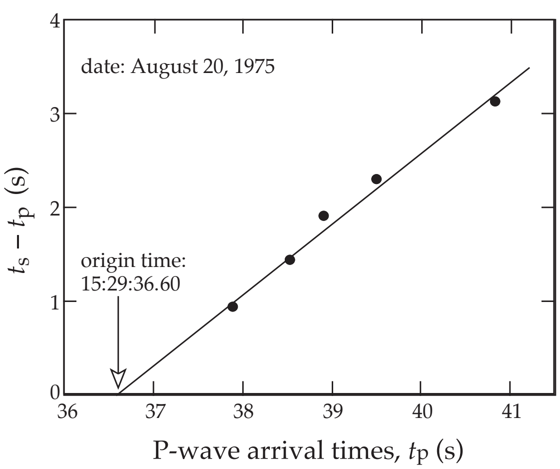
Übung 05.11.2009

Localization of Earthquakes.

The distance of a seismic station from the epicenter of an earthquake (the epicentral distance) may be expressed in kilometers Δ_{km} along the surface, or by the angle $\Delta°(180/\pi)(\Delta_{km}/R)$ subtended at the Earth's center. The travel-times of P- and S-waves from an earthquake through the body of the Earth to an observer are dependent on the *epicentral distance*. The travel-time versus distance plots are not linear, because the ray paths of waves travelling to distant seismographs are curved. However, the standard seismic velocity profile of the Earth's interior is well enough known that the travel-times for each kind of wave can be tabulated or graphed as a function of epicentral distance. In computing epicentral distance from earth- quake data the total travel-time is not at first known, because an observer is rarely at the epicenter to record the exact time of occurrence t0 of the earthquake. However, the difference in travel-times for P- and S-waves (ts – tp) can be obtained directly from the seismogram; it increases with increasing epicentral distance (Fig. 3.30a).

For local earthquakes we can assume that the seismic velocities a and b are fairly constant in the near-surface layers. The time when the earthquake occurred, t0, can then be obtained by plotting the differences (ts – tp) against the arrival times tp of the P-wave at different stations. The plot, called a *Wadati diagram*, is a straight line.



Wadati diagram for determining the time of occurrence of an earthquake

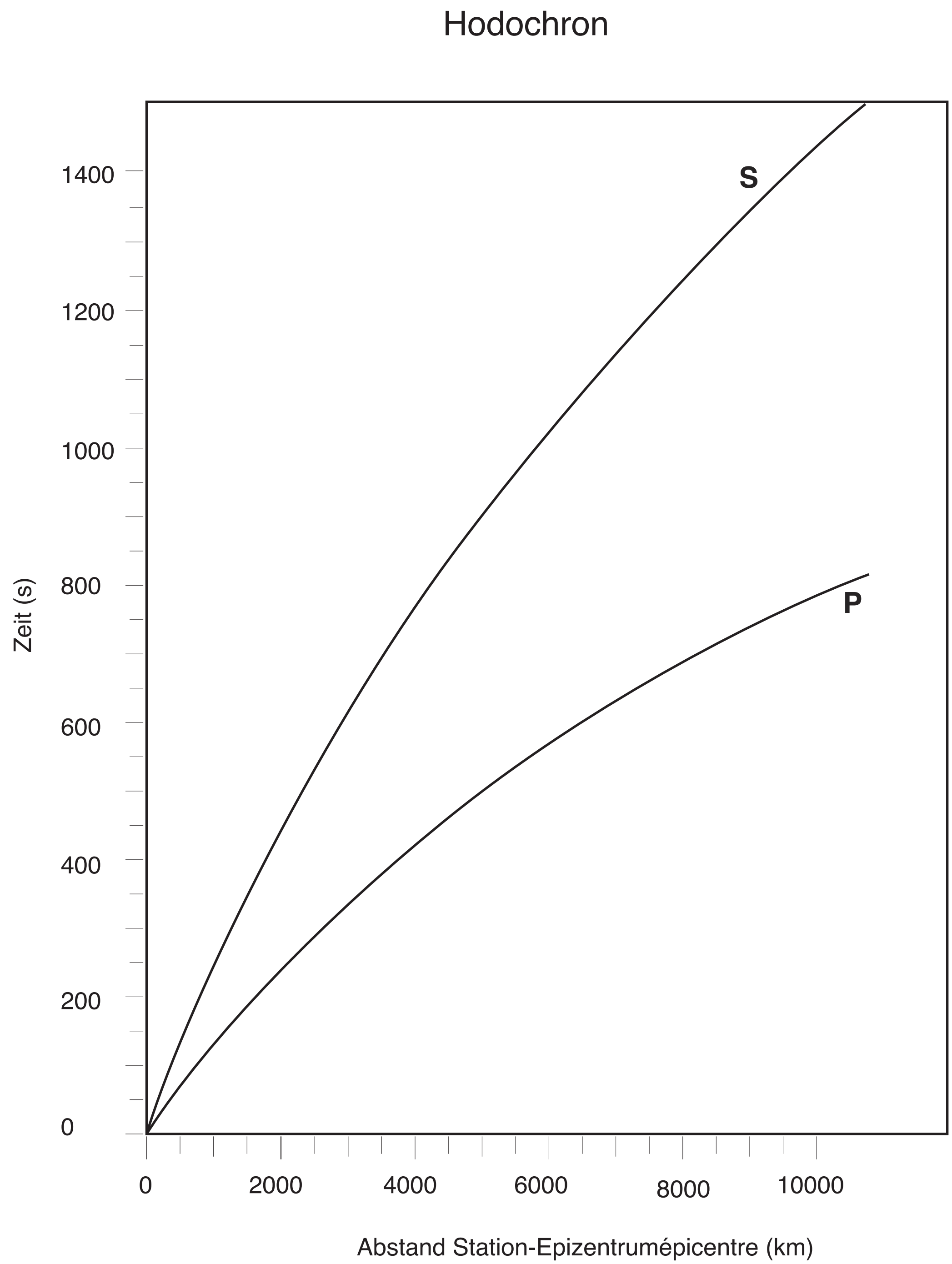
In order to determine the location of an earthquake, epicenter travel-times of P- and S-waves to at least three seismic stations are necessary (Fig. 3.31). The data from one station give only the distance of the epicenter from that station. It could lie anywhere on a circle centered at the station. The data from an additional station define a second circle which intersects the first circle at two points, each of which could be the true epicenter. Data from a third station remove the ambiguity: the common point of intersection of the three circles is the epicenter.

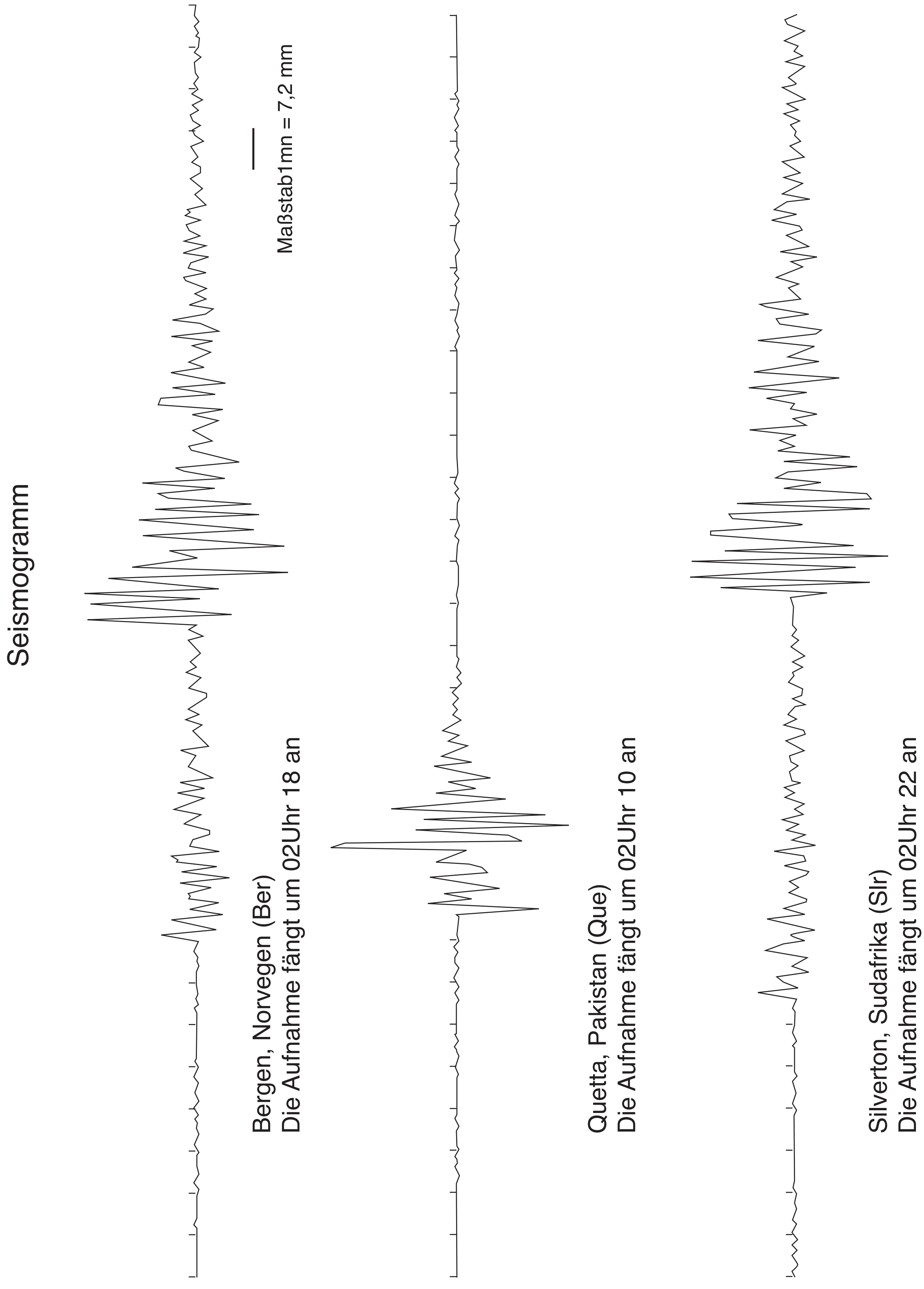
Generally the circles do not intersect at a point, but form a small spherical triangle. The optimum location of the epicenter is at the center of the triangle. If data are available from more than three seismic stations, the epicentral location is improved; the triangle is replaced by a small polygon. This situation arises in part from observational errors, and because the theoretical travel-times are imperfectly known. The interior of the Earth is neither homogeneous nor isotropic, as must be assumed. The exact location of earthquake epicenters requires detailed knowledge of the seismic velocities along the entire path, but especially under the source area and the receiving station.

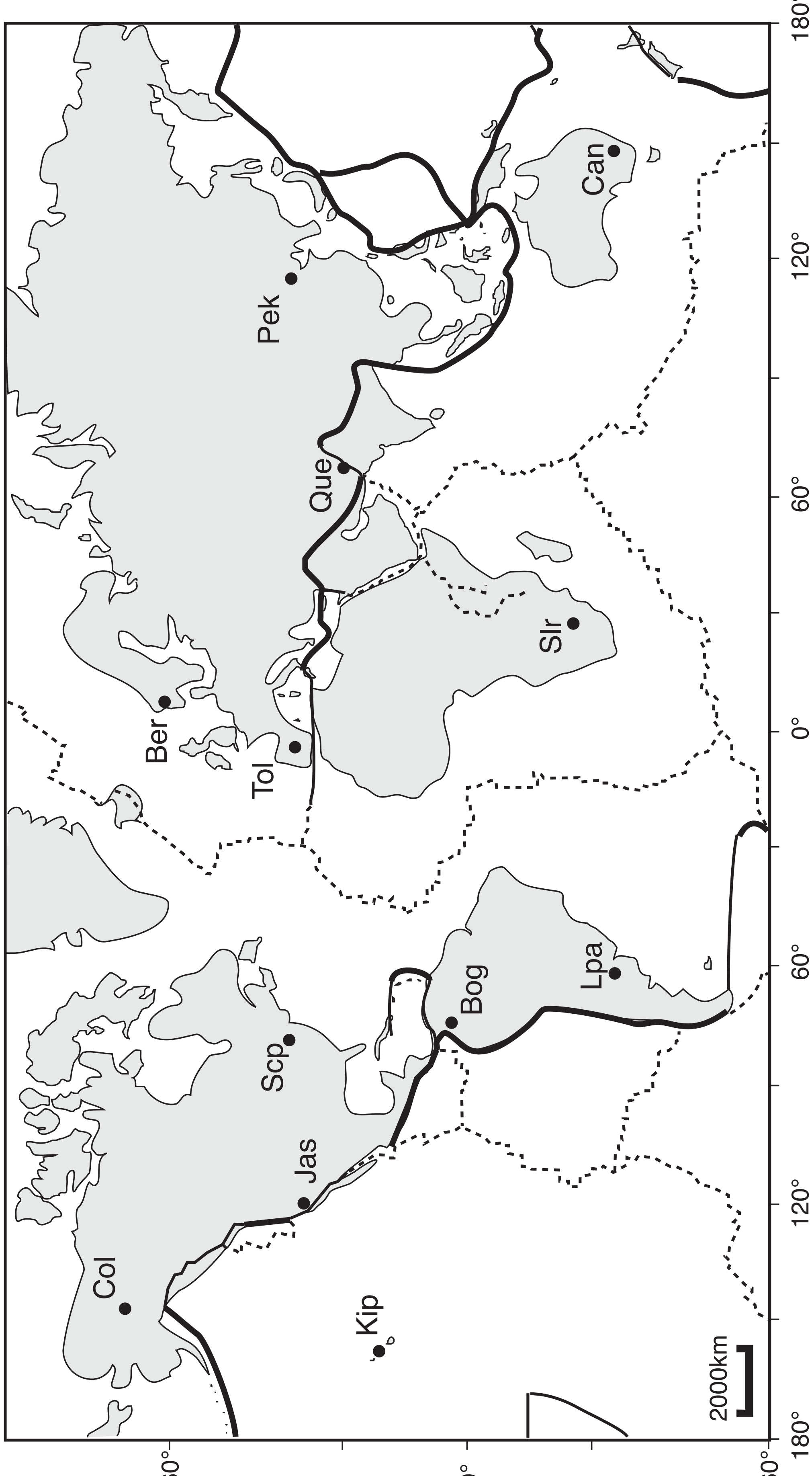
Exercise 1

a) With the helps of the seismograms, hodochrons and the map, localize the earthquake

b) At what time happens the earthquake?




Seismogramm
Maßstab1mn = 7,2 mm
Bergen, Norvegen (Ber)
Die Aufnahme fängt um 02Uhr 18 an
Quetta, Pakistan (Que)
Die Aufnahme fängt um 02Uhr 10 an
Silverton, Sudafrika (Slr)
Die Aufnahme fängt um 02Uhr 22 an



180°
120°
60°
0°
60°
120°
180°
60°
0°
60°
Col
Kip
Jas
Scp
Bog
Lpa
Tol
Ber
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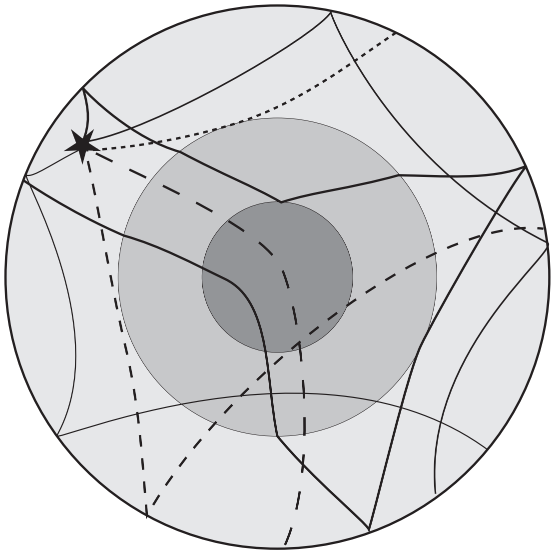
Slr
Pek
Can
2000km



gestrichelte Kurve S Welle
stetige Kurve P Welle

Exercise 2:

Give name to the different waves

Exercise 3: The crust below the Tibet plateau

The Tibet is the highest and the largest plateau in the world.

- By using the profiles given below, try to reconstruct the crustal depth variations from north to south and to west to east below the plateau

Tip:
We assume a homogeneous crust with has a density of 3 $t.m^{-3}$ below the Tibet, a homogeneous mantle with a density of 3.5 $t.m^{-3}$, and the "normal" crust has a thickness of 30 km.