

BOOK REVIEW

Review of *Paleoclimates. Understanding climate change past and present*, by Thomas M. Cronin (2010). New York: Columbia University Press. 441 pp. ISBN 978-0-231-14494-0.

A strong demand for a better understanding of past climate changes and their controls becomes evident when looking at the anthropogenically accelerated rapid warming during the past few centuries. In his book *Paleoclimates*, Thomas Cronin provides an excellent review and stimulating discussion of the state of art and current hot topics in this socio-economically important discipline to the scientific community of palaeoclimate researchers and students in this field.

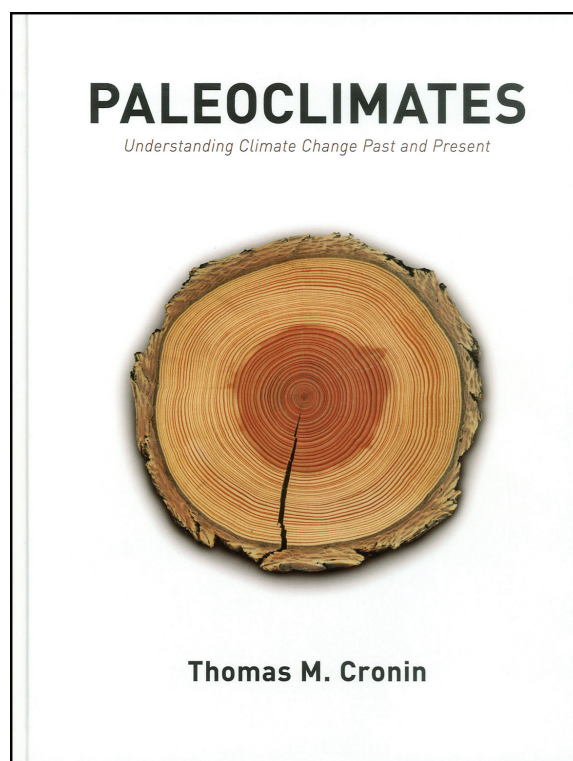
The first two introductory chapters inform the reader about basic processes, causes, controls and feedback mechanisms of the climate system; introduce the main archives of past climate change; and describe and evaluate the broad spectrum of methodological approaches and proxies used in climate research. In addition, these chapters provide first insights into the basics and developments of modelling concepts.

The following 10 chapters portray the evolution of past climates during the history of the Earth. The state of knowledge, or the lack thereof, regarding this extraordinarily long period is reflected by the number and volume of the chapters dedicated to certain periods. Chapter 3 deals with the very lengthy period from the Neoproterozoic to the Cretaceous. Emphasis here is on spectacular and extreme climates, like "Snowball Earth," or Mesozoic case studies of conditions with no modern analogue such as the Jurassic and Cretaceous anoxic events and the prolonged intervals of greenhouse climates during the Mesozoic. In the focus of discussion are long-term trends and the interpretation of particular proxy records, like the Phanerozoic oxygen and strontium isotope curves, in addition to various attempts to reconstruct and model Phanerozoic CO₂ levels and global sea-level fluctuations.

Chapter 4 is dedicated to the Cenozoic climate evolution, characterized by a stepwise global cooling that finally culminated in glacial build-up of extensive polar and mid-latitude ice sheets during the last half million years. The reader is supplied with useful information about special ocean drilling programmes dedicated to the study of Cenozoic climate evolution. In addition, the use

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of trace elements, radiogenic tracers and various proxies to reconstruct palaeo-CO₂ levels is reviewed. Subsequently, Cronin instructively addresses the revolutionary changes in plate tectonic constellations, gateway configurations and the uplift of huge mountain ranges and plateaus on the continents. In the context of these changes the author reviews the thresholds that were crossed in surface- and deep-ocean circulation, continental weathering, as well as biochemical and atmospheric cycling during Cenozoic time. A critical evaluation of the different, and often contradictory, reconstructions and models concerning controls and triggers for prominent Cenozoic climate shifts and gateway configurations provides the reader with a useful guideline for navigating through conflicting evidence published in the literature. Particular emphasis is on discussing four Cenozoic hyperthermal periods and their possible causes: (1) the Paleocene–Eocene Thermal Maximum, characterized by a distinct carbon isotopic anomaly and global warmth; (2) the Eocene–Oligocene Transition, marking a major step from global greenhouse into the icehouse world; (3) the mid-Miocene Climatic Optimum, abruptly shifting to global cooling at its end (the Monterey hypothesis explains this shift by CO₂ drawdown induced by

extensive burial of organic carbon); and (4) the mid-Pliocene Thermal Optimum, which was associated with prominent shifts at the Indonesian and Central American gateways, changes in high-latitude Southern Ocean circulation and modestly high CO₂ concentrations. Discussing controls and mechanisms of these different Cenozoic extreme warm periods, Cronin shows interesting and stimulating comparisons and implications to the current anthropogenically accelerated rapid warming.

The main part of Cronin's book—chapters 5 to 12—chronologically covers Quaternary and Holocene climates, emphasizing the main focus of climate research during the past decades. Furthermore, in contrast to the previous periods, the scales of the climate records have changed considerably. Starting with orbital time scales, the resolution in many marine records is now on a suborbital scale. High (millennial) to ultra-high (centennials to decades) resolution records are available now from many regions of global ocean basins. Many terrestrial records (derived from varves in lakes, tree rings and ice core records) and also some exceptional marine settings (proxies measured in corals and long-lived bivalves) often allow for the continuous monitoring of annual signals. This significant increase in resolution has enabled a much better cooperation of climate modelers and data producers. Examples of such successful collaborations are presented in the book.

Records of glacial (chapter 6) and deglacial (chapter 7) millennial climate change such as Dansgaard–Oeschger cycles and Heinrich events are presented in context of their global significance, controls, feedbacks and interaction between atmospheric and oceanic circulation patterns. Cronin has compiled useful and concise tables displaying the event stratigraphy and important case studies during the Last Glacial Maximum and the timing of deglaciation. This provides the reader with an important tool to travel through the thicket of abbreviations extensively used by specialists in this discipline. The citations of case studies from various regions in the oceans and the correlation to land records appear in my opinion to be adequate. However, one can always debate the selection of references. Altogether, the reader is supplied with a concise picture of the state of the art and the relevant models and theories under discussion. The final chapters discuss Holocene climates (chapter 8), abrupt climate changes (chapter 9), internal modes of climate variability (chapter 10) and anthropogenic climate change (chapters 11 and 12); that is, the past 2000 years or so. These chapters provide a thorough, encyclopaedic review on the causes and processes of important internal modes in the climate system such as the El-Niño–Southern

Oscillation, the Pacific Decadal Oscillation, the Atlantic Multidecadal Oscillation, the North Atlantic Oscillation and the Arctic Oscillation, to mention only some systems amongst many others. Cronin evaluates excellently the data basis of these modes, comparing atmospheric, terrestrial and marine records with results from climate models. In each of the chapters mentioned above, he addresses the main trends in the evolution and history of these prominent climate modes and highlights the implications assessing future climates. At the end of each chapter, recommendations and perspectives for future research are given.

In the chapter on Holocene climate, Cronin draws a clear picture of high climate variability recorded from various terrestrial and marine archives. Consistently, most records reveal the Holocene Thermal Optimum (11.5–5 Kya), the Little Ice Age (15–19th centuries) and the Medieval Warm Period (9–15th centuries). However, since the amplitude changes in many proxy records are rather small and, in addition, may display significant regional and inter-hemispherical variations, the signal-to-noise ratio is relatively small, posing unique problems for straightforward interpretations. Nevertheless, Cronin's up-to-date compilation of increasingly compelling evidence from the different Holocene climate archives provides the reader with some clear trends recognized for evolutionary patterns of monsoon systems, migration of the Intertropical Convergence Zone, the Holocene sea level and deep ocean circulation. Causes for this variability by orbital variations, solar irradiance and greenhouse gases are discussed in the context of their relevance for assessing future climate evolution. Particular emphasis is put on the serious problem of distinguishing between natural trends and anthropogenic changes during the past 2000 years.

In summary, Cronin's *Paleoclimate* fills a gap on the market of palaeoceanography and palaeoclimate textbooks. It provides an excellent up-to-date evaluation of current results and interpretation achieved by the different disciplines contributing to palaeoclimate research including atmospheric and oceanographic sciences, glaciology, geology, palaeoceanography and climate modeling. Covering an enormously broad scope of disciplines, the book provides a general background on natural climate variability and highlights facts that need to be considered in the discussion about the anthropogenic contribution to climate change and the evolution of future climates. It brings the reader to the state of art in climate research. I strongly recommend Cronin's book as an indispensable reference for palaeoclimate researchers and students in this field.