Climate change and the Antarctic: Studying the past to predict Earth's future

Imagine being able to look into past environments and climates on scales far in excess of a human lifetime. **Dr Sophie Warny**, an Associate Professor at the Centre for Excellence in Palynology (CENEX) at Louisiana State University (LSU) does just that. Her research involves detailed analysis of microscopic fossils, from samples which may be many millions of years old, to provide insights into how past climates might help us understand the planet's future.

Dr Sophie Warny is uniquely placed to deliver and reflect upon research that uses ancient microscopic fossils to elucidate past changes in climate with a view to informing what the future might hold should global warming and atmospheric carbon dioxide concentrations follow an upward trajectory. In addition to developing internationally leading research programmes at LSU, Dr Warny also has a clear interest in public engagement which is exemplified by her role in creating new public exhibits on her research and the research of colleagues at the Museum of Natural Science at LSU and in the development of outreach material on climate change for high-school students.

WHAT IS PALYNOLOGY?

Palynology is a branch of palaeontology in which the fossils studied have organic walls and can only be seen using a microscope. These microfossils or "palynomorphs" include for instance pollen, spores and algae, which may be of marine or terrestrial origin. Those of us who suffer from allergies may view pollen and spores as foes rather than friends, yet these microscopic palynomorphs are preserved throughout the geological record and can tell us which species of plant and algae were present at a particular location over a wide range of times in the geologic past.

HOW ARE PALYNOMORPHS USED?

Palynomorphs (a variety of organic-walled microfossils) are obtained by drilling through sedimentary sequences or sampling sedimentary outcrops. The similar organic composition of these microfossils means that they can be extracted from the sediments by chemical processing which dissolves the host rock and concentrates organic residues. These residues contain a suite of microfossils that can be examined under the microscope to reveal the species of plants and algae present. Our knowledge of the evolution of plants and algae through time means certain species can be pinpointed to key times in the geological record making them invaluable for dating sedimentary sequences. In addition to dating, they can be used to elucidate past climates because the type and range of palynomorphs present in a sample may be unique to different locations, environments, and thus climate. For example, the type and quantity of marine palynomorphs present can be related to the sea-surface temperature at the time of deposition. Changes in their abundance and diversity can be linked to changes in global temperatures or currents. For the same reason, palynomorphs such as pollen grains, are also a powerful tool for determining the provenance of samples of rocks and sediments. This "geolocation" has application other than geological, palynomorphs can even be used to trace illegal imports of drugs or stolen goods.

Palynomorphs are versatile and have many uses as geological markers and tracers

Dr Warny and graduate student Austin McGlannan

SEM picture of a *Nothofagus* pollen grain taken by Dr Warny and her former doctoral student, Kate Griener

Left: Microscope slides of palynomorph types at CENEX, LSU.

Right: Dr Rosemary Askin, a long time collaborator and mentor (left) and Dr Sophie Warny (right) in front of the ANDRILL cores that sampled the precious Antarctic Miocene sediment.

THE FOREST OF ANTARCTICA

Geoscientists often look for analogues, using the present to explain the past and vice versa. Dr Warny's research has used palynomorphs to provide evidence for past warmer climates in Antarctica. This also gives insight into potential impacts of current observed trends in global warming.

In 2007, Dr Warny collaborated with the Antarctic drilling programme (ANDRILL). This programme recovered 1138m of core sediments that were analysed by a multinational team comprising universities in the US, New Zealand, Italy and Germany for instance. Dr Warny acknowledges the ANDRILL project and its collaborators in providing core material that has revealed important and surprising evidence for climate variations in Antarctica throughout the past 20 million years. The range and variation of sediments along the length of the core were indicative of periods of fluctuating sea levels, glacier advance or retreat and changing climate. In particular, when analysing a section of core from around 15.7 million years ago, Dr Warny found a rapid increase in numbers of terrestrial and marine palynomorphs in a 2m thick section of core retrieved from 310–312 meters below the sea floor. This proliferation indicated a period of warming over a few thousand years when both the sea and land temperatures were much warmer than present day. Pollen grains found within these samples lead to the astonishing conclusion that the Antarctic Peninsula once supported beech forests. This is in stark contrast to the present-day icy landscape of this frozen continent. Knowing when this event occurred and under which atmospheric CO_2 concentration gives us some warning of what might happen if current CO_2 concentrations keep increasing via natural and human-induced processes.

Dr Warny's analysis of other core material also revealed when vegetation disappeared from the Antarctic Peninsula. Approximately 12.8 million years ago, as the continent entered a more intense period of global cooling, the beech-dominated forest that had been gradually replaced by sparser tundra was decimated. Soon thereafter, the region was covered by ice sheets. The results of this study also have implications for future global warming by helping to reconstruct how this area responded to changing global temperatures.

EMERGING EVIDENCE

In addition to providing fascinating insights into past climatic conditions, palynological research is also gaining recognition for its role in forensic investigations. One example of this occurred whilst one of Dr Warny's students, Shannon Ferguson, was on an internship with the Department of Homeland Security's forensic team. In June 2015, the body of "Baby Doe" was found in Boston Harbour. Pollen often sticks to clothes, skin and hair; therefore, it leaves microscopic signatures of the places a person visited. Hence, pollen recovered from a person can be used to reconstruct their recent movements and whereabouts. A series of specific pollen found in the samples collected during this case enabled the identification of possible areas where "Baby Doe" had lived. This evidence was instrumental in bringing the unsolved case to a close with a murder conviction.

THE IMPORTANCE OF PALYNOMORPHS

Palynomorphs are clearly versatile and have many uses as markers and tracers. Dr Warny advises that collections of these important microfossils face an uncertain future. For example, the CENEX collection contains over 10000 samples of pollen species from around the world. Warny's collection are safe as her lab was endowed by the AASP- The Palynological Society, but budget cuts for other museum science programmes threaten the survival of these special collections that are not only of great scientific interest, but also have great value as a forensic tool or for future climate, evolution or medical studies. These collections have been developed and curated by many scholars over a period of a century or more, with specimens from areas that are no longer safe to visit because of wars or drug cartels. Dr Warny's research serves to highlight and promote the importance of such microfossil collections for understanding climate change and future forensic uses.

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Q&A

How did you become involved in palynology?

By pure chance because it is quite an unknown field with few specialists around the world. I was pursuing a graduate degree in Oceanography at the Université Libre de Liège (Belgium) and had one month off. So, I went back to the Université Catholique de Louvain to visit the lab where I had just completed my bachelor's degree in Geology. One of the doctoral students, Suzanne Leroy (now a professor at Brunel University in London), invited me to help her with her project and travel with her to the University of Montpelier in France. There, I met her co-advisor, Dr Suc, and at the end of the month there, Dr Suc offered me to join their team as a PhD student. The project was a palynological study of the Messinian Salinity Crisis (a time when the Mediterranean Sea essentially evaporated). I was sold by the idea and joined that programme as a PhD student the following year.

What sparked your interest in the Antarctic?

To effectively study the cause for the desiccation of the Mediterranean Sea, I had to better understand the precise timing of various glacio-eustatic sea-level lowstands driven by Antarctic ice-sheet expansion. I realised that 20 years ago, we knew very little from the Antarctic, so that sparked my interest to study it once I completed my doctoral degree.

Where else in the world are you conducting this type of research?

My group mainly focuses on Cenozoic sections, i.e., those sediment sequences ranging in age from modern to 65 million years. We are currently working with IODP collaborators on the South China Sea and Indus Fan drilling campaigns. We also worked on sections in Papua New Guinea, the Gulf of Mexico, and in Morocco and Spain.

The use of forensic palynology is fascinating – how do you see this developing further for criminal investigations?

There are very few palynologists in the world, and there is only one lab (Dr Vaughn Bryant's lab at Texas A&M) that was training forensic palynologists – until Vaughn got my students and I involved with Homeland Security. So, now our two former doctoral students are the only two DHS palynologists for the US. Forensic palynology is a very powerful tool, but it takes years to become good at it. With hundreds of thousands of species of plant, it is an extremely difficult field to master, and it is very time consuming, but it can provide critical information.

What challenges does your research face?

As mentioned above, it takes a long time to become specialised in palynology. You must be very patient and be somebody who pays extra attention to details. Each time period and each geographic location will have different plants, thus different pollen types. So, each new project means that you have to start over, find reference collections (specimens or books) to get up to speed and train yourself. Our centre, CENEX, has a huge private library with thousands of books and reprints on palynomorph types. These are essential to our work. And of course, we need funding to support our research, and getting funding is likely to become more difficult in the current political climate.

Detail

RESEARCH OBJECTIVES

Dr Warny investigates the sedimentological record to decipher past sudden warming events and climate variability in the Antarctic through the study of pollen, spore, fresh-water algae, and dinoflagellate cyst fossil assemblages. Her primary goal from this seven-year study is to identify and date past climatic shifts to help constrain their triggering mechanisms.

FUNDING

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COLLABORATORS

Dr John Anderson (Rice University), Dr Rosemary Askin (retired from Ohio State University), Dr Philip Bart (Louisiana State University), Dr Rob DeConto (University of Massachusetts), Dr Sarah Feakins (University of Southern California), Dr Dave Harwood (University of Nebraska), Dr Dave Marchant (Boston University), Dr Amelia Shevenell (University of South Florida).

BIO

Sophie Warny received her PhD from the Université Catholique de Louvain working with Dr Jean-Pierre Suc. Since then, she has become the AASP Chair, Associate Professor of Palynology and the Curator of Palynological Collection at the Museum of Natural Science (MNS), both at LSU, and is also the director of the AASP-The Palynological Society's Center for Excellence in Palynology.

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