Nature’s Clocks: How Scientists Measure the Age of Almost Everything

by Doug Macdougall

reviewed by John W Geissman

The concept of time is central to virtually all human endeavor. That of deep time, a phrase first coined by John McPhee to refer to time beyond the past 50,000 or so years that we can examine with radiocarbon dating, is central to our entire understanding of the history of the natural world in which we live and, more “locally” speaking, the history of the earth, our only home, and the history of life and its evolution on this home of ours. Karl Popper wrote in the preface of *The Logic of Scientific Discovery*: “There is at least one philosophical problem in which all thinking men are interested. It is the problem of cosmology: the problem of understanding the world—including ourselves, and our knowledge, as part of the world” (Popper 2003:xviii, emphasis in original). In *Nature’s Clocks*, Doug Macdougall provides an exceptionally well-written and engaging description, for any “thinking man” (or woman), of how we know what we know about absolute age determinations and thus about our attempts to unravel the uncertainties of deep time. This book is very suitable for a general audience interested in the history of our planet, including the details of how geoscientists, based on absolute age determinations, infer the ages of specific geologic events (such as the extinction of the dinosaurs at the end of the Mesozoic Era) and the durations of specific processes (such as the formation of the Appalachian Mountains). In sum, the efforts to obtain accurate and higher precision age estimates have led to the establishment of the geologic time scale, a ruler, if you will, with which the endless details of earth history can be placed in an ordered and accurate fashion.

Unfortunately, space does not permit a summary of all of the components of *Nature’s Clocks*, so let me highlight material in three chapters. Chapter 2, “Mysterious rays”, is devoted to the discovery of radioactivity, and how, in particular, Ernest Rutherford followed the early research by Marie Curie and Henri Becquerel with an array of experiments that eventually led to his derivation of the “law” of radioactive decay. Macdougall’s detailed account of how Rutherford recognized the implications of his research for calculating the age of geologic materials (that is, minerals, which constitute rocks), together with his encounters with Lord Kelvin and his first reports of his work on uranium-bearing samples in several lectures at Yale University in 1905, is one of the highlights of the book.

Although the reader is poised to read more about the implications of radioactive decay for deep time, and determining the age of the Earth, Macdougall does an about-face in chapter 3, “Wild Bill’s quest”, where the history of the development of radiocarbon dating by Willard F Libby, a nuclear chemist at the University of Chicago, and his colleagues, is impeccably and thoroughly described. A highlight of the chapter is Libby’s “test” work on
a series of Egyptian artifacts, which came to be in his possession, in an unassuming box, two years earlier via a postdoctoral fellow, Jim Arnold, whose father, upon learning about his son’s research, became most excited and “passed on his enthusiasm to the curator of Egyptian archaeology [Ambrose Lansing] at the Met” (that is, the Metropolitan Museum of Art in New York). Two years later, a piece of acacia wood from the tomb of the Egyptian pharaoh Zoser was taken out of the box and became the first ancient material subjected to radiocarbon dating. What follows is an absolutely breathtaking account of the excitement surrounding the recognition that the technique worked! Arnold, who actually was, in June 1948, measuring the number of carbon-14 decays per minute from the sample, quickly realized that the decay rate was statistically indistinguishable from that predicted for an age of 4650 years for Zoser’s tomb, which the archaeological evidence strongly supported. Arnold remarked later, “One lives for such moments.” A fascinating section in this chapter also reveals how, early on, radiocarbon dating exposed a lot of fakes in the world of Egyptian antiquities, which came as no surprise to many. Radiocarbon dating began to rewrite some 50,000 years of history.

Chapter 7, “Clocking evolution”, nicely exemplifies how Macdougall is able to fluidly link several seemingly different subjects into a coherent account. It begins with the termination of the Mesozoic Era—the long-known end of the Cretaceous, when the demise of the dinosaurs allowed mammals to begin to dominate the planet. The hypothesis put forward by Luis Alvarez, his son Walter Alvarez, and other colleagues, that the extinction event defining the termination of the Cretaceous was caused by the collision of one or more asteroids with the earth over a short duration of time, is briefly discussed and then linked to the necessity of finding the smoking gun—the crater and associated impact material. This gets us to precise age determinations of the end of the Cretaceous and the impact crater itself, which is buried by younger sediment at the north end of the Yucatan Peninsula, but this time the age determinations are made using the potassium-argon decay scheme. We learn of the complicated steps involved in understanding the radioactive decay process, largely through the work of Alfred Nier, a physicist at the University of Minnesota, beginning in the mid-1930s. The steps include determining a half-life with great accuracy, developing the instrumentation necessary to conduct measurements of the radioactive isotope of potassium and its decay product, argon, and ultimately, in the 1960s, refining the approach by bombarding samples with neutrons in a nuclear reactor, so part of the potassium in the sample is converted into an isotope of argon, argon-39. This “argon-argon” isotopic age determination method is far more precise because the amount of potassium-40 in the sample does not need to be measured. Returning to the end of the Cretaceous, Macdougall describes the efforts to date the event with “impact spherules”, droplets of melted rock formed from the asteroid impact, and distributed over much of the planet with other forms of impact-related sediment, right at the boundary, which turn out to be about 65.5 million years old. Macdougall writes, “Although the pathway to the correct age for the K-T boundary—including the use of standards—may seem a bit tortuous, it is important to understand because it illustrates the care necessary to get things right” (p 168).

That statement nicely summarizes Macdougall’s passion for making certain that nothing of importance to the story of how we are able to measure the age of “almost everything” (from the cover of the book) is left out. Reading Nature’s Clocks is guaranteed to improve
one's understanding of how the determination of absolute age estimates is carried out and one's appreciation of the associated intricacies.

REFERENCES

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