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Palynology of surface sediments from caves in the Zagros Mountains (Kurdish Iraq): Patterns and processes

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ABSTRACT

Cave palynology has been widely used to reconstruct past vegetation in areas where other conventional sources of pollen are scarce. However, the mechanisms involved in pollen transport, deposition and accumulation in caves are still poorly understood, mostly because of the number of interplaying factors that affect these processes. In this paper we explore some of these factors further by assessing differences in pollen assemblages in transects of surface samples from six caves in the Zagros Mountains of Kurdish Iraq. Simple sac-like caves show a clear pattern in pollen distribution with anemophilous taxa declining from the highest percentages near the front of the cave to lower percentages at the rear of the cave and entomophilous taxa showing the opposite trend. There is a tendency for this pattern to be most marked in caves which are narrow in relation to their length. It is less clear at Shanidar Cave, most probably because of the geometry of the cave but also because of the disturbance and mixing of the superficial sediments caused by the large numbers of people visiting the cave. Only one of the sampled caves shows a different pattern, which is likely to reflect its geomorphological complexity and, consequently, its air circulation. Other factors, such as the presence of a cave entrance flora, are considered but here they seem to have little influence on the pollen assemblages, contrary to that found in temperate-zone caves.

1. Introduction

The central Near East has always been an area of particular interest for archaeology and prehistory because it is a location through which European, Asian and African populations interchanged. It is also a hearth of early domestication of plants and animals (Solecki, 1963). In comparison with Europe, however, the history of vegetation and climate change in this critical region has been the object of relatively few studies with most of them undertaken in Turkey, Iran and Syria (e.g. Van Zeist and Bottema, 1977, 1991; Van Zeist and Woldring, 1978; Bottema and Woldring, 1984; Bottema, 1975, 1995; Litt et al., 2009, 2011, 2012, 2014; Kaplan, 2013; Pickarski et al., 2015; Beug and Bottema, 2015; Van Zeist and Bottema, 1977; Djamali et al., 2008, 2009, 2011; Niklewski and Van Zeist, 1970; Deckers et al., 2009). For many years, the only pollen-based palaeoenvironmental work in Iraq was by Arlette Leroi-Gourhan on the Shanidar Cave deposits (Solecki and Leroi-Gourhan, 1961; Leroi-Gourhan, 1968, 1975, 1998, 2000). Shanidar Cave is an important Mousterian site located in the Zagros Mountains in the northeast of the country. This site is particularly important because a substantial number of Neanderthal skeletons were recovered in the 1950s and 1960s (Solecki, 1963). The context of one of these skeletons, Shanidar IV, was studied palynologically by Leroi-Gourhan (1975). The area around the skeleton contained clumps of pollen of spring flowers, which led Leroi-Gourhan (1975) and Solecki (1975, 1977) to the conclusion that complete flowers were deposited with the body as part of a funerary ritual. This interpretation caused considerable controversy (e.g. Sommer, 1999) but the political situation in Iraq prevented reassessment of the cave deposits at Shanidar for many years.

As part of the re-excavation and reassessment of the archaeology of Shanidar Cave (Reynolds et al., 2016) we have conducted pollen taphonomic work at Shanidar and other caves in the High Zagros with the aim of reaching an understanding of the processes leading to the pollen assemblages reported by Leroi-Gourhan (1975) and of the palynological sequence in the cave (Leroi-Gourhan, 1968, 1975, 1998, 2000). Our preliminary reassessment of this remarkable find suggests that other processes than those suggested by Leroi-Gourhan (1975) may have been implicated in forming the clumps of pollen that she linked with complete flowers (Fiacconi and Hunt, 2015). Shanidar Cave is, however, a major tourist destination, visited by hundreds of people a day during the spring and early summer, and the superficial deposits in the cave have been much disturbed by visitor footfall. It is therefore necessary to examine the taphonomic signature of other similar caves which are not affected by visitor presence, but are close to Shanidar Cave, in

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order to better evaluate the hypotheses of Leroi-Gourhan (1975) and Solecki (1975, 1977).

2. Pollen taphonomy in cave environments

In the last few decades, cave palynology has been widely used to reconstruct the past vegetation at local and regional scales, especially in arid and semi-arid areas where other depositional environments suitable for preserving pollen are scarce (e.g. Gale et al., 1993; Carrión et al., 1999; Hunt et al., 2011; de Porras et al., 2011; Edwards et al., 2015). However, the mechanisms involved in pollen transport, deposition and accumulation inside caves are still under investigation because of the number of interconnected factors that can affect them. These include

- environmental setting of the cave, including issues such as aspect and exposure to prevailing winds (e.g. Weinstein, 1983) and properties of vegetation outside the cave (e.g. Coles and Gilbertson, 1994; de Porras et al., 2011);
- geomorphology of the cave, including number and size of entrances, complexity of the cave network and air-circulation patterns (e.g. van Campo and Leroi-Gourhan, 1956; Coles et al., 1989; Coles and Gilbertson, 1994; Simpson and Hunt, 2009);
- inputs of pollen via drip waters and fluvial processes (e.g. Peterson, 1976; Coles et al., 1989; Genty et al., 2001);
- presence of cave entrance-flora (e.g. Hunt and Gale, 1986; Coles et al., 1989; Coles and Gilbertson, 1994)
- activities of animal and human vectors (e.g. van Campo and Leroi-Gourhan, 1956; Bottema, 1975; Bright and Davis, 1982; Davis and Anderson, 1987; Coles et al., 1989; Hunt and Rushworth, 2005; Fiacconi and Hunt, 2015).

Experimental studies undertaken during the last fifty years in caves in different areas of the world, and especially in Spain, have shown the presence of some general patterns in pollen distribution in this kind of environments even if the local characteristics can have a strong influence in the final pollen assemblages. In general, those studies (van Campo and Leroi-Gourhan, 1956; Burney and Burney, 1993; Coles and Gilbertson, 1994; Prieto and Carrión, 1999; Camacho et al., 2000; Navarro et al., 2001; Navarro et al., 2002; Hunt and Rushworth, 2005; de Porras et al., 2011) identified:

- the importance of the cave morphology, with small cave mouths and narrow shapes related to lower pollen concentration
- a decline of anemophilous/airfall pollen with distance from the cave mouth contrasting with greater importance of animal-transported pollen near the back of the cave;
- higher pollen concentrations in caves with high human and animal presence;
- good agreement between cave assemblages and those on open-air sites nearby;
- generally good representation of the vegetation at a local scale but often an under-representation of arboreal pollen and over-representation of fern spores;
- the positive impact of dryness in pollen preservation;
- the relevance of post-depositional processes such as differential preservation.

Clearly, the influence of these factors is quite variable. In this paper we explore some of them further by assessing differences in pollen assemblages in transects of surface samples from six caves in the Zagros Mountains of Kurdish Iraq. Most of the caves studied are simple phreatic remnants in morphology, none have streamways, all have little or no entrance flora and all have comparatively low levels of ingress of dripwater. They are therefore relatively simple systems in which to explore factors such as aspect and the influence of animal vectors relative to deposition of windblown pollen. The present study aims to understand the mechanisms involved in pollen transport and deposition in this kind of environment and the influence of the factors mentioned above on the composition of the related pollen assemblages.

3. Environmental setting

The study area is located in the northern part of Iraq within the Irano-Anatolian phytogeographic region (Guest and Al-Rawi, 1966). This region is species-rich, with altitudinal and topographic influence on the composition of the vegetation, which is characterised by zones of forest, steppe, halophytic and psammophytic vegetation (Fig. 1a). The caves studied in this paper are located within the mountain-forest zone, situated in the western slopes of the Zagros Mountains. The zone lies altitudinally between 500 and 1750–1800 m (Fig. 1b).

The main arboreal element of the forest is *Quercus* (*Quercetum aegilopidis*, *Quercetum aegilopidis-infectoriae* and *Quercetum infectoriae-libani*), while in some small areas near Mosul *Pinus halepensis* var. *brutia* is predominant. In undisturbed areas the tree cover is high, resulting in a closed forest that becomes an open forest in more densely populated places, since near villages, trees are slashed (their side branches are removed) to provide winter fodder for goats. Steppe vegetation can completely replace forest in those areas were the trees have been over-exploited and in dry places (Guest and Al-Rawi, 1966). In the study area, close to Shanidar Village, oak forests are rather open and quite heavily grazed, with grass-rich swards between the trees, characterised by abundant wild cereals and a rich herb flora (Fiacconi and Hunt, 2015).

The studied caves differ in morphology, aspect, location and human and animal presence (Table 1).

4. Material and methods

Caves were located by ground survey and through conversations with local informants. The caves were selected on the basis of their morphological characteristics and human and animal presence in order to understand the influence of those factors on the pollen composition and in particular: single vs double entrances, narrow vs wide shapes and human and/or animal presence or absence. Their locations were noted using handheld GPS units and on a Google Earth image. These GPS locations proved to be unreliable in the narrow, precipitously-sided valleys in the survey area. Locations obtained using GPS, when compared with the Google Earth locations, showed considerable discrepancies.

Surface samples were collected in each cave along a linear transect going from the back to the front of the caves in order to study the influence of sample location in the pollen composition and, in particular, the distribution of anemophilous and entomophilous taxa at different distances from the cave entrance (Fig. 2). At least one sample was collected outside each cave entrance to analyse the different pollen transport and deposition inside and outside the caves and to provide a 'baseline' of the local pollen rain close to the cave. A total of 48 surface samples were analysed (12 from Shanidar Cave, 9 from SLS203, 7 from SLS207, 7 from SLS210, 6 from SLS215 and 7 from SLS218). Additionally, six moss samples from polsters growing on seeps in the east wall of SLS203 were analysed. SLS203 was the only cave where moss polsters were present and they offered an opportunity to compare polster material with the pollen recorded in the surface soil samples, considering the inconsistencies usually noticed between these sampling methods (Cundill, 1991). Finally, four samples of bird droppings, two of droppings of sheep/goats, eight drip water samples and two pollen trap samples from the period March–August 2016 from Shanidar Cave were analysed for comparative purposes.

Samples were prepared by boiling in potassium hydroxide (KOH) solution to disaggregate the matrix and dissolve the humic material. Carbonate-rich sediments were treated with dilute hydrochloric acid (HCl). Boiling in sodium pyrophosphate ($Na_4O_7P_2$) solution was used