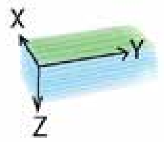
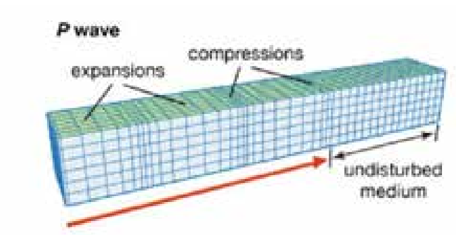
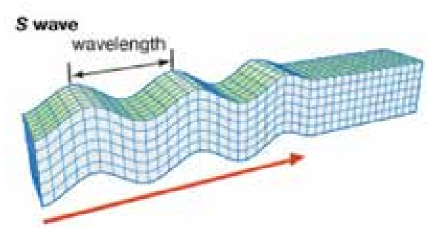
APPENDIX D—Types of Seismic Waves

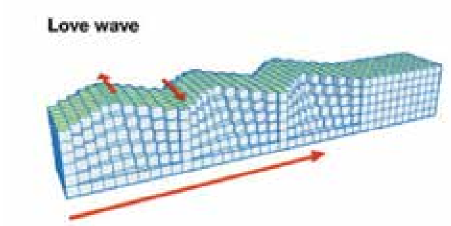
Types of seismic waves

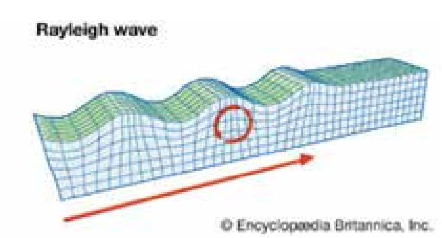
Perspective views of seismic-wave propagation through a grid representing a volume of material. X and Y are parallel to the Earth's surface; Z direction is depth.











This is how ocean waves develop on the surface of the ocean.

Table 1: Seismic Waves

Wave Type (and names)	Particle Motion	Typical Velocity	Other Characteristics
P, **Compressional**, Primary, Longitudinal	Alternating compressions ("pushes") and dilations ("pulls") which are directed in the same direction as the wave is propagating (along the ray path); and therefore, perpendicular to the wavefront.	**V_P ~ 5 – 7 km/s in typical Earth's crust; >~ 8 km/s in Earth's mantle and core; ~1.5 km/s in water; ~0.3 km/s in air.**	P motion travels fastest in materials, so the P-wave is the first-arriving energy on a seismogram. Generally smaller and higher frequency than the S and Surface-waves. P waves in a liquid or gas are pressure waves, including sound waves.
S, **Shear**, Secondary, Transverse	Alternating transverse motions (perpendicular to the direction of propagation, and the ray path); commonly approximately polarized such that particle motion is in vertical or horizontal planes.	**V_S ~ 3 – 4 km/s in typical Earth's crust;** >~ 4.5 km/s in Earth's mantle; ~ 2.5-3.0 km/s in (solid) inner core.	S-waves do not travel through fluids, so do not exist in Earth's outer core (inferred to be primarily liquid iron) or in air or water or molten rock (magma). S waves travel slower than P waves in a solid and, therefore, arrive after the P wave.
L, **Love**, Surface waves	Transverse horizontal motion, perpendicular to the direction of propagation and generally parallel to the Earth's surface.	V_L ~ 2.0 - 4.4 km/s in the Earth depending on frequency of the propagating wave, and therefore the depth of penetration of the waves. In general, the Love waves travel slightly faster than the Rayleigh waves.	Love waves exist because of the Earth's surface. They are largest at the surface and decrease in amplitude with depth. Love waves are dispersive, that is, the wave velocity is dependent on frequency, generally with low frequencies propagating at higher velocity. Depth of penetration of the Love waves is also dependent on frequency, with lower frequencies penetrating to greater depth.
R, **Rayleigh**, Surface waves, Ground roll	Motion is both in the direction of propagation and perpendicular (in a vertical plane), and "phased" so that the motion is generally elliptical – either prograde or retrograde.	V_R ~ 2.0 - 4.2 km/s in the Earth depending on frequency of the propagating wave, and therefore the depth of penetration of the waves.	Rayleigh waves are also dispersive and the amplitudes generally decrease with depth in the Earth. Appearance and particle motion are similar to water waves. Depth of penetration of the Rayleigh waves is also dependent on frequency, with lower frequencies penetrating to greater depth.

[Click here to view Animations of the seismic waves](#)

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