An Introduction to Seismology, Earthquakes, and Earth Structure

Seth Stein and Michael Wysession. Publisher: Blackwell Science, Inc., 2002. 498 pages. Paperback; ISBN 0865420785; $83.95.

When Sue Hough asked me to review this new textbook I accepted immediately. I've been watching it mature for almost two decades and am pleased it is now actually published as a real textbook. I first became aware of a much earlier draft when I began teaching and was tasked to teach an introductory seismology course for new graduate students. At that time (early 1980's) there was a major gap in seismology textbooks. Books of the time tended to be highly theoretical and seismocentric or overly descriptive and not very rigorous. The former is a big problem for a course taught in an Earth science department, as an overly theoretical focus can scare off geology students who could benefit from such a course. Seth Stein showed me an early version of this book when I gave a colloquium at Northwestern. I decided to use the manuscript form of the book when I first taught introductory seismology back in 1984 and continued to use various versions of it until Thorne Lay and Terry Wallace's book appeared in 1995. In between, Peter Shearer's book appeared in 1999. Thus, this book now joins a field with two other, similar textbooks that have already filled the void I noted above. I'll attempt to give some comparisons to its competition to help others decide if this book is a good choice for them.

This book and its two competitors are all excellent textbooks for a modern, introductory seismology course. This book is somewhat longer than either of its competitors, but the price is about the same because it is offered in paperback. The material covered in the three books is very similar although the material is presented in different orders. The extra volume of this book is largely taken up with more figures and extra words used to teach concepts and relate seismology observations to broader Earth science topics. This book begins with an overview chapter that has an emphasis on seismology's impact on society. It is pretty good, but pedagogically I like Lay and Wallace's introductory chapter better. It provides a better balance that helps students see the big picture before they dive into details. This chapter has good material, but it doesn't serve the same role.

Where the book really starts to win is in Chapter 2. This was the core of the book when I first used it and it hasn't changed that much. It outlines the basic theory of wave propagation beginning with the standard derivations of the wave equation and then moving to ray theory, plane-wave reflection and transmission, surface-wave propagation, and free oscillations of the Earth. I've always liked this section, as it provides a sound foundation for teaching some of the more difficult theoretical concepts of seismology that many students have a hard time grasping. The book then devotes almost 100 pages to applications of seismology to the estimation of Earth structure. It does this without any discussion of inverse theory, which is covered in the last chapter of the book, by focusing on wave-oriented topics like anisotropy and attenuation and by focusing mostly on travel-time methods that do not use matrix methods (*i.e.*, the refraction method and reflection travel-time methods). This chapter also contains a section I personally think is out of place. That is, it contains a very cursory introduction to reflection seismology methods. When asked both Seth and Mike told me this was included to give students some exposure to these concepts because in their programs some students might not get any other exposure to reflection seismology methods. The book contains more related material in Chapter 6 that I presume came from this same background. That is, Chapter 6 is titled "Seismograms as Signals" and is a nice introduction to basic signal processing concepts relevant to modern seismology. It is good that these subjects are in this book, as it can help the student see a link between earthquake seismology and exploration geophysics. On the other hand, some may choose to skip over these sections if the same material is covered more extensively in other courses.

Chapter 4 of the book is titled "Earthquakes" and is a very nice, modern review of the physics of earthquake sources. It is written at a level consistent with the rest of the book and provides a good foundation of key concepts, including moment tensors, magnitude estimation, and earthquake statistics. It goes further and brings in newer results from GPS measurements and various forms of waveform modeling.

Chapter 5 is a good, instructive chapter that shows how seismology methods have contributed to our modern understanding of plate tectonic processes. In some ways this is kind of the climax of the book, as it shows how seismology has helped constrain our modern understanding of plate tectonics. The chapter contains some material many people teach in other courses with titles like tectonic or structural geology. Like the reflection seismology material, the important role this chapter plays is in showing how all the concepts learned earlier relate to modern seismology research.

The final two chapters are titled "Seismograms as Signals" and "Inverse Theory", respectively. As noted earlier, Chapter 6 is basically a quick introduction to signal processing. The key seismology-specific topic it covers is the theory of how seismometers work and information about seismic instrumentation. In a similar way, Chapter 7's introduction to inverse theory is relatively brief and included mainly to provide the foundations for explaining a very basic technique in seismology: earthquake location. This chapter goes well beyond that, of course, and provides a nice concise summary of key inversion theory concepts. I note that Lay and Wallace have a similar chapter with similar content for the same reason.

The book has two other components that are important. First, the book includes an excellent collection of tractable problems that provide useful assignments to help students learn the concepts in the book. In contrast, Lay and Wallace's book has no problems at all and Shearer's book has fewer, less varied problems. The exercises may, in fact, be the strongest part of the book. Finally, the book has a useful Appendix that in earlier versions served as a Chapter 1 overview of mathematical concepts. This is a valuable addition to the book. It can be used as an auxiliary assignment for students at the start of the class. I tell students to read that section and if there are mathematical concepts in that section they aren't familiar with they need to talk to me about it and either learn appropriate material independently or drop the course and learn the background mathematics in other courses before trying to learn seismology at this level.

So which of the three competing books in introductory seismology is best? This is, of course, purely a matter of opinion. I find this book very similar in content to Lay and Wallace's book, but I think it wins as a textbook mainly because it has good problems and other exercises that are of an appropriate level. Shearer's book is shorter and may be a better choice for a course taught in a quarter system. This book has too much material to realistically cover in a quarter but is very appropriate for a semester time period.

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