MICROFOSSILS AND CLIMATE CHANGE IN VICTORIA OVER THE LAST 100 MILLION YEARS: EVIDENCE FROM THE BELFAST MUDSTONE TO THE TWELVE APOSTLES

Report on talk to the Geology Group by Dr Stephen Gallagher of Melbourne University on Wed 22 February 2006

Our speaker's aim was to go back to a starting point in the mid-Cretaceous in Victoria and show how climate has changed from then until now. To know if and how climate has changed, one must have evidence and the various forms of evidence available to geologists made up a major part of the presentation. There are several causes of climate change, some acting over thousands of years while others develop over millions of years and these different causes 'overprint' each other, giving rise to the fluctuations in climate that have clearly happened in the geological record. Finally, Stephen used the summation of all the data that has accumulated to show how Australia would be different if we, by our own actions, change the global climate and make the Earth revert to its 'greenhouse' state.

How do we know that the climate has changed? One useful tool is measuring the ratio of the two oxygen isotopes 16 and 18 in sediments. During icesheet expansion the light isotope 16O is locked into the ice leaving the rest of the ocean enriched in 18O. Therefore 'greenhouse' events are typified by low 18O values in the shells of marine organisms, whereas the opposite is true for the 'icehouse' world. The other major indicator of climate is fossils. Our speaker showed how four Victorian fossil assemblages could be used to map changes in the Earth's temperature; these are:

Belfast Mudstone 90-80 million years
Gippsland flora 75-65 m yrs
Otway record 60-7 m yrs
Gippsland record 25-2 m yrs

As Stephen showed us with graphs and timelines, the different types of fossil from the various locations, together with the time overlap and the O16/18 figures build up a convincing picture of climatic conditions at any one time. The principal fossil tool to determine ocean temperature is microfossils because they survive in the sediments and are small enough to found in the drill cores. The main microfossil used is foraminifera and these can indicate cold or tropical water and even oceanic up-welling and algal blooms. The Belfast Mudstone of Cretaceous age lies 4km deep so is only known from drill cores – we were shown one macrofossil, an inoceramid bivalve which liked muddy conditions but became extinct at the same time as the dinosaurs. The Gippsland flora (pollen and spores) shows alternating cold, wet periods with Nothofagus and warmer, drier spells with the Proteaceae present. The Otway and Gippsland fossil records can be examined on land but oil exploration provides many cores from offshore.

The pattern that emerges from all this evidence is cold-warm fluctuations measured over thousands of years but a long-term cooling from a 'greenhouse' temperature over much of the last 100 million years to 'icehouse' conditions for the past 15 million years. The present glacial period which began about one million years ago is regarded as an anomaly in this history. One cause of the short-term changes in climate is orbital eccentricity. The Earth's orbit round the sun is affected by the other planets on a 100,000 to 400,000 year cycle. During periods when the Earth is not drawn close to the sun ice-caps can develop. These are small ice-caps, not the continental ice sheets we have in Antarctica and Greenland now. Other factors can include volcanic eruptions adding dust or carbon dioxide to the atmosphere.

The long-term changes in climate are due to changes in oceanic circulation. During half the period we are looking at, Australia was still attached to Antarctica, but since then we have been drifting northwards. 45 million years ago there was shallow sea between Tasmania and Antarctica but by 33 million years deep ocean had formed and the cooling circum-polar current was established. Persistent ice was present on the Antarctic continent from 28 million years ago and by 10 million years it was completely covered in ice. There has been a steady decrease in global temperatures over the last 50 million years.

Fluctuations include climatic optima in the Eocene and mid-Miocene. The latter corresponds with the last brown coal in the Latrobe Valley. After this (15 m yrs ago) Myrtaceae become the dominant plant. A final climatic high occurred in the Pliocene 3 million years ago. It is with this period that we should draw parallels when we contemplate global warming.

If Australia reverted to 'greenhouse' temperatures, the southward-flowing Leeuwin and East Australian currents would cease, up-welling would increase off the SW corner of WA leading to more aridity in that area and low-lying areas everywhere would be flooded. The interior of the continent would receive increased monsoonal rain.

We are grateful to Dr Stephen Gallagher for his well-illustrated presentation which left us with plenty to think about. He has kindly offered to lead an excursion to the Torquay coast later in the year so we ourselves will be able to find the little creatures that tell us so much about past climates.

Rob Hamson

References

The following papers can be found in *Palaeo* published by Elsevier
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