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Seismicity distribution along recent and ancient convergent plate boundaries

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Convergent plate boundaries at continental margins belong to the tectonically most active areas on earth and are endangered by devastating earthquakes and tsunamis. Nearly all of the large earthquakes with magnitude >8 occur at shallow depths in subduction zones. They initiate within the seismogenic coupling zone, which marks the seismically active part of the subduction channel developed between the two converging plates. The seismogenic coupling zone occupies only a limited depth range along the plate interface depending on the subduction zone setting, i.e. a depth of 10 km to 50 km. The updip limit of seismogenic coupling is probably caused by the dehydration of stable sliding clay minerals to unstable sliding ones. The downdip limit may be caused by the increasing dominance of ductile behavior, the serpentinization of the forearc mantle or simply a result of changes in the geometrical setting of the subduction zone.

The north Chilean continental margin is a high strain margin driven by high plate convergence rate. The largest amount of strain is accommodated along the subduction interface. The last big event in northern Chile occurred in 1995 near Antofagasta. The Mw = 8.0 event ruptured the subduction interface 180 km along strike with an average slip of about 5m in the depth interval between 10-50 km. We carefully evaluated the aftershock sequence by examining the different categories of aftershock focal mechanisms to study the distribution of recent seismicity at a currently active subduction zone. Despite the well defined plate interface the width of the zone of seismic activity defined by the aftershocks corresponds to about 3 km. All possible kinds of focal mechanisms (thrust faults, normal faults, and strike-slip faults) occur along the seismogenic coupling zone during the narrow time span of the recorded aftershocks (2 month). This makes it quite difficult to use fault plane data gained from outcrops of first-order fault zones in order to obtain a relative event chronology on the basis of their kinematics.

In addition to recent plate boundaries, we examined an exposed fossil subduction channel in the depth range of the seismogenic coupling zone within the Central Alps of Europe to compare the recent seismicity with the fossil counterpart. The broader zone of seismic activity in the active example is well comparable to our field results within the fossil subduction zone – ancient seismicity occupies an at least few 100 m wide zone immediately above the base of the former upper plate. Seismicity seems to be additionally linked to clasts embedded in the subduction channel matrix when acting as mechanical heterogeneity. Clear evidence for fossil earthquakes is given by the occurrence of pseudotachylytes. They have been found at a limited depth range of the fossil subduction zone (previously published data points to app. 3-6 kbar, $<350^{\circ}$C, corresponding to a depth of about 10 km to 20 km) at the base of the ancient upper plate. Furthermore, coarse grained mineralized veins occur within matrix rocks of the fossil subduction channel. Their relationship to seismic faulting has yet to be evaluated. They may result from dehydration processes during prograde metamorphism within the subduction zone and subsequent rapid hydraulically fractured vein formation with rapid crystallization. They may be indicators for fluid driven seismicity.