Coordinator: Sofia Fonseca

Module 2: Introduction to African Archaeology: Methods

Archaeobotany: The study of pollen

Michèlle Diniez, German Archaeologucal Institut, botanist

Methodology: Pollen analysis

Potentials and presumptions of pollen analysis

Pollen analysis is an excellent tool to reconstruct vegetation changes in time and space. Past vegetation changes in response to climate oscillations, catastrophic events and other can be investigated, as well as human-environment interactions, e.g.:

- (over) regional vegetation responses to increased humidity and/or temperature such as the Greening and De-Greening of the Sahara during Early and Middle Holocene (ca. 11000 – 5000 cal BP).
- local to regional vegetation changes triggered by human land-use such as fostering useful plant species, e.g. doum palms, herding, up to creating new ecosystems by cultivating imported domesticates e.g. cereals, potatoes, vine or date palms.

Other applications of pollen analysis are honey or allergy studies.

Features possessed by pollen allow vegetation reconstructions by pollen analysis:

- Plants produce pollen (seed plants) or spores (ferns, mosses).
- Pollen vary in shape, surface structures, openings and size. These morphological characteristics are specific to a particular plant family (e.g. sunflower family), genus (e.g. teasel) or seldom to a plant species (e.g. garden cornflower).
- Pollen (and spores) need dispersal. As very small particles they are often dispersed through the air.
- Pollen are extremely resistant to decay under anaerobic conditions, i.e. in lakes and mires (or oceans).
- Pollen preserved in lake or mire sediments reflect the vegetation at the time of pollen deposition.

Sampling for pollen analysis and sample preparation

Drilling/Sampling in the field: The pollen-bearing sediments of mires, lakes and oceans usually are sampled by coring. To guarantee a complete sequence it is necessary to drill cores overlapping, i.e. two drillings in closest proximity. One drilling starts at the sediment surface, the other half of the core length deeper: If 1m cores are retrieved, the first drilling starts at the sediment surface, the second drilling at a depth of 0.5 m. In order to avoid contamination, the drilling of closed cores is highly recommended. Other possibilities are the sampling of well stratified, undisturbed open trenches. Contamination by actual pollen as well as older/younger sediments should be avoided by sampling cleaned trenches quickly and with closed sampling tubes. It is not possible to see in the field whether pollen are preserved in not water-logged sediments or not.

Sampling in the lab: According the research question to be investigated, the appropriate sampling resolution, e.g. every 30, every 100, every 1000 year, and sampling strategy, e.g. close to sediment changes, has to be chose.

Sample preparation in the lab: Different chemical and mechanical treatments are necessary to remove clastic (clay, silt, sand) and organic components other than pollen.

Pollen analysis – Microscopy

- **Microscopy**: A well homogenized subsample of the pollen sample is analyzed under the light microscope. The most appropriate magnification for routine counting is x400, while some pollen grains need inspection at x1000 magnification. The pollen size varies between ca. 10 to 200 µm. Phase contrast microscopy is very valuable for providing extra information about the structure of the pollen wall.
- **Pollen identification**: The identification of the pollen based on morphological features necessitates a stringent terminology of the structure and patterning. Identification keys based on these morphological features and complemented by photographs or illustrations exist for regions up to continents, increasingly available online.
- **Pollen counts**: According to the research question and the region, different pollen sums should be achieved. To ensure that rare pollen types are recorded, usually at least 1000 pollen grains should be counted (however low pollen concentrations or time restrictions may result in lower counts).

Results of pollen analysis

Pollen counts per sample are visualized in so-called pollen diagrams. The samples are ordered according their depth or ages. Linear interpolation or Bayesian statistics are common methods establishing age-depth models, based on e.g. 14C-datations of plant maco-remains (charcoals, seeds/fruits) and/or pollen concentrates, tephra layers or varve counts.

Pollen percentage values are usually plotted against depth or age. The sum commonly are the pollen types of terrestrial plant taxa, excluding pollen types of local aquatic or riparian vegetation formations. Concentrations or influx values (pollen deposited per time and surface) may be plotted as well. The different pollen types may be grouped together according the ecology of plant taxa they represent. Summation curves of these groups are useful to summarize results.

Interpretation of the palynological results

Pollen diagrams provide a quantitative, continuous record of vegetation composition and its changes through time, provided that the analysed sediments were deposited continuously. Because of its complexity, statistics can be useful to structure datasets and detect patterns: e.g. zonation or multivariate methods (e.g. CA, DCA, NMDS).

After tracing the patterns of changes in a pollen diagram, the ecological processes and the possible triggers of these changes has to be detected.

Attention should be paid on systematic biases such as over-representation of pollen-types dispersed by wind, e.g. pollen of grasses as compared to insect-pollinated taxa, as well as possible biases by e.g. fluviatile input of pollen-types belonging to other, distant vegetation formations.

Climate and human impact are supposed to be the main drivers of palaeoecological changes during the Holocene. For the Sahara e.g. the most conspicuous change is the Early and Middle Holocene socalled ‘African Humid Period’, resulting in vast and numerous ephemeral and permanent lakes and a ‘Green Sahara’. Definitely human impact usually can be traced by records of imported domesticates,
e.g. vine or date palms in the Sahara. Other vegetation changes triggered by human land-use are e.g. the fostering (or even cultivation) of native useful plants – detectable in pollen diagrams by an increase of the respective pollen type – or shifts in the vegetation composition due to grazing - detectable in pollen diagrams e.g. by an increase of non-palatable plants.

Another approach is modelling the changes of vegetation formations through time, based on pollen counts (e.g. LOVE, REVEALS based on pollen productivity estimates; or biomisation).

Why do pollen analyses matter archaeologists?

Past ecosystem changes can be reconstructed by means of pollen analysis. The pollen diagrams provide continuous records of changes in composition, its richness and diversity, as well as the cooccurrence (or not) of different plant communities.

The most obvious gain of pollen diagrams for archaeologists of course are the dated records of cultivated plants, informing about local cultivation of these domesticates. However, pollen diagrams provide informations on numerous other aspects: They allow the reconstructions of probable habitats of humans and wild animals. They allow the reconstruction of the primary biotic resources such as grazing resources for wild and domesticated animals, plants parts (fruits, seeds, rhizoms etc) which could have been collected by people for consumption, plants suited as fuel, suited for manufacturing commodities, suited as timber and more. The plant cover of a region thus determines the realms of subsistence strategies. Finally, the continuous sequences allow the reconstruction of the environments during ‘settlement gaps’ furnishing informations on periods otherwise unexplored.