An Introduction to Seismology, Earthquakes, and Earth Structure

Seth Stein and
Michael Wysession
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Seismology is the study of earthquakes and Earth structure using the waves that accompany quakes and other Earth vibrations. Analysis of those seismic waves is the basis of most current knowledge about our planet's interior. Seth Stein and Michael Wysession, two highly regarded seismologists, have written a massive book that is a welcome addition to the handful of seismology texts appropriate for graduate or advanced undergraduate study. But with its enormous quantity of material, often presented in detailed figures, and its emphasis on deep-Earth examples, *An Introduction to Seismology, Earthquakes, and Earth Structure* is a valuable reference for specialists as well.

The text covers the meat and potatoes of seismology—seismic-wave propagation, Earth structure, and earthquake sources. Much more is presented, though, including plate tectonics, signal processing, seismometry, and inverse theory. An extensive appendix outlines matrix algebra, vector calculus, and even principles of computer programming. Each chapter ends with a brief discussion of classic and current references, followed by homework problems. Some of those problems are designed to be solved with computers. Answers to odd-numbered problems are in the back of the book, and solutions to all of them are available to instructors over the Internet.

Stein and Wysession begin their book with an introduction on the societal implications of earthquakes, which, worldwide, cause significant economic disruption and an average of more than 10 000 deaths per year. The authors then present the basic seismological theory, beginning with a rather long section that discusses waves on a string. That treatment is followed by a more traditional development of waves in elastic solids, moving from stress and strain to wave equations. The book fully treats reflection and transmission of waves, including conversions between compressional and shear waves.

Theory, starting with reflection and refraction techniques, is then applied to determine Earth structure. Stein and Wysession pay particular attention to waves that travel through, bounce off, or refract around Earth's core. That's perhaps not surprising, because Wysession's research is in deep-Earth structure. The development of wave propagation is followed by a welcome section on the implications of seismological results—particularly Earth's radial velocity structure—for the composition of the crust, mantle, and core.

Stein and Wysession thoroughly describe earthquake sources and include a useful account of body and surface wave[illegible]n modeling. Also notable is their discussion of ground deformation during the entire earthquake cycle, and new deformation mapping techniques, such as those using interference of space-based radar images.

The material on plate tectonics highlights one of Stein's research specialties, the thermal evolution of the lithosphere. The text offers a clear and complete explanation of how a single physical process—the cooling of the lithosphere at mid-ocean ridges—controls ocean depth, plate thickness, and heat flow.

The description of the heating of oceanic plates as they reenter the mantle at subduction zones is likewise well developed. The mathematical descriptions of the lithosphere lead naturally to a clear explication of the forces that drive tectonic plates. The book presents, as well, extended and appreciated discussions of faulting, friction, and crustal strength.

The clear, precise, but sometimes long-winded style of the book reflects its comprehensive nature. The lengthy, thorough discussions contrast with the elegant brevity of Peter Shearer's *Introduction to Seismology* (Cambridge U. Press, 1999). On some topics, the book's very thoroughness renders it unwieldy, and the mathematical formalism is sometimes more complicated than necessary. Look elsewhere for a quick refresher on Snell's law—even the subscripts have subscripts.

The book's numerous figures are a key asset. Those illustrations, available online, often seem to have been constructed particularly for the text. In many cases, they compactly convey large amounts of detailed information. For example, a number of figures illustrate the surprising complexity of the interaction of seismic waves with material having jumps or gradients in wave velocity. That complexity is better conveyed by Stein and Wysession's book than any other text I know of.

An Introduction to Seismology, Earthquakes, and Earth Structure is a very good text with an up-to-date point of view. It's a bit expensive for a course textbook, but it is quite versatile. The large amount of material covered makes the book useful for several different courses. As the basis for a standard seismology course, it would work best for the more tenacious student. The text is appropriate for a geophysically oriented plate-tectonics course or for a course on time-series analysis and inverse theory with examples and homework problems taken from geophysics. All in all, it is an indispensable reference for serious students of solid-Earth geophysics.

Heidi Houston
University of California
Los Angeles