The use of isotopes in palaeontology and archaeology

The isotopes of a chemical element are the various configurations of its atoms. For example, there are three carbon isotopes in nature: 12C, 13C and 14C. These are three varieties of the same chemical element, carbon, whose nuclei contain the same number of protons (six), but a different number of neutrons (six, seven and eight, respectively). Thus, besides having the same chemical properties, the isotopes have different atomic masses: twelve, thirteen and fourteen, respectively).

The isotopes of many elements are useful to paleontologists and archaeologists, but we are going to mention just two of them here, namely Oxygen (O) and Carbon (C).

Carbon isotopes are used to reconstruct the diet of fossil animal and human populations, as explained in 'You are what you eat'.

Carbon isotopes are also used for radiocarbon dating, a method of dating which can be used to date organic materials, such as shell, bone and charcoal, up to about 40 000 years ago (see 'How old is it anyway?') .

The shells of shellfish or microscopic organisms which live in the sea, called foraminifera, can tell us things about the temperature of the sea water they lived in. The shells of these sea-living microscopic animals are composed of carbonates (CO_3) and can be used to trace changes in the temperature of the ocean over time. This in turn provides scientists with a record of when ice-ages and warmer climatic periods occurred. How do the shells provide this information? The ratio of two oxygen isotopes, $^{16}0$ and $^{18}0$, in the shell is used. The heavier isotope, $^{18}0$, is preferentially taken up in ice sheets during an ice age and will be found in relatively higher proportions in the carbonate shells of shellfish and foraminifera when there is an ice age, or cooler period. Scientists also look at the oxygen isotope ratios from cores of ice and snow taken from the Arctic and Antarctic, and have built up a temperature curve for the past few million years. An example of such a curve may be seen in the figure below. (see: What happens to global sea levels during an ice age?)

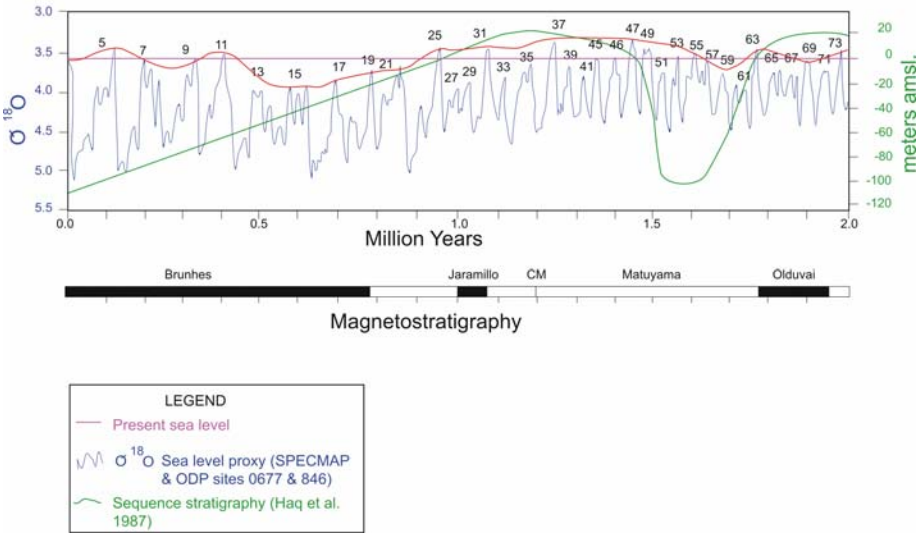

Figure 1: A global sea-level history curve elucidated from Oxygen isotope readings from ice cores

(Diagrams courtesy of Dave Roberts, Council for Geoscience, Cape Town)