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Book Review

Speleothem Science: From Process to Past Environments, I.J. Fairchild, A. Baker. Wiley-Blackwell, Chichester (2012). 432 pp., cloth, ISBN: 978-1-4051-9620-8

Sampling a natural climate archive is a way to obtain empirical evidence about past climates. The measured proxy variable indicates the state of the climate and the archive material allows also for dating. Archives that have recorded the climate information over a certain time span thus provide a proxy climate time series. The tree-ring archive has been employed since the 1920s, the marine sedimentary archive since the 1960s, and the ice-core archive since the 1980s (Cronin, 2010).

The speleothem archive and stalagmites in particular have significantly advanced our knowledge about past climates since the 1990s (Cronin, 2010). This leap forward is owed to (1) the improved accuracy of dating instruments, that is, uranium–thorium mass-spectrometers, (2) the automation of proxy measurements, that is, oxygen and carbon mass-spectrometers, indicating changes in precipitation and temperature, and (3) the availability of speleothems in caves around the world. Climate researchers have been waiting for a benchmark publication on speleothem science for quite some time, which the authors of the book have now finally accomplished. Their book tells the fascinating story about the speleothem archive, and it puts past achievements and future research prospects into a technological perspective: to understand past climates, new high-performance instruments are indispensable.

The authors introduce you, the reader of their book, to speleothem research. They put you into the speleothem factory. You study the production of stalagmites, made of the material calcium carbonate in its calcitic or aragonitic mineralogy. You learn about the ingredients from atmosphere, hydrosphere, and soil in speleothem formation. And finally, you witness the karstic cave environment in which speleothems can thrive. Chapter 1 gives an introduction to speleothems and conveys the book's structure. Chapter 2 deals with carbonate and cave geology, and Chapter 3 focuses on climate, soil, and vegetation. After establishing the geological framework, the book explains the transfer processes in the karst: the speleothem incubator (Chapter 4), inorganic water chemistry (Chapter 5), and biogeochemistry (Chapter 6). Chapter 7 deals with the speleothems themselves: their architecture, geometry, and mineralogy. Speleothem geochemistry is treated in Chapter 8 and their dating in Chapter 9. The final part of the book studies paleoenvironments on various timescales from the instrumental period (Chapter 10), the Holocene (Chapter 11), and the Pleistocene and further back in time (Chapter 12).

Speleothem Science possesses the necessary disciplinary width to establish speleology/speleothem-based climatology more firmly as a scientific field. Coming from physics, statistics, and geology, but not from chemistry, this book review author learned most from the geochemical sections of the book. This was especially in Chapter 8, which gives a thorough overview on the geochemical background, namely in those sections that consider the quality of the climate proxy signal in oxygen and carbon isotope records and that outline very recent approaches, such as clumped oxygen–carbon isotopes. The geological part certainly reflects the authority of the book authors, who are leading experts in speleothem research.

The strongest part of *Speleothem Science* is the technological–historical perspective, where readers learn how the young scientific field evolved and may change in future, and how those developments depend on the availability of high-technology analytical instruments. The authors perform equally well in reporting about and scrutinizing the various benchmark papers in speleothem science. This places the book at the front-end of research.

The weakest part of *Speleothem Science* is the lack of mathematical rigor. A deeper, quantitative understanding of climate can be acquired only via mathematical approaches. The associated uncertainties, which are mentioned in the book, can be evaluated quantitatively only via statistical methods. It is insufficient to report in prose only about time series analysis methods and download sites, as in Box 11.1 of the work. Two examples for lacking mathematical background are the following. (1) Regarding speleothem timescale construction (p. 300), it is reported that the “autocorrelation persists well beyond” ten time steps; however, what is relevant is not the number but the time span covered by the steps, which may be scaled using the persistence time (Mudelsee, 2002). (2) Regarding the significance of correlations between two time series, the authors correctly mention the problem of autocorrelation (p. 311), but then they state that a “non-parametric correlation such as Kendall's tau or Spearman's correlation is more appropriate” in such a situation; however, Kendall or Spearman (whose measures are not explained or referenced in the book) have nothing to do with autocorrelation but with the assumed distributional shape of the time series values (Mudelsee, 2010). Where the authors speculate about multi-decadal and multi-centennial climate variability (p. 342), they also consider “cyclical feedbacks”, a term not yet established in climatology.

“Robust” is a statistical term coined by George Box, meaning that a method performs well enough (gives reasonably accurate results) when the underlying assumptions (e.g., distributional shape) are violated (Box, 1953). Unfortunately, today's scientific output, written and spoken, abuses this term by substituting it for anything positive (e.g., accurate, unbiased, significant). It is regrettable that the book by Fairchild and Baker seems not to care about a correct usage of “robust”, as the term “robust transfer function” (p. 263) or the sentence “the further addition of annual laminated series are required to independently confirm that the common signal is robust” (p. 319) illustrate.

Fairchild and Baker do a good interpretative job when criticizing the “finding” of “statistically significant spectral peaks” in records with timescales that had previously been tuned to match some target curve (e.g., radiocarbon content as a proxy for solar activity variations). There really are too many papers that make this nonsense circularity argument. However, the three papers which they accuse of committing this error (pp. 344–345) are to be protected against that accusation. Fig. 4a in Neff et al. (2001)

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shows the coherency spectrum for the untuned record, Fig. S5a in Fleitmann et al. (2003) shows the univariate power spectrum for the untuned record, and finally Fig. 5 in Niggemann et al. (2003) shows the univariate power spectrum for the untuned record. All three papers thus find indications that the climate variations, as seen via oxygen isotopes in speleothems, have a relation with solar activity variations, as seen via radiocarbon content.

The proofreading for *Speleothem Science* has, unfortunately, not removed many minor errors: wrong grammar; wrong punctuation, especially in sentences that do include mathematical formulas; inconsistent usage of abbreviations and technical terms; and figure captions that fail to clearly explain what is shown in the figure. First example (p. 335): the figure on this page has two panel labels, which are not explained. The relation between locations (left panel) and records (right panel) is not given in the caption. The shaded bar sitting vertically on the age axis of the right-hand panel is not explained. The downward, shorter/longer arrows are not completely explained. The horizontal error bars for debris-flow fan ages are not mentioned. Second example (p. 338): although a nice figure from its content, there is no horizontal time axis with tick marks, labels, and units. Third example (p. 359): the famous speleothem cave in China is called Hulu and not Wulu. Fourth example (p. 363): the Plio–Pleistocene ancestors of modern humans are from the genus *Australopithecus*, not *Australopithicus*. The authors have opted to re-use figures from other, copyrighted papers and books, but these figures are not all perfect and introduce ambiguities (e.g., “ka”, “ky”, “kyr” for kiloyears). The reader is left to hope that this carelessness is not a proxy for carelessness in other, more sensitive parts of the book (e.g., where radioactive decay constants are reported). It is hoped that in the next edition of the book a more careful proofreading shall be exercised.

The target readership of *Speleothem Science* is threefold. First, researchers who are already working with the stalagmite archive can widen and considerably deepen their knowledge in sub-disciplines not already covered in their own training. Second, climate researchers who are not yet working on speleothems should be catapulted to the front-end once they will have studied the book together with the relating benchmark papers. Third, graduate students who are looking for a topic for their PhD dissertation. They might have found their textbook.

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