Times-Standard
Times-Standard / Humboldt Beacon

Not My Fault: Celebrating Inge Lehmann and women in science everywhere

Lori Dengler/For the Times-Standard
Posted: February 13, 2019

The United Nations designates February 11th as the International Day of Women and Girls in Science. There is no better way to mark the date than celebrating the achievements of Inge Lehman, Danish seismologist and discoverer of the earth's inner core.

Lehmann was born in 1888, at the beginning of the seismic instrumentation era. At a time when many girls and boys were educated separately, she attended a Fællesskolen (Shared School), a progressive coeducational school where both sexes took the same curriculum and girls were encouraged to excel in math and science. She specialized in computational mathematics, studying at Cambridge and the University of Copenhagen, and received a magister scientiarum degree in 1920.

Lehmann became Chief of the Seismological Department of the Royal Danish Geodetic Institute in 1928. It was still early days in seismology and there were no international standards or easily accessible data repositories. Regional networks used different types of instruments each with different responses and timing signatures. Timing is as important to seismographs as recording sensitivity. A second can make a difference in interpreting locations and earth structure. Lehmann developed relationships with other seismic groups and became a master at collecting data and accurately deciphering the smallest details in a seismogram.

Reading seismograms is a tedious business. I know from personal experience. Until the late 20th century, it was done manually with a well-trained eye picking out faint wiggles on paper records. As Lehmann was digging into seismograms in the late 20s and early 30s, a general picture of earth structure had emerged. The earth's core had been discovered about two decades earlier and she knew that it created a shadow zone, an area where seismic waves were blocked from making it to the surface.

If the earth were completely uniform in composition, the arrival of seismic waves with distance from the earthquake focus would be completely predictable. The seismic waves would steadily take a bit longer to arrive the further you were away. By the early 1900s, there were enough seismic stations to observe what happened in real earthquakes. Seismologists found that for seismic stations near the epicenter, the pattern was what would be expected for a relatively uniform earth. But when you looked at a seismic station a little more than a quarter of the earth's circumference away from the epicenter, the seismic waves suddenly vanished. They went from being sharp and easy to identify to being gone.

In 1906, the seismologist Richard Oldham published an analysis and explanation for this abrupt disappearance. There are two types of seismic waves that can penetrate the deep interior of the planet – compressional (P waves) and shear waves (S waves). It turns out the P waves didn't completely vanish, they showed up somewhat delayed and much further away than where a uniform earth would have predicted. The easiest explanation was a sharp discontinuity in earth properties with depth. The material below the discontinuity had slower seismic velocities and acted like a lens, causing the P waves to slow down and bend or refract at the boundary. Furthermore, Oldham argued that the deeper material or core was liquid because the S-waves truly did vanish and S-waves can't travel in liquids. The core created a shadow on the earth's surface, blocking the S-waves completely and a zone where no P-waves made it back to the surface.

Enter our intrepid heroine. Lehmann spent years looking very carefully at seismograms from large earthquakes in the early 20th century, identifying the seismic arrivals of the P and S-waves and the start of the shadow zone. With a very sharp eye, she observes small P-wave signals in the shadow zone where they didn't belong. It wasn't just a few scattered blips that might have been caused by instrument malfunctions or other sources of noise. She was able to trace out a clear zone where these anomalous P-waves began and continued. She examined dozens of seismograms for earthquake after earthquake, and every time they were still there.

In 1936, Lehmann published a paper called P', the shortest title that I am aware of anywhere in the scientific literature. P' is her notation for the compressional wave that travels through the mantle, is bent and slowed at the core mantle boundary but then hits a deeper interface and is reflected back to the surface and show up in the shadow zone. That deeper interface was the inner core. Further observations demonstrated that this interface also bent the seismic waves and because of the way in which the waves bent, this innermost part of the earth had a faster velocity than the outer core. The easiest explanation was that the inner core is solid.

Lehmann arguably had the longest scientific career of any seismologist. I nearly crossed paths with her in the late 60s at Berkeley where she spent several months as a visiting scientist and I was finishing my undergraduate degree in geophysics. She shared an office with a good friend of mine who recalls her being "a smiling person who always greeted me with small talk." She was in her 80s at the time. She continued to work actively for another decade and contributed to the understanding of upper mantle structure. The "Lehmann discontinuity," at depths of about 130 – 140 miles beneath the surface, is a zone where P-wave velocities increase, related to plate tectonic processes. She died at the age of 105.

I often thought of her during some of the more discouraging times in my academic career. Whenever anyone suggested that women did not belong in geophysics, I would just say Inge, Inge, Inge.

For more on Inge Lehmann:
https://www.youtube.com/watch?v=w2Tj-8FJFeY&feature=youtu.be&fbclid=IwAR07VRoHqGfsaAGUfC_EVrlsEVCS5l5tohF3hJ-tQUsQKADGRUCSddJymxc

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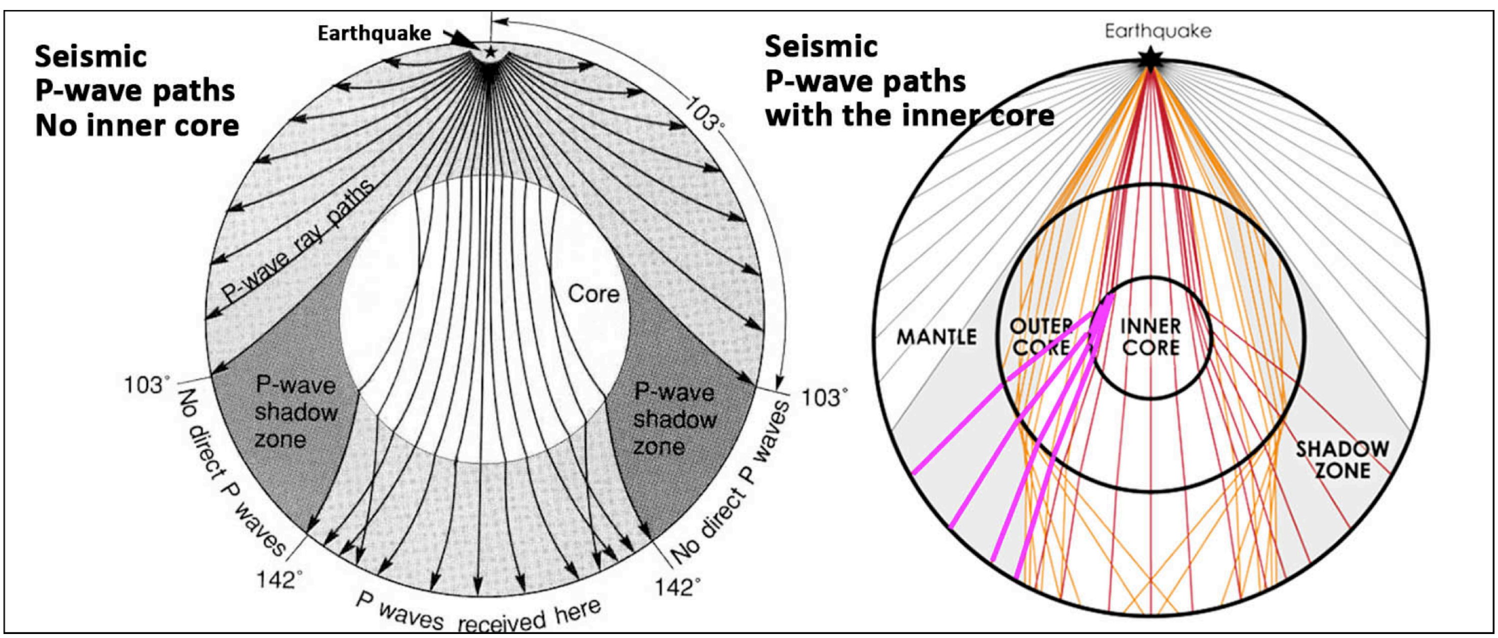
https://www.times-standard.com/2019/02/13/lori-dengler-celebrating-inge-lehmann-and-women-in-science-everywhere/



An illustration of how seismic waves are bent by interfaces within the earth - on the left, no inner core, on the right, with an inner core. The purple paths show the arrivals that Lehmann observed. Note - the illustrations are simplified and not to true scale.