Tien Shan - Introduction:

- Tien Shan is a chain of mountains range located in central Asia and extends approximately east-west for almost 2500 km long and wide of 300-500 km and has a maximum elevation of 7000 m.

- It is considered to be one of the most active intercontinental mountain belt in the world and it also represent a good example of mountain building process .

- Tien Shan has formed as a result of continental fragments in the Paleozoic due to the collision of India with Eurasia which occurred along the southern margin and the northern margin.

- The shortening of Tien Shan is in the N-S direction with a rate of 20 mm/yr.

- Earthquakes which occur at the southern edge of Tien Shan are quite shallow (10-20 km), while those on the north side happen at 40 km depth.

Tien Shan – Previous Results:

- Tien Shan has an average crustal thickness of 50-55 km and there is a probably a hot mantle play an important role in the deformation of central Asia.

- The crust thickens north to the Tien Shan and south to the Tibetan Plateau.

- The highest velocities were obtained in the middle of Tien Shan associated with the greater jointing of the south Tien Shan rocks.

- Velocities varies from 4.48-6.5 km/s for south Tien Shan and 4.2-6.5 km/s for the north part.

- Collision between the Indian and Eurasian plates is characterized by crustal shortening and uplifting.

- Metamorphosed rocks expose in most part of Tien Shan.

Steps:

- Convert the seismograms to radial and tangential components
- Calculate RFs
- Choose RFs
- Stack RFs using the procedure used by Dueker and Sheehan, JGR 04/1998.

-**FORTRAN:**

- Number of traps: 10
- Weighting factor; w1=0.5, w2=0.4, and w3=0.1
- Depth range: 35-80 km
- Vp/Vs range: 1.65-1.95
- Mean crustal velocity Vp(z): 6.1 km/s (IASP)
- Epicentral: 30°-180°
- Vs=Vp/1.73

IRIS (DMC):

Three component seismograms data (Vertical, N-S, E-W).

The three seismograms produced by a modern seismograph station show that the P wave is more visible on the vertical component and the S wave amplitude is larger on the horizontal components

Data from 1985/2010

Magnitude from 4.5-9

Epicentral: 30°-177°

Crustal thickness (H):

- Apply the method of Zhu and Kanamori (2000) for the stacking of receiver functions by the following steps:

1) Selecting a P-wave velocity model for the study area.

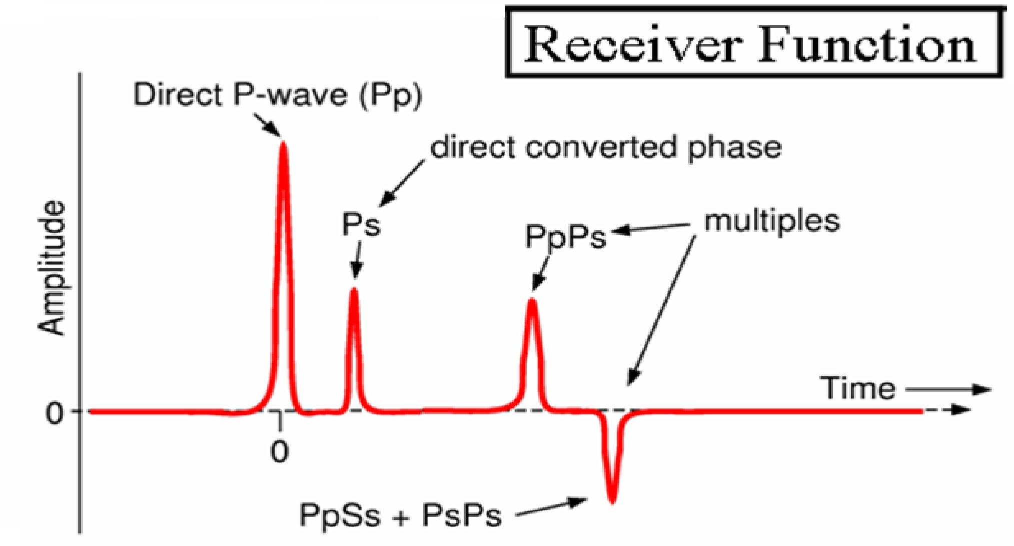
2) Dividing the top-60 or so km of the earth beneath a station into thin layers (e.g., 1 km thick).

3) By assuming that the Moho is located at the bottom of each of the thin layers, the receiver functions recorded by the station are move-out corrected from the following equations [Nair et al., 2006]:

$$t_1^{(i,j)} = \int_{-H_i}^{0} [\sqrt{(V_p(z)/\phi_j)^{-2} - p^2} - \sqrt{V_p(z)^{-2} - p^2}]dz \qquad t_2^{(i,j)} = \int_{-H_i}^{0} [\sqrt{(V_p(z)/\phi_j)^{-2} - p^2} + \sqrt{V_p(z)^{-2} - p^2}]dz$$

$$t_3^{(i,j)} = \int_{-H_i}^{0} 2\sqrt{(V_p(z)/\phi_j)^{-2} - p^2}\,dz$$

Where t1, t2, and t3 is for PmS, PPmS, and PSmS, respectively, Hi is the depth of the bottom of the i-th layer, and p is the real ray-parameter in sec/degree.



The receiver functions at each of the stations will be stacked using:

$$A(H_i, \phi_j) = \sum_{k=1}^{n} w_1 S_k(t_1^{(i,j)}) + w_2 S_k(t_2^{(t,j)}) - w_3 S_k(t_3^{(i,j)})$$

Where $w_1+w_2+w_3=1$ are the weighting factors, n is the number of RFs participating in the stacking. And Sk(t) is the amplitude of the point after the first P arrival.

Poisson’s ratio (σ):

- $\sigma = 0.5 [1-1/(\Phi^2-1)]$, where (Φ) is Vp/Vs [ranging from 1.65-1.95]

- Changes of the diameter proportional to the change of length.

- Material is stretched in one direction it tends to get thinner in the other direction.

- High Poisson's ratio indicates mafic composition of the crust.

- The range for most materials is from 0-0.5. Continental is 0.256 and oceanic is 0.30.

- Poisson’s ratio can be affected by:

1. Temperature and pressure: the ratio will increase with increased pressure.
2. Minerals contents: less heavy minerals will increase the ratio.
3. Silica contents: more silica will increase the ratio.

- Mineral experiments has suggested that variations in Vp/Vs are primarily due to SiO_2 content (Lower SiO_2 content corresponds to higher Vp/Vs) :

Felsic : Φ =1.76 or smaller

Intermediate: Φ =1.76 and 1.81

Mafic: Φ = larger than1.81

Upper continental crust mean: 1.74

Lower continental crust mean: 1.81

Mean value of continental crust: 1.78

Moho sharpness (R):

- The sharpness of the Moho is related to the thickness of the transition zone from the crust to the mantle.

- A sharp Moho produces strong PmS and its multiples.

- Factors affect the amplitude of the converted phases:

1. The lateral variation in Moho depth.
2. Velocity heterogeneities in the crust beneath the area surrounding the station.
3. The contrasts of the P and S wave velocities across the Moho.
4. The topography of velocity interfaces in the crust.

- To quantify the apparent sharpness of the Moho beneath a station, we measure R, the ratio between the stacking amplitude corresponding to the optimal pair of (H,Φ) and the mean amplitude of the direct p wave on the radial components.

- R is a function of the angle of incidence.

Delamination of the crust:

- Delamination refers to the loss and sinking of the portion of the lowermost lithosphere from the tectonic plate to which it is attached. This can occur when the lower portion lithosphere becomes more dense than the surrounding mantle. Because of this instability (higher density material atop lower density material), the lower lithosphere separates from the tectonic plate and sinks into the mantle.

- Delamination is of two basic types: brittle, or ductile. In the brittle type, the lower crust metamorphoses to the denser eclogite, causing a density inversion, which then may detach (rip away) and sink. The second type, ductile delamination, is related to convective instabilities. The convection can simply peel away the lower crust.

- Delamination of the lithosphere has two major geologic effects. First, because a large portion of dense material is removed, the remaining portion of the crust and lithosphere undergo rapid uplift to form mountain ranges. Second, flow of hot mantle material encounters the base of the thin lithosphere and often results in melting and a new phase of volcanism.

Bouguer gravity:

- Bouguer anomaly is computed from a free-air anomaly by computationally removing from it the attraction of the terrain, the Bouguer reduction. Bouguer gravity anomaly = expected value of gravity (location) - actual value. It corrects the observed gravity value. Free-air anomaly = observed gravity - theoretical gravity. It measures the increase/decrease in mass within the earth.

- The Bouguer anomalies usually are negative in the mountains because of isostasy: the rock density of their roots is lower, compared with the surrounding earth's mantle. Bouguer anomalies may indicate rock types.

- Anomaly in the local gravitational force that is due to the density of rocks rather than local topography, elevation, or latitude. A positive anomalies generally indicative of denser and therefore more massive rocks at or below the surface. A negative anomaly indicates less massive materials. Calculations of Bouguer anomalies are used for mineral prospecting and for understanding the structure beneath the Earth's surface.

Coda waves:

Are the directed converted phase (Pms), and the multiples waves (PPms and PSmS)

P-to-S contrasts observed in:

1. Moho.
2. 410-km.
3. 660-km.

Focus, epicenter, and Wadati-Benioff zone:

1. Focus: is the actual point/rupture within the earth.
2. Epicenter: is the point on earth's surface above the focus.
3. Wadati-Benioff zone: is the dipping zone of earthquakes.

Focal depths:

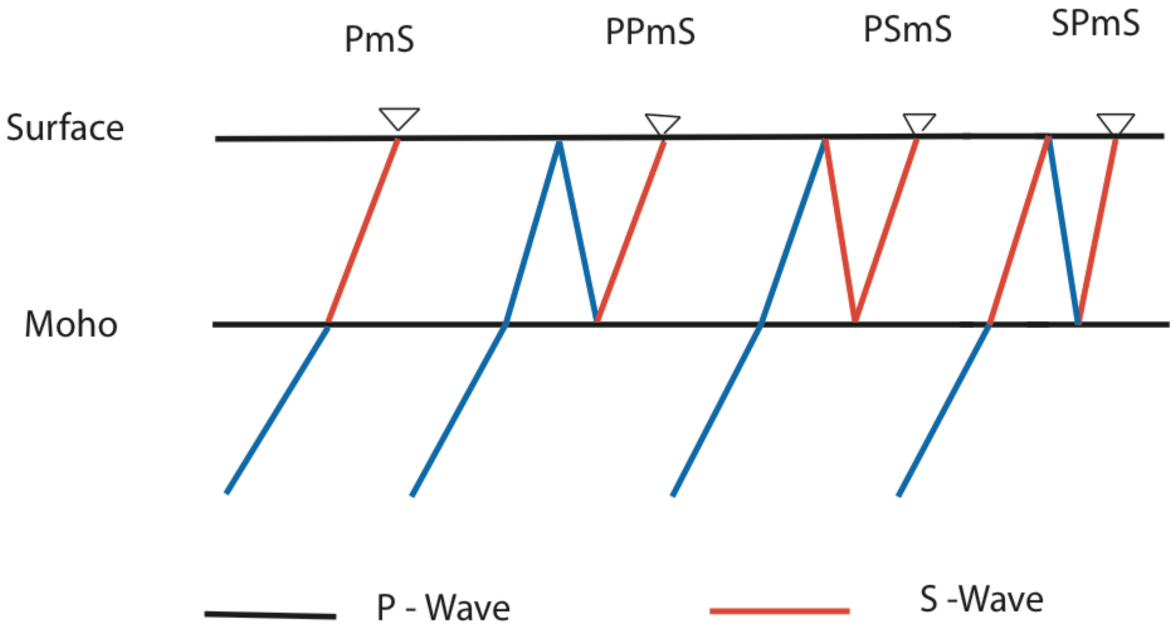
1. Shallow: 0-70 km occurs in all plate boundaries.
2. Intermediate: 70-300 km occurs in convergent plates.
3. Deep: 300-700 km occurs in convergent plates.

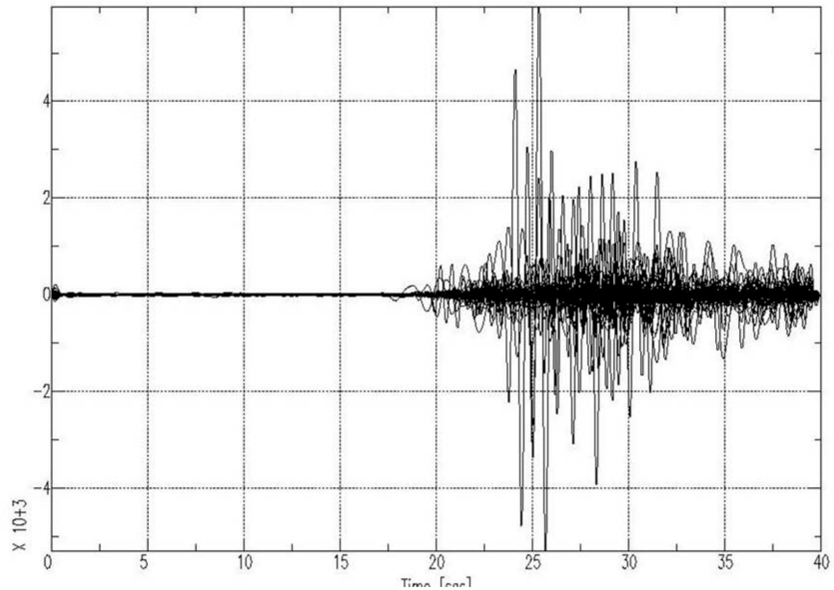
Staking receiver functions:

Are used to decrease the noise.

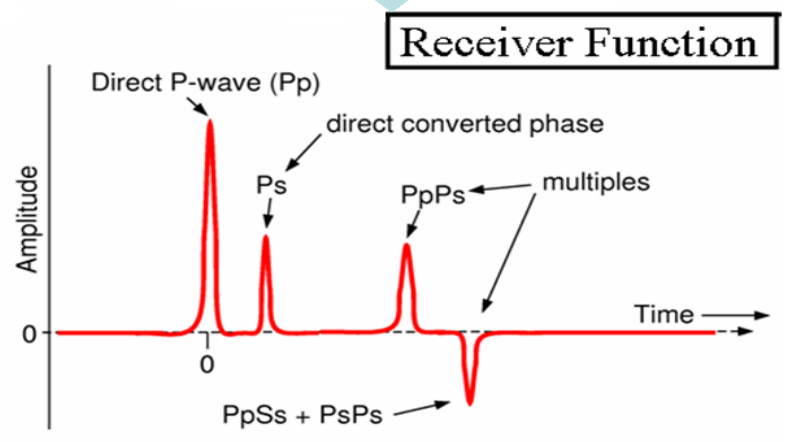
Receiver functions:

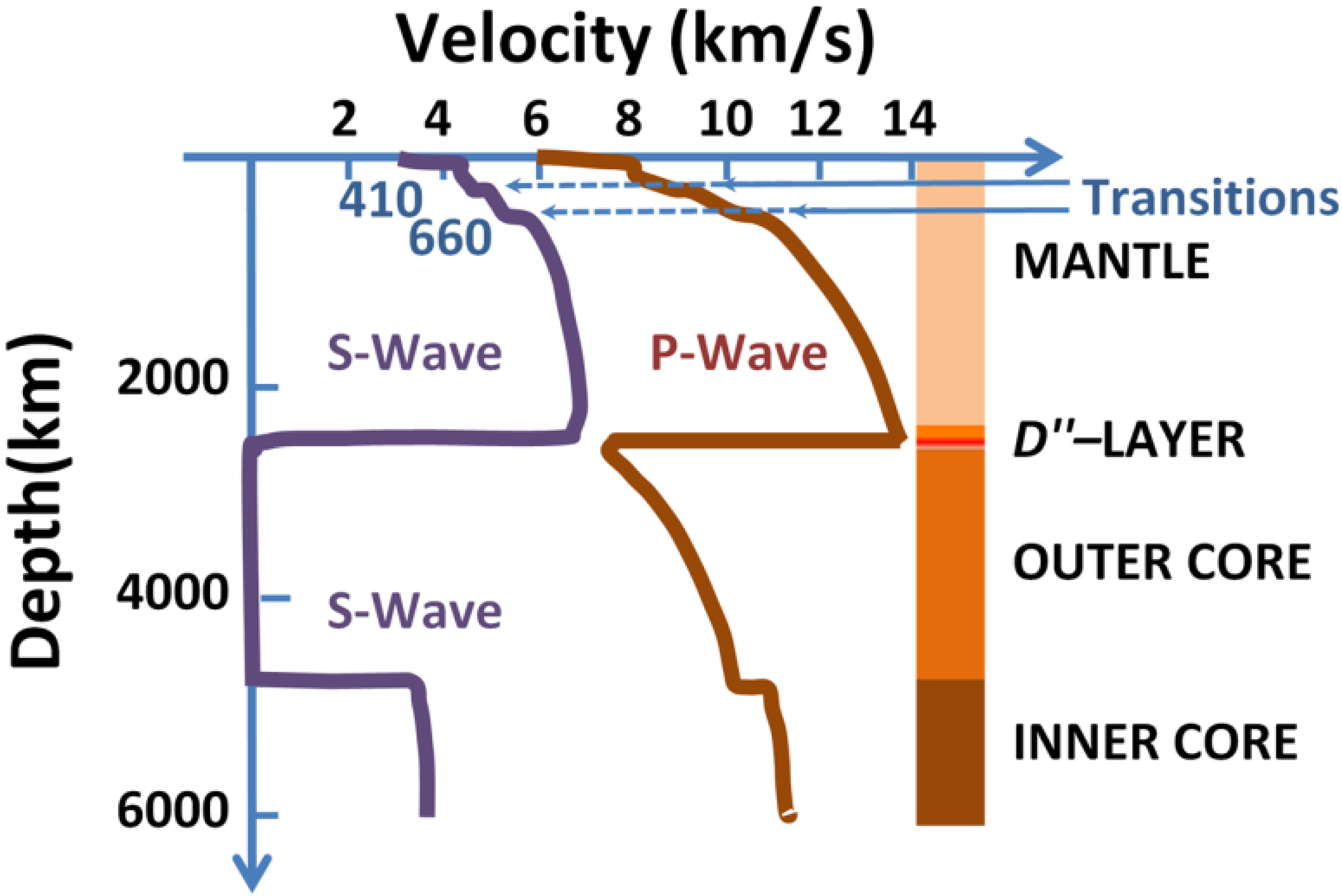
1. Model the structure of the earth.
2. Image the depth to major velocity discontinuities in the crust and the uppermost mantle.
2. Use information from teleseismic earthquakes data recorded at three components seismograms “the first arrival is a refracted P-wave”.
3. Receiver functions calculated by the de-convolving the vertical from the radial and tangential components.





After deconvolution




Velocity (km/s)
2
4
6
8
10
12
14
410
660
Transitions
MANTLE
S-Wave
P-Wave
D''–LAYER
OUTER CORE
S-Wave
INNER CORE
Depth(km)
2000
4000
6000