Tides: A Scientific History

David Edgar Cartwright
292 pages, Cambridge University Press
ISBN 0-521-62145-3

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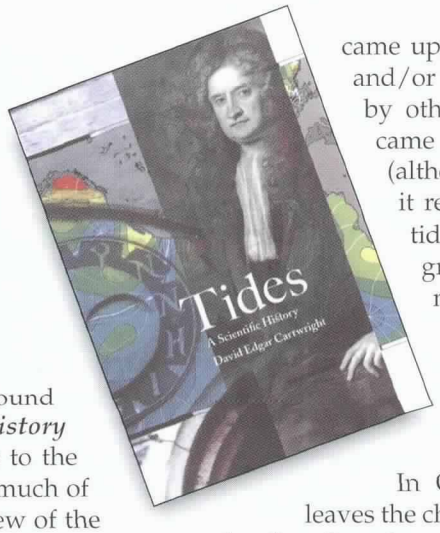

I should say right at the outset that I found David Cartwright's ***Tides: A Scientific History*** totally engrossing. This may partly be due to the fact that I have worked in the area of tides much of my career and so I found the idea of a review of the history of the development of tidal science seen through the eyes of one of its few living gurus irresistible. David Cartwright quite literally followed in the footsteps of Joseph Proudman and Arthur Doodson and worked side by side with Walter Munk, in the process making his own major contributions to tidal science, most notably in the areas of tidal analysis and prediction and the extraction of tides from satellite altimetry. That he downplays his own contributions, not even listing his own name in the author index (one will find some of his papers included in several of the References sections that follows each chapter), is a sign both of his own modesty and of the seriousness with which he treats the subject. For although he does provide some insights into personal aspects of the men who made contributions to tidal science over the centuries, for the most part Cartwright sticks to the development of the science itself. There are few if any who are in a better positionto examine this development and to put each contribution into a larger context. Cartwright does more than just chronicle various scientific papers written over the years. His expertise is fully utilized in his interpretation and critiquing of these works and in his estimation of their contribution to either the understanding of the tides or the useful application of tidal knowledge by particular users (for example, mariners).

The first five chapters of his book proceed chronologically beginning with the earliest ideas of thinkers in the ancient civilizations of Asia and Europe. The early history is fascinating, from the tidal dock built around 2000 BC in Lothal, India, to the world's first tide table (in the 10th or 11th century AD), etched in stone near Hangchow for predicting the arrival times of the spectacular tidal bore in the Qiantang River in China. Individual Indian, Chinese, Greek, Arab, and Roman thinkers all made the connection between the tides and the phases of the moon, and often deduced many of the daily, monthly, and even annual variations, only to have their work either forgotten, ignored, or disbelieved on religious grounds, and then to be rediscovered by a later scientist or philosopher. Equally interesting are the names of famous thinkers (among these Aristotle and Galileo) who came up with strange theories for the tides and/or rejected the correct ones presented by others. None of these early scientists came up with the actual *cause* of the tides (although a couple came very close) and it remained for Newton to explain the tides using his concept of universal gravitational attraction between all massive bodies, which is treated in detail by Cartwright in Chapter 5, along with the work of other scientists who built upon Newton's work, such as Maclaurin, Euler, and Bernoulli.

In Chapters 6 though 10 Cartwright leaves the chronological organization he used in the first five chapters for one more based on subject area, with Chapter 6 dealing with a history of tidal measurements. Chapter 7 deals with the work of Laplace, the second really important contributor to the development of tidal science (after Newton), along with other hydrodynamicists who found solutions for Laplace's tidal equations for various idealized ocean basins. Cartwright tries to keep the mathematics to a minimum, but some mathematical treatment is unavoidable. He appears to find the right balance, namely one that will probably satisfy the tidal research community while still getting the ideas across to physical oceanographers in general and other readers with some scientific and mathematical background. A few important mathematical treatments (such as development of the tide-generating potential) are included in Appendices.

Chapter 8 deals with local analysis and prediction, in particular the development of the harmonic analysis of tides by Kelvin, Darwin, Ferrel, and others, and the first use of mechanical analog tide prediction machines. Chapter 9 concentrates on the development of cotidal line charts for the world's oceans and their dynamic implications. Chapter 10 deals with tides of the geosphere (air tides, earth tides, and magnetic tides) and its place in the new science of geophysics. Chapter 11 deals with various tidal researches that took place between the two World Wars, including the work of Proudman and Doodson at the Liverpool Tidal Institute. The impact of computers beginning in 1950 is treated in Chapters 12, and includes the development of numerical tide models for the world ocean and innovations in tidal analysis such as Munk and Cartwright's "response method." A wide variety of instrument technology and its impact on understanding tides is treated in Chapter 13, with satellite technology left for special attention in Chapter 14. Chapter 15 covers miscellaneous topics, such as long-period tides and oceanic tidal dissipation, and ends with Cartwright's final retrospect of the subject.

Although at the beginning of this review I mentioned that my strong interest in the subject of tides might have been partly responsible for my great enjoyment of this

book, I should make it very clear that I think this book will be an enjoyable and educational reading experience even for those who haven't worked in this discipline. The history alone should be enough to interest many readers. Cartwright says he wishes to convey " the historical growth of ideas over the centuries"and that aspect is definitely interesting. Although not meant to be a teaching text for tides, this book should also be of benefit for those studying the tides, since sometimes a clearer comprehension of a subject can be gained by learning how the understanding of that subject evolved. While Cartwright states that his history is more concerned with the global aspects of tidal science, there are not too many aspects of the tides that Cartwright does not cover. (The nonlinear aspects of tides in shallow-water may be, in fact, the only subject that does not get any real coverage, and that subject is relatively recent in its major growth.) Thus, this book will also serve as a good reference, where you can go to find an initial understanding of some aspect of the tide, along with the best papers for learning more. But don't be surprised if you find yourself reading whole sections of the book that you might never have intended to.