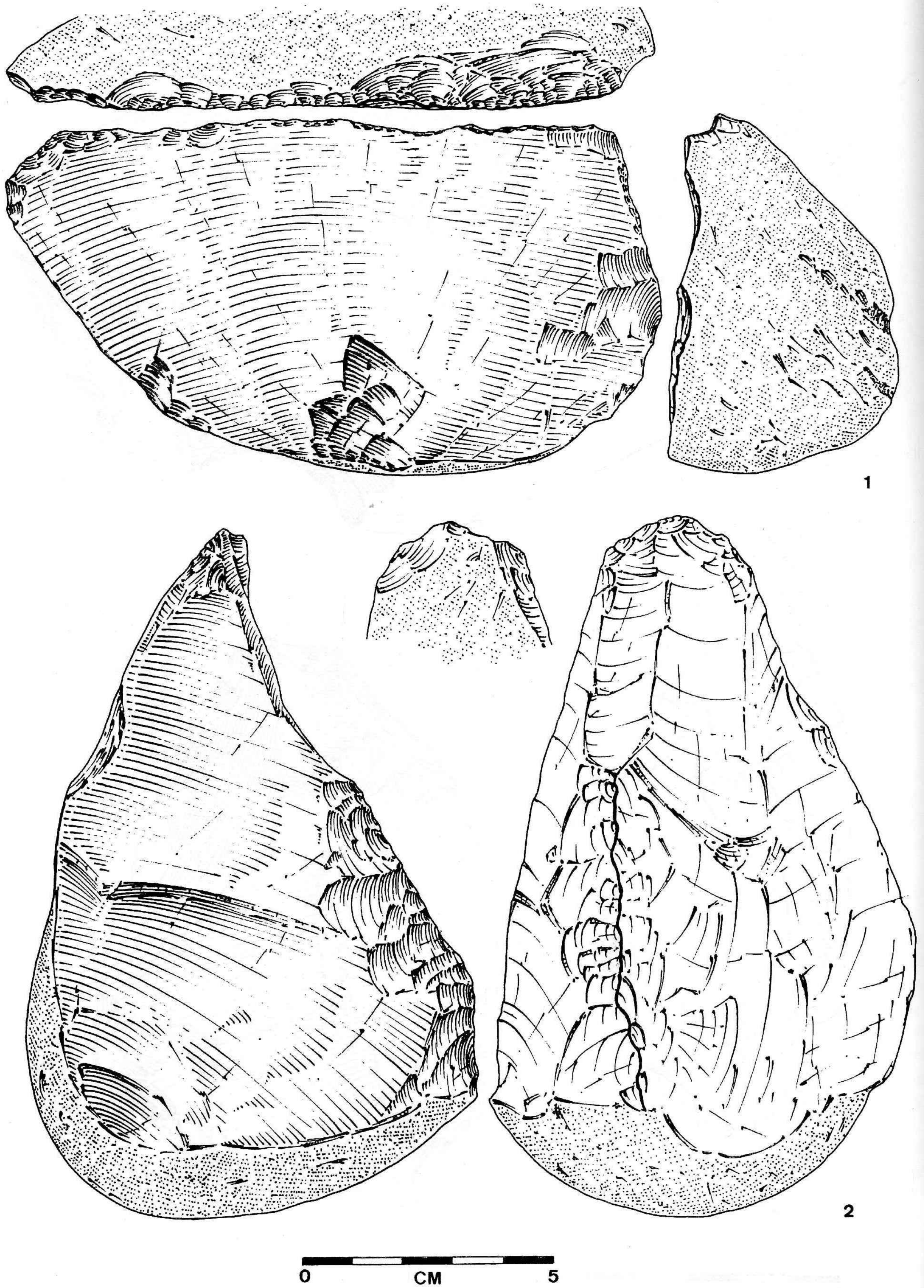

FIGURE 12. Calgary Site 2 (Silver Springs). Lithic industry: 1 transverse side scraper on a split cobble, 2 lateral side scraper on a cobble fragment (quartzite).

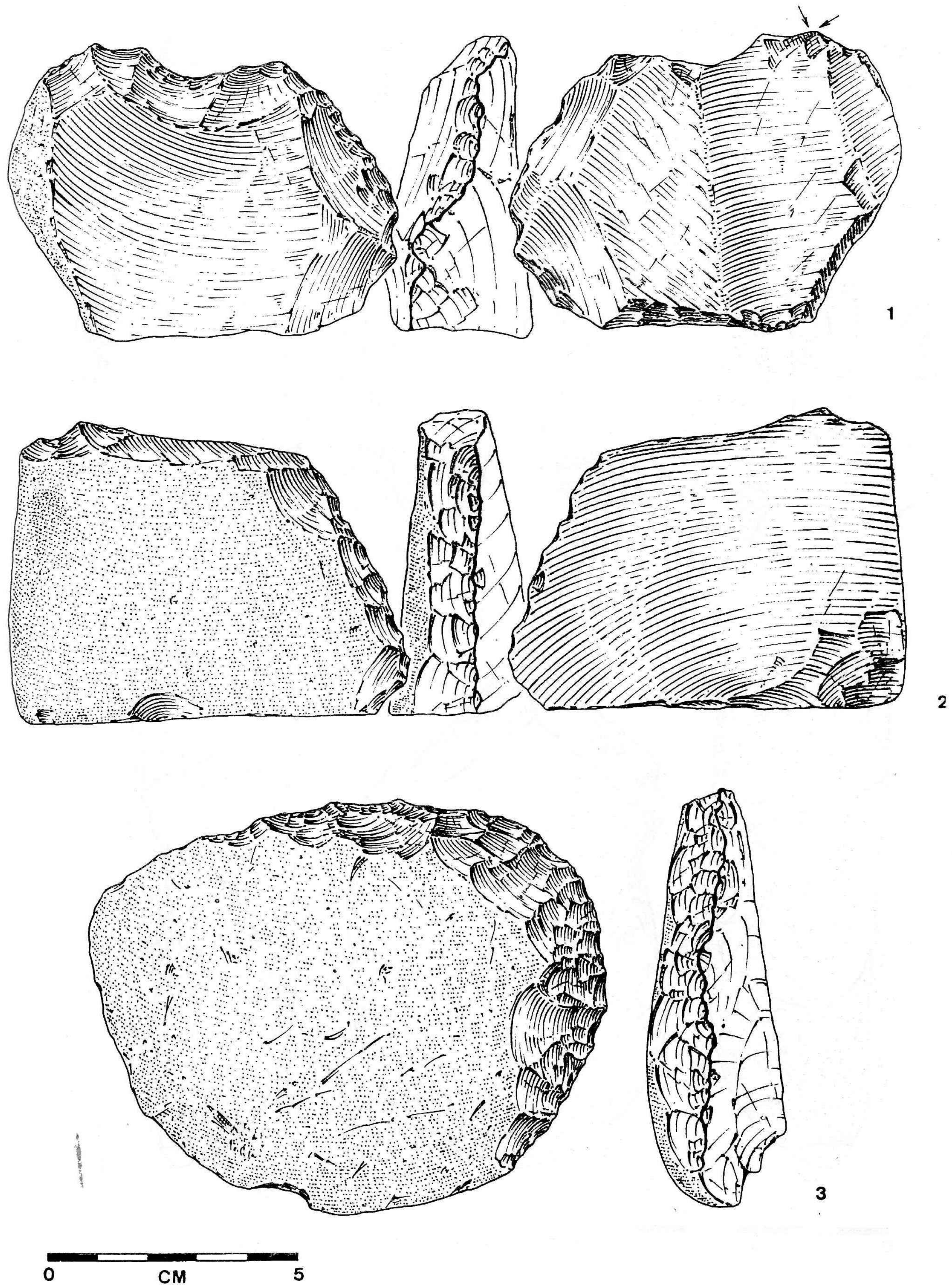

FIGURE 13. Calgary Site 2 (Silver Springs). Lithic industry: 1–3 side scrapers on quartzite flakes.

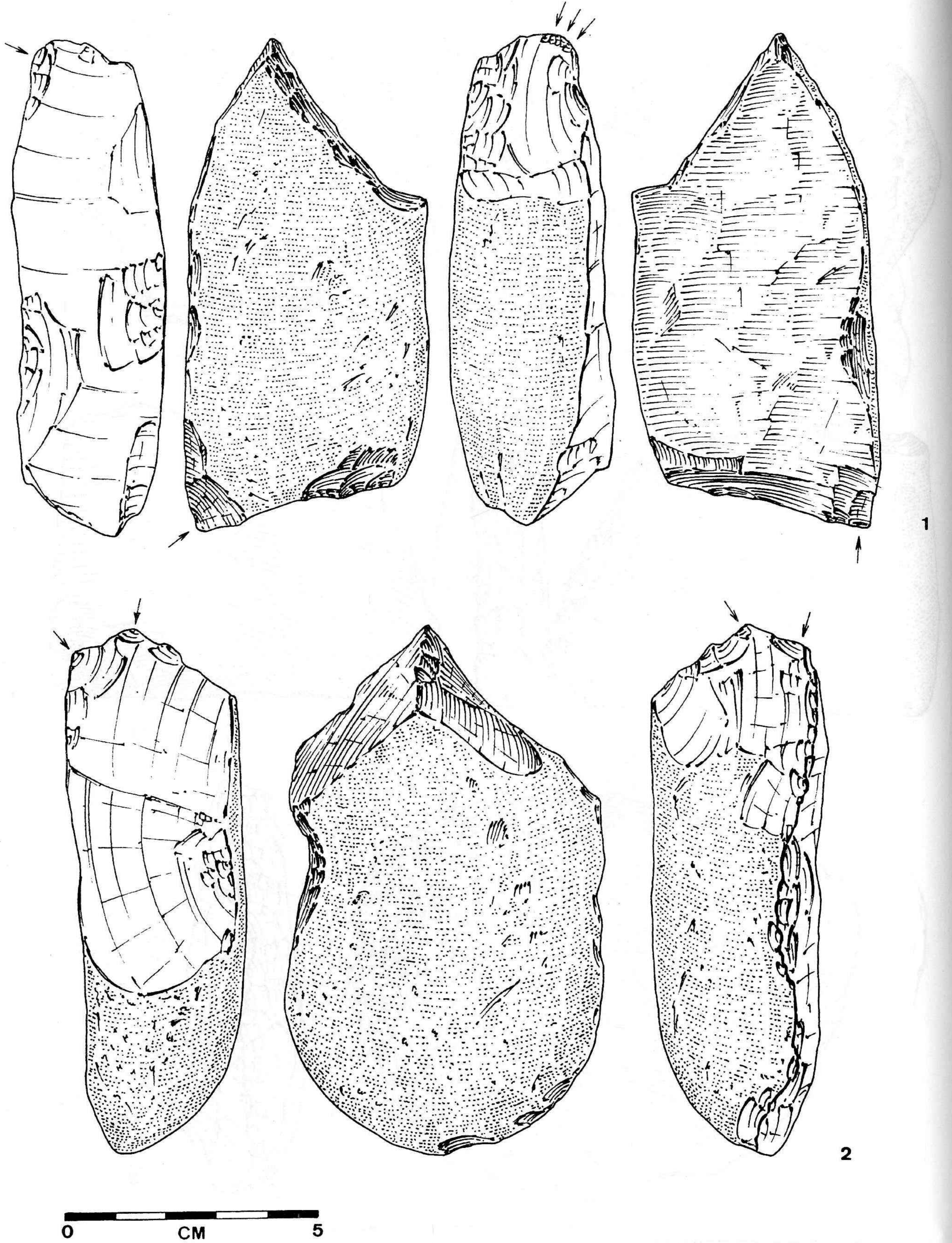

FIGURE 14. Calgary Site 2 (Silver Springs). Lithic industry: 1–2 dihedral burins on quartzite cobble fragments.

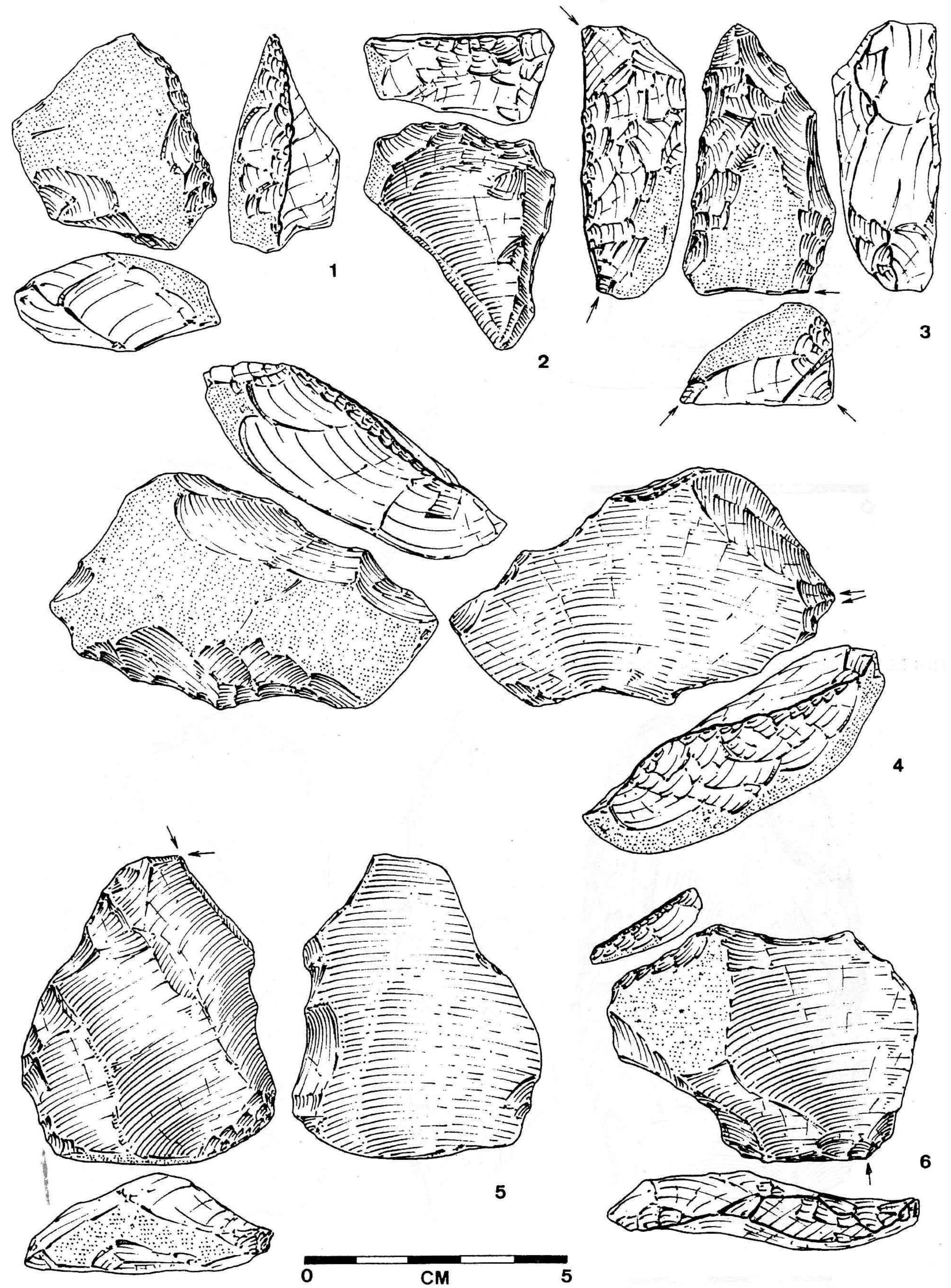

FIGURE 15. Calgary Site 2 (Silver Springs). Lithic industry: 1 retouched flake, 2 end scraper, 3 lateral side scraper and multiple burin, 4 double lateral side scraper, 5 dihedral burin, 6 retouched flake (1 siltstone, 2–6 quartzite).

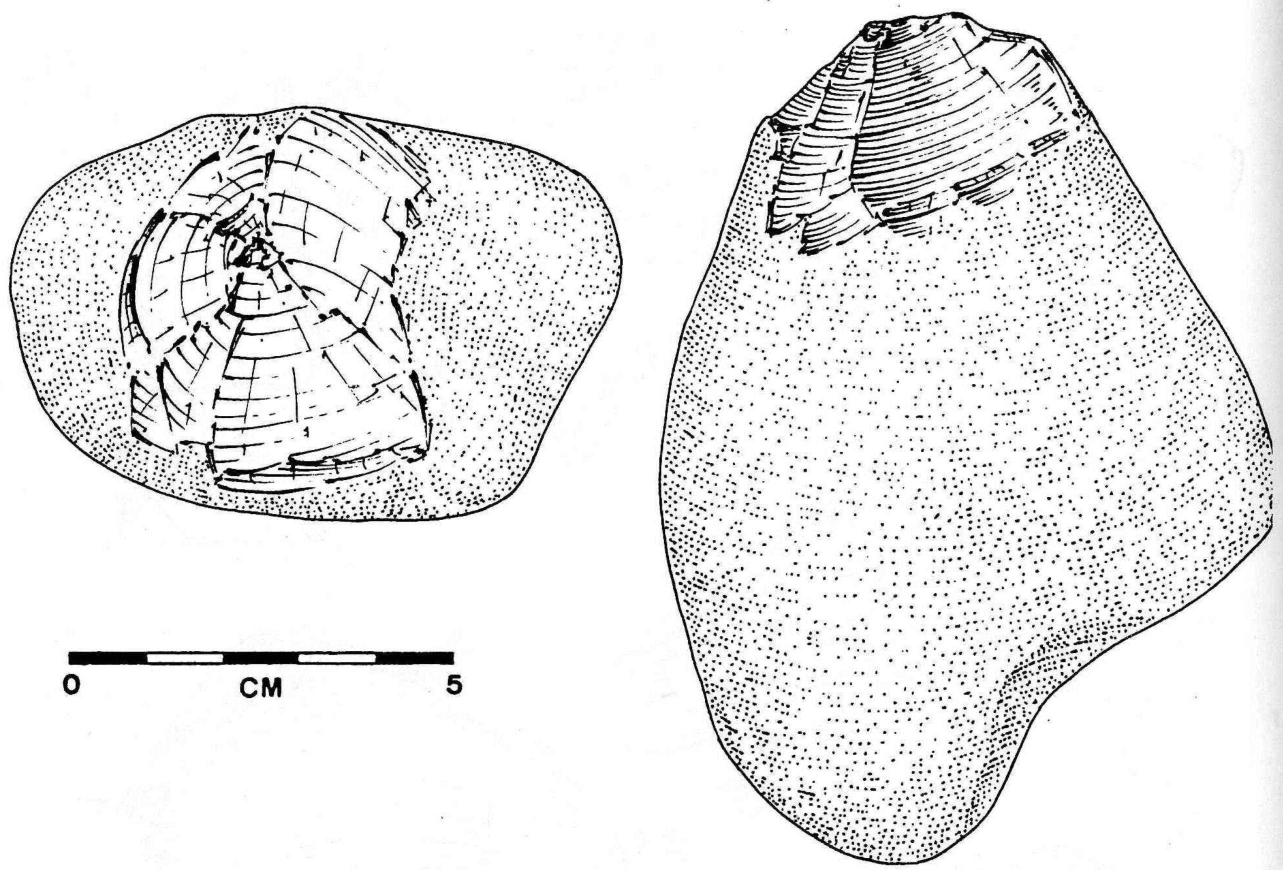

FIGURE 16. Calgary Site 3 (Bowmont). Lithic industry: A distally flaked quartzite cobble from eroding alluvial gravels beneath the till.

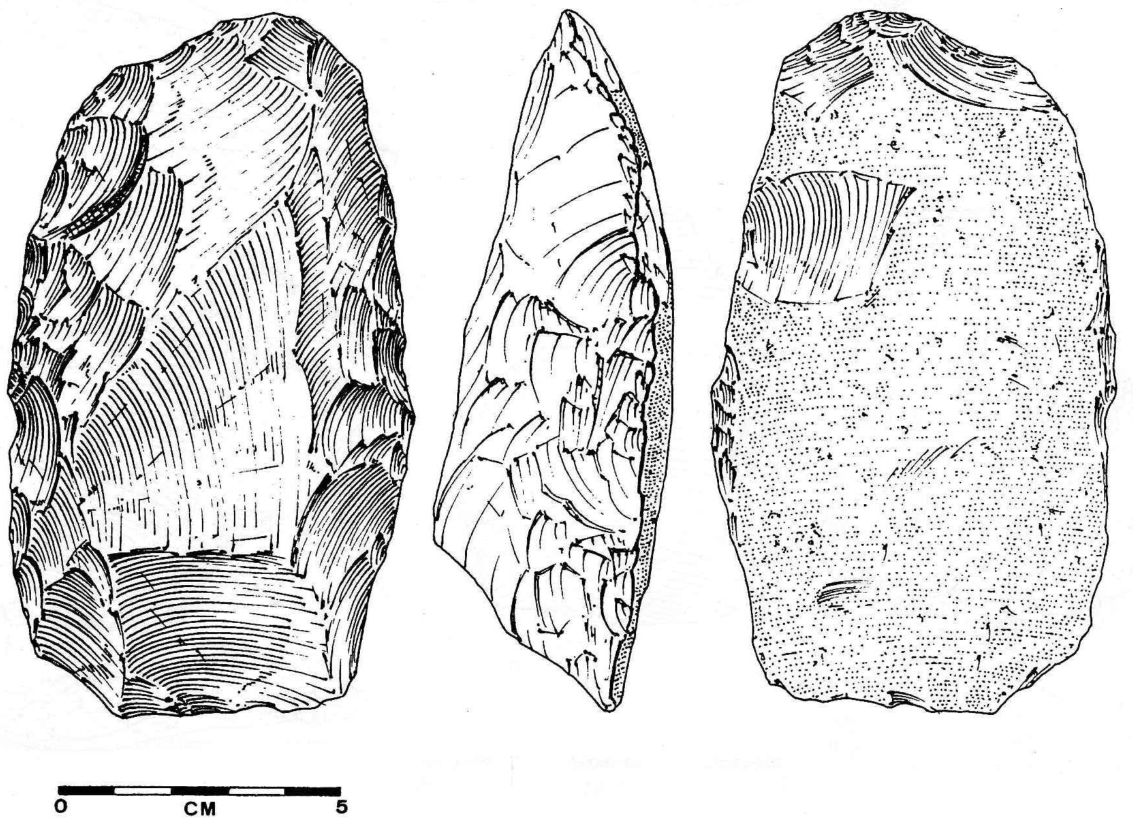

FIGURE 17. Calgary Site 3 (Bowmont). Lithic industry: unifacially retouched quartzite cobble flake (double side scraper).

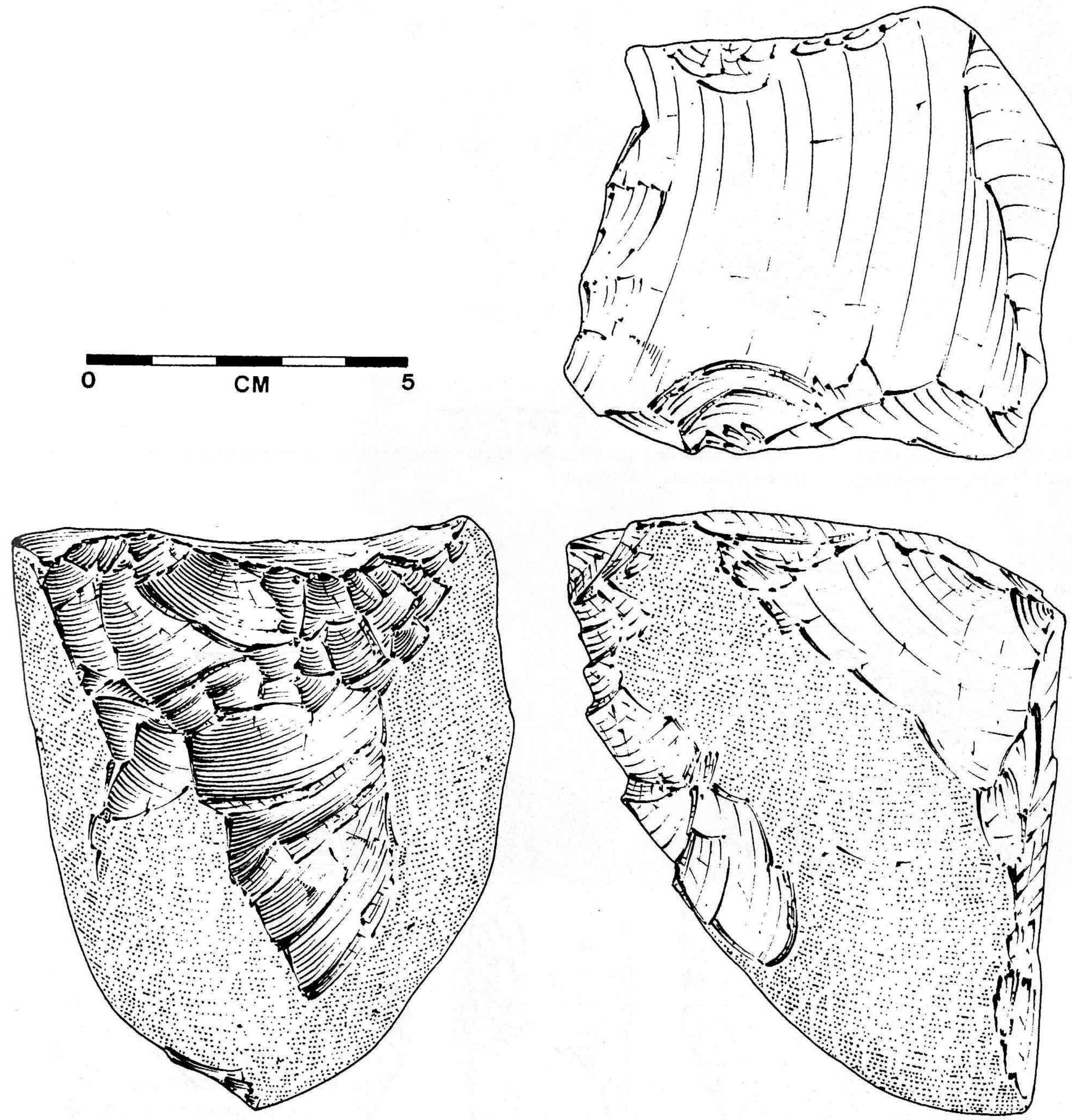

FIGURE 18. Calgary Site 3 (Bowmont). Lithic industry: quartzite core with one flaking platform and a series of small negative flake scars.

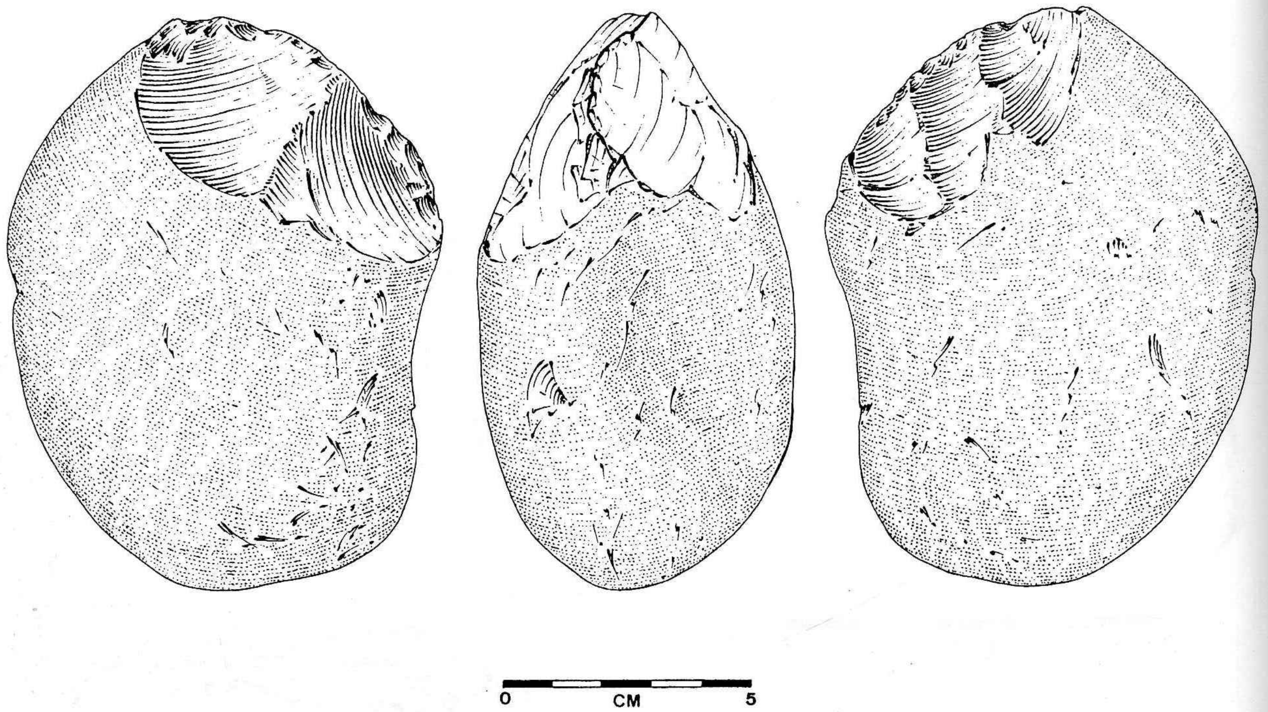

FIGURE 19. Grimshaw Gravel Site. Bifacial chopper on a quartzite cobble found with other artifacts at the base of a Laurentide (continental) Late Wisconsinan till on top of preglacial gravels (Chlachula, Leslie 1998).

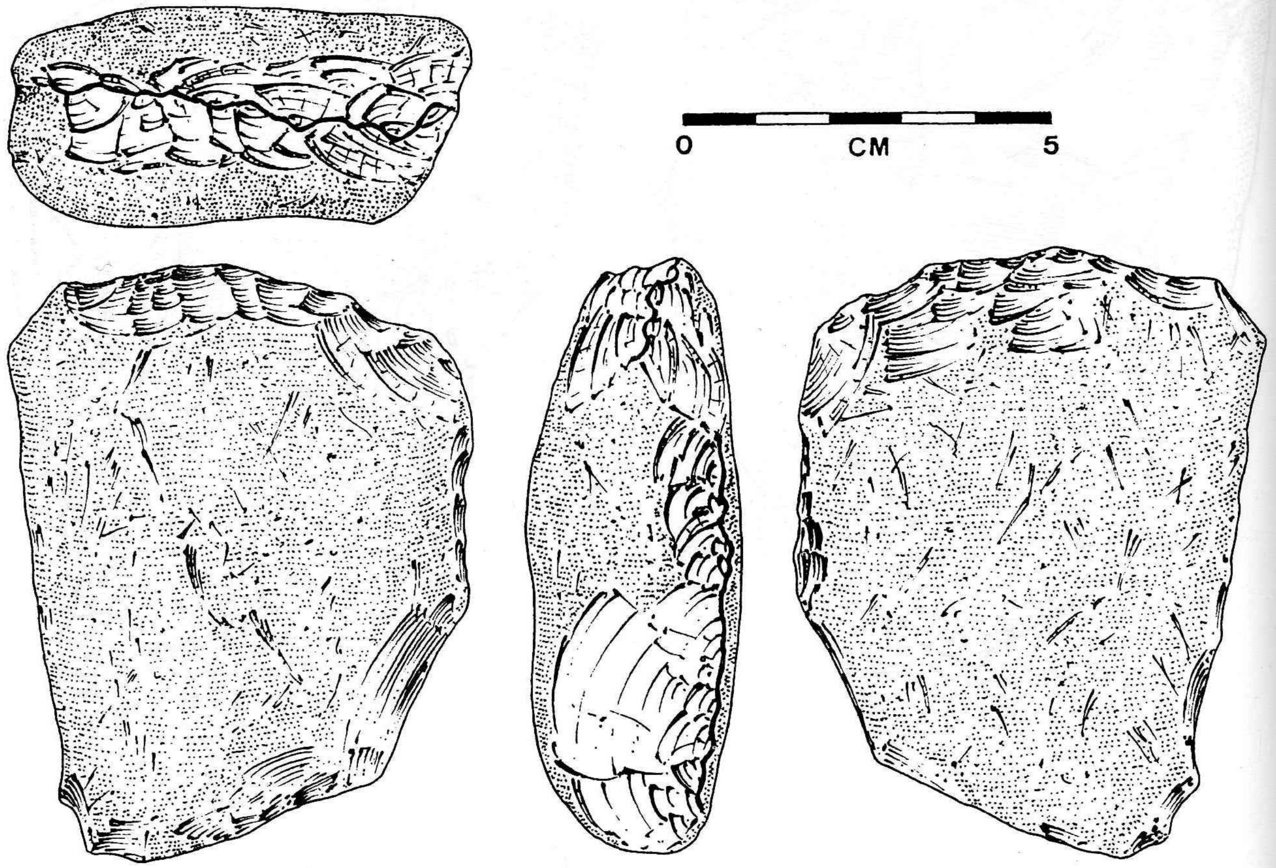

FIGURE 20. Eagle Cave. Bifacially flaked limestone cobble found in association with a Middle Wisconsinan small mammal fauna in a gravelly stratum overlain by a till blanket derived by a Late Wisconsinan valley ice advance intruding the cave opening in the mountain rock face (excavation by A. Bryan).

TABLE 6A. Grimshaw Gravel Site, northwestern Alberta. Mid-Wisconsinan alluvial gravels capped by a Late Wisconsinan Laurentide till. The contact of the two formations defines a certain time hiatus as also witnessed by the occurrence of a lithic industry spatially closely distributed at the base of the glacial diamicton as a result of redeposition during the continental ice advance (*ca* 23–20 ka) representing a *terminus ante-quem* for the age of the cultural record.

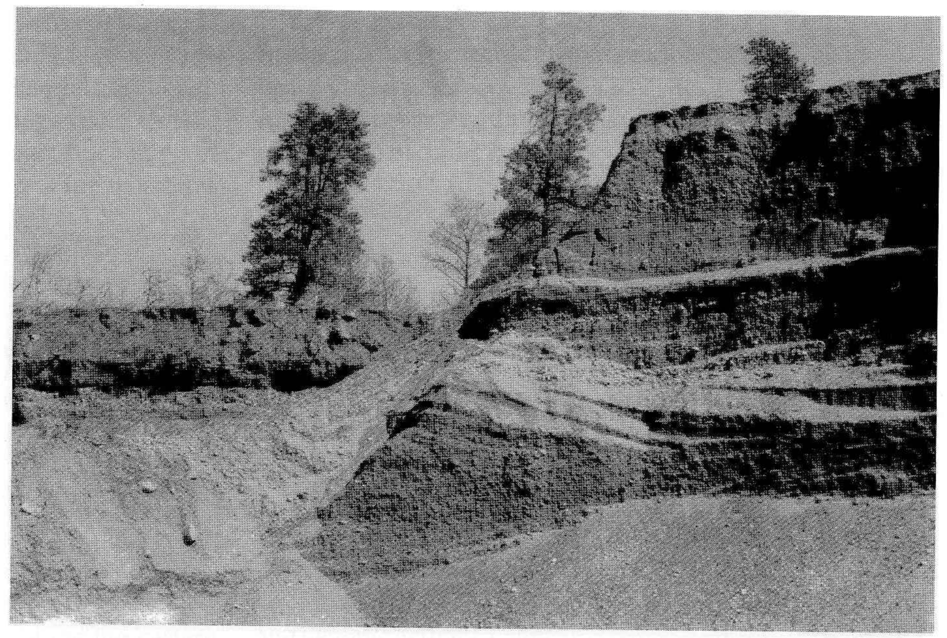

TABLE 6B. Grimshaw Gravel Site, northwestern Alberta. Close view of a distally flaked quartzite cobble tool exposed at the base of the till in the eastern part of the site (Chlachula and Leslie, in print).

of the derived clasts. However, the main source of a variety of fractured clasts, particularly close to the mountain areas, is a glacial diamicton (till), i.e. a massive, unstratified, poorly sorted deposit accumulated during an ice advance. Except for simple fracturing, the resulting damage patterns on entrained and transported and differentially abraded rocks carried by a glacier from its source area, or incorporated from former non-glacial deposits into its basal part as subglacial debris, include polishing, faceting and striating.

Other processes of mechanical disintegration and modification of clasts, especially encountered under periglacial conditions, are related to seasonal temperature fluctuations in permafrost regions, thawing of buried ice causing subsequent disturbance of surrounding deposits, frost action and thermal stress, periodic freezing of capillary water in rocks and migration of the fluid in the supporting matrix, movement of unconsolidated surficial materials over partly frozen ground (solifluction), cryostatic pressure (involutions and cryoturbation), glaciofluvial processes of episodic nature active at peaks of thaw seasons, and drastic desiccation of rocks exposed on a barren land by strong periglacial winds during minimal precipitation conditions. A flaked lithic industry may be difficult to detect in a buried context within a glacial deposit, particularly if generally recognisable cultural attributes are lacking. In such cases, comprehensive contextual as well as actualistic studies are useful to carry out, even if the results obtained are not fully conclusive or are limited to an assessment of a degree of probability (e.g. Schnurrenberger, Bryan 1985). Similarly, a glaciofluvial outwash may be considered as a rather

TABLE 7A. Edmonton, central Alberta. Late Pleistocene sections above the North Saskatchewan River. The stratigraphic situation includes Glacial Lake Edmonton clays above a Late Wisconsinan continental till and Mid-Wisconsinan "Saskatchewan" sands and gravels above Tertiary shales. Several isolated artifacts affected by strong aeolian abrasion found at the upper contact of the sands with the till indicate harsh environmental conditions in the area *prior* to the ice advance (Chlachula, unpublished data).

TABLE 7B. Villeneuve, central Alberta. Close view of planar and cross-laminated sandy beds interstratified with fine to medium cobbly gravel beds (direction of flow from left to right). Several isolated artifacts were found at the base of the formation in association with fossil wood (spruce) fragments (Chlachula, unpublished data).

unlikely depositional environment to incorporate early stone artifacts. This, however, should not be *a priori* discounted, as artifacts, as well as other cultural remains, although largely dispersed by high energy streams flowing across braided periglacial flood-plains, may be present. Although glaciofluvial outwash may be considered as a rather unlikely depositional environment to incorporate an early lithic industry, even this should not be completely discounted. Particularly in Alberta, the occurrence of early cultural records represented by lithic artifacts at the base or partly entrained in glacigenic deposits is to be expected in view of the regional Quaternary geology with deeply buried non-glacial deposits covered and partly distorted by overlying tills. A clear pattern of site distribution across the province under a mountain or continental till, analogous to the Silver Spring Site, is evident (*Figure 1, Tables 6A–B, 7A*).

Lacustrine settings

Lake basins have been preferred places for human settlement since the earliest prehistoric times. Apart of lakes occupying depressions formed by tectonic, volcanic, landslide or marine processes, which are marginally distributed in western Canada, old glacial and glaciofluvial lake settings have a key importance for Palaeo-American investigations. Periglacial agents were especially active in glaciated regions of North America, where glacial debris accumulated by erosion dammed part of a valley, subsequently filled by melt-water. Sedimentation rate in the Pleistocene glaciolacustrine deposits reflects fluctuation of the former lake shoreline and/or the ice margin, and the relative abundance of river-derived clasts. Clastic material as well as possible lithic artifacts, originally distributed along the shore, can be affected to some extent when

reworked by wind-generated waves, and, on a larger scale, by landslides or glacial calving. High energy lake drainage currents may also modify deposited materials, although only exceptionally in shallow shoreline waters. On the contrary, in lakes with an interior drainage, fluctuation of the lake level may cause much reworking of the sediments in the proximal shore zone. However, all these actions are more a source of abrasion and rounding of larger clastic materials than fracturing leading to geofact production. Accordingly, flaked lithics from early Palaeoindian sites in a lacustrine setting should be easily identified and preserved in a relatively fresh condition (e.g. the Varsity Estates Site, Calgary).

Sea-shore settings

The only, though principal area where Pleistocene-age sites are to be expected is along the north-west cost of British Columbia, which may have repeatedly served as another passage to early human immigrants to the New World alternative to the intercontinental route along the eastern slopes of the Rocky Mountains. Both tides and waves produce mass drifts of water due to coastal currents that are the major agent of shoreline sedimentary transport. However, only in exceptional locations are tidal currents capable of eroding coastal rocks (Selby 1985). As in lacustrine environments, wind-induced surface waves are the main source of kinetic energy, but acting here on a much larger scale. Accordingly, the natural modification of clastic rocks (as well as potential cultural remains) is expected there to be more effective. Coarse pebbly rocks occasionally used for stone tool manufacture until the late historic periods are being redeposited by on-shore water movement during periods of ocean transgression, or originate from the eroded parts of cliffs. Recognition of artifactual flaking patterns on lithics scattered on ancient beaches and terraces, or incorporated in marine sediments, therefore, can be extremely complicated by two factors: a high degree of abrasion of a possible culturally-produced implement; and a high probability of pseudo-artifact occurrences, particularly where rocks fall from eroded cliffs, and where frequent and violent storms occur. Another significant aspect involves visibility and preservation potential of possible early sites located on or near a sea-shore. It is likely that most of these, for example on the Northwest Coast, may have been completely scoured by fjord glaciers during later glacial advances and/or subsequently submerged by a rising sea-level during the Final Pleistocene and Early Holocene.

A detailed study of Pleistocene coarse-grained coastline deposits, subsequently uplifted and exposed above the present sea-level, reconstruction of the past depositional processes, and comparative observations on the frequency of naturally produced fractures in the local area, should all significantly contribute to the understanding of the true nature of modification of a lithic sample whose artifactual character is suspected but not proven.

Hillslope settings

In respect to the particular geomorphological position, preservation and recovery of early sites is less likely than in other, more stable landscape settings. In terms of recognition of rudimentarily flaked artifacts, it must be kept in mind that down-slope movement of coarse unconsolidated sediments can also produce fracturing, marginal flaking and other casual damage on individual clasts. In cohesive deposits, creep may produce stresses leading to an increased deformation of clasts, eventually resulting in their structural fragmentation. The same can be said about other high-energy slope and gravity phenomena including talus accumulations, rock-falls near steep cliff faces, and slope wash, all causing fracturing of incorporated debris to form a variety of geofacts, especially if fine-grained, matrix-supported deposit is absent. The scale of these processes depends on several factors, the most important of which are the relief gradient, presence and type of vegetation, amount and frequency of rainfall, and tectonic activity. Contextual studies aimed at clarifying the origin of clast fracturing at Palaeo-American sites, where the cultural activity is disputed and other compelling evidence is missing, are of the utmost importance.

Cave settings

There are only a few cave sites in the Canadian Rocky Mountains, which may have been shelters to early people during the Pleistocene Period (e.g. Eagle Cave). An early human presence in a cave setting is reported from the Yukon area (Cinq-Mars 1990). In cave setting in general, the possibility of natural production of lithics that would resemble genuine stone tools is relatively limited. This is because the natural intracavernal milieu *a priori* excludes the presence of other non-indigenous clastic material, unless these were secondarily derived by gravity slope phenomena, or external stream and glacial action. Chert nodules, occasionally occurring in limestone formations, may be an exception. Except for sudden structural disturbances resulting in roof falls, and the presence of cave streams, there are no other natural forces which could contribute to fracturing of stones. Thus, even a very "primitive" lithic industry made on mediocre-quality rocks showing rough "undiagnostic" flaking excavated from undisturbed cave deposits suggests cultural origin (e.g. Belle Roche Belgium, de Lumley 1969). This is particularly true if the raw material does not naturally occur in or near a cave (e.g. perfectly spherical siderite concretions originating from Cretaceous shales in the Rocky Mountains *ca* 90 km distant that were found beneath a late Wisconsinan glacial deposit in Eagle Cave, Crowsnest Pass, SW Alberta; A.L. Bryan, unpublished data) (*Figure 20*).

In sum, proper understanding of the geological context is crucial, particularly where no other evidence exists that might support the cultural character of a flaked lithic assemblage. This is especially important since early sites found in direct, conformably stratified and undisturbed geological contexts, i.e. *in situ*, are likely to be discovered very rarely. Contextual studies of depositional environments constitute a crucial part of any geoarchaeological studies. Further research on the lithic artifact / geofact flaking criteria may significantly contribute not only to resolving questions about the antiquity of man in the Americas, but also to early human dispersal in the Old World.

ANALYTICAL STUDIES

Physical properties of raw material

In addition to the contextual investigations, studies on physical properties of rocks must be included in the methodological framework for critical assessment of a potential pre-Palaeoindian stone industry distinguished in a geological context, particularly if this represents the only possible cultural manifestation. An adequate knowledge of the physical properties of particular rocks and clastic minerals in their natural depositional environment as a potential source of prehistoric raw material is one of the primary requirements for determining the cultural origin of a lithic assemblage. Structural strength of a lithic raw material should be assessed in terms of its ability to resist deformation by tensile, shear and compressive stresses. Especially in glacial and mass-wasting sediments, a study of once active frictional forces at the contact between bedrock (or the underlying materials) and the transported deposits may provide information about the potential of fracturing of individual clasts. Other aspects of the structural analysis relate to the mode and frequency of modification (i.e. breaking, crushing, chipping, cracking, grinding, polishing) identified in a local depositional setting, and a dominant surface patterning (fissures, striations, grooves, etc.). The latter are especially useful by reconstructing a geological history of the clast and the character of the most recent depositional processes. Similarly, the state of weathering, textural homogeneity, etc., should be included in every comprehensive study. Geological context of a lithic collection becomes important in determining if nature would have had the probable capacity of fracturing rock, especially in a percussive manner (Patterson 1983). This fully unexplored field of study deserves much greater attention by students of New World prehistory.

Experimental and functional analysis

Detailed technological analyses and experimental flaking should be an integral part of any scrutiny dealing with possible early stone tool assemblages. Both imply the testing of available raw material, including the production of tool replicas using indigenous rocks, and their comparison with possible artifactual specimens. Experimentation should be carried out on a variety of available raw materials occurring in local deposits over a broader size range and quality of clasts to deduce technological limits and the degree of potential cultural adaptation to a particular raw material after applying a set of specific technological procedures. Finally, comparative studies on reduction flaking, retouching, utilization traces and degree of overall standardisation of the resulting sample is of considerable importance.

Experiments in rock fracturing applied to a variety of raw materials for specific depositional environments, observations done on broken clasts of very ancient (pre-Quaternary) geological provenance, and comparative simulation of damage patterns can provide very important comparative data. It is evident that the potential of fluvial and alluvial depositional settings for direct percussion is strongly overestimated without any reasonable grounds (Kuenen 1956, Schumm, Stevens 1972). As a matter of fact, the majority of specimens in thick gravel beds have been broken by pressure of the overburden after the depositional process, whereas the principal factor of the syndepositional clast modification is rolling.

Since natural forces act in a random manner, the resulting modification features are accordingly arranged in irregular patterns. In demonstrating the artifactuality of an assemblage, it is necessary to document consistent and progressive modification traits separately for the clastic rock or its fragment, preform and the final product. Although many elaborate geofacts may also occur in natural, high-energy settings, they are generally characterised by a rather limited number of recurrent morphological forms. Thus, a frequency of repeatedly occurring lithic forms with identical flake patterns can be a very important factor to support the cultural origin of the sample. Solely technological criteria, as well as the use of individual "diagnostic" attributes are, however, only of limited value.

Finally, use-wear analysis is a useful technique in assessing not only the most likely function of a particular tool (e.g. Beyries 1988), but also the authenticity of a lithic specimen as artifactually produced and/or used (e.g. d'Errico 1985, Sussman 1988, Vaugham 1985). Nevertheless, the application of the use-wear analysis may be considerably limited by the fact that during redeposition processes of a lithic sample microscopic as well as macroscopic utilisation traces may be effaced by rolling and abrasion (e.g. Knutson 1988). Another main controlling factor is the particular property of raw material. Distinction of patterned, non-accidental microflaking from accidental "pseudoretouch" randomly distributed on morphologically functionless edges should be reliably determined in most cases.

Natural / cultural stone flaking: general aspects

Criteria specifying "diagnostic" flaking patterns of early stone industries, and distinguishing them from naturally induced fractures in a particular geological context, are only exceptionally stated in descriptions of presumably culturally modified lithic assemblages. In both the Old and the New Worlds, only a few attempts have been made to address this issue (e.g. Breuil 1955, Dies 1981, Patterson 1983, Schnurrenberger, Bryan 1985). Most of those, however, concern isotropic raw materials, and some of the attributes may not be observable on coarse-grained rocks and minerals. It is preferred (and imperative) in any study to derive *a priori* specific stone flaking criteria for the particular assemblages, as any uncritical generalisation may be rather misleading.

Authenticity of the Late Pleistocene palaeolithic stone industries from Alberta is based on quantitative and qualitative comparison with naturally produced geofacts (pseudoartifacts) from fluvial and glacial environments from the area, analogous Holocene-age lithic industries from surface context, and experimentally produced stone tool specimens. The identical raw material in all data sets contributes to the objectivity of the study in terms of a general scheme of the nature and arrangement of flaking patterns, and the specific modification of exposed edges. Surface texture, i.e. the range of features found on the surface of flaked specimens, is considered to be equally informative.

Artifact-diagnostic stone flaking attributes

The palaeolithic stone tool assemblages from Alberta are characterized by specific flaking and edge retouching features, which are not consistently observed in patterned associations with any of the studied naturally-produced comparative assemblages. Because of their dominant occurrence in definite quartzite industries, these particular formal, textural and edge-modification attributes are therefore considered to be diagnostic for the cultural flaking of the tested lithic assemblages, especially if they occur in patterned combinations. However, none of the particular attributes defined as "diagnostic" can be *de facto* considered as a reliable feature if found in isolation on flaked lithics. From this point of view, the cultural nature of the recorded lithic specimens is inferred on the basis of their *recurrent patterning*. In both the flake- and the cobble-core components, the cultural nature of flaking is well-documented if several independent flaking procedures are present.

The artifactual nature of the lithic assemblages from the Late Pleistocene sites in Alberta is based on the following general criteria (Chlachula 1994a):

a) regularity of flaking;
b) recurrent and technologically coherent patterns of modification;
c) standardised size range of the resulting forms;
d) presence of a set of associated attributes diagnostic for stone tool production which are absent in assemblages having an identical lithological composition from glacial and fluvial settings, despite the similarity of depositional environments.

The association of the above four criteria on flaked clasts in respect to the particular geological context excludes any possibility of modification of the lithic assemblages by natural forces acting during the accumulation of fluvial and glacial deposits preserved in the studied sections. In view of the characteristic flaking patterns and surface texture on the lithic specimens contextually incorporated on top of fluvial gravels below glacial diamictons, the actual modification must have occurred *after* deposition of the gravel beds by braided streams and *before* subsequent disturbance of the original depositional context in a glaciofluvial or glacial environment. Although there are many tools at the sites which can be easily recognised as artifacts even without any formal comparative lithic analysis, the criteria stated above address specifically those variably reworked specimens, about which questions could arise concerning their cultural authenticity. It is reasonable to suggest that the cultural origin of their flaking is supported because they are directly associated with a lithic industry whose artifactual status has been firmly established. In fact, these "less convincing pieces" do not change the implication about the "pre-Palaeoindian" settlement in the study area. The assumption is maintained that if definite stone tools are present, then it is an archaeological site.

Technology of palaeolithic industries from Alberta

Generally, quartzite artifact assemblages from Alberta pre-last glacial sites manifest most of the basic technological traits and corresponding typological forms of stone tool production and lithic inventories that are found in the Old World Early, Middle and Late Palaeolithic. Under the term industry is here meant a particular set of (lithic) artifacts spatially and chronologically associated in one technologically and typologically coherent assemblage defined by recurrent tool types produced by a set of specific flaking procedures. The term "Palaeolithic", applied in the description of the stone tool assemblages from Alberta, is primarily used to refer to a particular technological stage, but because of its contextually derived age as a time period corresponding to the traditional European and African concept. Whether or not this terminology can be applied to, or is appropriate for an early American lithic record may be a matter of debate. It must be agreed with the argument that "it is illogical for archaeologists to bar the term Palaeolithic from crossing the Bering Strait if the evidence indicates that people bearing simple stone and bone industries of Old World ancestry entered in Pleistocene times" (Bryan, Gruhn 1989:83). The term "Palaeolithic" has been avoided in North American archaeology in order to "preclude any attribution of great antiquity to New World lithic assemblages, as well as any indication of a direct cultural relationship with specific Old World lithic traditions of the Pleistocene" (*op. cit.*:82).

There is no reason why the lithic industry from the Late Pleistocene sites in Alberta should be formally described differently than the same lithic assemblages from a Pleistocene context in Europe or Siberia, just because they were found in North America. As the Late Pleistocene age of the local artifact assemblages has been firmly established, then this fact entitles to speak about a Palaeolithic industry in traditional culture-historical terms equivalent the Old World concept, where the upper chronological limit is determined by the Pleistocene / Holocene boundary, i.e.

10,000 years B.P. From this perspective, Clovis points are archaeological manifestations of a particular final Pleistocene North American Palaeolithic culture as well. The question is not whether or not existence of an American Palaeolithic has been demonstrated, but simply whether an Old World formal stone tool-classification system can be used in the Americas. It is evident that evolutionary pathways were different in the Americas than in the areas of "classic" Palaeolithic research, but probably not dissimilar from cultural developments in parts of Siberia and Eastern Asia.

In compliance with the Old World "Palaeolithic" concept, stone industry from the investigated sites in western Canada includes principal technological elements of "pebble-tool" or core and flake industries dominated by unifacial flaking techniques, more elaborate bifacial flaking, a variety of flake-based technologies, and a blade-oriented extraction technique. The typological variety within the stone tool assemblages corresponds to the technological level of their production. Accordingly, numerous forms can be found which have direct parallels with the Old World Early, Middle as well as Late Palaeolithic stone tool inventories. As stated above, these forms occur together without any particular association with each other, which is the principal characteristic trait of the Pleistocene artifact assemblages from Alberta.

The "Early Palaeolithic" level of technology includes rudimentary unifacial / bifacial flaking in the form of direct percussion (including anvil percussion flaking and bipolar flaking) (e.g. *Figures 19–20*). The "Middle Palaeolithic" technological elements are exemplified in a more specialised core preparation. In accordance with the overall technological trend, the application of hard-hammer flaking is also indicated by hammerstone percussion marks (*Figure 5*), short flake negative scars on cores (*Figures 4:3, 5, 18*), the well-developed bulbs, and the thick basal parts of detached and secondarily retouched flakes. The typical "Late Palaeolithic" technological features are much less frequently encountered in the lithic industry, but are nonetheless apparent. This particularly concerns cores with one or two non-cortical flaking platforms, with a series of parallel and well-organized negative blade scars after blade removals, as well as small blade fragments and some microblades.

In summary, the characteristic artifactual attributes, recurrent technological procedures, patterned typological variability, and a variety of utilisation traces clearly document a cultural origin of the pre-last glacial lithic assemblages from the investigated sites. *The specific mode and intensity of retouching when associated with other diagnostic attributes, and the appearance of distinct tool types produced in patterned technological ways explicitly differentiate the industry from naturally fractured clastic materials.* The variety of rock flaking methods on a different technological level and common recurrence of classifiable forms is the most characteristic trait of the local lithic artifact assemblages (Chlachula, Le Blanc 1996). Because of the patterned geological contextual and geomorphic distribution accross the province, the stone industries from Alberta are clearly part of a *palaeolithic*, pre-Palaeoindian (>12,000 B.P.) tradition, not an isolated phenomenon. At present, it is impossible to draw more definite cultural links with particular areas in Eurasia, as the sample size is still rather limited and likely not complete in overall typological representation.

DISCUSSION

Despite a certain progress in the earliest American studies, there is still no consensus about the timing of the initial Palaeo-American migration, the level of technology and the associated typological variety of stone tools that the early Americans might have brought with them or have originally developed in the New World. Most North American archaeologists tend to look for assemblages with bifacial or microblade flaking patterns in geologically recent deposits, assuming a possible continuity with Upper Palaeolithic bifacial projectile point (like Dyuktai) and palaeo-Arctic technologies, respectively. On the other hand, there is general and unfounded resistance to the notion that there could be anything on a Lower or Middle Palaeolithic technological stage. It may be this unwillingness to take seriously into consideration any lithic record from the Pleistocene-age deposits that differs from generally recognised industries, and/or inadequate professional knowledge and capability to evaluate objectively rudimentarily modified stone artifacts which may altogether be largely responsible for the "controversy" surrounding the earliest American prehistory. This directly reflects the fact that most North American students lack training in Quaternary geology. What is most important, they do not look for early American sites in the right, i.e. deeply buried, Pleistocene geological contexts. Not necessarily visibility, but primarily recognition of such tools is the main factor which can significantly contribute to new discoveries of early American sites. Especially the formerly glaciated areas and areas of a high sedimentation input should be surveyed for deeply buried palaeolithic records.

The dissension about the earliest prehistoric evidence is largely due to the absence of any uniform methodological framework which would be used as a standard procedure by judging the presented data. This approach should include both field geoarchaeological observations as well as a close laboratory scrutiny. One of the reasons for the persisting scepticism is a lack of "diagnostic" modification patterns on purported "pre-Clovis" lithic industries if only those represent the potential cultural record. Recurrent patterns (i.e. repeatedly occurring specific attributes or their association sets within a sample) in stone flaking should be regarded as a major criterion for documenting the earlier American occupations especially by dealing with individual artifact assemblages. It must be kept in mind, however, that nature can also produce recurrent patterning of rock modification, and any generalisation should be avoided. Rock flaking criteria should, therefore, comply only to local geo-contextual conditions.

The identification of an early "non-diagnostic" lithic industry in a deep (and unusual or unexpected) geological context may be a complex problem. This cannot be approached only intellectually without the necessary background in lithic, as well as contextual studies that provide the most vital sources of information. The cultural nature of rudimentarily modified artifacts can be satisfactorily established by a set of criteria applied in a simple but logical sequence. This includes discrimination on lithic specimens of unambiguous modification traits which do not occur in analogous deposits at other sites with identical raw materials, and which possess clear attributes encountered on definite stone industries easily replicated by experimental flaking. Accordingly, correct interpretation of the geological context, and a sufficient knowledge of physical properties of raw material and potential sources of natural edge-wear are of utmost significance. An exclusive reliance on formal morphological resemblances with Palaeolithic tool types, or a presumed lithic technology should be avoided. Nevertheless, the Old World Palaeolithic collections can be used only as proxy data, as they differ in provenance and the quality of raw material. Finally, the overall quality of presentation with clear description and detailed documentation of (archaeological) material, completely stated contextual data, and their critical evaluation are equally important. Especially in the case of rudimentarily flaked lithics, formal and processual criteria should be presented that would allow a comparative evaluation with non-culturally modified materials from the same depositional context.

Since one of the principal problems in the early prehistoric American studies concerns the recognition of artifactually flaked lithics (in isolated occurrence, or in association with naturally modified fragments), geological and technological studies are of primary importance. These should not be limited only to determining the degree of probability of the cultural status of a lithic collection, but their authenticity should be explicitly qualitatively assessed. Geomorphological, sedimentological, petrographic and rock-mechanical investigations, combining field observations and analytical laboratory expertise can play a crucial role in this process. Dynamics of a depositional environment should be thoroughly studied in order to determine the actual potential for natural modification of a particular lithic material. Easily accessible deposits with fractured rocks of old geological ages can be used for control testing. All these aspects are especially vital for lithic assemblages found without association with any other archaeological record or cultural features. This, however, is not possible without a broad multidisciplinary approach following more than one line of supporting evidence. It is very important to pursue such research, not only for elucidation of the earliest American prehistory, but also for the further development of both field and analytical methods, which might be applied in other parts of the world in similar study contexts and for the same ultimate goals.

CONCLUSION

At present, general recognition of potential pre-12,000 year-old American sites is still rather problematic for most archaeologists, especially if the evidence consists of rudimentarily or crudely flaked lithics. This is apparently one of the major issues of American prehistoric archaeology that must be resolved. This situation may reflect the absence of a uniform methodological framework and the dominance of traditional perceptions about the ways and timing of the colonisation of the New World. To cope with this problem, completely new study approaches and research strategies should be developed in order properly to investigate, evaluate, present and finally assess objectively any new pre-Palaeoindian site and, at the same time, re-assess former claims. For now, the pre-12,000 year old lithic record tends to be evaluated on a basis of personal opinions and arguments, rather than by rigorous and objective scientific methods. Assumptions derived from the "Clovis-first" paradigm, and using them as a tool for testing any potentially early archaeological site is the very reason why there has been so little progress in research on early Americans for the past several decades. Basic field experience and open mind can more readily contribute to the elucidation of the earliest occupation of the New World than new theoretical models which *a priori* cannot objectively assess the reliability of these claims. This is largely dependent on introduction of well-defined and uniform geoarcheological research strategies incorporating glacial geology and palaeolithic archaeology, and a more active role of other natural sciences.

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