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Carbon isotope thermometer

Carbon occurs in three isotopic forms ^{12}C , ^{13}C and ^{14}C . The first two isotopes are stable whereas ^{14}C is radioactive and disintegrates over time and is used for what is called 'carbon dating'. The three isotopes react chemically in the same way, but because the atoms have different atomic weights (and even different sizes) they react at different rates. Thus different chemical and metastable processes change the ratios between the isotopes in characteristic ways.

Before nuclear weapons added large amounts of radioactive ^{14}C to the atmosphere, the average ratios of ^{12}C , ^{13}C and ^{14}C on the earth were approximately 100:1:1 $\times 10^{-12}$. Since ^{12}C and ^{13}C are stable, the world wide average ratio between them has remained unchanged over time. But it has been found to differ from one carbon-bearing material to another. For example, marine limestone when decomposed with acid generates carbon dioxide which contains more ^{13}C than does an equal volume of carbon dioxide obtained from burning wood. To specify the small differences in isotopic composition between such material, the ratio of ^{13}C to ^{12}C of a given sample is compared in a mass spectrometer with the $^{13}\text{C}/^{12}\text{C}$ ratio in an agreed sample. The difference between the sample and the standard is known as the relative ^{13}C content and is measured in parts per thousand (‰). Due to historical reasons the commonly agreed reference standard is derived from a piece of Cretaceous marine fossil *Bellmitella americana* from South Carolina (PDB) which is assigned a $\delta^{13}\text{C}$ value of zero; so that most natural materials have negative δ values. It must be remarked that this piece of standard carbonate (PDB) has long since

been used up. The current measurements are related to this mythical fossil through secondary standards prepared by the National Bureau of Standards, USA.

Many minerals are known to be isotopically homogeneous on scales exceeding several metres. There are others which are heterogeneous on a centimetre scale. Many crystalline minerals show 'zoning'. Since the rates of reaction for ^{13}C and ^{12}C are different, the rates change considerably with temperature (as the masses of the two isotopes are different). Hence by measuring the $^{13}\text{C}/^{12}\text{C}$ ratios it is possible to establish a carbon isotope geothermometer. This has been used with some success in the study of metamorphism of rocks and minerals.

The knowledge of grain-to-grain isotope composition is a criterion used to test the attainment of chemical equilibrium. Often there are cases when equilibrium is not attained and one has to resort to microscale determination of isotopic composition. The analysis of these ultrasmall samples is still done with conventional mass spectroscopy (although laser techniques and ion probe microanalysis which have great potential may replace the conventional mass spectrometer in due course).

On page 320 M. Santosh and H. Wada report results of zonation of graphite crystals by microscale determination of isotopic composition. These graphite crystals have been precipitated in a pegmatite dyke in Kerala. They use the thermodynamic concepts developed earlier that carbonic fluids entering reduced rocks must precipitate graphite on a quantitative basis until the oxygen fugacity of the rock is high enough to be in equilibrium with the CO_2 -rich fluid. They suggest that carbonic acid-rich fluid that infiltrates this segment has possibly

been derived from a homogeneous carbon reservoir in the subcontinental lithosphere.

Crystal to glass at high pressure

Amorphous solids are made mainly by cooling a liquid below its 'glass transition' temperature. The substance then does not crystallize. This method was discovered empirically by man before recorded history. By application of pressure, a new method of melting a solid (ice) below its glass transition temperature and thus forming a new kind of amorphous ice was discovered in 1984 at the National Research Council, Ottawa. Since then there has been a spate of investigation and almost three dozen substances have been shown to undergo the 'crystal-to-glass transition'. Glasses have been with us for more than 3500 years and they are less understood than most other solids. No wonder the exact molecular origins of crystal to glass transformation are still ill-understood.

On page 317 S. K. Sikka (who has done much work in high pressure transformation) and S. M. Sharma present a reasonable approach to this problem. High pressure tends to make structures close-packed. Amorphization is a competition between close packing and long-range order. This is a principle that the renowned Kitaigorodskii proposed to explain some aspects and anomalies in crystals forming from organic liquids.

The Tehri Dam

That the Himalayan region is a tectonically active zone, prone to continual seismic activity is well known. The magnitude of this can be seen rather vividly by looking at the cover page of the January 1992

issue of *Current Science*, which shows the epicentres of the earthquakes in this region. On page 289 is an article by one of our well-known geologists, K. S. Valdiya, questioning the wisdom of constructing high dams in this earthquake-prone region. He quotes chapter and verse to show that: (a) Earthquakes in this region are devastating and hence even one may prove of great danger to the dam itself and the people. (We are yet to recover from the effect of the 1991 October earthquake which killed more than 1000 people, destroyed and damaged almost 50,000 houses and rendered 300,000 people homeless.) (b) The environmental effect of such dams would be disastrous to that region. (c) The sociocultural effect of the Tehri Dam on the lives of the people in the command area would be extremely serious. (d) The planning for these exigencies has been insufficient.

Valdiya belongs to this region of India and actually lives there and hence is emotionally involved with the land and the well-being of its people. We feel that the powers that be must most carefully examine many of Valdiya's arguments and only then decide whether such undertakings as building high dams in these regions is at all worthwhile.

Pollutants as food for plants

As early as 1300, King Edward I is said to have issued a proclamation that anyone guilty of burning coal shall lose his head, because coal-ovens were choking up the London atmosphere. Accelerated by the industrial revolution in Britain, which, incidentally, rendered King Edward's proclamation useless, air pollution has been a major environmental problem.

The oxides of nitrogen (mainly nitric oxide and nitrogen dioxide) and ammonia are the major atmospheric pollutants, next only to sulphur dioxide. They arise through a variety of industrial activities that use nitric acid, from automobile exhausts, furnaces, etc. Further, microbial conversion of excess nitrogenous fertilizers is also known to contribute to the nitrogen pollution. Plant physiologists have been siezed with a particular dimension of this problem and that is—are these pollutants actually injurious to plant growth? Their concern is well taken from the face of the fact that first, nitrogen forms an important and major constituent of plant growth and second, plants (belonging to the family Leguminosae) absorb and assimilate the atmospheric nitrogen to good use.

H. S. Srivastava addresses some of these issues in his review (page 310). He highlights a few of the ways by which plants can mitigate the deleterious effects of nitrogenous pollutants in the atmosphere. An interesting revelation is that low levels of the nitrogenous pollutants can trigger their absorption and subsequent utilization, resulting in increased plant growth. However, beyond a threshold concentration of the pollutants, plants are unable to use the absorbed pollutants and may also succumb due to phytotoxicity. The latter may result from a series of physiological events ranging from inhibition of photosynthetic phosphorylation to increase in cell pH. He also discusses a serious problem associated with increased uptake of nitrogenous pollutants by forest trees, but which is not well recognized. Increase in cell nitrogen pool may lead to imbalances between the mineral elements within the plant, leading to impaired physiological states of the leaves, inhibition of epiphytic and microfloral growth on trees and finally to a greater vulnerability to pests and diseases. Clearly, more research is required to understand the constraints in the use of nitrogenous air pollutants by plants as additional nitrogen source.