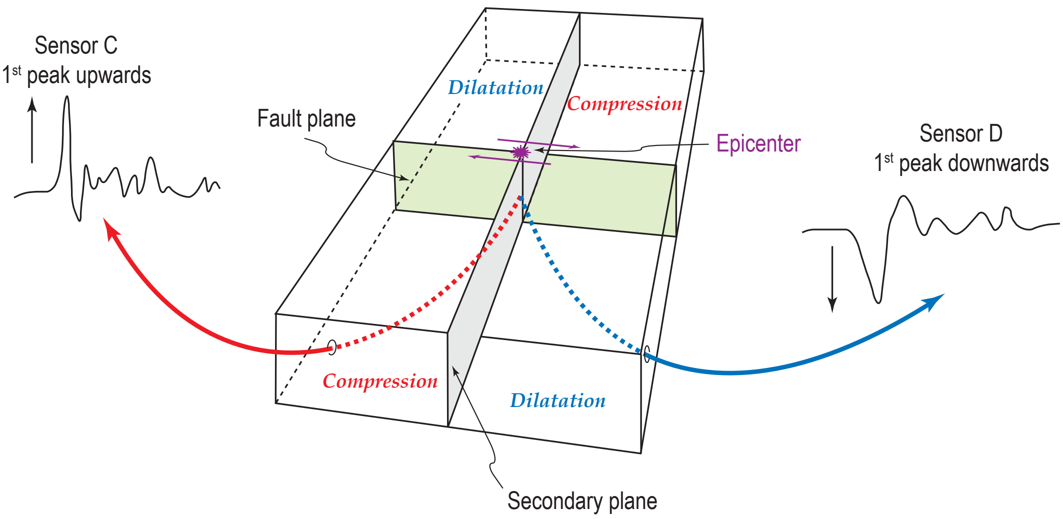
Übung 12.11.2009

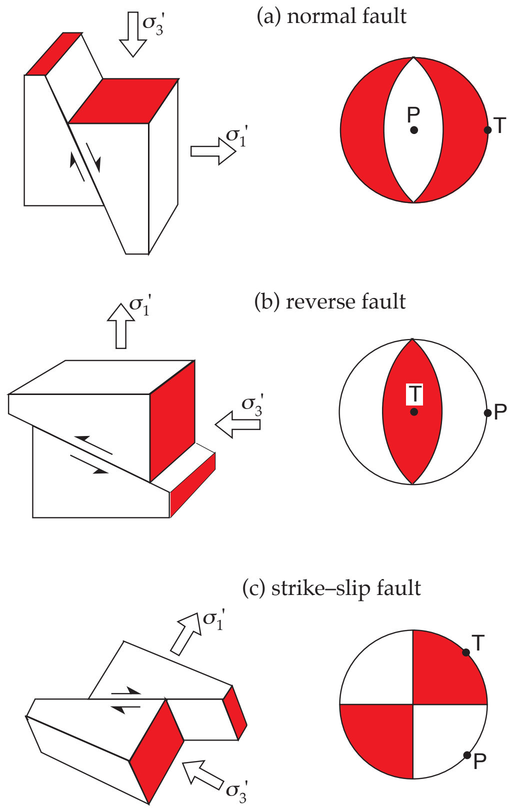
Analysis of earthquake focal mechanisms.

The ray path along which a P-wave travels from an earth- quake to the seismogram is curved because of the variation of seismic velocity with depth. The first step in the fault- plane solution is to trace the ray back to its source. A fictitious small sphere is imagined to surround the focus and the point at which the ray intersects its surface is computed with the aid of standardized tables of seismic P- wave velocity within the Earth. The azimuth and dip of the angle of departure of the ray from the earthquake focus are calculated and plotted as a point on the lower hemisphere of the small sphere. This direction is then projected onto the horizontal plane through the epicenter. The projection of the entire lower hemisphere is called a stereogram. The direction of the ray is marked with a solid point if the first motion was a push away from the focus (i.e., the station lies in the field of compression). An open point indicates that the first motion was a tug towards the focus (i.e., the station lies in the field of dilatation).

First-motion data of any event are usually available from several seismic stations that lie in different directions from the focus. The solid and open points on the stereogram usually fall in distinct fields of compression and dilatation. Two mutually orthogonal planes are now drawn so as to delineate these fields as well as possible. The fit is best made mathematically by a least- squares technique, but often a visual fit is obvious and sufficient. The two mutually orthogonal planes correspond to the fault-plane and the auxiliary plane, although it is not possible to decide which is the active fault-plane from the seismic data alone. The regions of the stereogram corresponding to compressional first motions are usually shaded to distinguish them from the regions of dilatational first motions. The P- and T-axes are the lines that bisect the angles between the fault-plane and auxiliary plane in the fields of dilatation (P) and compression (T), respectively.



The locations of P and T may at first seem strange, for the axes appear to lie in the wrong quadrants. However, one must keep in mind that the orientations of the principal stress axes correspond to the stress pattern before the earthquake, while the fault-plane solution shows the ground motions that occurred after the earthquake. The focal mechanism analysis makes it possible to interpret the directions of the principal axes of stress in the Earth's crust that led to the earthquake.



The three main types of fault and their focal mechanisms. Left: the orientations of each fault-plane and the principal deviatoric stresses, σ1 and σ3.
Right: focal mechanisms and orientations of P- and T- axes.T

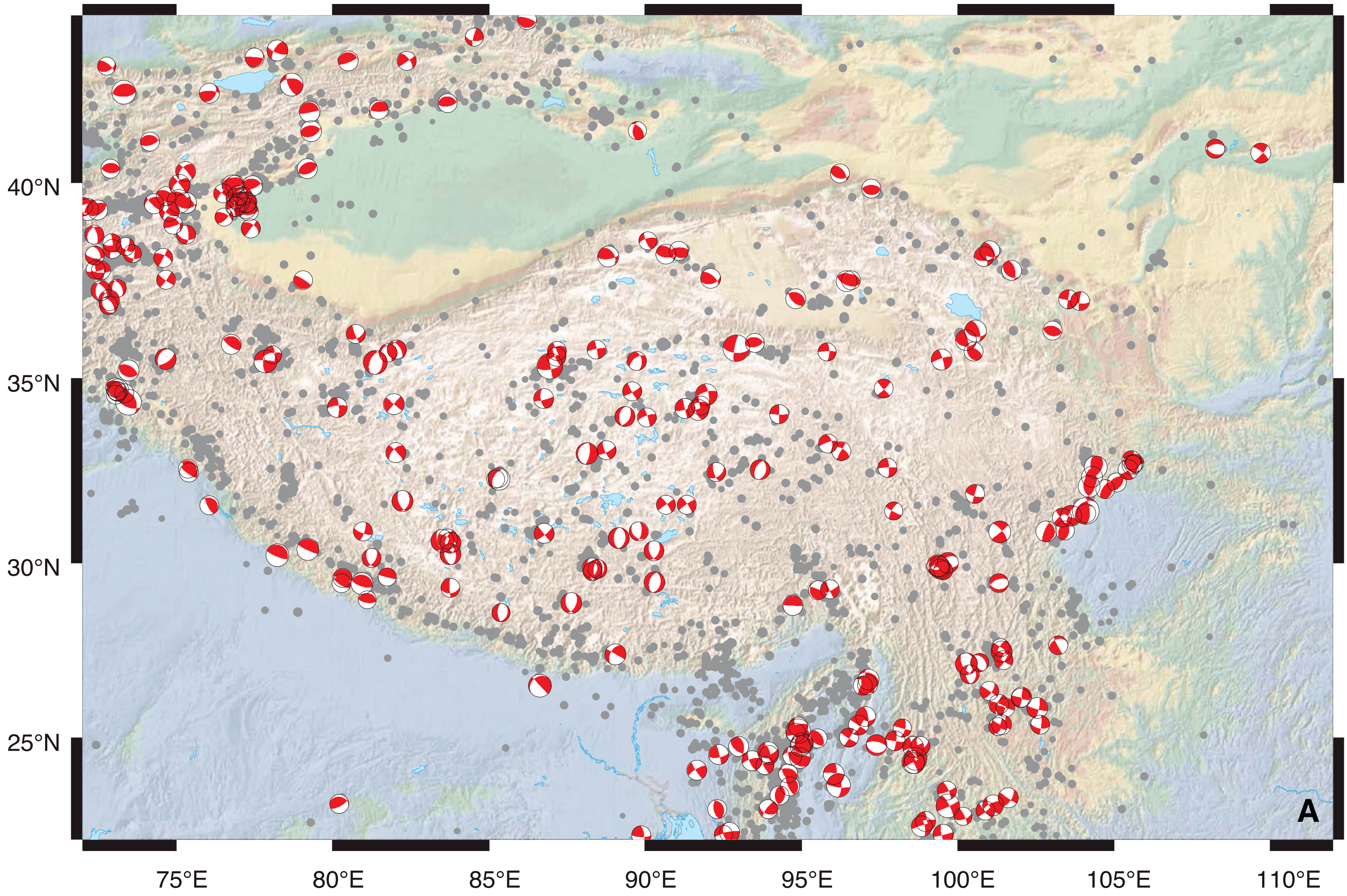
There are only three types of tectonic fault. These can be distinguished by the orientations of the principal axes of stress to the horizontal plane. The focal solutions of earthquakes associated with each type of fault have characteristic geometries. When motion on the fault occurs up or down the fault plane it is called a dip–slip fault, and when the motion is horizontal, parallel to the strike of the fault, it is called a strike–slip fault.

Two classes of dip–slip fault are distinguished depend- ing on the sense of the vertical component of motion. In a *normal fault*, the block on the upper side of the fault drops down an inclined plane of constant steepness relative to the underlying block. The correspond- ing fault-plane solution has regions of compression at the margins of the stereogram. The T-axis is horizontal and the P-axis is vertical. A special case of this type is the listric fault, in which the steepness of the fault surface is not constant but decreases with increasing depth.

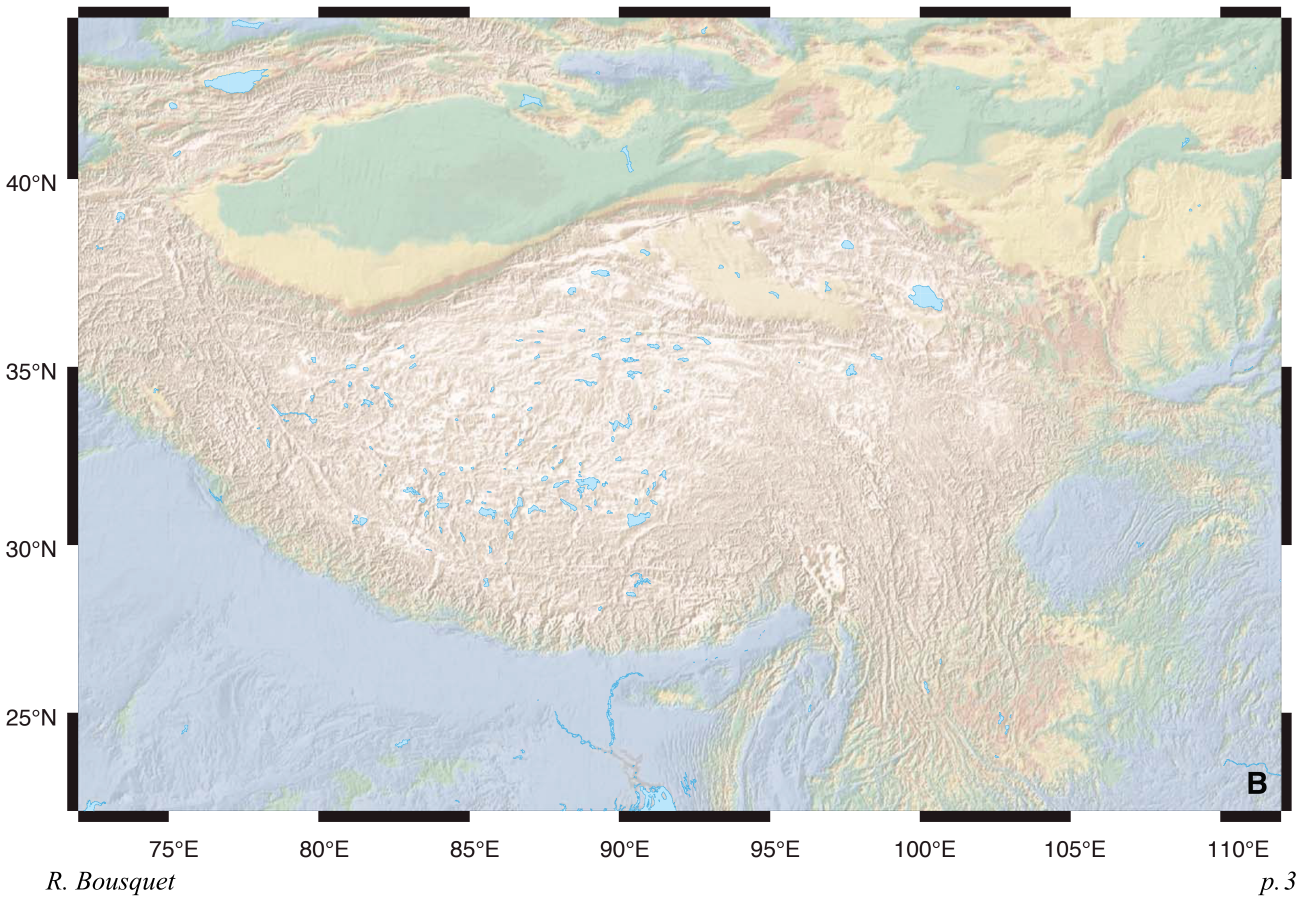
In the second type of dip–slip fault, known as a *reverse fault or thrust fault*, the block on the upper side of the fault moves up the fault-plane, overriding the underlying block. The fault-plane solution is typified by a central compressional sector. The orientations of the axes of maximum tension and compression are the inverse of the case for a normal fault. The T-axis is now vertical and the P-axis is horizontal. When the fault-plane is inclined at a very flat angle, the upper block can be transported over large horizontal distances. This special type of overthrust fault is common in regions of continental collision, as for example in the Alpine–Himalayan mountain belts.

Exercise

With the helps of map A, draw on the map B the major active faults in the Himalaya-Tibet system. Indicate also the type of each fault



40°N
35°N
30°N
25°N
75°E
80°E
85°E
90°E
95°E
100°E
105°E
110°E
A



40°N
35°N
30°N
25°N
75°E
80°E
85°E
90°E
95°E
100°E
105°E
110°E
B