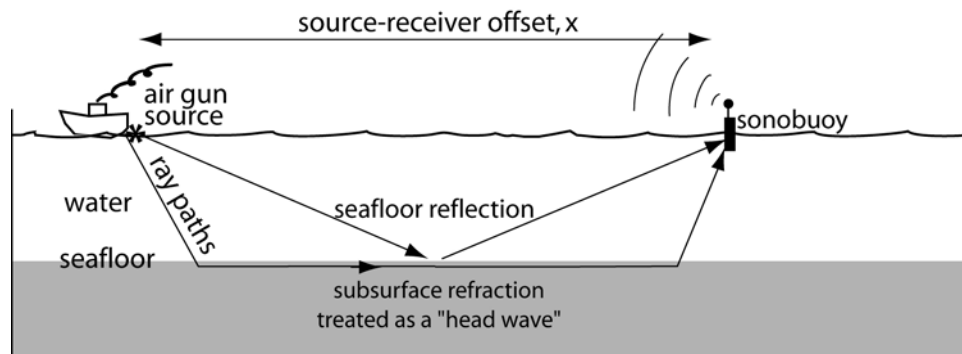


**Homework 8: Reflection and Refraction Seismology***Due Friday 3/13***9A) Read Lowrie Sections 3.6.1-3.6.5 and complete for discussion on Wednesday 3/11**

1) A P-wave with an angle of incidence of  $i_P = 18^\circ$  is propagating downward and encounters a contact separating two different rock types. The upper layer (from which the P wave originates) has a compressional wave speed of  $\alpha_1 = 2500$  m/s and the shear wave speed of  $\beta_1 = 1100$  m/s. The lower layer has a compressional wave speed of  $\alpha_2 = 3800$  m/s and the shear wave speed of  $\beta_2 = 1600$  m/s. The interface spawns reflected and transmitted energy in the form of both P- and S-waves.

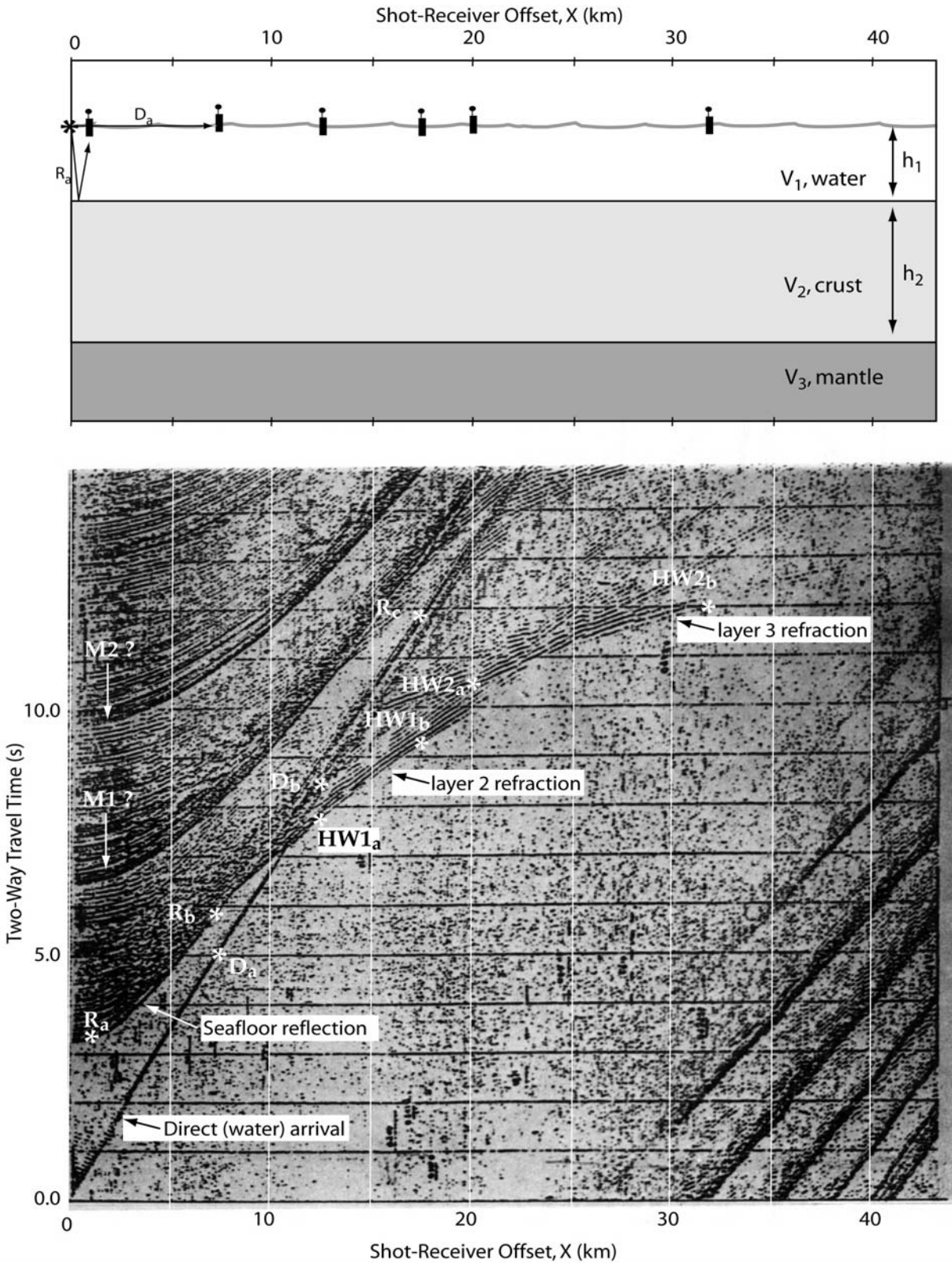
- Calculate the angles of the reflected P-wave,  $i_P$ , and the reflected S-wave,  $i_S$ .
- Calculate the angles of the transmitted (refracted) P-wave,  $r_P$ , & the transmitted S-wave,  $r_S$ .
- Roughly sketch the ray paths of the five rays, labeling the appropriate angles.

2) The figure below illustrates the geometry of an example marine refraction experiment. The “receiver” is a hydrophone that is attached to a “sonobuoy” dropped from the ship into the water. Airguns on the ship are shot every 20 s or so as the ship moves away from the sonobuoy. Each shot occurs at a given distance or offset from the sonobuoy, is recorded by the sonobuoy, and is then radioed back to the ship.



The bottom diagram on the next page shows a seismic record. The dark bands represent reflected or refracted sound recorded by the sonobuoy. The vertical axis is time since the last shot (or the time it takes the sound to travel from the shot to the receiver) and the horizontal axis is shot-receiver distance,  $x$ . Several phases and arrival points are labeled. For example, point “D<sub>a</sub>” records the “direct arrival”, a ray that traveled straight along the surface of the water to the sonobuoy when the sonobuoy was  $x \sim 7.5$  km away from the ship; point “R<sub>a</sub>” is a reflection from the sea floor recorded at  $x \sim 1.5$  km. The top figure on the next page shows a cross-section with the source on the upper left (marked by \*) and different locations of the sonobuoy across the surface. In this diagram, the paths of the rays recorded at points D<sub>a</sub> and R<sub>a</sub> are sketched.

- In the top diagram, sketch the ray paths for the arrivals at points D<sub>b</sub>, R<sub>b</sub>, R<sub>c</sub>.
- Determined the sound speed  $V_1$ , of the water.
- Approximately how deep is the sea floor? That is what is  $h_1$ ?



**Extra credit:** What are the phases M1 and M2? Hint: note their similar shape to the seafloor reflection and that they are separated from each other by the same amount of time, which is also the time (from zero time) the arrival associated with point  $R_a$  is recorded.

**9B) Read Robinson & Coruh Handout p. 39-50 and complete for discussion on Fri. 3/13**

3) The seismogram also shows refractions, which we can approximate as “head-waves”, from the crust (layer 2). Two points on this phase are labeled HW1<sub>a</sub>, HW1<sub>b</sub>. In the top diagram, sketch ray paths as head waves for rays that arrive at points HW1<sub>a</sub>, HW1<sub>b</sub>.

4) Determine the average velocity of the crust,  $V_2$ .

Do one of the following:

5(a) Use the distance  $X_c$  at which the direct ray crosses the crustal refraction to determine the water depth,  $h_1$ .

5(b) Use the intercept time of the crustal refraction,  $T_I$  to determine the water depth,  $h_1$ .

6) What is the minimum shot-receiver offset that you would expect to image this crustal refraction,  $X_{crit}$ ? How well does this match the minimum distance that you actually see this refracted phase? If the difference is appreciable what might account for the discrepancy (hint: the slight bending of the crustal refraction could be important)? Does the coincidence of the minimum distance observed with the seafloor reflection make sense?