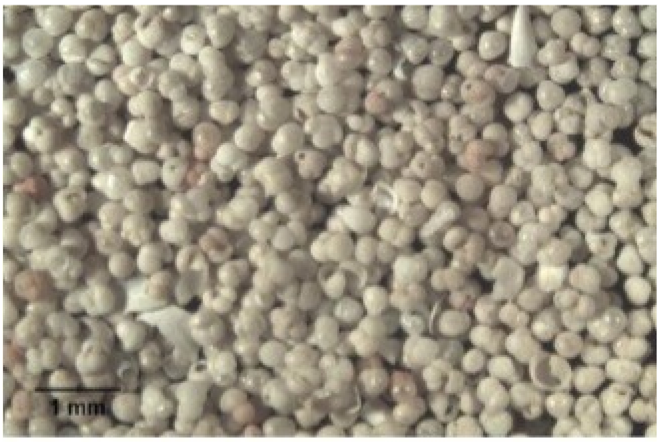
Changing Ocean Chemistry and the Impact of Global Warming by **Dr Pallavi Anand** on 20-9-19

Dr Anand spoke about the evolution of ocean chemistry through the study of marine shells. She said it was important to take into account the biological life of the creatures that produced the shells, and the conditions they had to live in. When they die their shell material locks in a chemical signature of these conditions. Different varieties of creature will have responded in different ways and comparisons can made to determine how conditions have changed over time. She listed a selection of creatures that make shells or similar that survive after death: Foraminifera, Coccolithophore, Coral, Fish (teeth) etc. Over time these drop to the seafloor and form a sediment. After long periods this fossilises and forms chalk.

Phytoplankton, of which there are thousands of varieties, are microscopic organisms using sunlight which penetrates the upper ocean layers (some light down to 50m, much less to 200m, none below 1000m) to make organic compounds from dissolved CO_2. These are protists which may themselves (eg coccolithophore) make shells or feed others which do. Some varieties of foraminifera are planktonic, floating at a preferred depth, but most benthic, in the sea floor sediment.



A microscopic view of marine microfossils greater than 250 Micrometres ⟷ = 1 mm

Foraminifera produce shells, mostly of calcium carbonate, which gently accumulate on the sea floor as they die. The shells in this image are about 0.3mm in size. Many are smaller. And collecting them for study from samples taken from the seabed is painstaking work; as is cleaning adherent slime from them. A recently developed device is a suspended tray with a set of bottles, each opened at a particular depth to catch shells descending to the seabed. This gives clean shells! But has not yet been widely deployed.
Studies of sediments at different depths also show differences.
Laboratory studies, where conditions can be accurately set, also provide useful results, despite their artificiality.

Several conditions affect shell formation, particularly salinity and temperature: but differently for different varieties – so by comparing them one can infer what the conditions were at the time the shells were formed.

As well as calcium trace minerals can be incorporated - such as magnesium or boron - or others with a locally high concentration. The Mg/Ca ratio acts as a proxy for sea bottom temperature: in shallow waters bottom temperatures can vary as much as $10^{O}C$. Boron isotopes B^{10} and B^{11} together with temperature can be used to indicate alkalinity.

The oxygen isotope ratio O^{16} /O^{18} also indicates the world temperature; evaporation from the oceans favours O^{16} which is lighter – in cold periods this is locked up in polar ice, the oceans being enriched with O^{18} - and vice versa.

An interesting study was carried out in the Bay of Bengall at the time of a monsoon. It is known that the vast resulting river flows reduce the salinity of the Indian ocean – not uniformly but how they interact with the ocean current. In this study, in which Dr Anand took part, foraminifera shells were collected. Subsequent study showed that the shells had incorporated minerals not seen anywhere else in the world; these were from the rivers, washed out from particular mineral beds.

A particular aim of the work Dr Anand had described is to try to predict what effects global warming might have. The loss of coral is already happening, due to higher temperatures, increased acidity, and the loss of sea urchins living symbiotically on coral reefs. Foraminifera shells have become 30% thinner but longer from pre-industrial times to the present.

One result that Dr Anand told us was that during the Pliocene age, when the temperature was about $3^{O}C$ hotter than now the CO_2 concentration had been slightly lower.