Preface[1]

In general, interfaces between the Earth's larger material reservoirs (i.e., the land, atmosphere, ocean, and sediments) are important in the control of the biogeochemical dynamics and cycling of the major bio-essential elements, including carbon (C), nitrogen (N), phosphorus (P), sulfur (S), and silicon (Si), found in organic matter and the inorganic skeletons, shells, and tests of benthic and marine organisms. These interfaces act as relatively rapid modifiers of storage, transport, and perturbation processes at geologically short time-scales. The continental margin constitutes an important interface between the land and the open ocean and includes the region between the land and the open ocean that is dominated by processes resulting from land–ocean margin and ocean margin–open ocean boundary interactions. This region includes the environments of the *proximal* estuaries, bays, lagoons, and banks, and the *distal* continental and island shelves, oceanic slopes, and adjacent marginal seas.

The surface area of the global continental margin is roughly equivalent to 21% of that of the total ocean if one includes the continental shelf, slope, and rise in the estimate (75.3×10^6 km^2). The area of the margin to the shelf–slope break is only about 24–29 $\times 10^6$ km^2 or about 7–8% of the surface area of the ocean. However, despite its relatively small size compared to the open ocean, the continental margin is an important interface between the land and the open ocean, and it is also in direct exchange with the atmosphere. Although the estimates are still controversial, continental margin environments may account for more than 20% of total marine productivity and a significantly higher amount of organic matter export production, and perhaps as much as 50% of the biological pump transfer of organic carbon to the deep ocean, and a minimum of 15% of the net air to sea CO_2 flux (Jahnke, Chap. 16). In addition, at least 80% of the mass of terrigenous materials reaching the ocean is deposited in continental margin environments, and 65% of total carbonate and more than 90% of total organic carbon accumulations in the ocean occur in continental margin sediment environments.

Large river drainage basins connect the vast interiors of continents with the continental margin through river and groundwater discharges. The ocean surface links the margin to the atmosphere via gas exchange at the air–sea interface, production of sea aerosols, and atmospheric deposition on the sea surface; substances released

[1] Some material for this preface was taken from Mackenzie et al. (2002) and Mackenzie and Lerman (2006).

at the air–sea interface of the continental margin may be subsequently transported through the atmosphere and deposited on land as wet and dry depositions; conversely, emissions from land to the atmosphere are in part deposited on the margin. Additionally, physical exchange processes at continental margin borders, involving, for example, coastal upwelling and onwelling and net advective transport of water, dissolved solids, and particles from the continental margin offshore, connect the margin with the surface, intermediate, and deep depths of the open ocean. Some materials biologically and inorganically produced in situ or delivered to the continental margin via river and groundwater discharges, upwelling, and atmospheric deposition may eventually accumulate in continental margin sediments. The processes of settling, deposition, resuspension, remineralization of organic matter, dissolution and precipitation of mineral phases, and accumulation of materials connect the water column and the sediments of the continental margin.

During the past several centuries, the activities of humankind have significantly modified the exchange of materials between the land, atmosphere, continental margins, and the open ocean on a global scale. Humans have become, along with natural processes, agents of environmental change, a geologic force in the system. For example, the oceans, which were a source of CO_2 to the atmosphere in late pre-industrial time, are now a sink, although the global proximal continental margin, strongly influenced by the high specific area CO_2 exchange fluxes of estuaries, still appears to be a source. This will change in the near future as atmospheric CO_2 levels continue to rise and global margin environments take up additional CO_2. During the 21st century, atmospheric CO_2 levels have been rising faster than during the later decades of the 20th century because of the worldwide increase in economic activity, and hence emissions of fossil fuel CO_2, and probably weakening of the natural CO_2 sinks. Owing to global warming, increased stratification of the oceans might be anticipated with poorly known effects on upwelling of deep water onto the continental margins. In addition, burning of fossil fuels and release of nitrogen and sulfur to the atmosphere and their fallout onto primarily continental margin surface waters are leading to acidification of these waters along with the acidification of the ocean as a whole due to the absorption of anthropogenic CO_2. In point of fact, the ocean in late pre-industrial time was a source of sulfur via atmospheric transport to the land but it is now a net sink of sulfur due to the burning of fossil fuels. The flux of nitrogen through the Earth's surface environment has doubled due to human activities. The acidification of the oceans will have a considerable effect on biological skeletal carbonate production and marine ecosystems in general. Despite the relatively small size of the global continental margin, environments, like coral reefs, represent a disproportionately large amount of this production, more than 30% of total benthic and pelagic calcium carbonate production in the ocean.

Furthermore, rapid population growth has occurred in coastal regions, with about 40% of the world population living within 100 km of the shoreline. The increasing population density in the areas of the major river drainage basins and close to oceanic coastlines, socio-economic development, and changes in land-use practices in past centuries have led to enhanced discharges of industrial, agricultural, and municipal wastes into continental margin waters via river and groundwater discharges and atmospheric transport, including carbon, nitrogen, and phosphorus loadings. Due to changes in global precipitation, evaporation patterns, and dam construction, material fluxes to the coastal ocean have been dramatically modified and will continue to be in the future as the climate changes and land-use changes, such as deforestation, continue to occur. This will have effects on the budgets and behavior of carbon, nitrogen, phosphorus, and silicon in continental margin environments.

Land-use activities have contributed to increased soil degradation and erosion, eutrophication of river and continental margin waters through additions of nitrogenous and phosphorus-bearing fertilizers to agricultural land and sewage discharges, degradation of water quality, and alteration of the coastal marine food web and community structure. It is estimated that only about 20% of the world's drainage basins have pristine water quality at present. In addition, rising sea levels will lead to flooding of low-lying coastal areas, like Bangladesh and Pacific atoll nations, movement of seawater farther up estuaries, and intrusion of seawater into groundwater reservoirs. It is thus understandable why the continental margin is regarded as both a filter and a trap for natural as well as anthropogenic materials transported from the continents to the open ocean. Estuarine and coastal regions showing much human-induced change are located, for example, along the coasts of the North Sea, the Baltic Sea, the Adriatic Sea, the East China Sea, and the east and south coasts of North America.

As demonstrated above, the continental margin is not only the oceanic region that is most susceptible to changes in water quality, organic productivity, and biodiversity but it also has been perturbed disproportionately more by human activities than the much larger area of the open ocean. However, and importantly to date, it has received far less attention and study in the context of the Earth's surface environmental biogeochemical system than the open ocean. This book will go a long way in rectifying that problem and draws our attention to consideration of the continental margin in a global context, including the important aspects of its exchange processes with the land, open ocean, and atmosphere. The book is an outgrowth of work done by scientists of the Continental Margins Task Team (CMTT), first established under the leadership of C.-T. A. Chen and Patrick Holligan in a meeting held in Taipei, Taiwan in 1992. The CMTT was co-sponsored by two core projects of the International Geosphere–Biosphere Program (IGBP): the Joint Global Ocean Flux Study (JGOFS) and the Land–Ocean Interactions in the Coastal Zone (LOICZ). In May 1999, a meeting of CMTT scientists was held in conjunction with the IGBP Congress in Shonan Village, Kanakawa, Japan. A result of this meeting, which led to preparation of this book, was a synthesis plan for the study of the continental margins in the context of their physical and biogeochemical dynamical processes and the role of the system in global change.

The book is divided into three parts plus references and appendices and consists of 16 chapters. In **Part I. Perspectives and Regional Syntheses**, a synthesis paper entitled *Biogeochemistry of continental margins in the global context* by Kon-Kee Liu, Larry Atkinson, Renato Quinones, and Liana Talaue-McManus sets the stage for the rest of the book. Under **Regional Syntheses**, the book deals with the various continental margin regions of eastern boundary currents, western boundary currents, Indian Ocean, subpolar, polar, marginal sea, and tropical margins. This main body of the book consists of 39 contributions written by experts who, generally, have personal experience with the physical and biogeochemical features of the regional continental margins under consideration. This section will constitute an important reference for those readers interested in the physical and biogeochemical behavior of regional continental margin ecosystems. **Part II. Arising Issues and New Approaches** contains four chapters dealing with the subjects of human impacts on the continental margin, silica and implications of its cycling for the global carbon cycle, submarine groundwater discharge and associated nutrient fluxes, and coupled circulation-biogeochemical models for the continental margin used to estimate carbon flux. The final four chapters constituting **Part III. Cross Boundary Fluxes and Global Synthesis** provide a global synthesis of what is known about cross boundary fluxes of carbon and nitrogen in marginal seas, carbon–nitrogen–phosphorus coupling in the coastal zone, sediment and carbon accumulation on the margins, and global synthesis of continental margin regions as used in the regional analysis of **Part I**.

It comes to mind that this book represents to some extent an outgrowth and very significant extension of the state of knowledge of continental margins in the global context as given in the 1991 volume *Ocean Margin Processes in Global Change* (Mantoura et al. 1991). At that time there was only a scant notion of the importance of continental margin processes in global change and certainly no global quantitative synthesis classification of continental margin regions. *Carbon and Nutrient Fluxes in Continental Margins: A Global Synthesis* provides the state of the art in the early 21st century in terms of how far we have come from the Mantoura et al. volume. However, it also shows how little we know and how far we have to go to obtain a fundamental understanding of the behavior of the continental margin in the Earth system. This understanding is necessary to predict the changes that continental margin environments will undergo in the future, as the system is continuously perturbed by the activities of humankind. In addition, increased knowledge is needed to predict the positive and negative feedbacks that the margin system will experience and their impact on the adjoining reservoirs of land, atmosphere, and open ocean. I would also hope that the information provided in this book would encourage the modeling community to use this synthesis to construct the spatial and temporal scale continental margin physical–biogeochemical models that will be necessary to predict the inevitable changes that will take place in this critical interface influenced by global warming and human activities.

Honolulu, HI, USA — Fred T. Mackenzie

References

Mackenzie FT, Ver LM, Lerman A (2002) Coastal-zone biogeochemical dynamics under global warming. In: Ernst WG (ed) Frontiers in geochemistry: organic, solution, and ore deposit geochemistry. Bellwether Publishing Ltd, Columbia, Maryland, USA, pp 27–40.

Mackenzie FT, Lerman A (2006) Carbon on the geobiosphere–earth's outer shell. Springer, Dordrecht, The Netherlands.

Mantoura RFC, Martin J-M, Wollast R (ed) (1991) Ocean margin processes in global change. Wiley, Chichester, England.

http://www.springer.com/978-3-540-92734-1

Carbon and Nutrient Fluxes in Continental Margins
A Global Synthesis
Liu, K.-K.; Atkinson, L.; Quinones, R.; Talaue-McManus, L.
(Eds.)
2010, XXVIII, 741 p., Hardcover
ISBN: 978-3-540-92734-1