

Hot Rocks: The Greatest Hits of the Fossil Record

Evolution of Fossil Ecosystems. By Paul Seldon and John Nudds.
Chicago: University of Chicago Press. 2005. 192 pp., \$40.00 (paper).
ISBN 0226746410.

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Published online: 27 December 2006
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One rarely used metaphor for the history of life is the career of the Rolling Stones. Both have a definite beginning and obvious periodization, with different people preferring different periods; both had episodic unexpected deaths; at the moment neither has an immediate end in sight, at least not in entirety; and both have resulted in living fossils. Conceived in this way, different subdivisions of geological time, whether eons or periods or epochs, would be the analog to the albums the Rolling Stones have produced over their career, and specific fossils or localities in each interval would be the songs on the albums. For example, the Archean fossil record would be the equivalent of the Stones' eponymous album from 1964, and stromatolites in the Fig Tree Group in South Africa would be the cover of Willie Dixon's "I Just Want to Make Love to You" (because like some stromatolites, the cover is arguably an inorganic facsimile of a truly organic composition). Extending the metaphor, Fossil-Lagerstätten would be the key songs from each album, the songs that get it just right and capture the sound and sense of the Stones during that period in their career, the hits. Fossil-Lagerstätten are those localities with either exceptional preservation, typically including preservation of soft tissues that are destroyed by most modes of fossilization (Konservat-Lagerstätten), or unusual concentrations of fossils in a single deposit (Konzentrat-Lagerstätten). In that case, *Evolution of Fossil Ecosystems* would be a greatest hits album on par with the truly remarkable *Hot Rocks 1964–1971*, for despite the title, this book is a survey of some of the best and most famous Fossil-Lagerstätten from the late Proterozoic Ediacaran fauna to the late Pleistocene Rancho La Brea tar pits.

The book is derived from an undergraduate course the authors teach at the University of Manchester that focuses on Fossil-Lagerstätten as case studies in the history of life. It is intended to provide summaries of well-known Fossil-Lagerstätten, as no other current textbooks focus solely on these remarkable fossil localities. Unlike the songs on *Hot Rocks*, the chapters follow a similar format with sections on background information on the significance of each locality and how life has evolved from the time period of the Lagerstätten in the previous chapter; the history of discovery and study; the general geological setting, stratigraphic framework, and taphonomy

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of the locality; descriptions of representative or key components of the biota; discussion of the paleoecology of the locality, which focuses as much on depositional environment as it does on ecology; comparison with other similar aged biotas; and generous and bibliographically complete lists of further reading from the scientific literature for each locality. This consistent organization is useful if the book is used as a text in a course and also if it is used for a more general reference on some of the highlights of the fossil record.

The authors have done a good job covering marine deposits, which are more abundant due to the nature of the rock record, as well as good examples of Lagerstätten dominated by terrestrial organisms. Similarly, they have balanced the representation of Lagerstätten that are dominated variously by plants, invertebrates, or vertebrates. They have also been even handed in the geographic coverage of localities, at least as far as the known geographic distribution allows given the much greater sampling of the fossil records of North America and western Eurasia. The biotas covered, with their locations and ages in parentheses, include the Ediacaran fauna (Australia, Ediacaran, which is the youngest period in the Neoproterozoic), Burgess Shale (British Columbia, Early Cambrian), the Soom Shale (Germany, Ordovician), the Rhynie Chert (Scotland, Devonian), the Hunsrück Slate (Germany, Devonian), Mazon Creek (Illinois, Pennsylvanian), Grès à Voltzia (France, Triassic), Holzmaden Shales (Germany, Jurassic), Morrison Formation (western US, Jurassic), Solnhofen Limestone (Germany, Jurassic), Santana and Crato Formations (Brazil, Cretaceous), Grube Messel (Germany, Paleogene), Baltic Amber (Paleogene), and Rancho La Brea (California, Pleistocene).

The book is nicely illustrated in color and the illustrations are definitely both informative and useful for teaching courses on Earth history, history of life, or any number of other specialized paleontology courses. Each chapter includes location maps for the locality or outcrop area of the lithostratigraphic unit. These maps are well done and include appropriate geographic information (latitude and longitude, locator maps, cities and other geographic features). Several chapters also include geological maps of the localities, for example the chapter on the Rhynie Chert. Both the geographic and geological maps provide excellent detail for many of the localities, but do not include explanations of some symbols that may not be as familiar to non-geologists, such as strike and dip symbols. All chapters also include a stratigraphic column for the locality or the appropriate lithostratigraphic units. For those chapters on Lagerstätten that occur in only one or a few localities in a restricted area (e.g., the Burgess Shale, Mazon Creek, Messel), the position of the locality is indicated in measured stratigraphic sections. For more widespread Lagerstätte based on whole lithostratigraphic units (the Morrison Formation, the Santana and Crato Formations), the stratigraphy is indicated either by a generalized stratigraphic column or an example of a local section. One criticism of the stratigraphic columns is that conventional lithologic symbols are not always used and the volume does not include legends for the columns, which would be helpful to augment the good descriptions of the stratigraphy in the text. Most chapters also have good diagrams illustrating aspects of the depositional environments or taphonomic processes that led to the formation of each Lagerstätte, as well as outcrop or other field photos of the locality or typical outcrops. Representatives of the biotas from each locality or unit are illustrated in good quality color photographs, accompanied in some cases by line drawings of reconstructions. Given the relatively small format of the book, most of the illustrations are relatively small, but they are of high enough resolution and quality that they can easily be used for handouts or lectures.

Any reader can quibble with their choices of localities to include, just as a greatest hits album necessarily will leave off someone's favorite song given the limitations of the medium. In general, I think Selden and Nudds have done an admirable job selecting the hits to include. One slight criticism is that the authors seem to stretch the meaning of both types of Fossil-Lagerstätte with a couple choices, the most obvious example of which is the treatment of the

Morrison Formation as a Lagerstätte despite an outcrop area that covers all of Wyoming and Colorado and parts of Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, New Mexico, Arizona, Utah, and Idaho, and a maximum stratigraphic thickness in excess of 250 meters in places. Some of the famous dinosaur localities in the Morrison Formation (Como Bluff, the Cleveland-Lloyd Quarry, Dinosaur National Monument) are definite Konzentrat-Lagerstätten, but it seems an unwarranted extension of the concept of Lagerstätten to treat a lithostratigraphic unit of this scale as such. However, my main quibble with their choices focuses on what they chose not to include instead of my view of the worthiness of what they did include.

One extremely important Proterozoic biota that is not even mentioned is the phosphatic microfossils of the Doushantuo Formation in China. The fossils from this unit include the oldest embryos of metazoans and so provide a critical constraint on the time of origin of Metazoa. While the Doushantuo fauna may not be as taxonomically diverse, or even recognizable, as later faunas, from an evolutionary standpoint it is a critical assembly. Another example is the Early Cambrian Chengjiang Fauna, which is discussed briefly in the chapter on the Burgess Shale, but is older and in many ways more significant than the Burgess Shale fauna. Given that one of the two Devonian faunas, the Hunsrück Slate in Germany, includes a considerable diversity of primitive vertebrates (heterostracans, placoderms, acanthodians, and one sarcopterygian) but no chondrichthyans, and that no Mississippian faunas are covered in the book, the fauna from Bear Gulch, MT seems an unfortunate oversight. That fauna is dominated by a remarkable diversity of chondrichthyans from the initial radiation of that clade and also includes other vertebrates and invertebrates. The Liaoning Fauna from China, now generally accepted as Early Cretaceous, is another remarkable fauna from China that was not included in its own chapter, although it is discussed in the chapter on the Jurassic Solnhofen Limestone. Fossils from both the Chengjiang and Liaoning faunas have now been sufficiently published in the western literature that enough information should be available to discuss these important localities in as much detail as those that are included. A final absence that seems notable to me is the biota of the Green River Formation in Wyoming and Utah. The small fish *Knightia* that, unfortunately, can be found for sale in almost every natural history and science museum in the United States, and many elsewhere, is arguably the most common vertebrate fossil on Earth, and its abundance and quality of preservation are exemplary of the vertebrate, invertebrate, and plant fossils from the Green River Formation. In the end, this criticism is as substantive as arguing that *Hot Rocks* is a truly great album, but that it would be truly greater if the Stones had also included “Monkey Man” from *Let It Bleed*.

I have three more substantive criticisms of the book. First, given the focus on greatest hits, the book somewhat lacks a focused evolutionary narrative. To be sure, because of the chronological ordering of the chapters, reading through the book or just flipping through the pages and looking at the specimen photos reveals the majestic sweep of life’s history since the Ediacaran fauna. Holding the book on its side so that the chapters get younger towards the top as in a stratigraphic column, the photos stand as an excellent example of the Law of Fossil Succession, one of the fundamental bases of the geological timescale. However, the book does not delve into any aspects of phylogenetic, macroevolutionary, or paleobiological significance of any of the biotas in any detail. Contrary to the title, it also does not focus on the evolution of ecosystems beyond the large scale changes in the taxonomic composition of biotas through time. The value of many of these biotas seems to be solely based on remarkable preservation and their position in the pageant of life, and not the details of the patterns of evolution, hence many of the processes, that can be gleaned from more complete morphological detail. The Burgess Shale comes across as being important because of the revelation of the diversity of soft-bodied forms alone and not the evolutionary implications of the morphological disparity and alternative interpretations of

that disparity offered by Gould and Conway Morris, or its implications for the timing of the Cambrian Explosion in relation to molecular rate studies.

A second criticism is that the book contains several instances of outdated, inexact, or incorrect information on the phylogenetic placement of taxa. For example, in the chapter on the Holzmaden Shale, ichthyosaurs and plesiosaurs are both described as parts of Lepidosauria, the clade that includes the living snakes and lizards. Another clade of Mesozoic marine reptiles, the mosasaurs, are considered by most to be lepidosaurs and possibly even the sister taxon to snakes, but ichthyosaurs and plesiosaurs are each parts of distinct clades that have as yet uncertain phylogenetic relationships with the lepidosaurs and the archosauromorphs. Furthermore, the discussion of plesiosaurs also does not reflect the current state of phylogenetic research on these animals, which indicates that the short necked/long headed pliosaur morphology evolved several times independently from long necked/short headed “plesiosaur” ancestors in the course of plesiosaur evolution. In the chapter on the Morrison Formation, the description of theropod dinosaurs includes a list of exemplars such as *Tyrannosaurus* and of course *Velociraptor*, but does not indicate that living and fossil birds are also theropod dinosaurs. The treatment of the phylogenetic position of birds is even more striking in the chapter on the Solnhofen Limestone. The paragraph describing *Archaeopteryx* points out the reptilian features of the earliest bird and is immediately followed by a paragraph that describes *Compsognathus* as the “only dinosaur from the Solnhofen Limestone”, which is true only if the term dinosaur is restricted to its out of date colloquial meaning of “non-avian dinosaurs”. Ironically, the Solnhofen chapter compares the fauna to the somewhat younger Liaoning beds in China, which contain not only an abundance of exquisitely preserved primitive, toothed birds, but also several species of feathered non-avian theropod dinosaurs!

Finally, the book has several incorrect statements. The Bighorn Mountains of Wyoming are not the Front Range of the Rockies, as one figure caption states. They may be one of the front ranges, but the Front Range is in Colorado. While Paleocene mammals may not be as abundant as Eocene mammals in general, it is certainly not the case that “few Palaeocene fossils exist,” as suggested in the chapter on Messel. Additionally, Paleocene mammals were not insectivore-like remnants of Mesozoic types, but instead were diverse in body size and trophic behavior in Europe as elsewhere. The treatment of the glacial periods in North America during the Quaternary is a bit dated as more than a score glacial-interglacial cycles are now recognized, rather than the traditional four major glacial intervals. Indeed, the figure depicting the glaciations and the temporal or stratigraphic position of Rancho La Brea is based on a publication from 1930! None of these are as substantive issues as the currency of phylogenetic practice in some places, but they do stand out in an otherwise fine book on Fossil-Lagerstätten.

Despite my criticisms, I think this is a valuable volume for undergraduate teaching either as a textbook or a source book. Moreover, it will be appreciated as a handy reference by paleontologists and other fossil enthusiasts, especially those with a little knowledge of sedimentology and basic geology. The strengths of the book are its accessibility and clear organization, its good coverage of the hits of the fossil record (even if I would have added a few more songs!), and the clarity and quality of the illustrations and photos. A number of the Fossil-Lagerstätten described (and some that are not) have also been covered in dedicated, non-technical volumes with illustrations (e.g., Burgess Shale, Santana Formation, Messel), but this slender paperback provides excellent overviews of the geology and biota for some of the best songs from the fossil record. It is worth having in your collection!