



Bonebeds, edited by Raymond R. Rogers, David A. Eberth, and Anthony R. Fiorillo, 2007, University of Chicago Press, Chicago, Illinois, 512 p., USD75.00 cloth, ISBN: 9780226723709, USD30.00 paper, ISBN: 9780226723716.

When I hear the word bonebed, my first thoughts are of dramatic images from famous megafaunal-dominated, fossil vertebrate sites prepared and preserved for public viewing. I picture the chaotically arranged dinosaur bones in various states of articulation from the exposed cliff face in Douglass Quarry at Dinosaur National Monument, Utah, and the beautiful, mostly articulated mammal skeletons preserved in three dimensions at Ashfall Fossil Beds State Historical Park, Nebraska. These, of course, are just two localities that contain geological units that fall within a broad spectrum of fossiliferous sedimentary beds that can be classified as bonebeds. And, while other examples of bonebeds may not be as visually stunning as the two I mentioned, each bonebed contains an incredible wealth of information waiting to be deciphered. I can only imagine the exhilaration elicited by the discovery of a bonebed, but I can also see the excitement quickly giving way to trepidation at the thought of recovering data that can be easily lost if careful precautions are not taken in the field and in the lab. *Bonebeds*, edited by Raymond R. Rogers, David A. Eberth, and Anthony R. Fiorillo, provides a practical guide to techniques for data collection and analysis as well as a convenient reference for theoretical frameworks surrounding the interpretation of paleobiological data derived from bonebeds.

The book contains eight chapters and is informally divided into two halves: chapters 1–4 cover basic concepts and interpretations of bonebeds through time, and chapters 5–8 present practical approaches to and instructional guides for the study of bonebeds. Chapter 1 introduces definitions of terminology and proposes a classification scheme for bonebeds. Bioclast size is used to distinguish macrofossil bonebeds, microfossil bonebeds, and bone sands. The classification system divides bonebeds into biogenic and physical, based on the inferred mode of skeletal concentration. Both categories are further subdivided and discussed in great detail, with modern and ancient examples. As a consequence, the chapter is an excellent source of references. The final section of the chapter, titled Caveats and Complications, discusses limitations of the classification scheme and provides scenarios that can complicate classification.

Chapter 2 analyzes data from Phanerozoic terrestrial bonebeds through time with the goal of providing preliminary

tests of four proposed hypotheses. Data are from the Evolution of Terrestrial Ecosystems Program database (www.nmnh.si.edu/ete/ETE_web_files/ETE_DB_description.html), which contains 315 localities and is available for download online. Before delving into the data, definitions are given for the term bonebed and three subcategories based on relative abundances of taxa represented in a bonebed. It becomes clear at this point that definitions and classification schemes vary from chapter to chapter. This may seem like a major source of confusion, but a very helpful appendix is provided that compares the different terminology presented in chapters 1–3.

Chronologic patterns in data are discussed and represented visually in figures and tables. Different treatments of the data are used to address such issues as geographic distribution, bonebed lithology and inferred paleoenvironments, taxonomic representation, and taphonomic features. Analyses are used to test the four major hypotheses as well as elucidate potential collection biases and raise additional hypotheses to be tested. Interpretations of causes of bonebeds are also discussed and used as the basis of a classification scheme. The major categories of this scheme are abiotic, biotic, passive attritional, and mixed.

Chapter 3 presents and reviews a bonebed database that contains data from over 1000 bonebeds. The discussion of the database design includes definitions and the classification scheme used for compiling data. This classification is based on element size, taxonomic diversity, and relative taxonomic abundance; all of this is summarized in a convenient table with examples given of each type. This classification is convenient because it is based on objective characteristics. The biggest potential barrier to its use would be the positive taxonomic identification of skeletal material. Before analyzing for patterns, there is a discussion of biases inherent in the construction of the database. Bearing those biases in mind, analyses of the data result in four patterns of occurrence that warrant further study. Finally, the entire database is provided as a 91-page appendix. It is also available for download online through the publisher.

Chapter 4 covers possible paleobiological interpretations that can be made from bonebed data. The chapter is divided into three sections. The first deals with the characterization of species based on bonebeds that appear to preserve entire populations.

Consideration is given to intraspecific variation, growth rate, and stratigraphic and paleogeographic species variation, with examples given for each. The second section covers interpretations of ancient behaviors and the evolution of behaviors through time. Included are examples of aggregations due to breeding, nesting, early ontogeny, herding, and paleoenvironmental conditions. The third section looks at faunal assemblages and paleocommunity reconstruction. Each section contains multiple referenced examples of paleobiology studies; this overview provides an extensive background that researchers can use to design future bonebed studies. This chapter is also an appropriate segue to the second half of the book, which provides methods for bonebed study and analyses.

Chapter 5 provides a field-oriented, step-by-step guide to the approach and study of bonebeds. It gives detailed descriptions of each step, including preliminary site assessment, working a site, collecting geological data, and collecting taphonomic data. Consideration is given to different approaches required for different types of bonebeds. Helpful examples and figures that illustrate visual means of displaying data are also provided. From this chapter it is clear that bonebeds contain a wealth of information that can be lost easily with improper handling. Regardless of the hypotheses you wish to test using bonebed data, this chapter is a must read.

Chapter 6 is entitled Numerical Methods for Bonebed Analysis and provides a primer on statistical methods. The chapter is organized into five major sections, each in response to research questions that commonly arise during the study of a bonebed; many of these build upon research avenues presented in chapter 4. Questions include counting individuals at a site, comparing taphonomy and faunal composition of multiple sites, comparing species richness between sites, estimating the original species abundance of ecosystems from bonebeds, and evaluating changes in faunas through space and time. Each statistical method is described in terms of execution and application to paleobiological questions. For a summary of statistical methods, I was pleasantly surprised at the amount of detail given, including equations and examples from the literature. Even if some techniques are too complex to be tackled based on the descriptions in the chapter, they should aid in deciphering results when reading published bonebed studies. Also, an extensive list of references is provided if the reader wishes to pursue any methods in more detail.

Chapter 7 covers trace element geochemistry of bonebeds. It begins with a description of early diagenetic alteration in bone, with a summary of changes during fossilization and how trace elements are incorporated into bone. The rare earth elements are then singled out as being particularly useful because they meet four criteria necessary for a feasible study of geochemical taphonomy. The next section of the chapter provides five different applications of trace element geochemistry to the fossil record, each with examples from the literature. The final section is a step-by-step basic guide to the collection, preparation, and analysis of bones for trace elements, including an introduction to the most commonly used technique, inductively coupled plasma-

mass spectrometry. This chapter will not instantly prepare you to begin sampling bones in the lab (and it is not meant to), but it is an excellent introduction to the subject.

Chapter 8 introduces stable isotope geochemistry of bioapatite in bonebed fossils as a means of reconstructing paleoenvironments, paleoecology, and paleobiology. The first section of the chapter covers natural stable isotope variability in plants and surface waters and how stable isotope ratios preserved in bioapatite vary with position in ancient landscapes and food chains. A discussion on bioapatite sampling weighs the practicality of analyzing tooth enamel and dentine, bones, and scales. The second section provides an in-depth discussion of issues with diagenetic alteration of isotope ratios. Susceptibility of various hardparts to diagenesis is considered, and five tests are outlined to identify diagenetically altered samples. The next section brings up issues that can complicate and complement isotope studies, including seasonality, taxonomic diversity, timing of accumulation of bonebeds, interpreting multiple bonebeds, and performing isotopic analyses on associated minerals and materials. The final section of the chapter contains examples of applications of stable isotope analyses to the fossil bonebed record. Examples include interpreting paleoenvironment, vegetation, paleoecology, paleoclimate, and vertebrate paleobiology. Overall, it appears that stable isotope data can be easily misinterpreted, but the information provided in this chapter along with the extensive list of references should allow the reader to design an effective study.

In summary, this edited volume is a thorough, well-organized, convenient, practical guide to the study of bonebeds. Chapters are well referenced with numerous examples and figures. Each chapter provides an important facet of the approaches and techniques currently used in bonebed analyses. The chapters complement each other well, but each is readable as a stand-alone document for those interested in a single aspect of bonebed studies. I do not have many criticisms of this book, although I was expecting some discussion about bonebeds in the larger context of instances of exceptional preservation since all bonebeds should be examples of *Konzentrat-Lagerstätten*. As I mentioned earlier, it appeared to me that the different terminology and classifications presented in chapters 1–3 would be confusing as I continued reading. As Anna Behrensmeyer points out in chapter 2, however, there is no one right way to classify bonebeds; the descriptive system used will vary by site and will be determined by such factors as the data available and the research question being investigated. The book's intended audience, as indicated in the preface, is experienced researchers, students, and interested amateurs; I would highly recommend it to all of those demographics.

Brian F. Platt
University of Kansas
Department of Geology
1475 Jayhawk Blvd., room 120
Lawrence, Kansas 66045-7613
bfplatt@ku.edu