APPLICATION OF ISOTOPES IN CLIMATE CHANGE STUDY

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ABSTRACT

Water isotope data provide key information about past and present global climate and the global water cycle. This is because the isotopes, both stable and radioactive, are preserved in various natural archives such as sediments in lakes and oceans, ice in glaciers or polar ice caps, water in precipitation and oceans, and even trees. The subtle changes in the concentration or type of isotopes can be accurately measured and compared to reconstruct an accurate climate history. This data can also be used to study the complex interactions between the sun, atmosphere, oceans, and biosphere, which together influence climate. One of the high priority areas for action identified in the IPCC report is the need for improved reconstructions of past climate periods. Understanding the causes of past climate changes is, therefore, an important part of climate change research, and is the only direct way to separate industrial versus pre-industrial climate controls. In this way, the past becomes the key to the present in the study of climate change.

The isotopes are like natural data-loggers or fingerprints occurring within the water molecule and within chemical substances and trace metals that are dissolved in water. One of the most common uses of isotopes, particularly carbon-14 (14C), is to determine age by measuring the decay products of14C over time and, based on the known decay rate for14C, estimating when the14C would have first been absorbed. This technique, known as radiocarbon dating, is widely used to date fossils and sediments, but can also be used in atmospheric studies, since carbon dioxide is present in large quantities in the earth?s atmosphere. Tracing of14C and related stable isotopes such as carbon-13 (13C) and oxygen-18 (18O) in atmospheric carbon dioxide can be used to study interactions between oceanic, atmospheric, and terrestrial carbon reservoirs over time. Carbon dioxide is also an important greenhouse gas,

making the study of its movement over time all the more important to understanding its role in climate change.

Isotopes of hydrogen and oxygen can also be used to date and study the movements of water, since water is made up of these two elements. For example, by comparing the ratio of certain oxygen isotopes in shells found in marine sediments deposited on the ocean floor, it is possible to determine the temperature of the water over time, because the ratio is affected by temperature. Further, stable isotopes of 18O, 2H and 13CTDIC are also useful for identifying the presence of palaeo-waters and the source of Dissolved Inorganic Carbon (DIC) for radiocarbon correction modeling. Stable isotopes are used to reconstruct regional climate variation from records of isotopic composition of very old precipitation, preserved in high and low resolution environmental archives including speleothems (cave stalagmites) and groundwater.

One of the greatest sources of information on past climate comes from studies of polar ice caps and mountain glaciers. In such studies, cores are drilled through the ice down to bedrock. The isotope composition from this ice core can then be determined to estimate such things as temperature, precipitation rate, wind speed, and greenhouse gas concentration over extremely long periods, since the isotopes are frozen in the ice in a virtually timeless record. The ice-core records from the Greenland Ice Core Project in central Greenland often are used as reference standards for abrupt climate changes. These records provide annual resolution for some indicators through 110,000 years and provide an exceptionally clear picture of events in Greenland (temperature and accumulation), regionally (wind-blown sea salt and continental dust), and more broadly (trapped-gas records, especially of methane).

Therefore, study of environmental isotopes plays an important role in understanding past climate change. It is this understanding of changes in the past that holds the key to predicting future changes --changes that may not only influence global temperatures, but also energy needs, availability of drinking water, and adequate food supplies. So in this sense, isotopes are an invaluable tool to help scientists look back to the future and develop options to minimize the effects of changes to the global climate.