Project: AFI 6/28

TERMINAL CRETACEOUS CLIMATE CHANGE AND BIOTIC RESPONSE IN ANTARCTICA

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Location: Seymour Island, Antarctic Peninsula

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Rationale:

This project is investigating latest Cretaceous to early Palaeogene (Maastrichtian to earliest Danian) climates in Antarctica to determine the nature of end Cretaceous climate change. Geological evidence suggests that after the peak mid Cretaceous greenhouse warmth climates cooled considerably during the Maastrichtian (~71-65Ma). Some scientists. now argue that cooling was at times so severe that high latitude regions suffered short term glaciations, causing sea level changes worldwide. This challenges the current view that the Cretaceous greenhouse world was ice-free, implying instead that short term glacial climates may have punctuated supposedly stable warm climates. Such dramatic environmental change would have stressed terrestrial and marine biotas and made them particularly susceptible to early extinction related to the global environmental catastrophe at the end of the Cretaceous.

Recent dating using strontium isotope stratigraphy has revealed that the Late Cretaceous sequence in the James Ross Basin, Antarctica is the best sequence in the world in which to investigate Maastrichtian environments and climate change that led up to the Cretaceous/Tertiary (K/T) catastrophe. This project will exploit this exceptional sequence to obtain high resolution records of palaeontological, sedimentological, and geochemical signals to: a) investigate the nature of latest Cretaceous-early Palaeogene climate change at high latitudes, b) to test the hypothesis that ice was present at times and test climate/ice-sheet model simulations, c) to determine the biological response to this environmental change in both terrestrial and marine high latitude ecosystems, and d) to understand the environmental context in which the K/T extinctions occurred.

Highlights:

During the field season in January -February 2006 we investigated the latest Cretaceous and earliest Palaeogene (Maastrichtian-Danian) sedimentary sequence on Seymour Island. We measured, logged and sampled over 1200 metres of the López de Bertodano Formation, taking samples at 0.25, 0.5, 1 and 2m stratigraphic intervals. This intensity of sampling sounded impressive in the grant proposal but once in the field it was a dauntingly ambitious challenge. However, with hard work, exceptionally good weather and temperatures up to +19°C – and despite Sahara-like dust storms – we completed our task and now have one of the best datasets in the world for studying latest Cretaceous climate change.

The sedimentary sequence consisted mainly of a superficially monotonous sequence of bioturbated muddy silts and silty muds. These quartz-rich sediments were originally eroded from the volcanic arc to the west (now the Trinity Peninsula region) and deposited in a rapidly subsiding marine basin (the James Ross basin). With over 1200 metres of sediment being deposited in about 4 million years, erosion and deposition rates must have been exceptionally high. The sediments are not lithified but still unconsolidated, like wet sand. However, a variety of concretionary nodules are common, from which we can obtain information about the chemistry of the basin waters and sediments during deposition.

Our samples of this sediment will be used to study the microfossils preserved within them. Fossil pollen and spores will provide a picture of vegetation and climate on the adjacent land and marine microfossils (dinoflagellate cysts) will be used to date the sequence. With such high resolution sampling we will be able to obtain an extremely detailed record of changes in vegetation and climate over short time intervals, perhaps recording even orbital influences.

Within this sequence, however, there are intervals of glauconite-rich beds. Glauconite is a green iron-rich silicate mineral that requires very quiet conditions to form within the seafloor sediment. The presence of glauconite in this sequence thus indicates that at times sedimentation on the sea floor stopped for some time. Why did sedimentation cease – was it due to higher sea levels and deeper water conditions in this area or a change in sediment supply from the Peninsula region? Was this related to phases of glaciation?

Exceptionally rich fossil beds are common in the upper parts of the sequence. The fossil remains of a diverse fauna of ammonites, bivalves, gastropods, echinoids, marine reptiles, corals, fish and sharks were discovered. Fossil samples were tied to our measured section line, thus we have a well-documented collection of fossils from which to determine changes in marine diversity through time. The marine fossils that have their original shell material preserved will be used to date parts of the sequence using strontium isotopes, and will also provide oxygen isotope data from which can be determined original Cretaceous seawater temperatures.

The youngest part of the sequence hosts the Cretaceous-Tertiary (K/T) boundary, the famous horizon in which ammonites and dinosaurs became extinct world-wide. Although elsewhere in the world this boundary is often marked by a break in deposition and contains geological evidence for a meteor impact, previous studies have reported that on Seymour Island there is no evidence for major environmental change affecting Antarctica. Although fossils become scarcer near the boundary and some (ammonites, marine reptiles) disappear, many fossils types are present across the boundary. However, this season a new boulder bed was discovered in the K/T interval on Seymour Island. Large pebbles and boulders of igneous rocks from the Peninsula are present, signifying a major event, such as a sea level drop or major erosive event. This discovery will provide important new evidence for events at this critical time in Earth history.

Fieldwork on Seymour Island would be extremely difficult without the excellent support of HMS Endurance. The helicopters made light work of putting in our camp - even though it took several hours for the crew to clean out the samples of Cretaceous silt that they inadvertently sampled when on the ground. The help of the crew in many ways was most appreciated. Thanks also go to our field assistants who dug over 1200 sample holes (and filled them in afterwards), wrapped hundreds of delicate fossils and remained enthusiastic to the end.

A spectacular ammonite fossil (*Grossouvrites gemmatus*) from the Late Cretaceous sedimentary sequence on Seymour Island

Celebrations after successfully logging and sampling over 1200 metres of Cretaceous sediments on Seymour Island.