Phytolith-based palaeoenvironmental reconstructions

- Phytoliths (phyto=plant; lith=stone) are opaline plant fossils that are produced in most plants where solid silica is precipitated in and among their cellular structures.

- The silica is absorbed by the plant in a soluble form (monosilicic acid) from the ground water via their various water transport mechanisms.

- In many plants the phytoliths are formed to provide additional structural support, or replace the function of other compounds such as lignins.
Phytoliths are mostly morphologically distinct from other siliceous particles that may be found in the environment, and are resistant to decomposition (diagenesis) in most sedimentary environments.

The cellular structures of certain plants where the silica is deposited and hardens may be very distinctive and thus produce distinct phytoliths.

Hence, plants may be identified to species level in some instances, but more generally they are identifiable at the plant family level.
Phytolith-based palaeoenvironmental reconstructions

• When a plant dies, the phytoliths remain when the organic composition of the plant decays. Most of the phytoliths may then be directly deposited on the soil.

• Because most of the phytoliths are formed predominantly in the vegetative tissue of a plant, they are more likely to be released where the plant dies rather than disperse great distances, thus we can expect most phytoliths to represent highly localised, in situ, assemblages.

• The picture is different when a plant is destroyed by fire. Phytoliths are generally resistant to burning and are often dispersed with ash debris. This can potentially disperse vast distances.
Processing for biogenic silica: Phytoliths

- **Preparing Sediment Samples for Phytolith analysis**
  - **A. Acid Treatment**
    1. Add ~ 30 ml of 10% HCl to the sample in a small beaker. If the sample is from an area where the sediments are known to be carbonate-rich, use a larger beaker and be careful as a violent reaction may cause the evulsion of the sample from the beaker with HCl. 2. Simmer the beakers for 1 - 2 hours depending on the carbonate content making sure that the water level is maintained and the HCl does not become overly concentrated.
    3. Allow the sample to cool and top up with distilled water.
    4. Thoroughly wash 3 times. Each time allow the sediment to settle for 6-12 hours and decant 50-70 % of the volume, topping up with distilled water.
  - **B. Peroxide Treatment**
    1. Repeat 1 - 4 above with 10% H2O2. As you ought to be particularly careful with HCl in carbonate-rich sediments, you ought to be particularly careful with peroxide in organic-rich sediments.
  - **C. Heavy Liquid separation**
    Using Sodium Polytungstate diluted to a specific gravity of 2.3
Processing for biogenic silica: Phytoliths

- Microwave digestion
- A. Acid Treatment
  - 1. HCl and Nitric acid
- B. Heavy Liquid separation
  - Using Sodium Polytungstate diluted to a specific gravity of 2.3
Phytolith morphology

- Phytolith morphology is immensely complex.

- As yet there is no universal classification system for phytoliths although a number of Australian phytolitharians have proposed a universal phytolith key (Lynley Wallis, Di Hart, Carol Lentfer and Doreen Bowdery).

- Most classification systems have been derived for regional floras or for individual projects.

- Is dependent on the nature of phytolith production in certain plants.
Phytolith morphology

- Some trends in phytolith production (two extremes (See Dolores Piperno’s 2006 book entitled “Phytoliths”):

- Plant families that are large producers of phytoliths tend to produce diagnostic phytoliths (e.g. Many monocotyledons: Palms, bananas, grasses, sedges; basal angiosperms: Magnolia; Dicotyledons: Cucurbitaceae, Moraceae)

- Families where phytoliths have not been observed: Many gymnosperms e.g. Araucariaceae, Podocarpaceae; some monocotyledons: Araceae, Dioscoreaceae, Liliaceae; and many Dicotyledons

![](Broussonetia_papyrifera_Moraceae.png)
Fig. 1. Hand drawings of principal morpho-types of short-cell phyoliths found in the 34 species of coastal prawns from the southeastern USA.

Lu & Liu (2003) Estuarine, Coastal and Shelf Science 58: 587-600
Microscopy

• Any high powered microscope

• Scanning electron microscopy for classification research and increasingly archaeological work
Ginini Swamp Phytoliths

- Short cell/chloridoideae
- Elongate/Pooideae
- Restionaceae verrucate type
- Restionaceae smooth type
- Point shape
- Chloridoideae
Ginini Swamp Phytoliths

Short cell/Chloridoideae
Point shape
Elongate/Pooideae
Choridoideae

Elongate/?
Panicoideae
Tracheid
Phytolith-based palaeoenvironmental reconstructions

• Phytolith based reconstructions generally follows that of palynology and diatom analysis

• Limited by the classification dilemma

• Nevertheless a growing number of resolute environmental reconstructions have been undertaken

• Qualitative and quantitative reconstructions have been attempted Prebble et al 2002; Prebble and Shulmeister 2002 Journal of Paleolimnology 27: 393-427
Peak in forest expanse (*Dacrydium*)

Poor pollen preservation for Late Glacial period
Peak in forest expanse

Well preserved phytolith record during the Late Glacial period
Absence of Chionocloideae and Chloridoideae phytoliths during Last Interglacial; Corresponding absence of *Dacrydium cupressinum* (~220-120 ka)
Absence of Chionocloideae and Chloridoideae phytoliths during Last Interglaciation; Corresponding absence of *Dacrydium cupressinum* (~120-70 ka)
Figure 2. Median phytolith diagram showing the sites (abbreviated names only) with each of the four replicates (110 samples) arranged in relation to altitude.
Figure 2. Principal Components Analysis (PCA) ordination diagram of the modern phytolith assemblage sample data set showing the relationship between samples and phytolith morphotypes. Samples with affinities towards particular vegetation types are outlined.
Figure 8. Log conductivity training set: (A) plot of predicted log conductivity against observed log conductivity based on a 2-component PLS model; (B) plot of residuals (predicted – observed) against observed log conductivity.

Figure 9. Average annual precipitation training set: (A) plot of predicted precipitation against observed precipitation based on a 4-component PLS model; (B) plot of residuals (predicted – observed) against observed precipitation.
Figure 5. Late Glacial and Holocene pH, average annual precipitation, log conductivity, and average autumn temperature estimates derived from phytolith assemblages placed in a 5th order polynomial scatter plot. The estimates are based on Partial Least Squares transfer functions of Prebble et al. (2002). The diatom salinity tolerance zones (refer to the text) are taken from Hughes (1999). Depths are below current mean sea level. The current average annual precipitation and mean annual temperature of the Waipori 99-1 core site are also presented.
What phytolith research is happening in Australia?

• A focus on archaeological applications in northern Australia and New Guinea

• Carol Lentfer (U. Queensland) focusing on starch and phytoliths of cultigens found in archaeological sites in New Guinea and SE Asia (e.g. stone tool residues)

• Jeff Parr (JCU) similar research in New Britain
What phytolith-stuff is happening at ANH?

• Doreen Bowdery’s work on remote sheep stations in NSW
• Palm phytolith morphology (SEM)
• Phytolith sites in SE Asia
• (me) Mat Prebble – Sago histories in Papua New Guinea
• Palm phytolith morphology of Pacific palms
Palm (Arecaceae) phytoliths

- Phytoliths important structural component of palms, form in most parts of the plant

- Palms produce a huge number of phytoliths

- Current hypothesis that palms at the ultrastructural level, may produce diagnostic phytoliths to the sub family level or possibly higher (e.g. some species)

*Cocos nucifera* (coconut) phytolith
Phytoliths from an extinct palm

Pelagodoxa henryana