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Pollen taphonomy at Shanidar Cave (Kurdish Iraq): an initial evaluation

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Abstract

Caves provide important locations for the study of ancient human activity and environment. One important strand of this ancient environmental work is palynology, yet the taphonomy of pollen in caves is locally contingent and often complex. Shanidar Cave in Kurdish Iraq was the site of important Neanderthal finds and early palynological research, but pollen taphonomy in the cave has not been previously studied, so it is difficult to judge what these ancient pollen assemblages might represent. In this paper we present pollen from a transect of surface samples within the cave and from comparative surface samples from outside the cave. These show that at present there is a reasonably close correspondence between assemblages accumulating within and in the external environs of the cave, and with the local vegetation. This may suggest that stratigraphic samples may also reflect past local vegetation.

Keywords: Caves; palynology; taphonomy; Shanidar; vegetation; palaeoecology

1. Introduction

Caves are often the only source of palynological data in arid and semi-arid landscapes where conventional sites such as lakes and bogs are not available and thus are important for understanding past climate and vegetation. Caves, however, represent one of most problematic parts of palynology because pollen taphonomy in caves is regarded as locally contingent and complex (Edwards *et al*., 2015). It is becoming evident from studies of pollen transport and accumulation in some caves with large entrances and free air/water passage that they show results broadly similar to those from comparable open-air sites (Coles and Gilbertson, 1994; Hunt and Rushworth, 2005; Edwards *et al*., 2015). In all other caves, pollen transport and deposition mechanisms must be investigated before judgements can be made about the representativeness and reliability of pollen assemblages.

This paper presents a preliminary study undertaken on superficial samples collected at Shanidar cave (Kurdish Iraq), as part of a 5-year programme of landscape surveying and excavation in collaboration with University of Cambridge, Birbeck College London and Queen's University Belfast. Shanidar is a highly important and controversial site, studied in the 1950s and 1960s by some of the most respected archaeologists of the time, but unavailable since for re-evaluation because of political issues. The present research represents an opportunity for experimental work to test the potential and the effectiveness of palynology in the reconstruction of palaeoenvironments and offers possibility to add new and fundamental palynological data to the Near East database for a better understanding of the vegetational and climatic history of that area. It also offers an opportunity to evaluate the highly controversial early work of Arlette Leroi-Gourhan (Solecki and Leroi-Gourhan, 1961; Leroi-Gourhan, 1968; 1975; 1998; 2000) on pollen assemblages from the cave fill.

2. Taphonomy and pollen transport in caves

The mechanisms involved in the transport and accumulations of pollen into caves are the subject of relatively few studies, which tend to show that local contingency is important in pollen taphonomy. Coles *et al.* (1989), working in temperate England, classifies pollen transport as airborne, waterborne and animal and insect-borne, while Lauritzen *et al*. (1990), working in Arctic Norway, summarise routes for pollen in three main categories: transport through the roof with percolating water, by floodwaters that submerge speleothems and in the air.

Key controls of air transport of pollen is the number of cave entrances and the depth that the air flow can reach inside the cave. What emerges from different studies (Coles, 1987; Van Campo and Leroi-Gourhan, 1956; Navarro *et al*., 2000) is a negative correlation between the pollen concentration and the distance from the entrance and the representativeness of pollen spectra obtained from inside the cave for the local vegetation (e.g. Burney and Burney, 1993; Coles and Gilbertson, 1994).

Transport by water can be both in streamways and in percolating water. As a general assumption, Birks and Birks (1980) estimate that the size of the hydrological catchment area is positively correlated to the scale (local or regional) of the pollen spectra. Some percolation waters do not contain pollen, however (Coles and Gilbertson, 1994).

Finally, transport by animals can occur. They may carry pollen on their bodies, within their bodies through gut contents or on bedding or food brought in by animals using the cave as a den (Coles *et al.*, 1989). In this case, contrary to airborne transport, the influence of animals on pollen spectra increases with the distance from the cave entrance, particularly for zoophilous taxa such as the Asteraceae (Navarro *et al.*, 2000). Localised concentrations of zoophilous pollen may reflect bee nesting (Bottema, 1975).

After deposition, several processes affect pollen grains and can cause redeposition and/or destruction of the pollen record. There are four different mechanisms, of wind and/or water, which result in the presence of younger or older pollen in a depositional layer: complete removal and redeposition, partial removal and complete deposition of the removed fraction, complete removal and partial redeposition and partial removal and partial redeposition (Campbell, 1999). This is not just a factor affecting pollen, but all constituents of the cave fill (Hunt *et al*., 2015). Pollen may infiltrate through porous sediments such as breccias and be incorporated in the sediment body by burrowing animals (Hunt and Rushworth, 2005). Grain composition and depositional environment play a key role in the preservation and differential destruction of grains. The amount of sporopollenin in the exine is the first factor that influences the grain resistance to oxidation and microbial attack (McGarry and Caseldine, 2004) but the physical and chemical parameters of the environment where the pollen is preserved are important as well. Havinga (1964) demonstrates that oxidised pollen grains are more easily affected by microbial attack and according to Faegri and Iversen (1975) conditions of high pH do not support pollen preservation. Finally, deterioration can occur *in situ* and in transit: both the collisions between pollen grains and clasts in flowing water and dehydration and rehydration caused by wetting-drying cycles can cause mechanical damage to pollen grains (Campbell and Campbell, 1994).

The difficulty of considering all the taphonomic mechanisms leaves cave palynology as the subject of debates regarding its reliability in the reconstruction of past environments. The main problems include possible discontinuities in the pollen record, the preferential preservation of different kinds of palynomorphs, the ‘over-representation’ of some taxa due to animal transport and the contamination by younger pollen from vertical movement (Carrión *et al.*, 1999). Furthermore, the standard models used to interpret the pollen record from lakes and bogs are inappropriate because caves are characterized by different depositional and taphonomical processes (Carrión *et al.*, 2002).

Despite the problems, taphonomic studies undertaken in the recent past - including Coles *et al.* (1989) and Coles and Gilbertson (1994) in England; Burney and Burney (1993) in USA; Carrión *et al.* (1999a, 2000) and Navarro *et al.* (2000), in Spain; Hunt and Rushworth (2005) in Borneo; Simpson and Hunt (2009) in Libya and Porras *et al.* (2011) in Patagonia - have studied caves of widely different morphology, size and aspect, in very different biogeographic situations, demonstrating the potential of this branch of palynology. All of these studies suggest that airfall pollen in the caves is a reasonably accurate reflection of the pollen rain outside the caves concerned.

3. Shanidar Cave

Shanidar Cave (Figs. 2-3) is one of the most important archaeological sites in Iraq and in the Near East because of the discovery, during the 1950s, of the first Neanderthal skeletons in the region by the American archaeologist Ralph Solecki and his team. The cave is located in the Zagros Mountains of north-eastern Iraq (N36˚ 50', E44˚ 20'), at an elevation of 745 m, about 2.5 km from the Great Zab River. The cave floor is about 1200 m^2, 53 m long and 53 m wide while the mouth measures about 25 m in width and 8 m in height (Solecki, 1963). Morphologically, the cave appears to be a truncated phreatic remnant.

The vegetation in the region (Figs 3-5) consists of a managed mixed montane grassland-woodland characterized by steppe of grassland and herbs with occasional to fairly common trees, which are slashed (pruned) into distinctive shapes near settlements. The tree branches are dried and used as winter fodder. The principal local trees are deciduous oaks and junipers, with maples, walnut, almond and ash at middle elevations and *Pistacia* and *Olea* in drier areas. Diversity of herbs is very high with grasses, wild cereals, *Anemone, Ranunculus, Crepis*-type and Asteraceae especially visually prominent during the April field-season. The climate of the region is characterised by precipitation during the winter and aridity during the summer (Trinkaus, 1983). Until recently, the cave was inhabited, during the winter, by at least 45 Shirwani tribal Kurds with their animals. They built temporary houses and shelters and corrals for cows, horses, donkeys and goats (Solecki, 1979). More recently, the cave has been managed by the local Antiquities Service, and has become extremely popular as a local Kurdish tourist destination.

The site was excavated by Ralph Solecki during four seasons of fieldwork (1951, 1953, 1956-7, 1960). He divided the deposits of the cave, 14 m deep, into four major cultural layers on the basis of both natural stratigraphy and cultural material, and suggested that they were separated from each other by discontinuities. The upper layer, Layer A, goes from modern to Neolithic; Layer B is divided into two sub-layers, Layer B1, the proto-Neolithic –with cultural materials and human burials- and Layer B2, Mesolithic. Layer C, the upper Palaeolithic or Baradostian, contains lithic assemblages and Layer D, the middle-Palaeolithic or Mousterian, has the most famous Shanidar finds including several Neanderthal skeletons (Trinkaus, 1983). At the end of the last seasons, the findings consisted on a total of nine Neanderthal skeletons and a proto-Neolithic cemetery with 26 graves.

Pollen analysis on 23 sediment samples from Shanidar Cave were carried out by the French palynologist Arlette Leroi-Gourhan (Solecki and Leroi-Gourhan, 1961; Leroi-Gourhan, 1968; 1975; 1998; 2000). Her results were interpreted as showing an alternation of wet and dry conditions going from the Mousterian to recent times. She also studied several samples from the sediments around the Neanderthal skeleton Shanidar IV, and found assemblages that she interpreted as of cultural origin.

4. Materials and methods

Surface samples from Shanidar Cave and the surrounding landscape were collected during the first season of fieldwork in April 2014. Samples were collected on transects from the back of the cave to the entrance, from one side to another, along the perimeter and alongside the entrance, together with single samples from particular areas of interest including animal droppings. External surface samples were collected in the mountains around the site along an altitudinal transect to analyse vegetational and palynological change with the altitude. In addition, other samples from stands of different vegetation in the region were collected.

Stratigraphical and surface samples were also taken from other caves, from low-land adjacent to the Greater Zab and at sites at high elevations. Here, we report on samples from a transect from the back to the front of Shanidar Cave (Fig.1). Further analyses will be the subject of future papers.

In order to obtain the maximum concentration and a good preservation of pollen grains, different laboratory methods were tested. Chlorination, acetolysis and density separation were compared to verify abundance and conservation of pollen grains after the processes. The results obtained from the preliminary analysis showed that several methods for sample preparation can work and that a check is necessary after each stage in order to verify the necessity of further treatments. Density separation, however, gave better results in most cases. Potassium hydroxide (KOH) was used to disaggregate the matrix and dissolve humic material and hydrochloric acid (HCl) was used as a preliminary treatment in case of carbonate-rich sediments. A solution of Sodium Polytungstate (SPT) and water with a specific gravity of 1.9 was prepared and added to the samples in order to separate mineral fragments from organic according to their relative density. Samples were stained with aqueous safranin and mounted using an aqueous mounting agent (Microscopy Aquatex). Using an optical microscope (Meiji *MT4000 Series* with magnification of x400 and x1000) pollen grains were identified (with reference to Reille, 1995, Moore *et al.*, 1991 and Faegri and Iversen, 1975) and then counted.

5. Results

A total of 12 surface samples from the front-back transect (CL series), cave mouth transect (SM series) and altitudinal transect (SS series) were analysed to investigate the difference in pollen composition at different distances from the cave entrance and in the environs of the cave. Pollen counts fluctuate between the highest value of 508 (sample C08L) and the lowest of 121 (sample S16M). Pollen percentages were used to produce a pollen diagram. Relative pollen frequencies have been calculated on the basis of a pollen sum including all terrestrial pollen. Two main zones (Internal and External) were defined on the basis of location of samples.

As shown by the pollen diagram (Fig.6), herbs are the more abundant in the record, followed by trees and shrubs. Samples are characterised by a good variety of taxa (more than 50 different taxa have been identified). Most of the taxa, however, appear sporadically or in single samples while only few are present constantly in all the samples. In general, samples from inside the cave show a good concentration and a better preservation than samples collected from the external environment, where grains are highly damaged and with a lower concentration. This is reflected by the number of unidentified grains, higher for the external samples compared with the internal one. The main taxa identified, with regard of abundance, are *Quercus*, Rosaceae, Asteraceae, Poaceae, Lactuceae and Caryophyllaceae. *Quercus* displays an almost constant trend throughout the cave and outside it, with the exception of a lower percentage at the back of the cave. Rosaceae show essentially the same tendency, with lower values at the back of the cave and no significant differences throughout the internal and external transect. The Asteraceae (large type) record is regular throughout the cave transect, except for one single sample characterised by a high percentage; lower values are recorded outside the cave. A different trend is shown, however, by *Bidens* type, with the highest values at the back of the cave and a decrease towards the entrance, to reach the lowest levels in the samples collected from the external transects. Cyperaceae values are characterised by fluctuations both inside and outside the cave without a clear pattern. Poaceae (small type) presents the highest percentages outside the cave; inside, it shows a decreasing trend going from the back to the front and disappears at the end of the internal transect (with the exception of a very small amount close to the cave mouth). Poaceae (cereal type), on the other hand, has higher values inside the cave without any clear pattern. Finally, Lactuceae is characterised by high pollen percentages both inside and outside the cave.

6. Discussion

The surface assemblages at Shanidar Cave suggests that two different pollen transport mechanisms occur at the site. Both wind- and animal-pollinated taxa have been recorded and different distribution patterns can be identified in the pollen diagram.

Air-pollinated taxa, such as *Quercus, Pistacia,* Cyperaceae and Poaceae, show similar percentages both inside and outside the cave. This homogeneity suggests that the percentage of pollen recorded inside the cave can be used to infer the amount outside and, therefore, that samples collected inside are representative of the outside vegetation. This result seems to agree with several studies undertaken in cave environments elsewhere (e.g. Coles and Gilbertson, 1994; Burney and Burney, 1993; Navarro *et al.*, 2002; Porras *et al.*, 2011). Indeed, the cave structure is likely to facilitate a good air circulation because of the presence of a single wide entrance. The role of shape and size of cave entrances in pollen transport and deposition has been previously underlined by numerous studies, such as the ones by Burney and Burney (1993), Coles and Gilbertson (1994) and Navarro *et al.* (2000). Among anemophilous taxa, a large amount of cereal type pollen has been recorded both inside and outside the cave, with higher values inside. Shanidar Cave has always been used by people in the past and it is used even now as winter refuge by Kurdish shepherds and by random visitors who benefit from the cave as destination for excursions; cereal pollen accumulated on the cave floor can therefore be partly related to human activities - storing and/or use. Some of the taxa, such as *Ephedra*, are instead recorded only outside the cave. This could be related to a low grain mobility that prevents pollen reaching the inside of the cave.

Considering the insect-pollinated taxa, such as most of the Asteraceae (*Bidens* type, Lactuceae), Rosaceae, *Scabiosa* and *Vicia*, it is possible to recognise trends comparing the pollen percentages from inside and outside the cave. For most of these taxa, the percentage recorded inside is higher than that outside, suggesting insect transport, likely carried out in particular by bees, as they represent the most important vectors in entomophilous pollination because of their complete dependency upon pollen and nectar for food (Tepedino, 1979). The extremely high amount of Asteraceae pollen recorded in sample C08L could credibly be related to the presence of a former bees' nest, as it has been demonstrate that a large amount of pollen of those species is accumulated by bees in their nests (Bottema, 1975). Some of these taxa are also edible plants (e.g. Lactuceae) and their presence might be related to human activities as well, although this is less likely.

The difference between anemophilous and zoophilous taxa in relation to their position inside the cave has already been suggested by Solecki and Leroi-Gourhan (1961) in their preliminary interpretation of Shanidar Cave pollen. Leroi-Gourhan (1998) analysed a 9.6 m deep section, identifying the alternation of dry and wet phases (suggested by the Lactuceae and Poaceae signals, respectively) going from the Mousterian to recent. Most of the taxa recorded (*Quercus*, *Pistacia*, *Alnus*, *Betula*, *Rhamnus*, Cupressacese, Caryophyllaceae, Chenopodiaceae, *Ephedra*, Dipsacaeae, Liliaceae) are the same as those found in the present study. This seems to suggest an essential stability of vegetation in the region since the middle part of the last glacial period.

Analysis focussed in particular on samples from the soil around Shanidar IV, where a different pollen composition was found. Two of the samples, n. 313 and n.314, were very rich in pollen, with grains assembled in groups and, in some cases, maintaining the shape of the anther of flowers. Moreover, 7 of 28 of the taxa identified in this assemblage were found in clusters, leading them (Solecki and Leroi-Gourhan 1961; Solecki 1963; Leroi-Gourhan 1968, 1975, 1998, 2000) to conclude that complete flowers were introduced intentionally into the cave. To support this conclusion, they pointed out other peculiarities regarding these samples, such as the sediment composition of the samples, the presence of numerous vegetal elements – some of which were carbonized- and the fact that seven of eight of the taxa are known for their herbal and medical properties. If substantiated, this represents the earliest case of flowers associated with a prehistoric burial and it has been interpreted as part of a deliberate ritual, suggesting a re-evaluation of our understanding of Neanderthals. Leroi-Gourhan's work has, however, been considered highly controversial and has been criticised by several authors (Gargett *et al.*, 1989; Sommer, 1999). At present, we can point out that all of the families encountered in the samples from Shanidar IV were found in the surface transect reported here, except the Malvaceae. Much of the Asteraceae pollen found in this study was in groups of 2-5 grains, suggesting that the grouping of grains noted by Leroi-Gourhan (1975) can occur naturally.

7. Conclusions

This work represents a first study of pollen taphonomy at Shanidar Cave. Two different pollen transport mechanisms – wind and animals - act at the site. Air-pollinated taxa seem to have similar percentages both inside and outside the cave suggesting that samples collected inside are representative of the outside vegetation. The cave structure, with a single wide entrance, is likely to facilitate good air circulation bringing anemophilous pollen into the cave. The anthropogenic contribution in the pollen diagram is clear in the large amount of Poaceae grains recorded in the cave: people used Shanidar as refuge during the past and a small community of Kurdish shepherds are currently winter inhabitants, suggesting possible accumulation of pollen due to storage and use of cereals and grasses. On the other hand, entomophilous taxa show different trends inside and outside, with higher values in the interior of the cave, suggesting a strong influence of insect transport, most likely carried out by bees. The pollen diagram also shows a difference between anemophilous and entomophilous taxa in relation to their position compared to the cave entrance, and in particular a predominance of the wind-dispersed taxa near the entrance and of the insect-dispersed near the rear of the cave. Further studies on surface samples will in due course clarify the mechanisms of pollen transport and accumulation in the caves of the region and will offer the opportunity to test the effectiveness of this science in the reconstruction of palaeoenvironments.

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Fig. 1. Plan showing the location of the surface samples used in this study from within and immediately adjacent to Shanidar Cave. Inset: map showing the location of Shanidar Cave in the Middle East.

Fig. 2. Photograph showing Shanidar Cave and its immediate environs, with herb rich grassland with wild cereals managed by grazing immediately adjacent to the cave and mixed stands of oaks, walnuts and other trees to the left. Most oaks show a single-trunk form characteristic of slashing.

Fig. 3. Shanidar Cave, taken from the valley of the Greater Zab. In the foreground is herb-rich grassland with occasional trees. A light cover of trees is evident on the slopes above and below Shanidar Cave, with denser vegetation on marly bedrocks on a 'shelf' above the cave.

Fig. 4. View from Shanidar Cave showing herb-rich grassland with abundant wild cereals and sparse trees.

Fig. 5. Herb community on rock outcrop adjacent to Shanidar Cave, with prominent *Anemone* and Asteraceae.

Fig. 6. Pollen diagram for the surface transect at Shanidar Cave, and samples from adjacent localities.

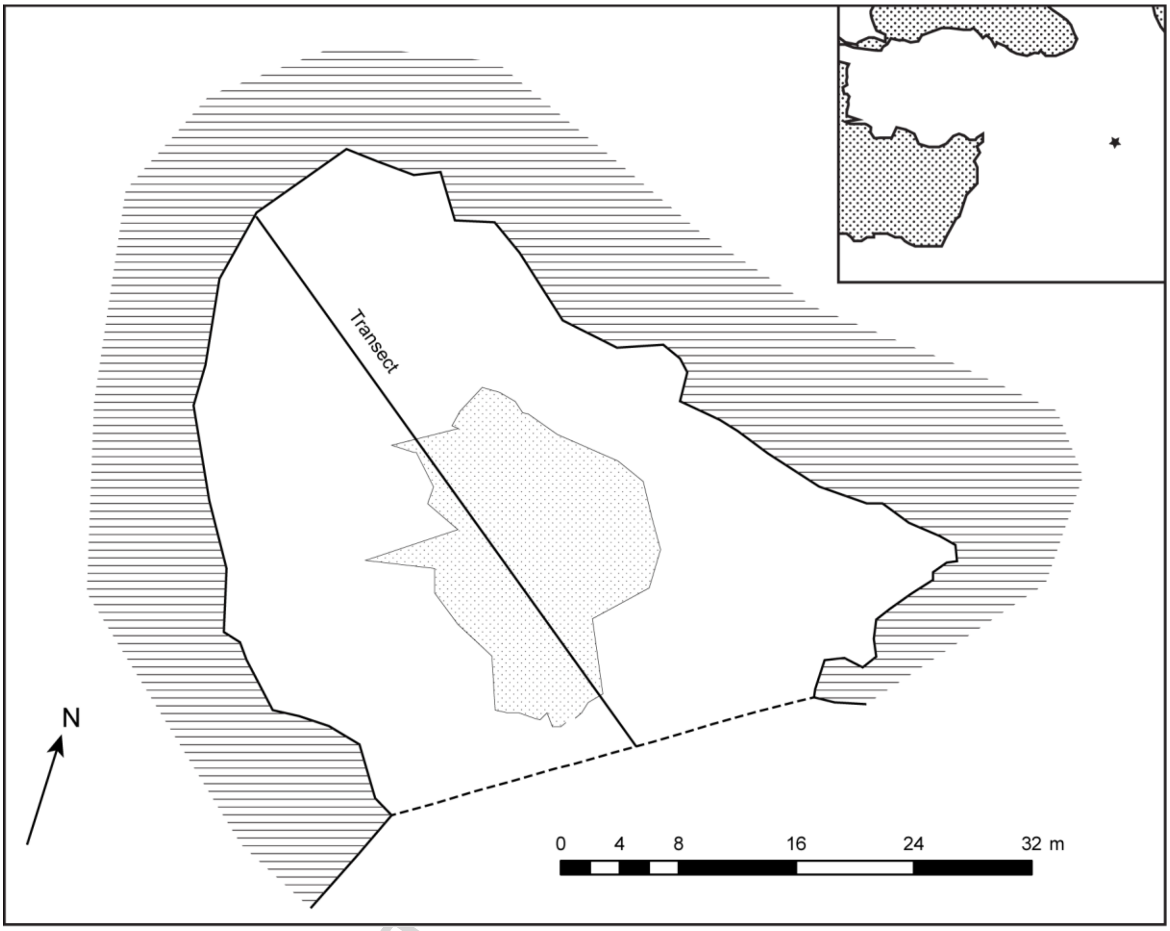

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

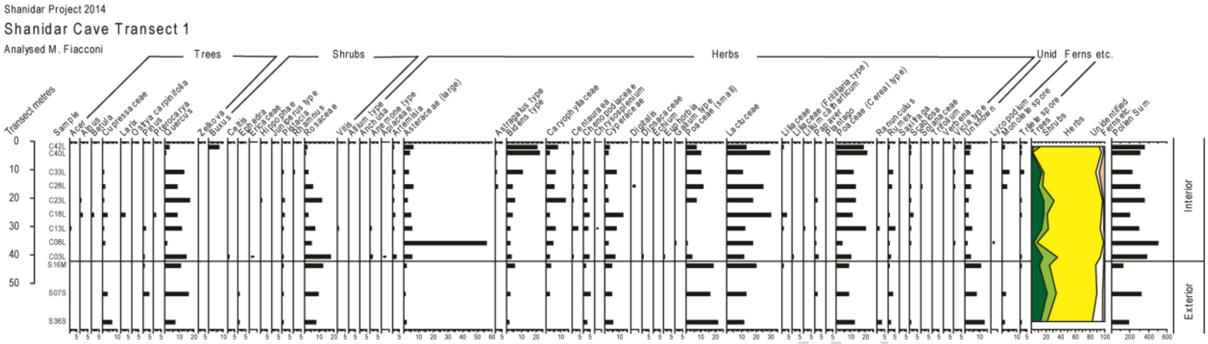
Shanidar Project 2014
Shanidar Cave Transect 1
Analysed M. Fiacconi
Trees
Shrubs
Herbs
Unid
Ferns etc.
Interior
Exterior

Figure 6

Highlights

- Surface pollen study in Shanidar Cave (Iraq)
- Anemophilous pollen % similar inside and outside the cave
- Entomophilous pollen % rises to rear of cave
- Assemblages similar to those associated with Shanidar Neanderthals