December 2011 Vol.56 No.35: 3741–3742
doi: 10.1007/s11434-011-9944-0

Foreword for the special topic "Geological Processes in Carbon Cycle"

Discussions of the relationship between global climate change and the increase in atmospheric greenhouse gas concentration have attracted public attention to the Earth's carbon cycle. The latter is defined as those processes of transformation and movement of carbon between lithosphere, hydrosphere, atmosphere and biosphere, in the form of CO_3 (mainly $CaCO_3$ and $MgCO_3$), HCO_3, CO_2, CH_4, and $(CH_2O)_n$ (organic carbon). On one hand, the carbon cycle can constrain a series of resource and environmental problems, such as agricultural, forestry and cement production, the formation, distribution and burning of fossil fuels, and the change in atmospheric CO_2 concentration. On the other hand, the cycle is controlled by a series of geological processes, such as weathering, transportation and sedimentation, earthquakes and volcanism. A better understanding of the rules and mechanisms of the global carbon cycle is an important scientific reinforcement for sustainable development.

Since the discovery of CO_2 in the 17th century, and of photosynthesis processes in 1799, the human quest for knowledge about the Earth's carbon cycle has been ongoing for about 400 years. In 1896, S. Arrhenius (1859–1927), a Swedish chemist, made numerical computations based on *in situ* infrared radiation measurements in different regions of the Earth with varying CO_2 and water vapor concentrations. He calculated that when the atmospheric CO_2 concentration is doubled, the mean air temperature of the Earth surface would rise 5–6°C; and when the atmospheric CO_2 is reduced by half, the mean air temperature would be lowered by 4°C. Moreover, if the atmospheric CO_2 concentration is zero, then the mean air temperature of the Earth surface would be lowered by 20°C. A hundred years ago, T.C. Chamberlin (1843–1928), an American geologist, put forward a hypothesis for the regulation of atmospheric CO_2 concentration by the interaction between exogenic and endogenic geological processes. These include crust uplift followed by the consumption of more CO_2 from the atmosphere by the intensification of weathering processes, the release of CO_2 into the atmosphere by volcanism and deposition of carbonate rocks in the sea, and the consumption of CO_2 from the atmosphere by fossil fuel deposition. Chamberlin believed such interactions responsible for the alternation of warm and cold periods in Earth's history, thus explaining the onsets and retreats of the Permian and Quaternary glaciations. But Chamberlin's hypothesis was ignored because of the general acceptance of the contemporaneous (1920) M. Milankovitch cyclic theory, which asserted that cold and warm cycles on the Earth's surface are mainly the result of variations in the Earth's orbital parameters. However, in the past two decades, resolution of past climatic change data has improved remarkably as a result of many new research technologies. It has been found that Milankovitch cycles cannot explain all the processes behind periodic climate changes; thus, attention has shifted to the Arrhenius effects and the impact of geological processes on the global carbon cycle.

Twenty-five years ago, the International Geosphere-Biosphere Programme (IGBP), initiated at the ICSU (International Council for Science), became interested in the carbon cycles of the terrestrial ecosystem, and the atmospheric and marine systems. Thus, corresponding major, multilateral cooperative projects were implemented, including the Global Change and Terrestrial Ecosystems project (GCTE), International Global Atmospheric Chemistry Project (IGAC), and Land-Ocean Interactions in the Coastal Zone project (LOICZ). Much scientific progress was achieved; however, geologic processes in the global carbon cycle were ignored because of limitations in the carbon cycle model of the time. This model took the geological processes to be pure inorganic processes, and their reaction rates were one to two orders of magnitude less than the carbon cycle in biological systems. Moreover, the stability of the carbon sink in geological processes was also in question. In 1995, at the IGBP Scientific Board meeting, a suggestion was made to enhance research on the carbon cycle in geological processes. Although this suggestion was included in the recommendations of the meeting's resolution, no substantial follow-up was made by the IGBP.

In recent years, fundamental and interdisciplinary research on the carbon cycle in geologic processes has made exciting progress. It has been found that the catalytic function of microbial carbonic anhydrase (CA) can increase the dissolution rate of CO_2 in water by an order of magnitude. It has also been found that the photosynthetic processes of aquatic algae and the catalysis of peptides on carbonate deposits can bind the carbon entering the hydrosphere. These findings have put forth possible answers to the two main questions regarding the importance of geological processes in the global carbon cycle, i.e. the roles of reaction rate and stability. Following this trend, understanding of the carbon cycle in Earth system science will improve; the carbon cycle model that separated inorganic and organic processes will give way to a more unified reaction process that will finally renew the carbon cycle model. The international carbon cycle community has enhanced research on geological processes in the global carbon cycle. Many relevant papers have been published. In China, the National Natural Science Foundation of China (NSFC), Ministry of Science and Technology (MOST), and Ministry of Land and Resources (MLR) have all increased funding in this direction. Relevant investigation, surveys, and research have been carried out. A monitoring network of geological processes of the carbon cycle that covers all of China is forthcoming. The amount of new data, discoveries, and assessments is growing. In this special topic, representative manuscripts treating carbon cycling in karst processes and the weathering of silicate rocks, the carbon sink in soil, and CO_2 outgassing from active tectonic zones, are selected to provide more information for those interested. Among these, evidence of the enhancing carbon sink in southwest China's rock desertification rehabilitation areas may provide scientific background for climate change mitigation measures in the country. There are 43 Chinese climate-change scientists working together with more than 700 international colleagues on the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, i.e. the IPCC-AR5. The outline of the report is now available. Chinese climate-change researchers are asked to publish their results in a timely and direct manner. This request deserves a positive response.

YUAN DaoXian

Institute of Karst Geology, Chinese Academy of Geological Sciences, Karst Dynamic Laboratory, Ministry of Land and Resources, Guilin 541004, China (*email: dxyuan@mail.karst.edu.cn*)