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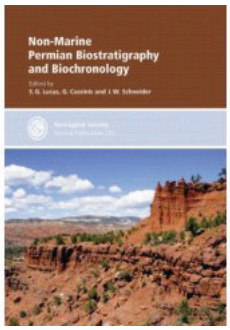

Non-Marine Permian Biostratigraphy and Biochronology, edited by Spencer G. Lucas, Giuseppe Cassinis, and Joerg W. Schneider, 2006, Geological Society Special Publication No. 265, 344 p., 85.00 GBP, 170.00 USD, ISBN-10: 1-86239-206-4.

The Permian is a fascinating time in Earth history, and it includes events and processes to arouse the interest of almost anyone working in geology or paleontology. For example, there is the accretion of the supercontinent of Pangea and its associated tectonic events, a transition from an icehouse to a greenhouse climate, and flood basalt volcanism on a scale unrivalled during the Phanerozoic. There are two great mass extinctions, the origin of continental ecosystems that display modern food web structures, unusual patterns of ocean circulation and ocean chemistry, and the first appearance of cynodonts, the clade of nonmammalian synapsids that includes our own distant direct ancestors. The Permian is a particularly interesting time for those of us studying the history and evolution of the continental realm because the Permian rock record includes extensive continental deposits exposed on every continent. Many such exposures as those in the American southwest, European Russia, or southern and eastern Africa are richly fossiliferous and provide a picture of Permian continental ecosystems that is surprisingly detailed when their antiquity is taken into account.

Unfortunately, telling time in the continental Permian record is not always a trivial task. Radiometrically dateable rocks are rare in several important basins, well-supported correlations between marine and continental strata are often lacking, continental microfossil-based biostratigraphies have not been examined in detail in all basins, and enduring taxonomic problems complicate attempts to use fossil tetrapods for biostratigraphic purposes. In this context, a broadly synthetic volume that provides a comprehensive overview of current biostratigraphic research in Permian basins around the world, and identifies new problems and questions to drive the field forward, would be a valuable tool. I had hoped that *Non-Marine Permian Biostratigraphy and Biochronology* would be this type of definitive treatment, but the book falls short of this goal despite including interesting and useful papers.

Perhaps the greatest problem with volume is the fact that its treatment of biostratigraphic and biochronologic research in the Permian is very uneven. For example, no less than 9 of the 15 chapters focus on the continental Permian of western and central Europe, and the majority of these contributions deal with the Lower Permian or the Permo-Carboniferous transition. Given the long history of study of the European Permian, there is nothing wrong with it receiving ample coverage in the volume. This level of attention seems excessive, though, when one considers the topics that are missing from the book. There is an extremely active community of researchers working on the paleontology and biostratigraphy of the Karoo Basin of South Africa, and the tetrapod biochronology that has been developed for the middle and upper Permian strata in this area is the standard for correlations among similarly aged tetrapod-bearing rocks around the world. Yet members of this research community are conspicuous in their absence from the volume's contributors, and Karoo biostratigraphy receives a cursory treatment in only one chapter. Similarly, there have been extensive revisions of the tetrapod biostratigraphy of the middle and upper Permian in European Russia, but this work is not presented in detail. Continental Permian exposures in such areas as China, Laos, India, Australia, and Antarctica receive little or no attention at all. The three chapters that are more global in their coverage mostly represent minor updates, revisions, or compilations of previous work.

A related issue is the fact that several papers in the volume do not consider, or only peripherally consider, biostratigraphy and biochronology. Instead, they focus on such topics as magnetostratigraphy, Permo-Carboniferous climates and their relation to the changing configuration of Pangea, or documenting the composition and paleobiological implications of Permian petrified forests. Again, such contributions are not entirely out of place in a volume on Permian biostratigraphy and biochronology, but considering the important topics that are not covered in detail, I think that some of volume's space could have been better spent on more on-topic pieces. The net result of these problems is that I was left wishing the editors either had narrowed the focus of the book to include only the continental Permian of western and central Europe or produced a volume that was truly global in scope. The middle ground they chose on this spectrum was unsatisfying.

These misgivings notwithstanding, there are several papers in *Non-Marine Permian Biostratigraphy and Biochronology* that I found interesting and thought provoking, and they deserve some comment.

One of the best contributions of the book is also one that does not deal directly with biostratigraphy or biochronology. Maureen Steiner's examination of Permo-Triassic magnetostratigraphy is in many ways an example of an ideal contribution to this type

of edited volume. It brings together data on basins around the world that are scattered throughout the literature and synthesizes them into a coherent framework, while also identifying potential problems and question that need additional scrutiny. Given my own research interests in the Permo-Triassic transition among terrestrial vertebrates, I was particularly interested in Steiner's conclusions about the location of the Permo-Triassic boundary in the Karoo Basin (most likely at the fungal spike described by Steiner et al., 2003), and her suggestion that the Russian Tartarian includes most or all of the late Permian (in contrast to the older age suggested by Gradstein et al., 2004).

I had mixed feeling about Spencer Lucas' review of Permian tetrapod biostratigraphy and biochronology. On one hand, it is useful to have much of the current thinking on Permian tetrapod biochronology summarized in a single paper, and I have no doubt that this work will be frequently cited in the future because of this fact. On the other hand, the work represents only a minor update on previous papers by the author (e.g., Lucas, 2002, 2005), and it is not without potential problems. For example, some of the decisions Lucas makes in developing his biochronological scheme, such as not recognizing the *Pristerognathus* Assemblage Zone of South Africa or assuming dramatically changing sedimentation rates in the Karoo Basin, are bound to be controversial. The brevity with which these decisions are presented does not do justice to the complexity of the underlying issues, and readers who do not specialize on these topics are presented with little material with which to judge the arguments for or against them.

A more serious issue is the fact that the biochronologic scheme Lucas presents is based on genera. He is not solely to blame for this; it is a reflection of long-standing taxonomic problems in several biostratigraphically important tetrapod clades, and attempting to build a species-level biochronology at this time likely would cause more problems than it would solve. Nevertheless, the use of genera will always tend to produce time scales of lower resolution than would be the case for a scheme based on species. Lucas mentions a few instances where species-level distinctions could be useful, and some relevant stratigraphic data are beginning to accumulate for a few genera (e.g., the species of the dicynodont *Lystrosaurus*; Botha and Smith, 2006, 2007), so it would have been interesting if he could have developed this theme further. There is also the fact that some traditionally important index genera may not be monophyletic clades (Angielczyk and Kurkin, 2003a, 2003b). If that is the case, then a species referred to a genus from one basin is not necessarily part of the same biological entity as a different species from another basin. A correlation based on those species, therefore, does not reflect an occurrence of the same thing at the genus level and, instead, is akin to making correlations based on the occurrence of taxa of similar evolutionary grade. Ultimately, these criticisms point to the fact that there is much work to be done on Permian tetrapod biochronology, and I suspect that future breakthroughs will come as much from refining our picture of the taxonomy, phylogeny, and biogeography of these animals as from collecting new biostratigraphic data.

Three papers in the volume (Gand and Durand, Hunt and Lucas, Lucas and Hunt) focus on Permian tetrapod footprint biostratigraphy and biochronology and together provide a useful overview of the field at both a global and a more local (in this case European) scale. The main conclusions of the works are generally similar; many Permian tetrapod footprints have long stratigraphic ranges and, therefore, can only be used to construct a relatively low-resolution biochronologic system. This is not surprising considering that tetrapod tracks are often strongly facies controlled and that specific tracks can be made by more than one type of animal. Given the conclusions of these papers, I wonder if there is much future for tetrapod footprint biochronology in the Permian. On a much finer scale, I was surprised that Hunt and Lucas and Lucas and Hunt did not cite De Klerk's (2002) description of the South African Asante Sana tracksite, which stands out as a particularly fine example of recent ichnological research in the Karoo Basin.

The contribution of Alfredo Arche and Jose López-Gómez on the Permo-Triassic transition in northeastern Spain was thought provoking because they provide additional evidence for widespread plant die-offs and associated changes in sedimentary environments that were likely part of the end-Permian biotic crisis. Similar changes have been noted in other areas, particularly in the latest Permian and earliest Triassic (e.g., Ward et al., 2000; Benton et al., 2004). Arche and López-Gómez, however, recognize two such intervals in the upper Permian of Spain, the first near the Guadalupian-Lopingian boundary and the second at the Permo-Triassic boundary itself, and they suggest that these dead zones may have been caused by Emieshan and Siberian flood basalt volcanism, respectively. Their conclusions fit well with the recent suggestion of a two-pulsed, end-Permian extinction in the continental realm (Retallack et al., 2006) and will be useful in helping to test that hypothesis. In addition, Arche and López-Gómez's suggestion of a prolonged recovery interval fits well with recent research that portrays the Early Triassic as a time of repeated environmental perturbation and unstable terrestrial ecosystems (e.g., Payne and Kump, 2007; Roopnarine et al., 2007), although it is in contrast to the rapid recovery of vertebrates observed in the Karoo Basin (Botha and Smith, 2006).

Recent work has greatly increased our knowledge of the late Permian continental fossil record of Niger, ranging from vertebrates to plants, bivalves, and trackways (e.g., Sidor et al., 2005; Steyer et al., 2006, 2007), and this fauna appears to display patterns of climate controlled endemism. I, therefore, read Roscher and Schneider's paper on Permo-Carboniferous climates and Hmich et al.'s report of new terrestrial faunas from Morocco with an eye to implications for the Nigerian fauna. Although both papers mostly focus on the lower Permian, they

do contain data relevant to work in Niger. For example, I could not help but wonder whether the Nigeran fauna might have existed during Wuchiapingian climatic wet phase that Roscher and Schneider conclude was associated with the Zechstein-Bellerophon Transgression. If this is the case, it would help to constrain the age of this otherwise poorly dated fauna and perhaps help to explain its unusual composition. Likewise, Hmich et al.'s paper provides good overviews of Moroccan floras, faunas, and ichnofaunas that will be useful for drawing comparisons between fossils from that area and much of the newly discovered material from Niger. In particular, faunal and ichnofaunal similarities between the Tourbihine Member in the Moroccan Argana Basin and the Moradi Formation of Niger suggest that they may have had sampled similar faunas or environments.

In conclusion, the uneven treatment of current work on continental biostratigraphy and biochronology makes it difficult to recommend *Non-Marine Permian Biostratigraphy and Biochronology* as a comprehensive treatment of the current state of the field. Even for specialists in Permian paleontology, I think the book's relatively high price would make it a worthwhile investment only for those workers whose research concentrates on the lower Permian of western and central Europe. Nevertheless, individual papers will likely be of interest to many parts of the community, so the book is definitely worth a look when it arrives in your local library.

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Kenneth D. Angielczyk
Department of Geology
The Field Museum
1400 South Lakeshore Drive
Chicago, IL 60605 USA
kangielczyk@fieldmuseum.org