A story about the evolution of life and changing levels of oxygen on Earth

Out of Thin Air: Dinosaurs, Birds and Earth's Atmosphere
Peter D. Ward
Joseph Henry Press, Washington, D.C., 2006

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This book is a free-flowing, imaginative outline of how Earth's supposedly changing oxygen levels had affected (even governed) the evolution and extinction of living things in Earth's history—as interpreted by uniformitarianism. Ironically, the "out of thin air" in the title may apply in a manner that the author had not intended. Since this book is now several years old, and requires some background knowledge of computer-derived geochemical modelling, I intro duce some more recent, and supplementary, information into this review.

For purposes of this review, I treat the geologic periods, and the purported evolutionary events during those periods, as if they were real. I provide a synopsis of these events, and finally examine the geochemical modelling used to deduce the supposed changes in the oxygen content of the earth's atmosphere in the distant past.

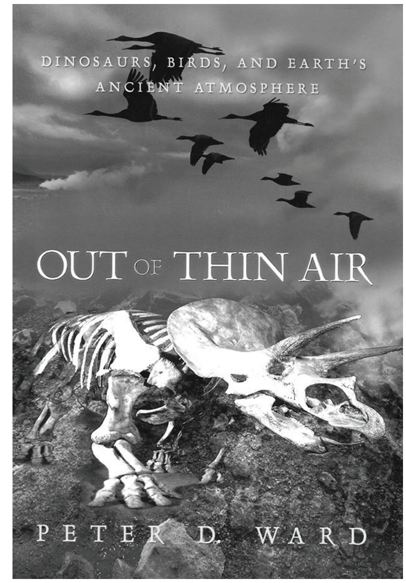
The author realizes that past O_2 levels, contrary to earlier beliefs, can not be directly measured (as by air bubbles trapped in amber: p. 37). Instead, he relies on GEOCARBSULF, a computer program—developed by Robert Berner and colleagues—that models the earth geologically and geochemically in order to arrive at estimates of past atmospheric oxygen levels. Using some recently published scientific material, I elaborate on some of the questionable features of this kind of modelling in the latter part of this review.

Speculative evolutionary hypotheses

The reader should be aware, before reading any further, that the biological interpretations presented in this book are highly conjectural. Author Peter D. Ward admits as much:

> "It will be up to scientists to see how many of these new hypotheses offered in this radical revision of Earth's history are accepted. If even a few are ultimately accepted, it will mean that we will have to revise our understanding of the *whys* in the history of life. If oxygen has varied through time along the lines that Robert Berner and others suggest, it seems highly likely that organisms would adapt in varied ways to these different conditions [emphasis in original]" (pp. 234–235).

The author speculates that the origin of tetrapods was related to changes in oxygen, and uses the word scenario to describe the effects of the Devonian high-oxygen peak (p. 102). His choice of words is excellent. Ward then relies on a 'molecular clock' to deduce when the lung fish and primitive amphibians had separated, but acknowledges that there is no direct evidence for any role of atmospheric oxygen levels:



> "And just how terrestrial *were* those first tetrapods? Could they walk on land? More importantly, could they breathe in air without the help of water-breathing gills as well? Both genetic information and the fossil record are of use here. But in some ways we are very hampered. Not until we somehow find the earliest tetrapods with fossil soft parts preserved will we be able to answer the respiration question [emphasis in original]" (p. 100).

Atmospheric O_2 levels—an all-purpose explanation

The author 'reads' virtually the entire evolutionary history of Phanerozoic life through the 'lens' of inferred changes in atmospheric oxygen. Owing to the fact that he presents so many topics, I can only focus on a few of them.

Ward contends that major extinctions are governed by low atmospheric oxygen levels. However, as if to cover all bases, he also suggests that extinctions can be driven not so much by the low levels of atmospheric oxygen, but by *changes* in atmospheric oxygen (p. 49). He relies on this seesaw many times in this book.

The relative shortage of oxygen, as during the Early Cambrian and the Early Triassic, is supposed to have created selective pressures that led to evolutionary novelty, such as the Cambrian explosion and the appearance of dinosaurs. This, to begin with, assumes that environmental stressors are what drives evolutionary novelty. What if, instead, environmental stressors tend to inhibit evolution? What if, more fundamentally, evolutionary novelty is driven more by the kinds of mutations that occur than by the kinds and/or severity of environmental stressors?

Interestingly, the relative shortage or abundance of atmospheric oxygen can lead to diametrically opposite conclusions as to its purported evolutionary impact. Thus, Ward believes that the pneumatic bones in saurischian ('lizard-hipped') dinosaurs, such as *T. rex* and *Brachiosaurus*, were an adaptation to the low atmospheric levels of oxygen at the time that these dinosaurs originated (p. 180; the ornithischian ('bird-hipped' dinosaurs show no evidence of pneumaticity)). However, Robber Bakker, another iconoclastic dinosaur scientist, had earlier suggested that pneumatic bones were an adaptation to, or at least a feature strongly consistent with, *high* atmospheric oxygen levels (p. 176).

The extant *Nautilus* serves as a model for the extinct ammonoids. It lives in highly oxygenated waters. Perhaps ironically, the cephalopod conch is believed by Ward to have been a superb adaptation to the low oxygen levels of an earlier time (p. 217).

The Carboniferous—implications of high oxygen levels

One of the most dramatic features of the 'oxygen curve', as deduced from computer modelling, is the 'hump' in atmospheric oxygen at the time of the Carboniferous. By some estimates, atmospheric oxygen could have been as high as 35%—nearly double that of today.

The author notes that one of the most important determinants of relative oxygen concentration in the atmosphere is the amount of reduced carbon, from dead plants and animals, available to react with the oxygen (p. 37). One of the main 'forcings' modelled by GEOCARBSULF is that caused by the inferred burial rates of organic carbon (p. 38). When it comes to the inferred peak of atmospheric oxygen during the Carboniferous, Ward comments:

> "When a great deal of organic matter is buried, oxygen levels go up. If this is true, it must mean that the Carboniferous period, the time of Earth's highest oxygen content, must have been a time of rapid burial of large volumes of carbon and pyrite, and evidence from the stratigraphic record confirms that this indeed happened—through the formation of coal deposits" (p. 116).

The potential for circular reasoning is obvious. The high Carboniferous levels of atmospheric oxygen are, at least in part, inferred from the large amounts of organic carbon sequestered in coal. Then we are told that the large amounts of Carboniferous coal are predicable from the inferred high atmospheric O_2 levels!

Let us, however, assume that no circular reasoning is involved in the inference of high atmospheric oxygen during the Carboniferous. Ward mentions, but glosses over, many problems with this idea.

A high level of atmospheric oxygen would tend to inhibit plant growth. Ward acknowledges no evidence that such was the case. If anything, the presence of tree ferns, and other lush foliage (figure 1) that is obvious to students of Carboniferous paleobotany, would tend to contra-indicate such a situation.

The author acknowledges that huge fires could have been a problem, but glosses over them with the explanation (or rationalization) that the vegetation, being of a wetland nature, was resistant to burning. In addition, bark was thicker, making trees more resistant to burning. Was it? If oxygen levels were high enough, materials would be so combustible that their moisture content and thickness of the bark would be largely irrelevant.

In addition, the author glosses over the self-intensifying nature of fires. As fires get larger, their convection brings in more oxygen to feed the fire. How much more easily, and more intensely, would this feedback loop progress in a higher-oxygen environment? How much more effective would firebrands be, in spreading even a geographically stabilized fire, when operating in an enriched-oxygen environment?

Figure 1. The Carboniferous was supposed to be a time of extensive vegetation, which is not exactly consistent with a much higher atmospheric oxygen environment.

There is also the unmentioned question of firestorms (figure 2). As a fire grows large enough, the rate at which superheated air rises away from the fire is more than offset by the new superheated air that is being generated by the massive fire. Consequently, a permanent layer of superheated air exists over the entire area, radiating heat back downward, and igniting virtually everything combustible situated beneath it. How much larger, more common, and more intense would firestorms be in a higher-oxygen environment?

The issue of mass fires and firestorms has an additional implication. If sufficient material is burned, and the smoke lofted into the upper troposphere and lower stratosphere as large fires are known to do, a 'nuclear winter' effect is created. Sunlight is blocked, on a near-global scale, to an extent sufficient to prevent plants from growing for several years. Thus, we would likely expect the high-oxygen Carboniferous biosphere to be repeatedly self-annihilating, and therefore self-refuting.

The author speculates that the large size of Carboniferous insects owed to the high oxygen levels at the time. Ward mentions some lab experiments that indicate that insects grow larger in a high-oxygen environment—but some, such as cockroaches, do not.[1] However, he acknowledges that not everyone is persuaded that the high inferred levels of atmospheric oxygen had anything to do with the large size of insects in the Carboniferous. The argument was stronger when entomologists thought that insects didn't 'breathe' but relied on oxygen diffusion. But it has now been proven that insects really do breathe after all, so the main argument collapses.[2]

Figure 2. A forest fire can develop into a firestorm. In a higher-oxygen atmosphere, such firestorms would be much larger, and much more common.

Computer modelling—GEOCARBSULF uncertainties

The reader is probably familiar with the 'global warming' debate, which 'warmists' (or 'warm-mongers') earnestly would have us believe is a settled issue. One of the issues has been the limited ability of sophisticated computer programs to predict weather and climate. Much the same questions can be raised about any computer models of the earth's past, including GEOCARBSULF.

A detailed analysis of GEOCARBSULF has recently been published.[3] It is revealing. GEOCARBSULF depends upon a plethora of modelled processes. This includes the inferred chemical weathering of calcium– and magnesium-rich silicate rocks, as these are a critical sink for atmospheric carbon dioxide. Various processes are assumed to be time-dependent or time-invariant. The number of exposed rocks of various kinds, critical for geochemical modelling, is derived from paleogeographic maps. (The informed reader probably realizes that paleogeographic maps are quite subjective.[4]) Continental ice sheets are assumed to have occurred only at specified, known times. Large vascular plants are assumed to have accelerated weathering rates at a prescribed rate. The rate of weathering caused by gymnosperms, relative to angiosperms—admittedly poorly constrained to begin with—is included in the calculations. In addition, angiosperms are assumed to have phased in linearly during the time interval of 130 to 80 Ma ago.

Computers do not think. They only crunch numbers—hence the saying GIGO (Garbage in, Garbage Out). Let us consider the implications of GIGO. The authors are frank about the data behind the modelling, "Quantitative uncertainties for most input parameters in GEOCARBSULF are poorly known."[5] In addition:

> "Second, many equations in GEOCARBSULF are based on parameterizations. That is, the equations are built on correlations and do not include an explicit physical description of the underlying process (for example, the dependence of continental weathering as a function of climate, the dependence of global air temperature as a function of CO_2)."[3]

An eye-opening GEOCARBSULF Monte Carlo analysis

Most interesting of all, this study has examined 68 input parameters in GEOCARBSULF, and subjected them collectively to a Monte Carlo analysis, featuring both the individual and collective variances. It did so with an assumed Gaussian distribution of results. Even then, the study makes two crucial assumptions: that GEOCARBSULF is not missing any key processes, and that the parameter means are correct[2].

Even granting the assumptions, the results of the Monte Carlo analysis are unambiguous. Nearly all the 'peaks' and 'valleys' of atmospheric O_2 content are more or less 'washed out'. The inferred high Carboniferous atmospheric oxygen levels remain. However, even these could be reconciled with a largely unchanging atmospheric O_2 level, over time, if some of the factors were shifted in one direction.[6] The inferred drop of oxygen, near the Triassic-Jurassic boundary, is also believed to be left standing.

There's more. Earlier error envelopes for the GEOCARBSULF oxygen curve, over time, had been 'best guesses',[7] and the new error envelopes of the Monte Carlo analysis are much greater than the earlier-conjectured ones. One need only glance at the guesstimated error envelopes shown by Ward (p. 30) with the calculated 95% confidence envelopes of this new study.[8] The 95% confidence envelopes overlap the 21% oxygen, of today's atmosphere, for almost the entire Phanerozoic time interval!

The error ranges, indicated by the Monte Carlo analysis, are staggering. At 95% confidence levels, the Carboniferous 'hump' spans 22–44% oxygen, the Triassic-Jurassic boundary 'trough' spans 7–18% oxygen, and the Early Cambrian 'low' spans 13–23% oxygen.

The new study also examines inferred past CO_2 levels, and the authors claim that the GEOCARBSULF calculations compare favorably to independent records, from proxies, for the Paleozoic through early Mesozoic. However, the supposed agreement is much less so for the time interval of 200 to 30 Ma ago.[9] Considering that the latter includes some of the most noteworthy evolutionary deployments featured by the author (diversification of dinosaurs, birds, etc., and the appearance of large mammals), this takes on further significance.

COPSE and GEOCARBSULF agreement?

The author claims that the atmospheric gas levels indicated by GEOCARBULF are broadly corroborated by the results of COPSE, another computer model of the earth's past (p. 39). However, a more recent scientific source[10] is instructive. It turns out that COPSE and GEOCARBSULF share many of the same input parameters and inferred forcings.[11] For this reason alone, it is doubtful if the 'conclusions' of the two models are independently derived, and if the intervals of concordance are necessarily significant.

In addition, close examination of the two models shows considerable disagreement between the two models in some parts of the Phanerozoic timescale. The inferred RCO_2 (relative carbon dioxide) for 420–500 Ma ago, which is 8–10% according to GEOCARBSULF, is glaringly contradicted by the 16–18% indicated by COPSE.[12] Another major contradiction between the two models is for 380–500 Ma ago, and is applicable to RO_2 (relative oxygen). The GEOCARBSULF results trend near 1.0, while that of COPSE trends near 0.3.[13]

The time interval of 380–500 Ma ago is believed, by evolutionists, to be a time of pivotal evolutionary changes in living things. For instance, Ward discusses the Ordovician 'rebound' that followed the Cambrian extinctions, the appearance of the first land-dwelling arthropods, the appearance of the first land plants, and the inferred transition from fish to the first amphibians. For this reason, the contradictions between the two models, for 380–500 Ma ago, take on additional significance.

Conclusions

This book has some value for at least two reasons. Its free-flowing, relatively non-technical narrative provides a readable history of life, as imagined by evolutionists, for the layperson. It also provides insight on the oxygen needs of different organisms.

The computer modelling used in this work raises all the questions about computer modelling of the earth in general. The large margin of error for inferred past oxygen levels makes their uses questionable for understanding of past life on Earth, even in an evolutionary-uniformitarian context.

It is obvious that the atmospheric modelling, as presented in the book, has no direct bearing on creationist models. Apart from all its built-in dubious features, the modelling assumes the reality of geologic periods. It takes for granted a steady-state uniformitarian Earth where mountains are built and eroded, organic matter gradually accumulates or is destroyed, seafloor spreading takes place (and at very slow rates), and so on.

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