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BONEBEDS: GENESIS, ANALYSIS, AND PALEOBIOLOGICAL SIGNIFICANCE

Reviewed by Jean-Pierre Cavigelli

Raymond R. Rogers, David A. Eberth, Anthony R. Fiorillo (Editors)
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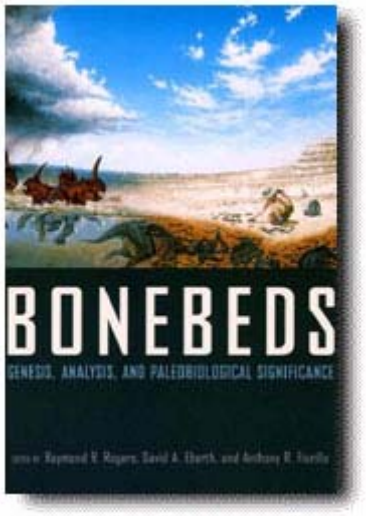
When my copy of *Bonebeds* arrived at my office, my colleague Russell saw it and remarked, "That looks interesting." Seconds later, one of my work study students commented, "That looks dry as toast." She is a geography and agriculture major, and Russell is interested in all things paleo. Having cut my paleo teeth on Cretaceous and Paleocene microsites, I was excited to see this book.

Editors Ray Rogers, Dave Eberth and Tony Fiorillo have collected eight chapters written by a variety of authorities on different aspects of bonebed studies. This compilation was inspired by a symposium on bonebeds at the 1998 meeting of the Society of Vertebrate Paleontology. I was particularly interested in what insights I might be able to glean from this book in regards to several bonebeds I am currently involved with. The chapters are longer than your average scientific paper and run about twenty pages each.

My first impression was the nice cover artwork by Michael Skrepnick of Cretaceous centrosaurs swimming to their death and into a bonebed being excavated in the Canadian badlands. As usual nice, work by this artist. Upon flipping through the book I noticed an impressive, long list (90 pages worth) of bonebed studies near the middle, appendix 3.1. An impressive compilation in and of itself. I also noticed some frightening looking mathematical equations.



One of the obvious difficulties in tackling a subject like bonebeds is defining the term. In the preface the editors admit that this was a challenge, but that they settled on a fossil accumulation that meets these two criteria: "whether a site […] or sedimentary stratum preserves […] the hardparts of more than one individual in close proximity, and whether a site or stratum preserves hardparts in an abundance greater than the associated 'background' facies." (p. viii). Having said this, they additionally conclude that "any vertebrate locality that preserves the hardparts of two or more individuals in close association begs […] closer scrutiny." (p. viii). In this light, some of the authors use different definitions; there is even a table (appendix 2.1) outlining the different definitions (including that for "bonebed") used in the book.

This got me thinking about sites I am familiar with, and would they fit this definition. The above-

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mentioned microsites would certainly be called bonebeds, as would the dinosaur death assemblage illustrated in the cover. But how about a hadrosaur our museum has been working on? The site has occasional turtle pieces and gar scales. In the end I think they are not above the background noise of microfossils expected in a Lance Formation sand body. So, not a bonebed. How about the mosasaur we have been working on? It is a disarticulated skeleton with many shark teeth and shells are found in the matrix. Considerably more shark teeth than in the background rock. According to this book, this is a bonebed. However, even after reading the book, I have a hard time calling this a bonebed. Several references are made to a White River Formation accumulation of three snake skeletons. By the book's definition, this is a bonebed. I have held this specimen in my hand, so I have a hard time calling this amazing fossil a bonebed. How about the Mongolian fighting dinosaurs? Bonebed or not?

I asked a few paleontology friends their thoughts about the definition of a bonebed. I got answers that ranged from accepting the snake accumulation to elimination of single species death assemblages from consideration. The confusion the editors felt about defining a bonebed seems to be widespread among the vert paleo community. This book may be a first step in standardizing it.

Chapter one by Ray Rogers and Susan Kidwell is titled "A Conceptual Framework for the Genesis and Analysis of Vertebrate Skeletal Concentrations". This is an extension of Kidwell's work with invertebrate fossil accumulations. The chapter classifies different bone accumulations, whether accumulated by biological (e.g. carnivores) or physical (e.g. riverbeds) agents. Throughout chapter one, the authors give extensive examples of bone accumulations from the fossils and modern records. These examples piqued my curiosity enough that I found myself continuously reaching into the bibliography to check out the sources. This made for slow, yet engaging reading.

In Chapter 2, ("Bonebeds Through Time"), Anna K. Behrensmeyer discusses many trends visible by studying the whole suite of known bonebeds. She uses a database of bonebeds, the ETE Bonebed Database. (ETE stands for Evolution of Terrestrial Ecosystems). The database is available online as a Microsoft word document (the web address is given in the book) and is quite extensive. The ETE Bonebed Database is based at the Smithsonian, as is the author. The chapter has many charts and tables that work as tandem pairs. I found that the information in the tables could easily have been added to the charts to make them more easily readable, without having to bounce between the two. Other than that this chapter shows what one can do with such a database, especially in the area of comparing databases over the course of geological time. For me, Behrensmeyer's line in her concluding statement of the chapter also sums up a lot of what this book is about: "its most important contribution is to open the door to a wealth of interesting questions to pursue in the future." Much of this book is an invitation into the future, rather than a summary of the past.

Chapter 3, by Dave Eberth, Matthew Shannon and Brent Noland, is also based on a bonebed database. The 90 page listing of bonebed publications is, like the ETE Bonebed Database, available online as a Microsoft Excel file. As with chapter two, this chapter includes definitions of pertinent terms, and a bonebed classification system, which are both a touch different than Behrensmeyer's. In addition, the authors describe their database and show numerous examples of trends they have found, mostly looking at things from a different perspective than Behrensmeyer. I found browsing through the 90 pages of appendix 3-1 to be interesting and fun.

Starting with chapter 4, we start to see what sorts of science can be done with bonebeds. "From Bonebeds to Paleobiology: Applications of Bonebed Data" by Don Brinkman, Dave Eberth and Phil Currie is loaded with examples of paleontological studies based on bonebeds from microsites to single species bonebeds and more. Here we start getting into the meat of the book. What information can we get from bonebeds? The authors give many detailed examples of paleobiological studies and the results found from these. The variety of information gleaned from bonebed studies makes for great reading. Chapter 4 also includes a good lesson in all things taphonomic. Starting in the next chapter, things get more technical.

Chapter 5 ("A Practical Approach to the Study of Bonebeds" by Dave Eberth, Ray Rogers and Tony Fiorillo) provides a comprehensive guide to how to collect data from bonebeds. This chapter considers everything a paleontologist, experienced or budding, might want to consider when actually working on a bonebed field project. As a preparator and a field paleontologist, I particularly liked the line on p. 266: "Before field work begins […] a researcher […], preferably in conjunction with an experienced preparator and/or field crew manager,

should carefully consider a variety of preliminary concerns." Having done my fair share of field work on bonebeds, I found much in this chapter to agree with, but also found a few new tidbits of information to consider incorporating into my work. The section on geology made me want to learn more geology, but "Perhaps the best advice would be to always include a well-trained sedimentary geologist as part of the research team" (p. 283). The next chapter deals with "Numerical Methods for Bonebed Analysis". Richard Blob and Catherine Badgley discuss statistics as a tool for studying bonebeds. They start with some simple specimen counting using (and explaining) terms like NISP, MNE and MNI, (number of identifiable specimens, minimum number of elements and minimum number of individuals, respectively). Most of the chapter gets more technical than this. Someone with a good statistics background can get some good ideas from this. Myself, well, I was mostly lost. And there were those scary equations I had noticed in my initial perusal. Most were still scary, even in context. My statistics knowledge is limited to one class in college twenty-five years ago, and I do not use it in my work. But each statistical technique is followed by examples, which at least helped me see what results they can yield. Blob and Badgley say in summation of this chapter: "use of appropriate techniques can yield novel insights into paleofaunal questions." (p. 389). I learned that it may be a good idea to collaborate on a bonebed study with someone who understands and is confident in statistical methods. This chapter is a good guide for doing so.

Before reading the next two chapters, I was able to guess that they would have similar lessons: collaboration with an expert is a good goal. Clive Trueman's "Trace Element Geochemistry of Bonebeds" and Henry Fricke's "Stable Isotope Geochemistry of Bonebed Fossils: Reconstructing Paleoenvironments, Paleoecology, and Paleobiology" are both well explained discussions of their fields of specialty, and an invitation to all bonebed workers to consider what these budding techniques can tell us. Both writers use ample examples of the topics as they relate to bonebeds. At least one example is from modern bones, showing the newness of these techniques. I would have liked to see Trueman give the English names, at least once, of the Rare Earth Elements that are so important to his work, rather than simply using the periodic table symbols.

This book will be a useful addition to any paleontologist's library, especially to anyone working or thinking of working on a bonebed. It is well written and uses examples profusely to illustrate techniques and concepts. Each chapter has its own bibliography. Those for chapters 1 and 3 are very extensive. Add the bibliographies for the other six chapters and you have the makings of a very useful tool for any paleontologist. The big picture message is that to get the moist out of bonebed studies, assembling a team of specialists is a great help. In addition to that, I also did get a few tidbits of information to consider for the bonebeds I am involved with.

I only noticed a few typos throughout the book, but one stood out: on a few pages dealing with oxygen isotopes "δ18O" was written as "δ18O" (pp.465-466), making me wonder if there was something I hadn't learned about oxygen isotope notation. In another place, "were" snuck through the spell-check as "where". In the end, *Bonebeds* is much more "interesting" than "dry as toast". More importantly, I think even seasoned paleontologists will find at least a few chapters useful and insightful.