24. Imaging in seismology is based on geometrical optics

- ❑ For all types of tomographies
- ❑ In P-wave tomographies
- ❑ In normal-mode tomographies
- ❑ For none ot the methods used in seismology
- ❑ Only for tomographies using reflected waves

25. Subduction zones are imaged by P-wave tomography as

- ❑ Fast regions
- ❑ Slow regions
- ❑ Attenuating regions
- ❑ Diffracting objects
- ❑ Subduction zones are not curved

26. The rays are curved in the Earth because

- ❑ The Earth is spherical
- ❑ The Earth has a core
- ❑ The wave velocity is changing with frequency
- ❑ The wave velocity is changing with depth
- ❑ No, the rays are not curved

27. A time-difference of 100 s between the P and the S waves at a station tells us that the earthquake is

- ❑ 12 km away
- ❑ 80 km away
- ❑ 800 km away
- ❑ 8 000 km away
- ❑ There is insufficient information to determine the distance

23. Seismic tomography is a method for:

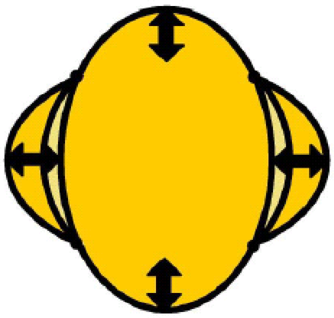
- ❑ Predicting earthquakes
- ❑ Imaging the Earth's crust with sound waves
- ❑ Imaging the Earth's interior with waves from earthquakes
- ❑ Measuring the temperature in the Earthæs core
- ❑ Measuring the velocity of the tectonic plates

24. P-waves have a lower velocity in the Earth's core than in the Earth's mantle. When a P-wave propagates downwards in the mantle and reaches the core-mantle boundary, it will:

- ❑ Be fully reflected
- ❑ Be converted to an S-wave in the core
- ❑ Get its ray path refracted towards the center of the Earth
- ❑ Get its ray path refracted away from the center of the Earth
- ❑ The P-waves never reach the core-mantle boundary

25. The Earth's eigenvibration with longest period is 0S2. It has a period of 54 minutes and deforms the Earth as shown in the figure below. The Earth has a radius of 6371 km. This allows us to estimate the average seismic wave velocity in the Earth to be about:

- ❑ 3 km/s
- ❑ 6 km/s
- ❑ 12 km/s
- ❑ 118 km/s
- ❑ 370 km/s



Exercise related to imaging in seismology - INF-GEO 3310/4310

We have seen that the analysis of arrival times of different waves as a function of distance from the earthquake to the station has been central in early seismology to infer the structure of the Earth. These arrival times can be interpreted using ray theory and simple reflection and refraction laws. In the present exercise, we will make simple calculations which are similar to what pioneer seismologists did to locate earthquakes and to determine the existence and properties of the core.

1 - On April 5, 2006, you have registered the arrivals of P, PcP (core-reflected P wave) and S waves at 5 stations. Assuming that the velocity for P waves in the mantle is 12 km/s and the velocity for S waves is 6 km/s, locate the earthquake and calculate its origin time. The radius of the Earth is 6371 km on average.

Location	Latitude	Longitude	P wave	S wave	PcP wave
Kongsberg	60.°N	10.°E	12:10:45.1	12:21:30.2	12:11:36.8
Canberra	-36.°N	145.°E	12:10:21.2	12:20:42.4	12:11:21.9
Kipapa	20.°N	-165.°E	12:08:06.0	12:16:12.0	12:10:07.2
Alma Ata	43.°N	75.°E	12:06:57.5	12:13:55.1	12:09:35.7
Djibouti	10.°N	45.°E	12:11:52.4	12:23:44.9	12:12:22.0

Table 1: Station location and arrival times

2 - Use the PcP wave arrival times to calculate the radius of the core.

3 - Calculate what is the maximum distance for the observation of the PcP wave.

4 - Assuming that the velocity of P waves in the core is 9 km/s, calculate at which distances and at which times PKP and SKS waves leaving the source with angles of incidences (angles between the ray and the radial direction) of 0, 10, 20 and 30° come back to the surface of the Earth. PKP waves travel as P waves in the mantle and in the core. SKS waves travel as S waves in the mantle and as P waves in the core. Use the formula for refraction of waves in a spherical body $\frac{r \sin i}{v} = cst$, where r is the radius, i the angle of incidence and v is the velocity. Do you expect to observe PKP and SKS waves at the stations above?