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Cultural and Natural Formation Processes in Late Quaternary Cave and Rockshelter Sites of Western Europe and the Near East

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Caves and rockshelters have played a fundamental role in the demonstration of human antiquity and in the development of prehistoric archaeology. In the 20th Century, they have been important in the development of the cultural and paleoenvironmental sequences that constitute the organizational frameworks for the study of the residues of past human behavior (Daniel 1975; Straus 1979, 1990; Grayson 1983). Especially in the western European "heartland" of paleolithic archaeology, our knowledge of Pleistocene and early Holocene foragers comes largely from cave and rockshelter contexts, to the near exclusion of any other kinds of sites. This has had both good and bad consequences.

We have had the opportunity to "do" cave and rockshelter archaeology in a wide variety of geographic and geomorphological settings in the circum-Mediterranean Old World, spanning time ranges from the beginning of the Upper Pleistocene (ca. 130 kyr B.P.) to the mid-Holocene (ca. 5-6 kyr B.P.). We share briefly here some of the results of this experience. We begin with an overview of the geomorphology of caves and rockshelters in diverse environments and proceed to a discussion of some of the cultural site formation processes associated with the human use of these features of the prehistoric landscape.

Geomorphology and Cave Deposits

From a geological perspective, formation processes in caves and rockshelters are complex and somewhat resistant to generalization (Butzer 1964a: 197-208). What archaeologists call caves and rockshelters represent a wide range of depositional and erosional processes and environments, fully comparable to the geomorphological diversity found in fluvial, lacustrine or glacial deposits (Farrand 1985; Laville et al. 1980:45-73; Straus 1990). Although, from the standpoint of prehistory, rockshelters and the occupiable parts of caves may persist as dynamic features of the landscape for significant, although variable, spans of time, they tend to be short-term phenomena from a geological perspective (Clark 1979, 1983). This is because most such features are in a state of disequilibrium with the geomorphological environment in which they are found.

True caves are formed subareally, primarily through the dissolution of (usually) calcareous bedrock by the action of groundwater as it infiltrates fissures and crevices in the rock. Once a solution cavity has formed and become more or less stabilized (a condition dependent upon the temporal scale of observation), the temperature and relative humidity of cave environments tend to vary little over long periods of time. Percolation through the rock is typi-

cally slow and more or less constant, and changes in flow rates tend to take place very gradually. Once opened to the surface through erosion and/or collapse, caves become subject to external environmental conditions quite distinct from those of their formation, including much greater fluctuations in temperature, humidity, and in the quantity and flow rate of surface water. The effects of such episodic changes in the moisture and temperature regimes include roof spalling and collapse, erosion or transport of floor sediments, and the addition of fluvial, colluvial and aeolian sediments from external sources. The end result is often the disappearance of one or several cave entrances through collapse, infilling, or a combination of both.

Rockshelters, on the other hand, tend to result from differential erosion rates, mass wasting, or weathering over a restricted area (e.g., and especially, the formation of an overhang or cornice through differential erosion of relatively soft strata overlain by or interstratified with harder, more resistant ones). These processes can include stream scour at the base of cliffs or differential weathering of rock strata of varying hardness. Over a relatively long time, these differential rates of mass loss will tend to come into equilibrium, resulting in the eventual disappearance of the shelter. Major processes involved here include collapse of a series of retreating overhangs and infilling from fluvial, colluvial, and/or aeolian sources. Although usually of lesser consequence volumetrically, anthropogenic and biogenic contributions to the infilling of both caves and rockshelters are of considerable significance to archaeologists.

Because geomorphological equilibrium generally results in the infilling of these cavities, both caves and rockshelters tend to experience overall aggradational environments. Also, these features often generate their own clastic material (e.g., from roof spall or collapse, carbonate precipitation, or fluvial transport of fine sediments from inside caves) in addition to serving as traps for sediments from external sources. Hence, deposits tend to be a mixture of externally and internally derived sediments.

Finally, the permanent presence of water in heavily karstified terrain (e.g., northern Spain), as well as the springs and streams commonly associated with rockshelters, means that deposits are often strongly altered chemically. This alteration can include eluviation/illuviation of clays and fine clastics, chemical leaching (i.e.,"corrosion") and other forms of *in situ* alteration of minerals, and mineral precipitation. Regularly waterlogged sediments are more susceptible to plastic deformation (e.g., from cryoturbation) and structural collapse (e.g., debris flows). Archaeologists often seem to assume that, with the exception of block falls and clearly-identifiable episodes of roof collapse, aggradation will be gradual and relatively constant in caves and rockshelters; any other catastrophic alterations of deposits are felt to be erosional in nature. However, on the basis of detailed reanalyses of caves and rockshelters in France and England, Simon Colcutt (personal communication, 1984) suggests that a considerable amount of deposition in rockshelters is episodic and catastrophic in nature, resulting from such processes as slope collapse of mouth cones and mud flows.

Examples of Cave and Rockshelter Depositional Environments

Caves and rockshelters at which we have worked serve to illustrate the diversity of processes responsible for deposits that archaeologists encounter in these features. We emphasize that it is unwise to treat caves and rockshelters as a monolithic class of geomorphic features in which a limited suite of depositional processes are consistently represented. Nevertheless, we believe that cave and rockshelter depositional environments admit to some generalization. Our examples are drawn from opposite ends of the Mediterranean Basin (the Iberian Peninsula, the Levant) and from a variety of environmental settings, including humid karst topography, the Mediterranean coast, upland Mediterranean forest, and semi-arid steppe.

Karstic Systems

La Riera

La Riera cave is located in the town of Posada de Llanes, in the Principality of Asturias, on the north-central Spanish coast (Figure 1). It is a small solution cavity which is part of an extensive karstic system formed in the Lower Carboniferous limestone of the Llera ridge. The cave lies at an elevation of ca. 30 m above present sea level (Figure 2). A steep talus slope descends about 5 m from the cave mouth to the course of the Río Calabres, a small stream that disappears into the Llera ridge about 250 m west of La Riera. At present, the Calabres flows within 40 m of the cave, but during times of protracted, heavy rainfall, it can back up due to partial blockage of its karstic passage, flooding the Posada valley and nearly flooding La Riera. The Río Calabres re-emerges at the Niembro estuary, 1.5 km northeast of La Riera. The present day shore of the Cantabrian Sea is about 1.75 km due

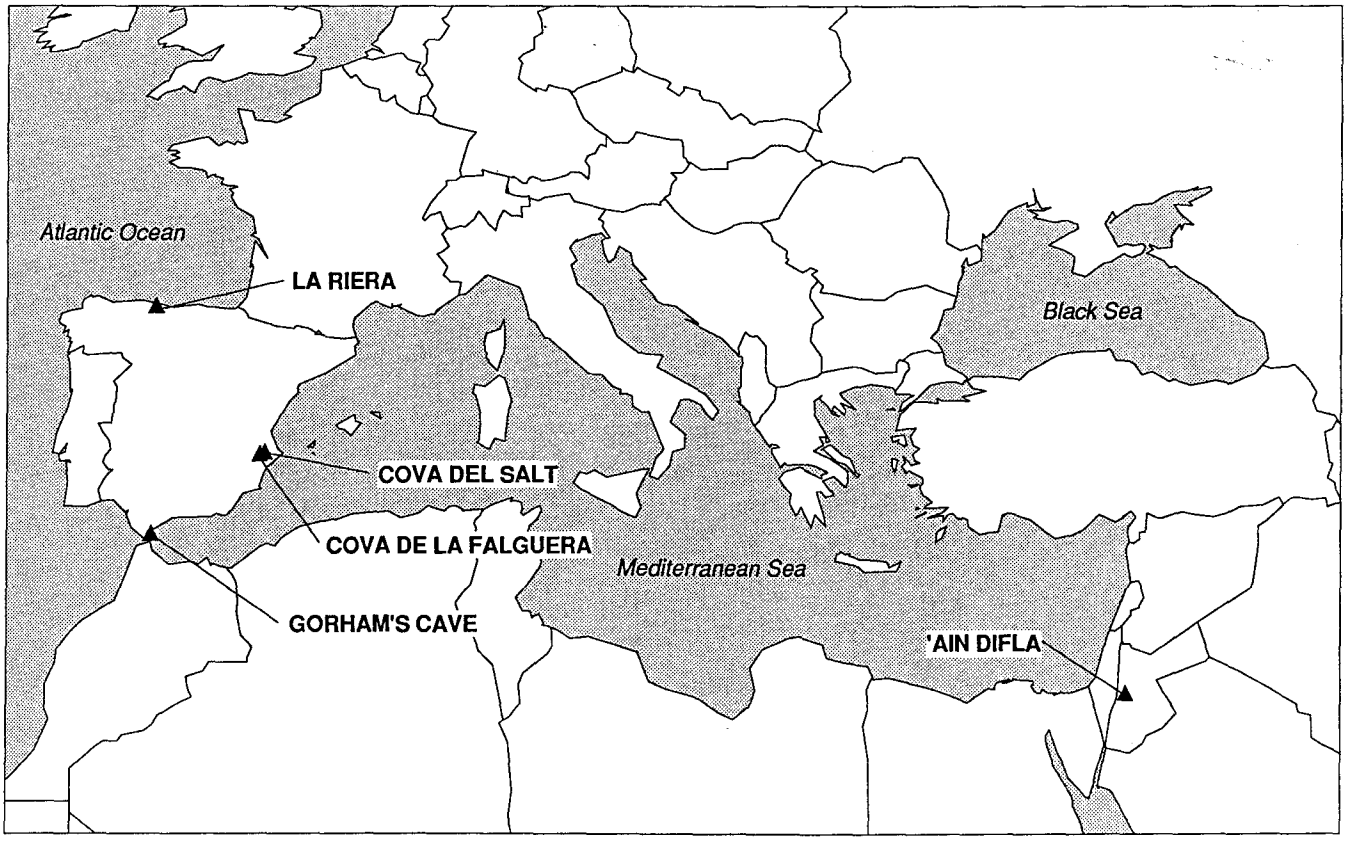

Figure 1. Map of the Mediterranean region, showing sites mentioned in text.

north of the cave. Karstic activity continues today, and the Llera ridge is riddled with a system of narrow galleries that extend over many kilometers.

Most of the archaeological deposits in the cave vestibule were excavated by the Conde de la Vega del Sella in 1917, leaving only restricted intact areas in the cave entrance. These were tested by Clark in 1969, and excavated by Straus and Clark in 1976-1979 (Straus and Clark 1986) (Figure 3). The 1976-1979 excavations revealed a rich and complex Upper and post-Paleolithic archaeological sequence extending in time from ca. 21 kyr B.P. until ca. 7 kyr B.P. (Figure 4). Sedimentological and palynological analyses indicate episodic and differential human use of the cave beginning in the cold, dry Tursac/Laugerie stadial phase, and extending throughout a succession of four additional cold and eight temperate, relatively humid episodes, before the cave was capped with a thick flowstone deposit late in the Boreal Period (Laville 1986; Leroi-Gourhan 1986).

The La Riera deposits present great petrographic, granulometric and morphological diversity due to two overriding characteristics of the cave. The cave was open to the exterior throughout much of its history, and thus was exposed to local climatic variations that affected its depositional environment. These climatic variations are expressed differentially throughout the deposits as a result of their interaction with processes of sedimentation and alteration. The former include frost-weathering of the limestone roof and walls of the cave, producing *éboulis* of various sizes and shapes, as well as the deposition of colluvial and alluvial deposits from the cave exterior. Alteration processes include secondary fragmentation of limestone debris as they were spalled off or after deposition, cryoturbation of deposits, translocation of fine sediments, and chemical changes in the deposits.

The cave is also part of a vast karstic system, and was thus affected by at least some episodes of that system's reactivation. This had profound effects on both the sediments in the cave mouth and on their subsequent, physical alteration. In particular, the apparently frequent inundation of the cave, the partial removal of deposits by erosion and the leaching and brecciation of many sedimentary units can be attributed to the cave's role in this larger karstic system.

Over the 14,000 years of sporadic human use/occupation, the depositional environment at La Riera was aggradational overall, although interrupted on at least two occasions by erosional events and punctuated by episodes of accelerated frost-weathering, cryoturbation

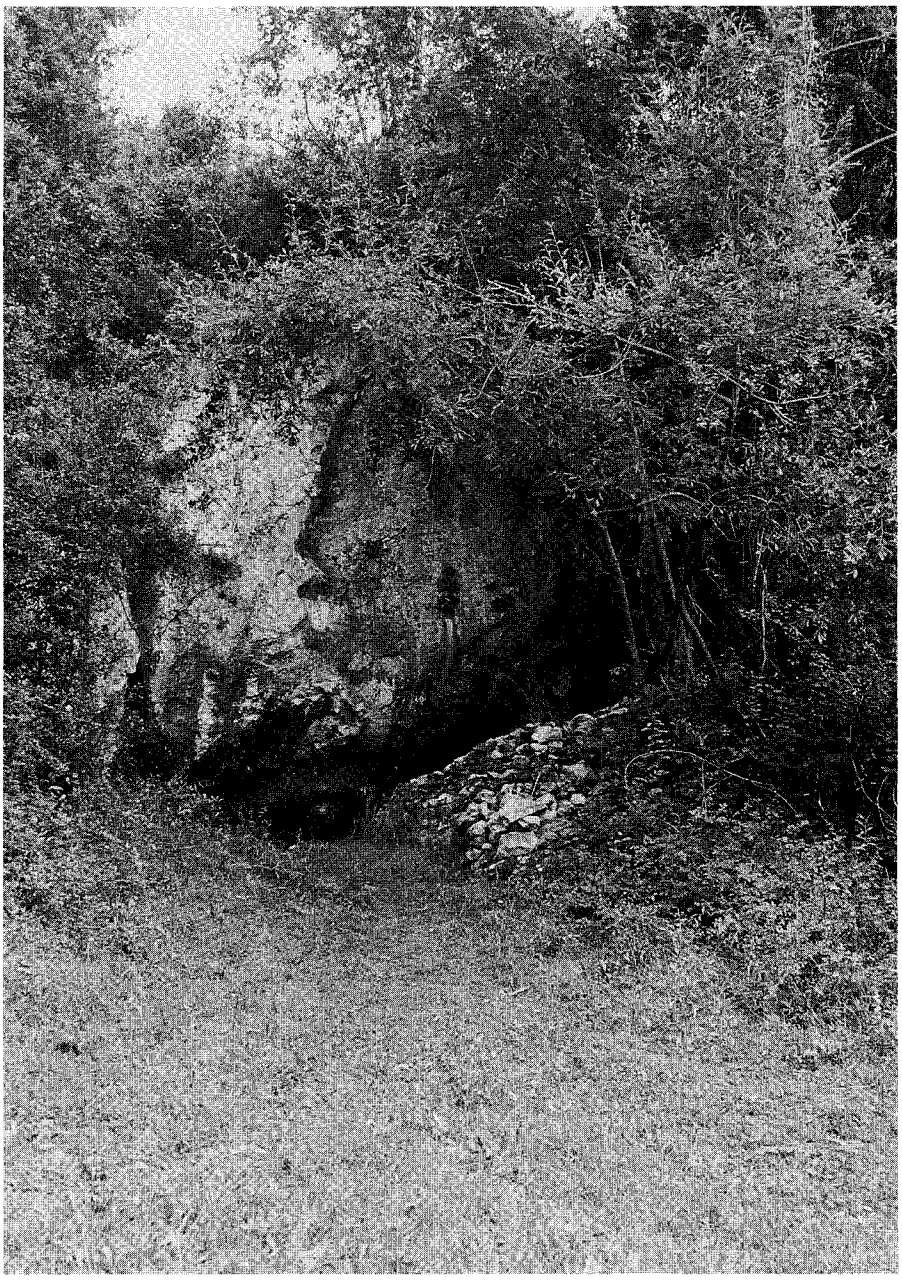

Figure 2. Entrance to La Riera Cave, Posada de Llanes, Asturias, Spain.

and by the formation of congelifraction layers, and, on at least one occasion, by an apparent, low-energy inundation of the cave mouth, resulting in the deposition of a thick, distinctive yellow clay "marker bed" (Lev. 23/21, Figure 4).

Gorham's Cave

Gorham's Cave offers an example of a cave that experienced a different suite of depositional environments than did La Riera (Figure 1). Located at the southern tip of the Iberian peninsula, Gorham's is one of seven caves cut into the base of cliffs which form the eastern face of the Rock of Gibraltar (Figures 5, 6). Formed by a combination of erosional, structural, and karstic processes, the cave extends more than 50 m into the rock. Its current floor is about 10 m above sea level, but when first noted by Major A. Gorham in 1907, it was filled with sand to a height of 17 m above sea level. At various times in its long history, springs or seeps have been present in the cave, as they are today (Barton 1987:35-54, 1988:17-30; Waechter 1951; 1964; Zeuner 1953).

Deposits in the inhabited mouth of Gorham's Cave exhibit an unusual variety of sediment sources and

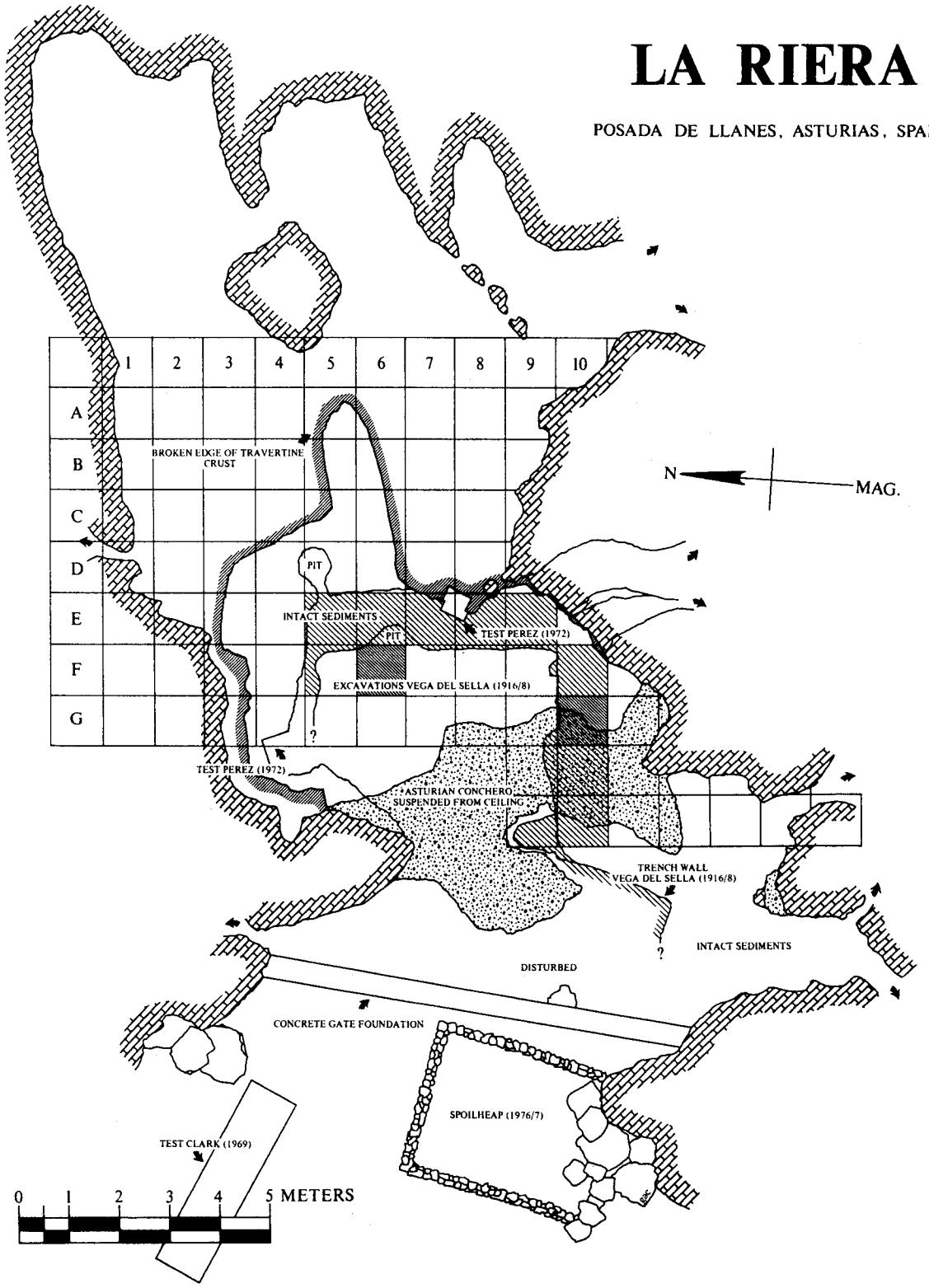

Figure 3. Plan of La Riera (after Straus and Clark 1986:10).

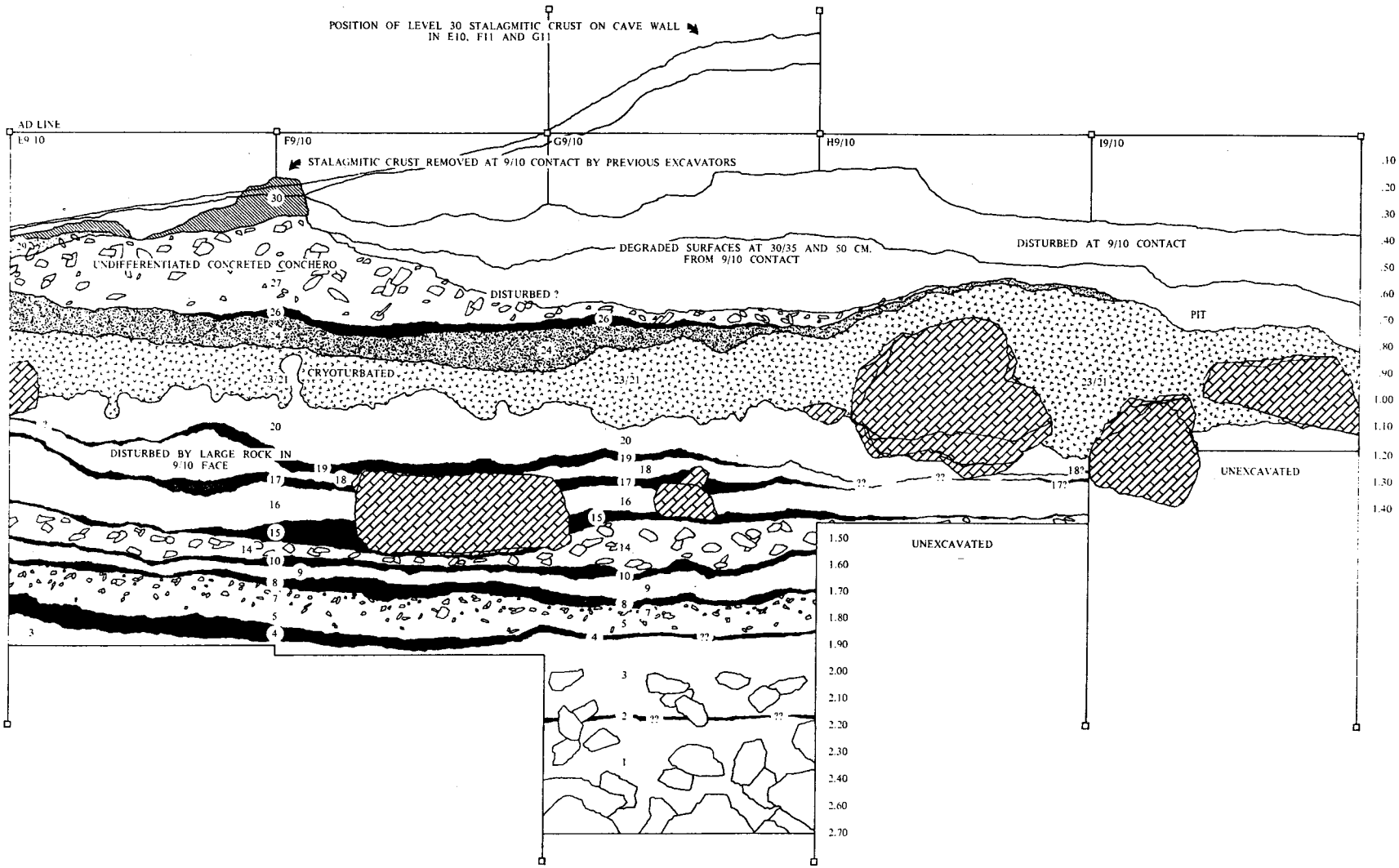

Figure 4. Profile from the 1976-1979 excavations at La Riera. Stratigraphic section at the 9/10 interface in Squares E-I. The arbitrary datum plane is indicated with vertical extent of strata shown on the right. Note cryoturbated Level 20/21 contact (after Straus and Clark 1986:32).

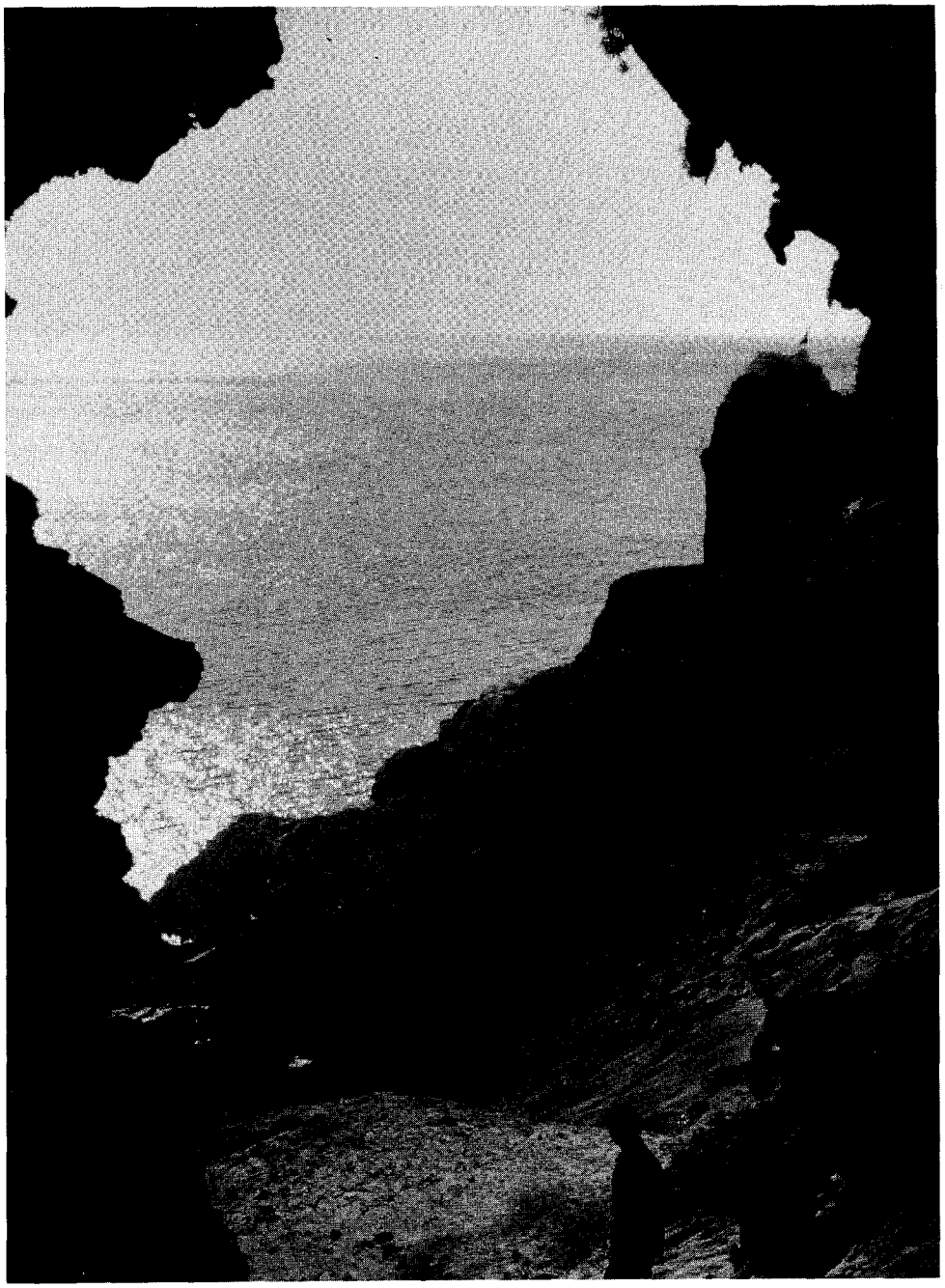

Figure 5. View through entrance to Gorham's Cave, Gibraltar, showing Mediterranean Sea (looking southeast).

transport mechanisms (Figure 7). These include wave-deposited sands and gravels from nearshore and onshore beach sources (often with large amounts of water-worn shell), wind-deposited beach and foreshore sands, silts and clays from exterior (aeolian) and interior (water-laid) sources, carbonates precipitated from flowing water in the cave interior, and infrequent coarse clastics from roof spalling. Anthropogenic and especially biogenic deposits comprise an important part of the fill. These include hyena droppings and biogenic carbonates derived in part from moss and algae growth when standing water was present for intervals in the cave (Goldberg and MacPhail 1991). The cave appears to have been scoured during the last maximum sea stand at ca. 120 kyr B.P. and wave erosion may have removed sediments at the entrance during subsequent transgressions. While the volume of sediment lost is unclear, it appears that the cave has not been completely emptied of its contents since the last inter-

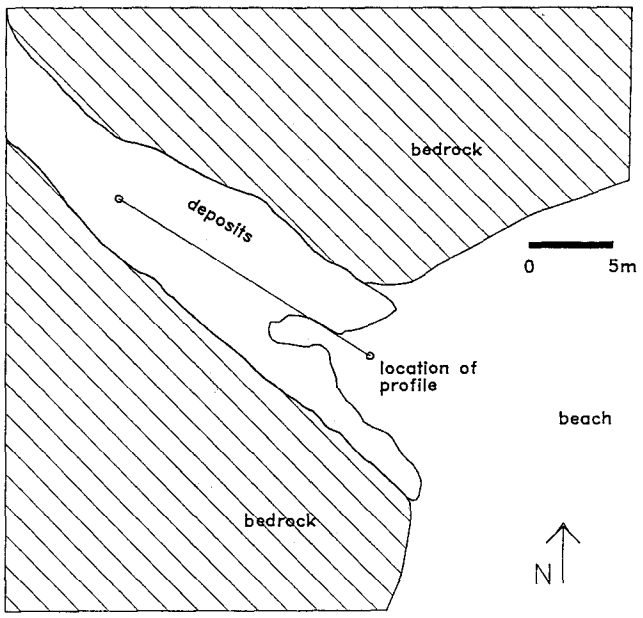

Figure 6. Plan of Gorham's Cave (after Barton 1988: Figure 2.1).

glacial. In addition to erosion, episodes of depositional stability are indicated by zones of carbonate and organic matter accumulation.

Archaeological deposits in Gorham's Cave attest to its episodic occupation by Middle and Upper Paleolithic humans at various times since the last interglacial. It is possible that it was also occupied earlier, but scouring during the last interglacial has removed any evidence of that.

In summary, the depositional environments at Gorham's Cave seem to have been generally aggradational throughout the Upper Pleistocene and Holocene. The overall rate of aggradation was slow (i.e., 8 m in ca. 120 kyr, or about .0067 cm/year), punctuated by episodes of erosion and stability.

Rockshelters

Cova del Salt

Cova del Salt is located about 2 km southwest of the city of Alcoi, in eastern Spain (Figure 1). Both a cave and a Middle Paleolithic archaeological site have formed within a very large rockshelter created by an extinct fall of the Río Barxell, which now flows a short distance to the southwest (Figure 8). Originally, the

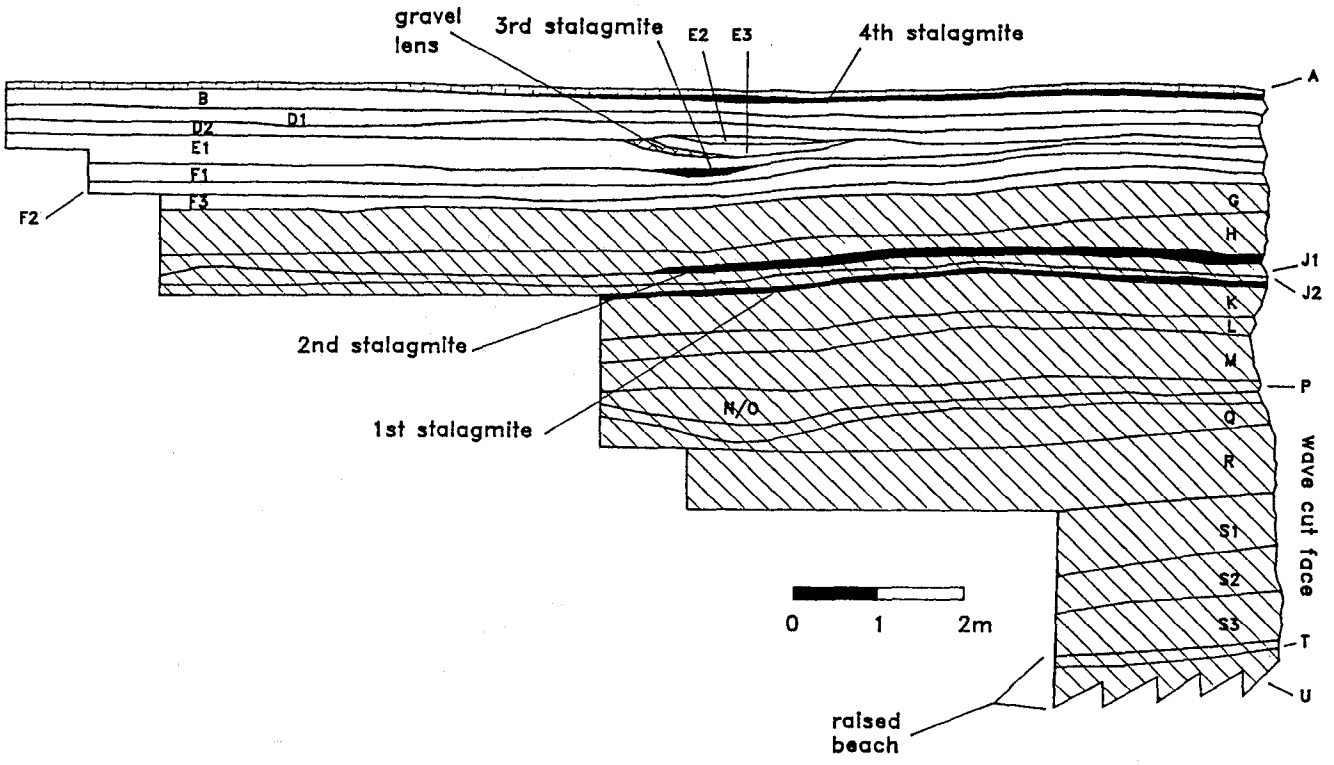

Figure 7. Stratigraphy of Gorham's Cave exposed by Waechter's 1948-1954 excavations (after Waechter 1964). See Barton (1988:21) for descriptions of deposits.

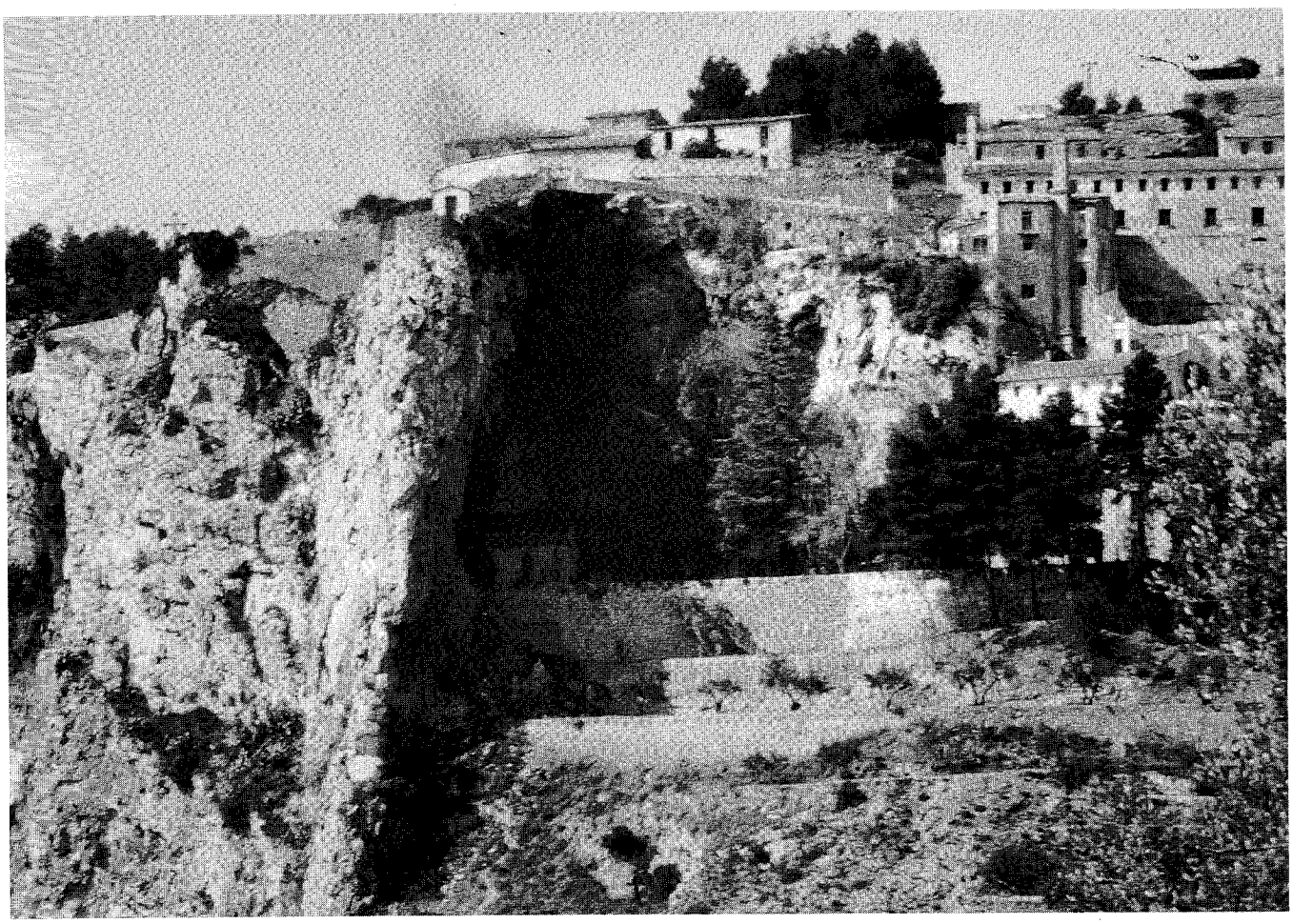

Figure 8. Cova del Salt, Alcoi, Alicante, Spain (looking west).

shelter was filled with a talus cone that reached at least to the elevation of the cave. The upper part of this accumulation was removed in this century to provide *abono* (rich, organic, garden soil) (Barton 1987:68-90, 1988:37-52; Villaverde 1984:280).

Cova del Salt reflects the potential diversity of rockshelter deposits (Figure 9). The angularity of the coarse gravels and blocks in the upper series indicates that they are largely a product of mass wasting (i.e., collapse of the shelter overhang). However, part of these deposits also may have been reworked by slumping and contain clastics that may derive from the Polop/Barxell valley above the shelter. The lower deposits are much finer, well sorted, and laminated, suggesting transport over considerable distance and deposition by water. An intervening bed consists of fine sediments trapped behind a large block and cemented by spring carbonates. It is likely that the site experienced considerable erosion between the deposition of the lower and upper series of sediments.

The lower series of deposits contain Middle Paleolithic artifacts assigned a late Early Glacial-early Pleniglacial age (i.e., oxygen isotope stages 5a-4) on the basis of geomorphic evidence (Barton 1987:80-86, 1988:40-48) and uranium series dating (Bischoff, personal communication, 1992). The upper series was probably deposited during the Pleniglacial. As it is unlikely that coarse gravel would make good *abono*, the uppermost sediments removed during terracing were probably similar in character to those of the lower series. Furthermore, because subrecent ceramics are embedded in the top of the coarse gravels, these lost sediments were probably Holocene in age and reflected present-day conditions of occasional, low-energy flows of water over the extinct falls.

Depositional environments have varied significantly, then, at Cova del Salt over the past 80,000 years. Early in the rockshelter's history, aggradation—possibly relatively slow—seems to have predominated. This was followed by a significant

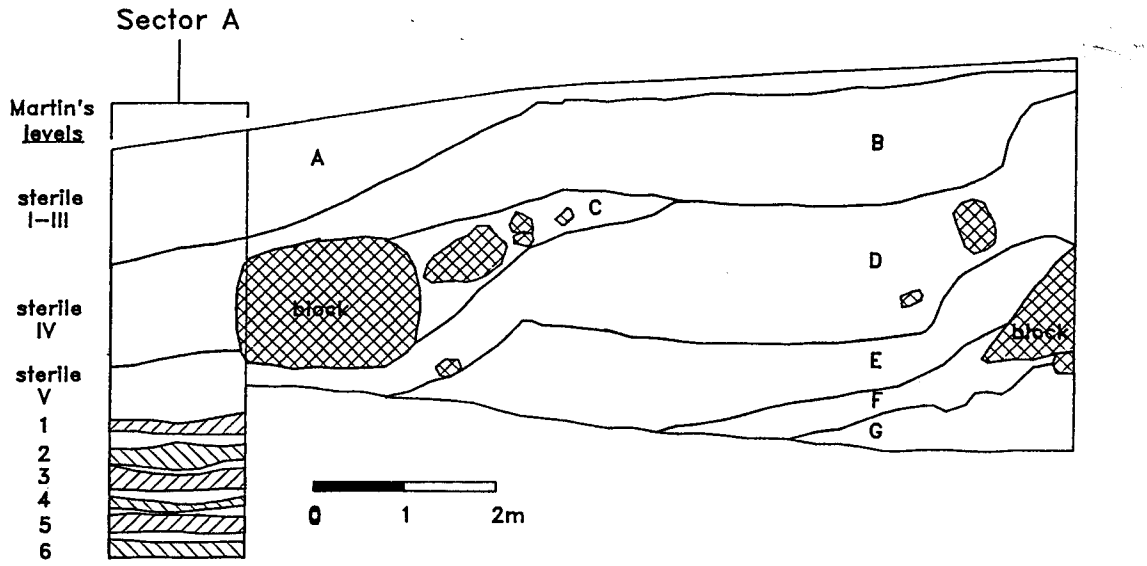

Figure 9. Profile of Cova del Salt deposits exposed by 1961 excavations (after Barton 1988:43). See Barton (1988:41-42) for descriptions of deposits.

erosional episode of unknown duration and extent. While the overall effect of Pleniglacial environments was aggradational in these western Mediterranean caves and shelters, aggradation was almost certainly episodic and interrupted by numerous erosional intervals.

Cova de la Falguera

Cova de la Falguera is located a few kilometers upstream from Salt in a montane *barranco*—the Barranc de Coves—in the Sierra Carrascola (Figure 1). It was formed by lateral stream erosion of the limestone cliffs of the *barranco* wall and is, therefore, a more "typical" rockshelter with respect to its origins (Figures 10, 11). Its 2.5 m stratigraphic section appears to be a mix of roof spall and coarse, subangular fluvial gravels (Barton et al. 1990; Domenech 1991; Rubio Gomís and Barton 1990). The sediments are almost certainly of local provenance as erosion of the upper reaches of the *barranco* is the most likely source for the fluvial gravels. Even the fine sediments were probably derived from further upslope on the Sierra Carrascola, the crestline of which is less than 2 km distant.

Immediately below the shelter, large blocks choke the *barranco*. Below these blocks, the *barranco* is deeply incised; other rockshelters cut into the *barranco* walls have been almost completely emptied of sediments. It is uncertain at present whether the blocks, by damming the *barranco*, caused Falguera (and the nearby shelter of Cova de la Figuera) to fill with sediments, or whether the blocks have simply protected the deposits from erosion. In any case, the fill of Falguera is relatively recent. A radiocarbon determination from near the base of the deposits gave a date of 7,410 ± 70 B.P. (AA2295) and the top of the fill appears to be late Neolithic in age (i.e., ca. 5,500 B.P.) on the basis of ceramic evidence (Barton et al. 1990; Domenech 1991; Rubio Gomís and Barton 1990).

Falguera's deposits, then, appear to result from a brief (i.e., ca. 2 kyr) interval of aggradation in a generally erosional regime in the Barranc de Coves. Deposition greatly slowed or halted altogether following the Neolithic because stream entrenchment had reached the base of the blocks choking the *barranco* at the site, and because the sediments trapped behind the blocks had accumulated to their top. It is unlikely that further deposition will occur under present conditions. In fact, the deposits at Falguera may well be lost to erosion over the course of the next few millennia.

'Ain Difla

'Ain Difla comprises a small pocket of sediment preserved under a rockshelter located at ca. 780 m above sea level in the Wadi Ali, a southern tributary of the Wadi Hasa in west-central Jordan (Figure 1). The site is a remnant of a much larger rockshelter (Figure 12), the contents of which have mostly been removed by fluctuations in the course of the Wadi Ali, now located some 12 m below it. The rockshelter probably formed during the late Middle Pleistocene in a series of interbedded sandstones and limestones of Lower Cretaceous age. Originally (i.e., at some point in the early Upper Pleistocene), the site might have

Figure 10. Cova de la Falguera, Barranc de Coves, Alcoi, Alicante, Spain (looking north).

extended for as much as 150 m to the west of the preserved remnant, since the shelter itself extends at least that far. The site covers about 50 m^2. The talus deposits in front of the rockshelter are steeply sloped (ca. 30-35°). Due to a paucity of vegetation cover, erosional processes continue to act on the remaining sediments.

Excavations were conducted at 'Ain Difla in 1984, 1986 and 1992 (Lindly and Clark 1987; Clark et al. 1988, 1992). Although the natural stratigraphy is not particularly well-defined, 16 depositional units were identified provisionally in Trench A, which was divided into upslope and downslope steps, each 4 x 1 m in extent (Figure 13). Surface sediments in the upslope portion (Lev. 1) are 10-20 cm thick and consist of loose, grey and light brown, powdery fine silts and sandy silts. Lacking sedimentary structure, they have probably suffered postdepositional disturbance due to the activities of burrowing animals and sporadic use of the shelter overhang by shepherds. The block of sediments underlying the surface deposit ranges in thickness from 20 to 60 cm. These sediments are all of colluvial origin and are more consolidated than those of Level 1. They appear to be *in situ*, roughly horizontal lenses (they follow the inclination of the slope), brecciated in places due to percolation and subsequent evaporation of lime-charged water. The brecciated pockets suggest paleoclimatic episodes substantially wetter than the present, since they do not form in the area today.

In the lower, downslope part of the trench, differences other than the degree of consolidation are not so clearly marked. At the base of the test is a clayey silt that is more reddish brown than the overlying sediments. A concentration of large roof-fall blocks about three-quarters of the way downslope probably represents a major collapse of a part of the shelter overhang.

Surficial deposits contained no temporal or cultural diagnostics of periods later than the Middle Paleolithic, thus indicating that the shelter was a concentrated locus of sporadic human activity only during some part of the long Levantine Middle Paleolithic time span (ca. 230-45 kyr B.P., Bar-Yosef et

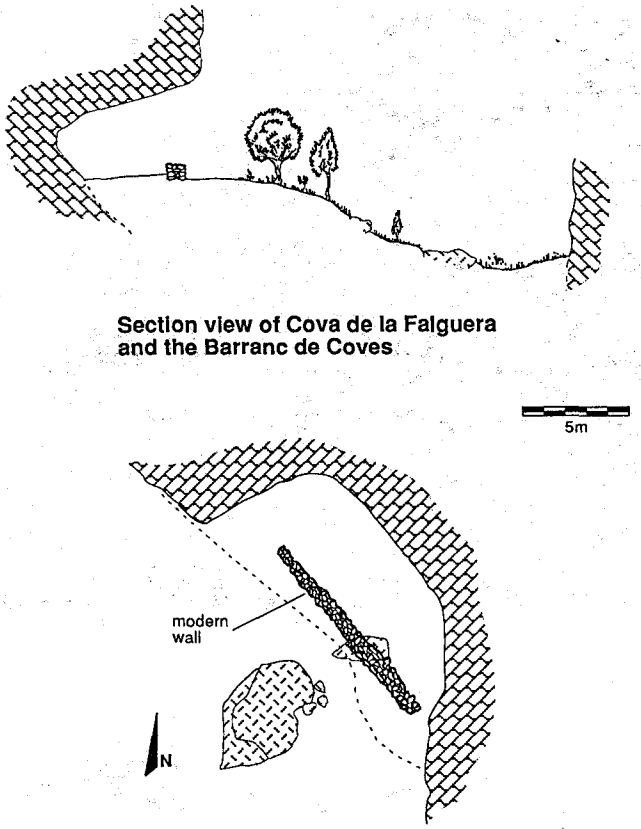

Figure 11. Profile and plan views of Cova de la Falguera.

al. 1992). Since the site is under a cornice at one end of the shelter, it probably became filled with cultural and natural debris during the Middle Paleolithic and could no longer be used as a habitation or campsite during subsequent periods.

There is one TL date for 'Ain Difla — an Oxford determination on burnt flint from Level 5 (105 ± 15 kyr B.P.). However, the date is at variance with the 'Ain Difla pollen data. Although Levantine paleoenvironmental data are extremely "coarse-grained" relative to those of Europe, cool, relatively mesic paleoenvironments are suggested for the 127–90 kyr B.P. interval (Besançon and Sanlaville 1990; Besançon et al. 1990; Horowitz 1979). Pollen evidence from 'Ain Difla indicates that human use/occupation of the site coincided with a cool, *dry* interval, with an absence of trees and a chenopodia/artemesia-dominated NAP fraction that suggests a later date for the site (S. Fish, personal communication, 1989).

Artifact and faunal densities were relatively high throughout the deposits in the upslope exposure in Trench A. The downslope area showed a decrease in artifact densities in the lower levels, indicating either more concentrated human activity upslope, under the (present) overhang, or, perhaps more likely, removal of downslope deposits by continuing lateral erosion of the talus deposits below the shelter by the Wadi Ali, which presently flows almost directly below 'Ain Difla. Bedrock was not exposed in any of the excavations, and it is estimated that 3-4 m of deposits remain intact under the present shelter.

Site contextual integrity is exceptionally high at 'Ain Difla, allowing for the reconstruction of 12 cores—an astonishing number in light of the very limited area tested. This suggests that the excavated deposits at 'Ain Difla represent a restricted period of occupation during the early Pleniglacial, followed by fairly rapid burial of cultural debris and minimal postdepositional disturbance. The infrequency of retouched pieces and the lack of edge damage also attests to a limited span of occupation, and minimal post-occupational surface exposure (Potter 1991). The implied rapidity of sediment accumulation is consistent with the primarily colluvial character of the deposits. On the other hand, the lack of sediments in the remainder of the shelter indicates the predominantly erosional character of the local geomorphological regimen after ca. 100,000 years ago.

Site Formation Processes in Caves and Rockshelters

Natural Site Formation Processes

One of the reasons that cave and rockshelter sites are often grouped together with respect to excavation methods and interpretations is because there is a general preconception that they share a number of characteristics with respect to formation processes. With regard to natural formation processes, these assumed similarities include a consistently aggradational depositional regime, a slow rate of deposition, and the protection of deposits (and their "cultural" contents) from erosion, weathering, or other forms of alteration.

The examples presented, however, indicate the great variety of depositional environments that can occur in these features. While the deep interiors of true (i.e., karstic) caves may be characterized by environments of slow, relatively continuous aggradation, the mouths of caves and rockshelters (i.e., those parts normally used by humans and thus of interest to archaeologists) tend to have much more complex and idiosyncratic depositional histories. As with any other geomorphic setting, rockshelters and inhabitable cave mouths variously experience deposition by wind, water, gravity, and chemical precipitation; alternating

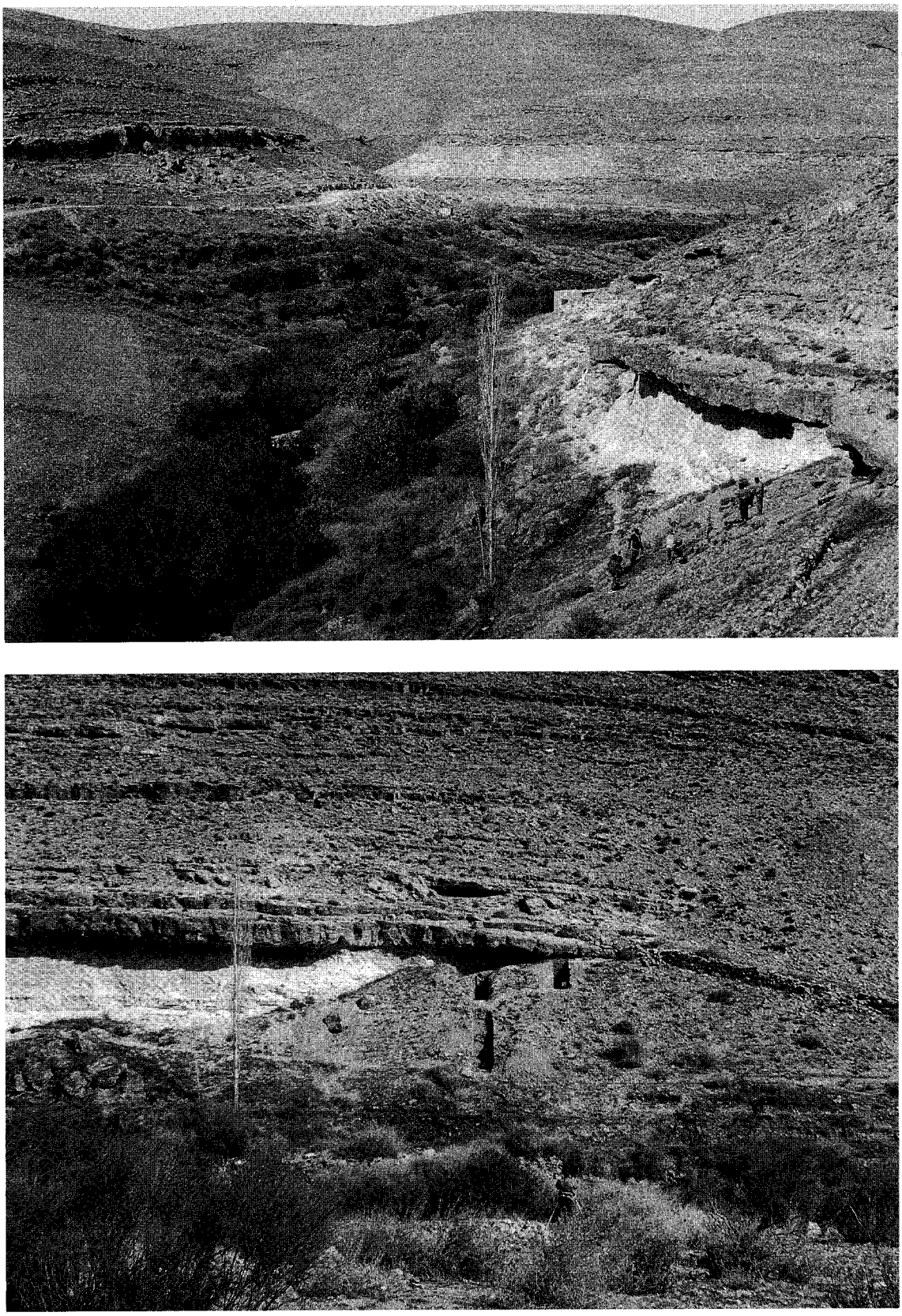

Figure 12. 'Ain Difla (a). View of the rockshelter from a fragment of the 27m terrace preserved on the north wall of the wadi, above the site (looking southwest). (b). 'Ain Difla as seen from the 3 m terrace on the south bank of the wadi (looking north).

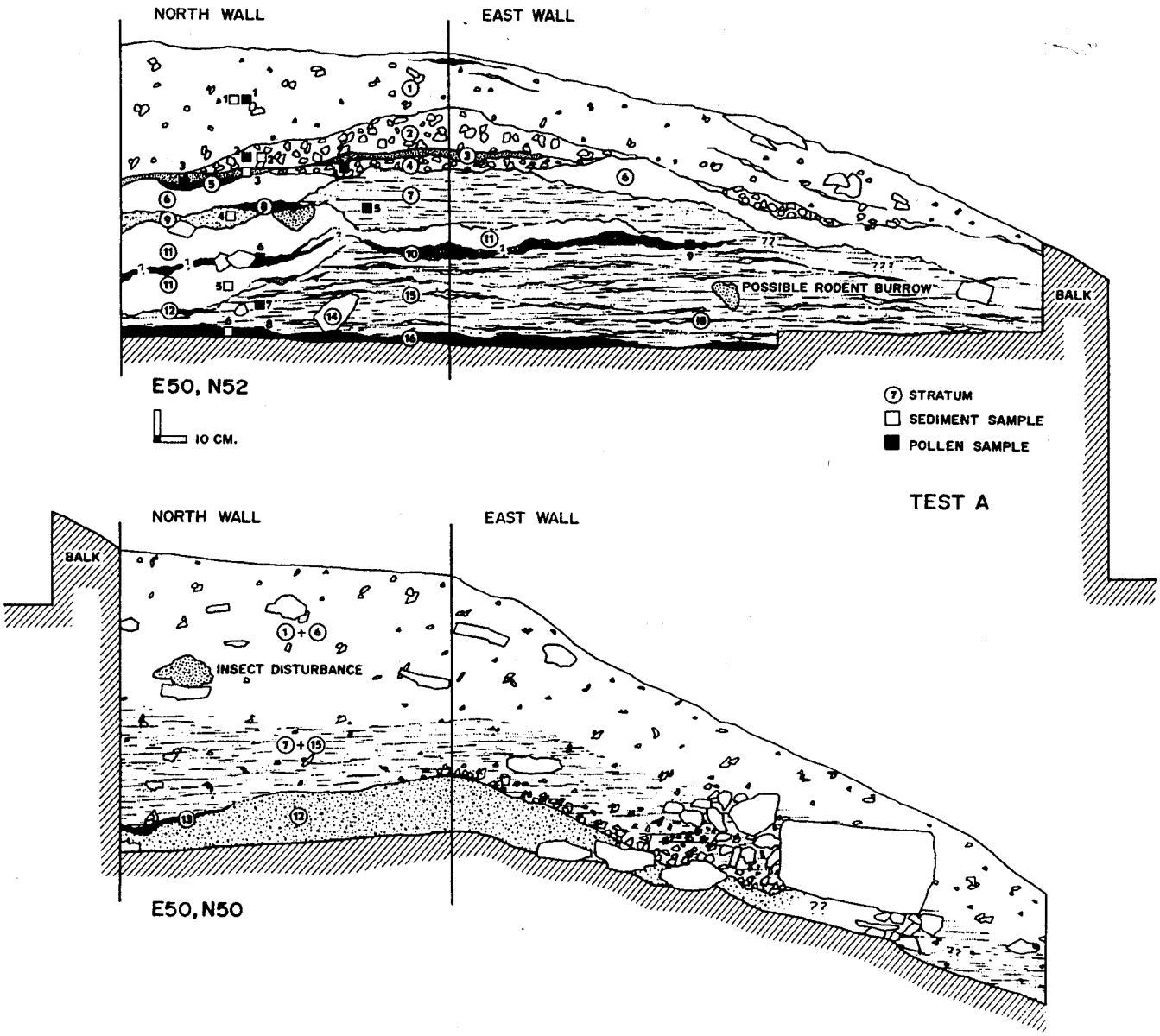

Figure 13. Stratigraphy at 'Ain Difla exposed in the 1984 excavations (after Lindly and Clark 1987:283).

episodes of erosion and deposition; and varying rates of deposition and erosion.

This makes it dangerous to generalize *across regions* about the long-term character of depositional processes in these features. A classic example is the wide-spread application of cryogenic models of clastic accumulation developed in southwestern France (e.g., Laville et al. 1980), but applied to caves and rockshelters in other, and quite different, climatic and geomorphic settings (see Butzer 1964b; Colcutt 1979; Petraglia 1987). The diversity of geomorphic processes affecting caves and rockshelters requires that each site be approached individually, and in much the same way that these processes are (or should be) treated at open sites. This is not to say that there are never depositional similarities among cave and rockshelter sites. Similar deposits result from parallel depositional histories, however, and not simply from the fact that the sites involved are caves or rockshelters.

As with cultural formation processes, discussed below, some biogenic and anthropogenic aspects of cave and rockshelter deposits permit a somewhat greater degree of generalization. For example, these solution cavities were, and continue to be, attractive to non-human animals for many of the same reasons that they have been attractive to humans (i.e., as a ready-made shelters). While not invariably occupied, carnivores especially often use caves and rockshelters

for dens and lairs of various kinds and at various seasons of the year, for caches, and for nests (in the case of raptors, bats). The analysis of the remains of carnivore meals (bones, coprolites, raptor pellets, bat droppings) can lead to a better understanding of the biological component of cave and rockshelter deposits (Binford 1981; Brain 1981). If not distinguished from the remains of human prey, however, these remains can easily distort reconstructions of human subsistence activities (Stiner 1991). For example, the presences of hyena coprolites in Gorham's Cave makes it difficult to assess, in default of a complete reanalysis of the fauna, the extent to which it can be attributed to Middle Paleolithic hunting and/or scavenging, or kills by non-human predators (Goldberg and MacPhail 1991).

Cultural Site Formation Processes

Caves and rockshelters also share a suite of characteristics affecting cultural formation processes that differentiate them from many open sites. Primary among these are the results of spatial constraint of human activities and their residues by the walls of these features. Constraint affects site structure and discard patterns and, in association with variability in aggradation rates, affects artifact morphology (Straus 1979, 1990).

In open sites, the primary locus of human activity practically always shifts over time, even when sites are reoccupied at relatively short intervals. This has several generalizable consequences. One of them is that, the greater the frequency of reoccupation, the greater the horizontal dispersion of the artifact scatters. Another is that patterned residues of different activities, which can sometimes shed light on task organizational structure, tend to be more distinct and easier to associate with individual occupation episodes. This is because spatial patterning is often clearer when features and artifact associations are horizontally distributed in a relatively thin veneer, rather than superimposed, and because, in a spatially unconstrained open site, each subsequent occupation has a reduced probability, *vis à vis* caves, of disturbing evidence from previous occupations.

The situation at many caves and rockshelters is, of course, quite different. Except in very large rockshelters, the walls of these features bound both human activities and their residues (Straus 1990). When inevitable, even minor, shifts in the spatial distribution of activities with each subsequent reoccupation of a site are combined with very slow aggradation rates and the resolution of current archaeological techniques, it may be virtually impossible to recover meaningful information about site structure. In truth, this is often problematic in open sites as well (Binford 1982; Coinman et al. 1989). Compounding this problem is the fact that caves and rockshelters are "long-term" features of the human landscape (albeit not of the geological one) and can serve repeatedly as foci of human settlement. Thus, the direct superpositioning of activities and their residues, and the subsequent perturbation of the latter, are much more likely in the confined spaces of caves and rockshelters than they are at open sites. Assuming correct interpretation of (often complex and convoluted) stratigraphy, this is why caves serve so well for chronology building. However, it also makes isolation of individual occupation episodes difficult to achieve and to interpret in behavioral terms.

Artifact (especially lithic) morphology also can be affected differentially by both natural and cultural formation processes that take place in caves and rockshelters. As discussed above, deposition and erosion rates can vary greatly over the long term in rockshelters and in cave mouths. However, in those situations where sedimentation is relatively slow and accumulation of cultural debris relatively rapid, artifacts can comprise a significant component of these deposits, and can remain exposed for long periods of time. Cultural residues also can be exposed (or be repeatedly re-exposed) over long time periods on stable or deflationary land surfaces, especially in arid environments like those of the desert Southwest or the Middle East, where the surface is armored by a gravel veneer or "desert pavement". The effects of long exposure on site formation are exacerbated, however, in situations where repeated reoccupations of the same locality are more likely. In addition to producing palimpsests of multiple occupations, discussed above, this has several predictable consequences for artifact morphology.

Artifacts may, for example, be altered postdepositionally by trampling or burning. While the potential effects of trampling have long been recognized (Neilsen 1991), potential problems associated with postdepositional burning of lithics and ceramics have only appeared with attempts to evaluate recent advances in analytical techniques, especially dating methods. Measurements of thermoluminescence (TL) and electron spin resonance (ESR) have been used recently to date burned artifacts in a variety of contexts ranging from Middle and Upper Pleistocene hominid localities in Africa and in the Near East to refired potsherds less than 1,000 years old (Aitken 1985, 1989; Dreimanis et al. 1985; Grün and Stringer 1991; Ikeya 1985). If the artifacts have only been burned once, and at a time close to their interval of manufacture and use (e.g., lithic debris burned in a hearth shortly after manufacture, or ceramics when initially fired), these

techniques have the potential to provide useful age estimates for associated human activities (but see Jelinek 1992 for a critique of TL and ESR dating methods in ancient contexts). However, if artifacts remain at or near the surface, they may be reheated by fires of subsequent reoccupations of a site. Because of the greater potential for direct superimposition of activities, this is far more likely to occur in caves and rockshelters than in open sites. Such reheating can release trapped electrons in the artifact, effectively "resetting" the TL and ESR "clocks" (Aitken 1985; Dreimanis et al. 1985). It is important to note that this resetting can be either complete or partial, depending upon the temperature and duration of heating. The overall effect is to produce dates younger than the original manufacture/use date of the artifact. The amount of time lost will depend on the time elapsed between the initial and last firings, and the TL effects of each firing (which are multiple and complex). In the case of repeated cave or rockshelter occupations over long periods of time, TL (or ESR) values recorded from a burned flake or sherd may show little relationship to the time of manufacture and use of the artifact. Dating artifacts recovered from widely spaced sample points within a deposit could help to control for such problems, as could more rigorous adherence to the many constraints of TL and ESR sampling procedures (see Aitken 1985 for a discussion of these). Often, however, neither solution is feasible due to excavations of restricted horizontal extent or to the ever-present limitations of time and funding.

To make matters even more complicated, long-term exposure to sunlight can also decrease the accuracy of TL/ESR determinations (Dreimanis et al. 1985; Yanchou et al. 1988). A worst-case scenario might be artifacts periodically re-exposed by erosion and/or human activity long after manufacture on a stable surface in a south-facing rockshelter or in an open site. These conditions are frequently encountered in the Middle East.

Another consequence of lengthy artifact exposure is that they tend to be reused more by subsequent occupants of a site. Again this is a possibility at any site where the depositional environment leaves cultural residues exposed on the surface but is perhaps more likely in caves and rockshelters where the same locality is a highly visible feature of the landscape and may be repeatedly reoccupied over many millennia. Although, in theory, practically any artifact has the potential for reuse, reuse is probably most likely in the case of lithics due to their ability to be preserved in usable condition over extremely long time periods, and the tendency to discard them prior to exhaustion in many contexts where curation is not a high priority (Barton 1990; Kuhn 1990, 1991). The end result of significant reuse of chipped stone, especially when accompanied by edge rejuvenation, is an increase in the frequency of retouched pieces in assemblages and an increase in the intensity of retouch (Barton 1988, 1990, 1991; Clark 1989; Dibble 1988; Rolland 1981; Rolland and Dibble 1990; Jelinek 1988). Some of these arguments about pattern also apply to ground stone. Increased reuse of ground stone should be signaled by size reduction, increased regularity in form, and possibly increased breakage.

An important implication of greater reuse is that lithic assemblages from cave and rockshelter contexts may differ systematically from those at open sites, even though an identical activity suite may have taken place in both cases (see, e.g., Henry 1989; Coinman 1990; Potter 1991 for Levantine examples). Also, due to the processes just mentioned, the "grain" of cave and rockshelter archaeological assemblages may vary according to the aggradation rate, with the frequency and intensity of retouch inversely related to the rate of deposition (Jelinek 1988). Because the rate of deposition may, in part, be a function of local and regional geomorphic processes affected by climate and vegetation, it may appear that there is a more direct relationship between lithic variability and environmental change (e.g., behavioral adaptation to climatic change) than is actually the case.

In addition to the effects of deposition rates and reoccupation on artifact assemblages, caves and rockshelters might have played consistent roles in regional settlement-subsistence systems over fairly long periods of time (e.g., Bordes [1972] at Combe Grenal; cf. Clark [1989]; Straus and Clark [1986] for changing site function over time at La Riera). If consistency in site function can be demonstrated, however, it probably had more to do with the topographic settings of caves and rockshelters than with the fact that they *are* caves and rockshelters (cf. Binford 1978, 1980). As would be expected, many of these features occur in vertical or near vertical bedrock outcrops, most commonly along upper valley margins (Cova del Salt, 'Ain Difla), in ravines and canyons (Cova de la Falguera), and along or near sea coasts (Gorham's Cave, La Riera).

Discussion and Conclusions

In summary, we have tried to point out some of the salient features of caves and rockshelters as loci for concentrated prehistoric human activities. Although these features share some characteristics, their deposits represent a wider variety of geomorphic processes than is commonly recognized. We have tried to indicate the range of this geomorphological diversity with capsule discussions of natural forma-

tion processes at five cave and rockshelter sites from opposite ends of the Mediterranean.

With respect to cultural formation processes, caves and rockshelters share at least two characteristics that are much less commonly found at open-air sites. The first is that the rock walls of these features constrain the spatial distribution of human activities and their residues to relatively small spaces, and these spaces are often utilized repeatedly, although intermittently, over long time intervals. The second and related characteristic is that, because of physical constraint, cave and rockshelter reoccupations tend to result in direct superimposition and subsequent perturbation of the residues of human activities, thus creating stratigraphies that are typically more complex than those of open sites. Both characteristics have important implications for interpreting spatial patterning, artifact morphology and diversity, and even the results of some dating techniques.

We think it is especially important to try to distinguish between natural and cultural formation processes at cave and rockshelter sites (Schiffer 1987). To fail to do so can easily lead us to confound the effects of these two major kinds of processes. It also appears unwise to try to make broad generalizations about natural formation processes at caves and rockshelters simply because they are located in natural catchments. These features often have complex and diverse depositional histories that must be studied on a case-by-case basis. On the other hand, there are generally recognized geomorphological processes that can affect material culture residues in the same or similar ways. Because caves and rockshelters are relatively easy to locate and often contain deeply stratified residues of human activity accumulated over long time periods, these "paleoanthropological resources", as Straus (1979) called them, will continue to be of considerable importance to prehistoric archaeology in the foreseeable future. Hopefully, archaeologists will maintain a balanced perspective in investigating them, recognizing the limitations as well as the advantages of these site contexts for providing information about the human past.

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