Building Planet Earth: Five Billion Years of Earth History, Peter J. Cattermole, 2000, Cambridge University Press, Cambridge, 283 p. (Hardcover $39.95) ISBN: 0-521-58278-4.

Recent years have witnessed the revision of several historical geology texts to accommodate advances in the field, as well as the changing demands of students and their professors. With these new and revised additions, one would think choosing a text to suit one's particular taste would be easy; however it is not, and the addition of *Building Planet Earth* by Peter Cattermole to this list will not make it any easier as it fell quite short of my initially high expectations.

This book is essentially a revision of an earlier one co-authored with Patrick Moore, entitled *The Story of the Earth* (also published by Cambridge). The revised text does have some welcome additions, most notably in format and in quality of many of the illustrations. The book is written as a sequential story of Earth's history and is organized into four parts: (1) Beginnings, (2) The Earth's heat engine, (3) Patterns of Earth history, and (4) Gondwanaland and more recent events.

The first part of the text, Beginnings, discusses the origin of the solar system and that of Earth, its atmosphere and oceans. It provides a very clear account of a variety of introductory topics including the nebular hypothesis, the origin of the moon, the composition and significance of meteorites, a few general geologic principles, and the historical foundation of geology as a science. Also included in this section is a discussion of the nature of the fossil record and the methods of gathering and using geophysical and geochemical data.

The second section of the book, The Earth's Heat Engine, deals with the composition, mechanics, and processes of Earth's interior. A large part of this section is devoted to volcanic processes and their various manifestations in the geologic record. The section on minerals is very short and there is virtually nothing on rocks (or the rock cycle for that matter)—topics that would have fit in nicely here.

Chapters 10 and 11 of the book's third section, Patterns of Earth History, discuss absolute and relative dating followed by a chapter on geological cycles that provides the foundation for orogenic episodes of subsequent chapters. Unfortunately, Chapter 10 provides very little information on stratigraphy, stratigraphic principles, or depositional environments, essential topics in a text like this.

The latter half of the third and fourth parts of the book are essentially a "trip through geologic time." These two parts (especially Chapters 12 through 25) contain an account of ancient distributions of land and sea, tectonic events, sedimentary cycles, and a limited discussion on the faunas and floras of the various time periods. The chapters and subheadings generally are presented in terms of geography (e.g., Antarctica), or geo-tectonic features (e.g., Hercynian mobile belt) and, for the most part, are dealt with in temporal succession.

A serious deficiency in this text is the scant attention that is given to ancient life and the evolutionary and ecological processes that have shaped it. For example, Paleozoic life is only brought up under the topic of Gondwanaland and contains about only one page for plants and one for marine animals. Likewise, the discussion on Mesozoic life is only two pages long and is mostly a discussion about dinosaurs, without any mention of other terrestrial vertebrates or any marine invertebrates. Even the dinosaur discussion is overly simplified considering the breadth and depth of knowledge on the subject. There are also some glaring errors regarding various fossil organisms. For example, in the discussion on relative dating, Cattermole (p. 88) refers to stromatolites as "colonial animals", whereas in his discussion on the origin of life, he states (p. 104) that stromatolites "unquestionably are plants." He likewise mentions (p. 186) some "marine" dinosaurs when I can only assume he is referring to some euryapsid reptile such as ichthyosaurs.

While I understand the emphasis on European geology, I found some of the detailed chapters lacking in their coverage of important North American geology. Chapter 15 on the Appalachian Story is very brief and not congruent with conventional terminology. For example, Cattermole's uses (p. 144) the term "Alleghenian" for mountain building events that took place between 500–400 m.y.; these events would normally be referred to as the Ordovician Taconic Orogeny (as Cattermole later does on the same and subsequent pages). He seems to have missed, altogether, Devonian events in the Appalachian region normally referred to as the Acadian Orogeny. In a related vein, I was somewhat confused by the author's usage of the term Pangaea for a possible late Proterozoic supercontinent (in addition to the Late Paleozoic-Early Mesozoic land mass).

One of the strong points of the book is Cattermole's pleasant narrative style of writing. This style is in welcome contrast to the often dry list of facts presented in many other text books. The drawback of this style is that it is often difficult to find specific information without constantly referring to the index.

On average, the book is very well illustrated. It is evident that considerable effort went into improving the quantity and quality of illustrations from the earlier edition with Patrick Moore (with some notable exceptions such as the aerial view of the Alps on p. 178, or the poorly drawn diagram of the atomic structure of silicate minerals on p. 60). This brings me to another point: the figures are not at all numbered or identified. As such, they are not referred to in the text and it would be very difficult to refer students to them for study.

To be truly useful as an introductory college text, the book could benefit from chapter summaries or key points to keep the students on task. Additionally, the layout of the book is only somewhat linear and, in places, headings are confusing. Resources to accompany this book include a table on planetary data (e.g., distance from sun, rotation period, and mass, etc.), a chart on the history of life, a two and one-half-page glossary, and a two page annotated bibliography that includes a short list of web sites. The index is relatively comprehensive and proved to be valuable when searching for specific information.

Building Planet Earth is, on the whole, an adequate survey of Earth's non-organic history and the processes that have shaped it. It is worth the modest price and may possibly be suitable for your bookshelf or for introductory courses that focus on the more physical aspects of the planet; yet, if you plan on giving the history of life equal time, I recommend you look elsewhere. As a historical geology textbook there are some clear alternatives that have formats and resources more akin to a college text such as the excellent text by Stanley's *Earth System History* (Freeman), perhaps Levin's *The Earth Through Time* (Saunders), or Wicander and Monroe's *Historical Geology* (Brooks/Cole).

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The Carbon Cycle, T.M.L. Wigley and D.S. Schimel (Editors), 2000, Cambridge University Press, Cambridge, 292 p. (Hardcover $64.95) ISBN: 0-521-58337-3.

Carbon dioxide is one of the most potent greenhouse gases that have been released in increasing amounts by human activity since the beginning of the Industrial Revolution in the early 19th century. An exponential rise in atmospheric CO_2 concentrations over the same period has been attributed to industrial activity. A number of international scientific programs have been developed in order to address two crucial topics regarding the possible influence of this rise on global climate. These topics include (1) the extent to which anthropogenic perturbations influence biogeochemical cycles and (2) the sensitivity of Earth's climate to variations in atmospheric CO_2. Elucidation of these issues requires understanding of the mechanisms that control interaction among carbon reservoirs, regulate atmospheric CO_2, and dictate the influence of the carbon cycle on other biogeochemical cycles (Falkowski et al., 2000). Annual meetings of the Global Change Institute (GCI) provide an opportunity for interdisciplinary communication among scientists to address these topics. The present volume is a compilation of papers contributed by the participants of the sixth annual Global Change Institute (GCI), which was held in 1993 in Snowmass, Colorado. The book is divided into three main sections that cover the missing carbon sink, past records of CO_2 levels, and modeling strategies. The volume is introduced by two excerpts from

the 1994 and 1995 Intergovernmental Panel on Climate Change (IPCC) reports, which cover a brief description of the carbon cycle, past records of atmospheric CO_2, the anthropogenic carbon budget, the influence of climate and other feedbacks on the carbon cycle, as well as modeling of future concentrations of atmospheric CO_2.

The first part of the book deals with the missing carbon sink. Early studies of atmospheric CO_2 revealed an imbalance among the primary sources of CO_2, the ocean sink, and the rate of atmospheric buildup. An additional sink ($\sim$ 1 to 3 GtC/yr) is required to balance the CO_2 budget. Terrestrial processes, primarily the CO_2 fertilization effect of land photosynthesis, are usually invoked to explain the discrepancy. The papers compiled in this part of the book address the major uncertainties of the fertilization effect and of other components of the atmospheric CO_2 budget.

Contributions by Andres et al. and Houghton cover the studies concerning CO_2 emissions from fossil fuel consumption, cement manufacture, and changes in land use due to agricultural expansion and extensive logging. Based on an extensive time series analysis (from 1751 to 1991) of the latitudinal distribution of carbon emissions, Andres et al., identified a southward shift in CO_2 emissions from European-North American latitudes towards Central-Southeast Asian latitudes. After reexamining the isotopic composition of CO_2 emissions, the authors also concluded that the emissions of the past two decades were approximately 1% lighter than previous estimates. This was attributed to changes in the type and sources of fossil fuels. Houghton reports the results of land-use analysis, which show that terrestrial ecosystems were a net source of carbon to the atmosphere over the period from 1850 to 1990. He estimates a net release of 120 Pg C over this period. In 1990, the net release from changes in land use was roughly 1.7 Pg C, which was higher than estimates obtained from analyses of data from forest inventories and from inverse calculations using geochemical data.

The next several chapters address the CO_2 fertilization effect on vegetation growth in terrestrial ecosystems. Gifford et al. briefly explain the mechanism of CO_2 fertilization and the interaction of CO_2 with other growth-determining factors. The authors also discuss the potential magnitude of the influence of CO_2 fertilization on the global C cycle. The effect can account for the missing carbon sink, which is approximately 1 to 2 GtC/yr. The authors also address the fact that the growth of tree rings apparently does not record changes in C storage. Apparently, only a 0.07% /yr (or less) increase in ring width would be evidence for the missing C sink; hence, the effect may be hardly measurable. The paper by Schlesinger et al. is short but informative. The main point of this contribution is that the soil carbon pool does not appear to contain the missing sink. On the contrary, large amounts of CO_2 are likely to be lost from soils, thus amplifying the greenhouse warming of the atmosphere. Hall et al. discuss the effects of climate change on grasslands worldwide. The possible influence of climate change on the grassland carbon budget has not attracted much attention previously. According to Hall et al., model simulations (using a general model called the Century) suggest that changes in atmospheric CO_2 will lead to little additional carbon storage. This low level of sequestration is projected to take place in certain tropical savannas where changes in climate will not result in restricted primary production or accelerated decomposition.

Chapters 8 and 9 address the use of inverse modeling to determine the magnitudes of sources and sinks from atmospheric concentrations. Enting addresses the problems related to this approach (especially on the global scale), and reviews various techniques to solve these problems. Special attention was given to Bayesian analysis, which can estimate the degree of uncertainty of the deduced sources. Fung and Takahashi evaluate the factors that contribute to uncertainties ($\sim$ 0.8 μatm) in the estimated air-sea CO_2 fluxes. To alleviate these uncertainties, the authors suggest developing a special program to measure pCO_2 variations in time and space, particularly over large areas of southern oceans. In addition, they propose measuring high-frequency fluctuations in pCO_2 in the surface waters, covariance between high-frequency fluctuations in wind and pCO_2, variations of temperature and pCO_2 within the ocean boundary layer, and the dependence of gas exchange coefficient on the height and depth of pCO_2 measured.

It is surprising that the topic of paleo-CO_2 variations is covered by such a brief section. The second part of the book, which deals with this issue, has only two chapters devoted to various applications of carbon isotope (^{13}C and ^{14}C) records and the effect of shallow-water carbonate deposition on the carbon cycle. Future meetings of the Global Change Institute should consider important advances made in this area during recent years, particularly in the fields of glaciology and organic geochemistry (e.g., Pagani et al., 1999; Petit et al., 1999).

The third part of the book contains eight chapters concerning modeling of CO_2 changes. Both oceanic and terrestrial carbon pools are given considerable attention. This section begins with a paper by Edmonds et al. who provide a literature survey regarding potential future CO_2 emissions, in the absence of control policies. This is an interesting chapter that could be useful not only for climate scientists but also politicians, businessmen, and the general public. Long-term projections of global and regional fossil fuel CO_2 emissions as well as associated energy production and consumption, are considered. Emission trajectories vary significantly based on differing combinations of key assumptions. According to the authors, the range of realistic assumptions is sufficient to result in a very broad range of CO_2 emissions by the year 2100. The importance of reforestation in reducing buildup of atmospheric CO_2 is considered by Marland. His main conclusion is that in spite of a wide range of possible strategies for using forest land to alleviate the buildup of CO_2, the most likely future strategy will be "sustainable and efficient use of forest products rather than long-term accumulation of carbon." Box models of ocean and terrestrial carbon cycles follow this discussion.

Caldeira et al. describe a simple ocean-carbon cycle model that simulates the interaction between atmospheric and oceanic carbon reservoirs. Specifically, the authors use a two-box ocean model to illustrate principles of constructing simple ocean-carbon cycle models, describe different varieties of these models, and compare their results. According to Caldeira and his coworkers, well-calibrated simple oceanic models may yield CO_2 adsorption predictions that are more reliable than more complex ocean general circulation models. This assertion is predicated on the fact that simple ocean models are calibrated using carbon isotopes, which are distributed by the same mechanisms as the anthropogenically produced CO_2. In the next chapter, Keir reviews the effects of ocean circulation on steady-state atmospheric CO_2 in application of ocean models dealing with glacial climates. The main conclusion of this work is that changes in ocean circulation could result in four effects, including changes in deep ocean CO_3^{2-} concentration, in the ratio of organic C to $CaCO_3$ production, and in the shape of the vertical gradient of dissolved CO_3^{2-}. In addition, changes in the thermohaline circulation may alter primary production and air-sea exchange in high-latitude deep water, thus altering atmospheric CO_2 through solubility and biological pumps. The application of box models to simulate the interaction of atmospheric CO_2 and the terrestrial biosphere is addressed by Harvey. The mechanisms of various vegetation-climate feedbacks are identified. The author concludes that simple box models of the terrestrial biosphere provide a wide range of useful information and are suitable for coupling with simple models of the complete carbon cycle.

The volume concludes with a chapter that addresses stabilization of CO_2 concentration levels. Wigley describes the methods for constructing profiles that stabilize atmospheric CO_2 concentrations at various levels. The author also explains the inverse carbon-cycle modeling procedure for calculating the emissions that result in these profiles. Wigley considered two different pathways towards each stabilization level. The conclusion is that in spite of the fact that emission requirements vary significantly according to the pathway, CO_2 emissions must eventually drop well below present levels to achieve and sustain stable concentrations.

Overall, this book is a good reference for Earth scientists dealing with global biogeochemical cycles and climate change. Each chapter contains an extensive number of figures and tables that help convey the main point of the article. In addition, each paper provides a large list of references. Undergraduate as well as graduate students will find it useful for becoming aquatinted with specific research efforts that address the global carbon cycle. The book, however, will have to be supplemented by more recent studies in the field (e.g., Bousquet et al., 2000; Falkowski et al., 2000; Sigman and Boyle, 2000, and references therein), as the material in this book is slightly outdated; in spite of its recent publication, the contributed papers date from 1993.

I do not recommend this volume as a textbook. Most of the papers in

this volume assume an extensive knowledge of the subject matter prior to reading. In addition, the cost of the book does not make it attractive for personal ownership. The most appropriate place for this book is an academic or public library.

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Cladistic Biogeography, 2nd Edition: Interpreting Patterns of Plant and Animal Distributions,

Christopher J. Humphries and Lynne R. Parenti, 1999, Oxford University Press, Oxford, 187 p. (Hardcover $65.00) ISBN: 0-19-854818-4.

Four chapters, each written as a separate paper with introduction: (I) Historical Biogeography, (II) Methodological Developments, (III) The Real World, and (IV) A New View of the World.

This book is an excellent introduction for the student who wishes to embark on the rather arduous trail of what has become of modern biogeography The authors have produced a fairly comprehensive, yet readable coverage of the various aspects of cladistic biogeography as it is now practiced. The historical perspective on the contributions of authors such as Croizat, Nelson, Platnick, Rosen, Wiley and others provides a very useful chronicle, and source of entry, for the early and seminal works on modern historical biogeography. From the practical side, the authors have utilized real-world examples, both with previously published analyses and new analyses, to illustrate methods and principles, and presented some far-reaching hypotheses based on these examples—actually points of departure for future biogeographic analyses. The examples include both plants and animals, and where available, these have been updated with new information since the first edition. These updates definitely enhance the value of this new version. This clearly is not just a superficial review of previous work, but an effort to critically evaluate and augment those results with further analyses, and place all in a larger context. From this standpoint, the book has a strong practical and experimental value that often is lacking in similar treatments.

The authors provide a strong and fairly concise description of the theory and goals of vicariance biogeography—and in both theoretical and practical terms, what information is being extracted from cladograms and how it might be interpreted in terms of distributions of taxa. This aspect of the book, in combination with the real examples, is its greatest strength and makes it an essential reading for both advanced and beginning students of the subject. The greatest difficulty, not solved by this book, is for the student to sift through the various possible approaches to cladistic biogeography and determine what might be the best approach for a particular study. In their chapter 3—"The Real World"—Humphries and Ladiges examine patterns of area cladograms, utilizing various computer programs including CAFCA, COMPONENT, and TASS. Comparisons are made between the results of these analyses, yet there is no obvious conclusion regarding which method is best, either from a theoretical or practical standpoint. This is understandable in light of the complexity and controversy surrounding the various possible methods (e.g., component analysis, or three-item analysis). When contrasted with the area of phylogenetics systematics, where a strong consensus has emerged regarding the use of parsimony, historical biogeography appears to still be in its infancy in terms of theoretical development. Although united in the general theory (plant and animal distributions reflect common causes, and cladograms provide the means of corroborating common distributions), there is as yet no single obvious way to get from theory to precise and agreed upon interpretation of patterns. It remains to be seen if a consensus can emerge among historical biogeographers to the extent that a single unifying methodology will predominate. In the meantime, this book is an important contribution, and an excellent starting point for anyone interested in delving further into the sometimes inaccessible and daunting world of historical biogeography.

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