EQA – Environmental quality / Qualité de l'Environnement / Qualità ambientale, **25 (2017) 39-47**

THE PALYNOLOGY CONTRIBUTION IN PALAEOENVIRONMENTAL INVESTIGATIONS. A CASE-STUDY OF A LATEGLACIAL-HOLOCENE SEDIMENTARY SEQUENCE NEAR BOLOGNA (NORTHERN ITALY)

Marco Marchesini [(1)(2)]*, Silvia Marvelli [(2)] , Antonella Lobietti [(1)]

[(1)] Dipartimento di Studi Umanistici, Università di Ferrara, Ferrara, Italy
[(2)] Laboratorio di Palinologia e Archeobotanica,
C.A.A. Giorgio Nicoli Srl,, San Giovanni in Persiceto, Italy

* Corresponding author Email: mmarchesini@caa.it**;**

Abstract

The palynological studies are extremely relevant in the investigation of the evolution of palaeoenvironments. A case of pedopalynological studies was applied to the Lateglacial to Holocene sedimentary sequence derived from a small site located in San Lazzaro di Savena in the surroundings of Bologna, (Emilia Romagna, Northern Italy). Several disciplinary and analytical approaches, including pedostratigraphy, geochemistry, radiocarbon dating, archaeobotanical investigation and δ13C stable isotopes analyses, were taken into account for the complete characterization of the pedosequence.

Keywords: *pedosequence, geomorphology, pollen analysis, landscape, human impact.*

Introduction

In the purpose of highlighting the study of pollen grains in soils, Turner (1985) suggested the term "pedopalynology" to define and distinguish it from other palynological studies, also from those that concern wetland environments, for its different taphonomy of pollen assemblage.

Pedopalynological research differs from traditional practices of palynology (concerning sediments laid down in wetland environments) examining some important aspects, such as the taphonomy of pollen assemblages, the preservation of pollen exines, the vertical distribution of pollen concentration and the palaeoenvironments which are being studied. Consequently, the framework of the interpretation is quite different and more complex.

Nevertheless, it is recognised that pedopalynology gives valuable insight into past vegetational and climatic conditions and the study of soil pollen becomes fundamental in shedding light on palaeoenvironments.

Interdisciplinary working groups in geological, biological and archaeological fields are extremely relevant for the analysis of stratigraphic soil sequences.

The aim of this case-study is to survey the various factors governing the occurrence and the significance of pollen and spore assemblages in soils and their

DOI: 10.6092/issn.2281-4485/7633

pedopalynological value for palaeolandscape reconstruction and vegetational dynamics of Lateglacial to Holocene sedimentary sequence derived from a small site located in San Lazzaro di Savena, in the surroundings of the city of Bologna (Emilia Romagna, Northern Italy).

Soil pollen content and dynamic transformations

Preservation of pollen and spores depends on the soil organic content and pH, whereas the conditions of soil texture or temperature appear to be irrelevant.
Acidic soils (pH below 5.5) may contain a great deal of pollen, and the floristic composition of their pollen may vary greatly in samples from successively greater depths. The pollen grain dynamic migration in soil is based on two fundamental processes: the first one is referred to the migration of pollen grains, firstly collected in humic clusters and then spread in the whole soil. The second is based on the mixture of humic clusters as the main dynamic factor, followed by migration as a consequential process (Accorsi, 1986).
The result of pollen soil analysis is assembled with a simultaneous combination of many factors modifying the variation of pollen concentration: the level and type of soil corrosion, the pedological characteristics of the stratigraphy (and the specific events connected to various kinds of pollen grains), the pollen migration along roots paths, the movement of pollen clusters mixture caused by soil animals and the movements of secondary pollen grains for anthropic manipulation of the layers of soil. An environmental reconstruction to clarify fluctuations of environmental conditions, including climatic changes and past anthropogenic impacts on the natural landscape, would benefit from the integration of all available data on the biocenosis of the context under study, as well as data on any other aspect of its abiotic environmental factors.
For example, the integrated analysis between the study of the pollen grains and the malacological remains is of extreme interest when both types of finds are preserved. This is because, while a study of pollens can provide environmental data on the medium and large scale, archaeomalacology can provide extremely precise small-scale palaeoenvironmental information when applied to a single site (although it can be less effective in a more comprehensive analysis) (Vittori Antisari et al., 2015). Likewise, significant palaeoenvironmental studies could be produced based on the totality of archeozoological and/or archaeobotanical data available.

Materials and methods

The site

The case-study is focussed on a carefully cleaned section in the Municipality of San Lazzaro di Savena, 5 km eastward of Bologna (44°28’17” N, 11°24’34” E) at an elevation of 62 m above sea level. It is located at the foothill Apennine hills and is crossed by the Via Emilia which is an important route since the Roman age. The investigation started in connection to a building excavation that reached the depth of ca 5.5 m.

Field observation and soil sampling

The field observation led to the distinction of stratigraphic units and buried soil horizons that have then been preliminarily characterized for layer contact morphology, thickness, particle size distribution, colour and other texture characteristics. The soil thickness correspond to 325 cm (from the deepest level of 325 cm to the present soil surface of 0 cm). From the pedological point of view, the buried soils were described according to Schoeneberger et al. (2012) and a sequence of 16 horizons was recognized.

Palynological sampling

The sampling area in a stratigraphic sequence is defined by previous geological and pedological analysis. The procedures for pollen and spore studies begin with the collection of soil samples directly on the stratigraphic sequence with the use of one syringe for each sample, every 5 cm, in the vertical stratigraphic sequence (Fig. 1).
Sometimes it could be required to tear off the entire surface of the stratigraphic section (fig. 2) before using the syringes.

Figure 1. *Vertical stratigraphic sequence for extraction of soil samples for pollen analysis.*

Figure 2. *Soil sampling: methodological extraction for pollen analysis.*

Before taking a soil sample, it is necessary to remove the tip end of the syringe, thus using it as an empty cylinder, and pushing it into the soil (fig. 3) so that the sample is stored inside (fig. 4). It is necessary to keep each sample in a dedicated

DOI: 10.6092/issn.2281-4485/7633

plastic bag, protecting it from contamination. 12 samples were collected in the field, from 385 to 50 cm depth, at intervals of 3 to 12 cm. Samples were dried at room temperature and protected from contamination.

Laboratory treatment

The chemical treatment (Lowe *et al*., 1996) begins with the removal of 10 gr of soil from each sample, then treated in 1% Na-pyrophosphate to deflocculate the sediment matrix.

Figure 3. *Methods to "rip-off" the entire surface of geological stratigraphic section.*

Figure 4. *Soil samples for pollen analysis.*

A *Lycopodium* spore tablet is added to calculate pollen concentration (expressed as pollen grains per gram p/g). The sediment is then washed through 7μ sieves and treated with 10% HCl to remove calcareous material. The residues are subjected to Erdtman acetolysis for 10 minutes (fig. 5) and a heavy liquid separation method. Following this procedure, the retained fractions are treated with 40% Hydrofluoric acid for 24 hours, washed in ethanol and finally prepared and preserved in glycerol. One drop of the final residues of each sample are mounted on slides in glycerol jelly and the coverslips are sealed with paraffin.

Microscopic analysis

The microscopic analysis (fig. 6) consists in the screening of the sample slides with optic microscope magnification from 400 to 1000 (ocular 10X and objective 40X to ocular 10X and objective 100X).

The identification of pollen grains is based on the "palinoteca" of our laboratory, atlases and a vast amount of specific morpho-palynological bibliography.

The pollen terminology is based on Berlung and Ralska-Jasewiczowa (1986), Faegri and Iversen (1989), Moore *et al.* (1991); the botanical terminology is based on APG III classification (2009) with slight modifications that tend to simplify the nomenclature of plants.

The APG III system of flowering plant classification is the third version of a modern, mostly molecular-based system of plant taxonomy being developed by the Angiosperm Phylogeny Group (APG).

The term "taxa" is used in a broad sense to indicate both the systematic categories and the pollen morphological types (Beug, 2004). The identified pollen groups have been expressed as percentages of the total (usually between 300 and 400 grains).

Figure 5. *Chemical treatments (acetolysys) of the soil samples.*

Figure 6. *Microscopic analysis.*

Results

Pollen analysis

Pollen grains were found in all samples in a good state of preservation, allowing their identification of most of the cases. Overall, 3.850 pollen grains were counted from 12 sample depths. Pollen concentrations were variable, depending on the richness of organic matter and the preservation conditions. The pollen flora was consisted of 92 types (31 trees, shrubs, lianes and 61 herbs). Although pollen can be transported and remobilized, in our view the small size of the site implies a local (likely in-situ) origin of the grains, and the palynological results were corresponding to the pedological data.

Palaeoenvironmental evolution and human impact

This multidisciplinary approach (Vittori Antisari et al. 2015) allowed us to identify the main factors that affected the ancient environment over a prolonged time

DOI: 10.6092/issn.2281-4485/7633

interval (~12 ky). The soil can be divided in six different horizons; each horizon (Fig. 7) describes a particular landescape as shown below:

Steppe conditions. The sample S16, corresponding to the deepest one, was characterized by high presence of Cichorioideae and Asteroideae (81.2%), followed by Poaceae spontaneous group (6.7%) with only low percentages of Pinaceae (1.8%). *Dryas octopetala* pollen grains were also detected (1.2%). These pollen grains indicate a landscape developed on steppe conditions (dry and cold), typical of late glacial period.

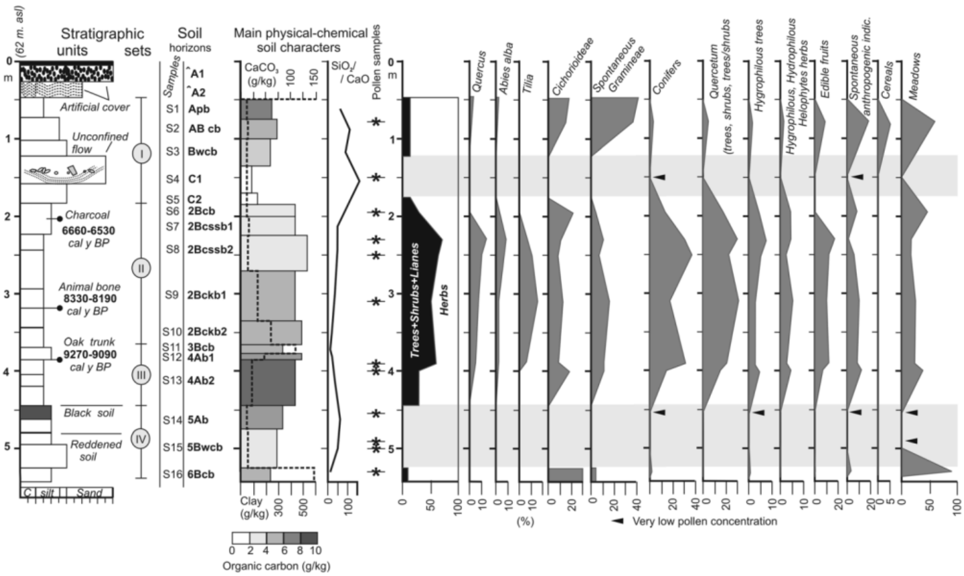

Figure 7. *On the left: soil sequence coupled with selected parameters of the studied PFS site. In the left, distinct horizons have been grouped in four sets with precise indication of the sampling depths which have been constrained by radiocarbon datings. The central part of the figure reports description of the soil horizons in terms of clay, organic carbon and carbonate content and SiO_2/CaO ratio. On the right, vegetation contents obtained by palynological investigations (from Vittori Antisari et al. 2015)*

Transition from steppe to Preboreal conditions. The samples S15 and S14 revealed a high percentage of *Pinus*, followed by Cichorioideae and Poaceae spontaneous group which indicates a transition between the steppe condition (delineated above) and a landscape dominated by conifers, which possibly occurred in the Preboreal period.

Preboreal conditions. The sample S13 (the lowest horizon of the third stratigraphic set), containing more pollen grains (and more pollen species), showed a drastic decrease of Cichorioideae, a more diversified association of *Pinus* species coupled with the appearance of *Quercus* deciduous (especially *Quercus* cf. *robur*), *Ostrya carpinifolia, Fraxinus excelsior, Tilia, Ulmus* and *Corylus*. This rich biodiversity suggests an important climatic change with the establishment of more temperate conditions. It's noteworthy that this horizon corresponds to the surface, where the burnt oak trees were rooted, and it can be assigned to the Preboreal period.

Atlantic period. The samples S12, S9 and S8 were characterized by a further increase of coniferous pollen; in particular, S12 corresponded to the part of the sequence where the burned wooden logs (9270–9090 y BP) were found. These horizons were characterized by the significant presence of Lime tree (*Tilia*) and Silver fir (*Abies alba*), which plausibly ascribe them to the Atlantic period (Accorsi et al. 1999; 2004).

Anthrosol. In the sample S9 and S8, the decrease of Pinaceae was connected with an increase of *Corylus*, *Ulmus* and *Tilia*, which could suggest the beginning of an opening in the vegetation cover. This process was accompanied by the presence or expansion of taxa indicative of human impact (e.g. Cerealia types).

Additional anthropogenic influence. In the sample S6, an increase of Cichorioideae and Asteroideae (45.8%) together with Plantaginaceae, Ranunculaceae, Sparganiaceae/Typhaceae and also Poaceae spontaneous group and Fabaceae (about 4.2% for each species) has been observed. The vegetation suffered a further sharp change in correspondence of the first, more superficial stratigraphic set (e.g. sample S2), where an additional anthropogenic influence, demonstrated by the diffusion of high Cerealia types with the presence of pollen grains of both *Hordeum* and *Avena- Triticum* groups, together with pollen grains ascribed to *Triticum* cf. *spelta* and *Secale* cereal, can be observed. Further proxies of human activities were represented by Amaranthaceae and *Plantago*, *Rumex*, *Urtica dioica* species (Cremonini et al., 2012).

Conclusions

The attention in palynology of soil/paleosols has been increasing in recent years, in view of the great interest in pollen analysis for geobotanical, pedological, and geomorphological purposes. This study resumes the palynological methods applied in soil sampling, the chemical treatments and the final microscopic determination of pollen grains in order to connect the dynamics of the local vegetation, the anthropic influence and the physiographic evolution of landscape. The statistic elaboration model collects and evaluates all the aspects of the studies merging pedological, geomorphological and geobotanical data. The conclusions that arise from this multidisciplinary approach can portray the evolution of whole aspects of ancient natural landscapes.

This case-study emphasizes the importance of alluvial sediment and soil investigations to clarify the fluctuations of environmental conditions, including climatic changes and past anthropogenic impacts on the natural landscape.

In particular, we identified the main factors that affected the ancient environment over a prolonged time interval (∼12 ky). From 14 ky BP, with a palaeosol ascribed

DOI: 10.6092/issn.2281-4485/7633

to the Bølling period, the cold-arid conditions characterized by a steppe vegetation gradually evolved to a more humid and slightly warmer setting. This climatic change allowed the development of a forest constituted by abundant conifers at ca 10 ky. Humans also altered the environment, at least since 9 ky BP, as indicated by repeated traces of fires, plausibly for deforestation and land clearance. The data allows for a comparison with findings provided by other neighbouring sites, and contributes to the ongoing debate on the relationships between climatic and anthropogenic impacts on the landscape dynamics.

The considered stratigraphic sequence exposed in San Lazzaro di Savena provides information on the Lateglacial-Holocene evolution of the northern foot-hill Apennine area, suggesting that at the beginning of this period the climate was quite cold and relatively arid, favouring a steppe vegetation growth. With the Holocene inception, a slight increase in temperature and a relative increase of precipitations favoured the development of forest constituted by abundant conifers. Humans acted on this environment making fires during the Mesolithic to clear the area, and during the Neolithic to obtain land for agriculture and animal farming. The human presence favoured geomorphological and hydraulic instabilities, accelerating soil erosion. Therefore, the observed data suggests that human impact on the landscape started to be effective in the Mesolithic period, earlier than usually considered by previous studies. Finally, more recent hydraulic works, probably Roman, confined the water streams leading to the inactivation of this alluvial area, making the surrounding lands suitable for settlements.

References

ACCORSI C.A. (1986) La palinologia dei suoli: aspetti e interesse. Boll. Acc. Gioenia Sci. Nat., 19(329):477 - 509.

ACCORSI C.A., BANDINI MAZZANTI M., FORLANI L., MERCURI A.M., TREVISAN GRANDI G. (1999) An overview of Holocene forest pollen flora/ vegetation of the Emilia Romagna region-Northern Italy. Archivio Geobotanico, 5, pp. 3–27.

ACCORSI C.A., BANDINI MAZZANTI M., FORLANI L., MERCURI A.M., TREVISAN GRANDI G. (2004) Holocene forest vegetation (pollen) of the Emilia Romagna Plain-Northern Italy. Colloques Phytosociologiques, 28:1-103.

BERGLUND B.E., RALSKA-JASIEWICZOWA M. (1986) Pollen analysis and pollen diagrams. Berglund B.E. (Ed.), Handbook of Holocene Palaeoecology and Palaeohydrology, Wiley, Chichester, pp. 455–484.

BEUG H.J. (2004) Leifaden der Pollenbestimmungen fur Mitteleuropa and angrenznde Gebiete, Pfeil, Munich.

CREMONINI S., FALSONE G., MARCHESINI M., VIANELLO G., VITTORI ANTISARI L. (2012) Suoli olocenici sepolti nell'Emilia orientale-Holocene buried soils in Eastern Emila Region, EQA,1:107-121.

FAEGRI K., IVERSEN J. (1989) Textbook of Pollen Analysis, 4th Edition, Chichester, John Wiley & Sons.

LOWE J.J., ACCORSI C. A., BANDINI MAZZANTI M., BISHOP A., VAN DER KAARS S., FORLANI L., MERCURI A.M., RIVALENTI C., TORRI P., WATSON C. (1996) Pollen stratigraphy of sediment sequences from crater lakes Albano and Nemi (near

Rome) and from the central Adriatic, spanning the interval from oxygen isotope stage 2 to the present day. Memorie Istituto Italiano Idrobiologia, 55:71-98.

MOORE P.D., WEBB J.A, COLLINSON M.E. (1991) Pollen analysis. 2nd Edition, Blackwell, Oxford.

SCHOENEBERGER P.J.,WYSOCKI D.A., BENHAM E.C., SOIL SURVEY STAFF (2012). Field book for describing and sampling soils, Version 3.0., Natural Resources Conservation Service, National Soil Survey Center, Lincoln.

TURNER C. (1985) Problems and pitfalls in the application of palynology to Pleistocene archaeological sites in Western Europe, CNRS, Centre Rech. Notes et Monograph. N. 17 "Palynologie Archéologiques, Act. Jorn., 25-27/1, 1984", pp. 347-372.

VITTORI ANTISARI L., BIANCHINI G., CREMONINI S., DI GIUSEPPE D., FALSONE G., MARCHESINI M., MARVELLI S., VIANELLO G. (2015) Multidisciplinary study of a Lateglacial-Holocene sedimentary sequence near Bologna (Italy): insights on natural and anthropogenic impacts on the landscape dynamics. Journal of Soils and Sediments, Soils, Sec 5, Soil Landscape Ecology, 16(2):645-662.

DOI: 10.6092/issn.2281-4485/7633