

### III. GLOBAL GEOCHEMICAL PROBLEMS

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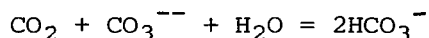
Many significant problems in geochemistry demand for their solution continuous and widespread measurements. Those of global concern involve the formulation of budgets for the elements or their compounds. Yet they become vexing due to inabilities up to the present to accumulate the data necessary for their consideration. Perhaps, inroads can be made using remote sensing techniques.

Foremost among these problems is the so-called "carbon cycle" which seeks a worldwide accounting of the compounds of carbon as well as those of calcium, strontium, magnesium, and other elements. The activities of human society are now altering the carbon cycle to such an extent that there may be serious implications for climate change and the consequential impacts upon living organisms. Two interrelated aspects of the carbon cycle may be amenable to solution with remote sensing techniques: the problem of carbon dioxide sinks and the areal extent of coral reefs.

The concentration of atmospheric carbon is increasing at a rate of about 1 percent per year from a preindustrial revolution value of 280 ppm. Today the value stands at 335 ppm. The increase is due to fossil fuel burning (coal, oil, and natural gas) and perhaps in part to the destruction of components of the terrestrial biosphere. Of the carbon dioxide introduced to the atmosphere from fossil fuel burning, it is estimated that about 50 percent has remained there; the rest is divided between the oceans (35 percent) and the terrestrial biosphere (15 percent) on the basis of model calculations.

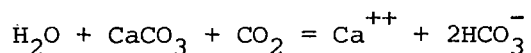
The possibility that the terrestrial biosphere is a source rather than a sink for atmospheric carbon dioxide has gained acceptance among many scientists. The practice of deforestation and the oxidation of soil organic matter may mobilize carbon dioxide in amounts similar to those resulting for fossil fuel burning. Thus, an additional demand may be placed upon the oceans to accept carbon dioxide.

The uptake process by marine surface waters, if equilibrium takes place, can be represented by the equation



The accommodation of carbon dioxide in the marine system would result in an increase in carbon dioxide and bicarbonate ion in surface waters, a decrease in carbonate ion, and no change in the carbonate alkalinity.

But such a reaction may be complexed by the interaction of the dissolved carbon dioxide with marine carbonates, namely,



If such a reaction takes place, there would be an increase in both carbonate alkalinity and in bicarbonate ion concentration.

For an assessment as to which, if either, of these two possibilities is important in the present day carbon cycle, we need to monitor globally the carbonate and bicarbonate concentrations in surface waters of the world ocean. Assuming equilibrium, a 10 percent increase in carbonate alkalinity would accompany a change of atmospheric carbon dioxide levels from 280 to 335 ppm, if dissolution of  $\text{CaCO}_3$  takes place. Such measurements would also provide an estimate of the degree of calcium carbonate saturation in surface waters. These studies should be complemented with investigations of the downward mixing of the surface waters and might be carried out simultaneously on a remote sensing vehicle.

Another potential sink for atmospheric carbon dioxide is incorporation into the biosphere which may be enlarged from increased carbon dioxide levels. Recent investigations suggest that the amount of industrially produced carbon dioxide in sedimentary matter is comparable to the amount of combustion carbon as yet unaccounted for. Thus, it is important to monitor the freshwater and oceanic biomass and associated dissolved organic carbon.

The urgency to ascertain the extent to which surface waters of the world ocean can accommodate carbon dioxide from the atmosphere relates to a prediction that an average  $2^\circ$  to  $3^\circ$  C temperature rise, with an  $8^\circ$  rise in high latitudes, will take place by 2050 with a doubling of atmospheric carbon dioxide levels. There would be a shifting of the Earth's climatic regimes and some melting of the ice-caps.

Finally, an assessment of the depositional rates of calcium carbonate in coastal marine zones is warranted. Of great importance in the marine carbon budget are coral reefs. They appear to accommodate an amount of carbon annually that is equal to the amount delivered by the rivers to the world ocean. The coral reef formations are substantially involved in the geochemical mass balances of strontium, magnesium, and fluoride, as well as other elements. If their overall net growth today is negative, they can provide a way to bring more carbon dioxide into the ocean system. There is an urgent need for an inventory of coral reef areas and types and the associated oceanographic climatic conditions. Satellite imagery and air photography would be employed. Parallel inquiries to published papers, atlases, and hydrographic charts would provide essential surface truth.

The atmospheric burdens of many heavy metals are poorly understood and their sources may be identified by remote sensing techniques. The relative enrichments of such elements as copper, zinc, silver, and chromium in the atmosphere over their values in crustal rocks appear to be nearly uniform over the Earth's surface although the concentrations of a given element may vary markedly from place to place. The elements enriched in the atmosphere are those that are volatile themselves or have volatile compounds. Conventional wisdom indicates

that these metals have natural, as opposed to anthropogenic, sources. Origins for them might be vegetation, volcanos, crustal rocks, the sea surface, or man's activities. Some of these metals may jeopardize the well being of living organisms if exposure levels are high. Thus, the determination of the relative contributions of natural and anthropogenic inputs to the atmospheric burdens of these metals can provide regulatory agencies with a scientific basis to evaluate potential hazards. Such data may be of interest to epidemiologists who seek relationships between the geographic occurrences of disease and environmental factors.

The measurement of fluxes from the Earth's solid and liquid surfaces is an extremely difficult task. Still, the recent developments through remote sensing in the measurement of wind velocities may provide a simple entry to the problem. If both the wind velocity and the atmospheric burden of a metal in an air column can be simultaneously measured, a flux can be obtained. Needed researches into the atmospheric heavy metal problem might be initiated in the laboratory and extended in the field with the aim of measuring heavy metal fluxes from forested and vegetated areas, from volcanos, from different types of crustal rocks, from soils, and from sea surfaces. In addition, where possible, the species of the metal involved should be sought for a better understanding of the atmospheric behavior of the element.

In both the carbon cycle and heavy metal fluxes problem, it is recognized that present day technologies are not as yet developed for immediate applications. Yet, it appears that such techniques as laser induced fluorescence and Raman backscatter remote sensors may be capable of solving these problems.