Geophysical Research Abstracts, Vol. 7, 04303, 2005
SRef-ID: 1607-7962/gra/EGU05-A-04303

Subduction channels - model assumptions and constrains from nature

R. Bachmann, **O. Oncken**
GeoForschungsZentrum Potsdam, Germany (raik@gfz-potsdam.de)

Introduction

Nearly all of the large earthquakes with magnitude >8 occur at shallow depths in subduction zones, especially beneath continents (Peacock & Hyndman 1999). They initiate within the seismogenic coupling zone, which marks the transient, seismically active part of the subduction channel developed between the two converging plates. Despite the enormous social, economic and scientific importance associated with seismogenic zones of plate interfaces (e.g. destructive earthquakes, tsunamis), processes occurring in the intervening subduction channels are poorly understood. Accordingly, there is a growing interest in studies of convergent geodynamic settings.

Model assumptions

A subduction channel focus deformation within subduction zones by transporting oceanic and continental material down into the mantle and by return-flow of low-viscosity material back to the surface. The subduction channel can be defined by gradients in the flow velocity of the deforming material in respect to the upper and the lower plate. Unstable slip in the upper part of the subduction channel occupies a limited depth range along the plate interface (seismogenic coupling zone), i.e. a depth of 10 km to 45 km (e.g. Oleskevich et al. 1999). The updip limit of seismogenic coupling (about 10 km) is probably caused by the dehydration of stable sliding smektite to unstable sliding illite or chlorite (Hyndman et al. 1997). The downdip limit, i.e. the maximum depth of thrust earthquakes and aftershocks (Peacock & Hyndman 1999), is located at about 30 km to 60 km (approx. 45 km), and may be caused by the increasing dominance of ductile behavior (Nedimović et al. 2003, Oleskevich et al. 1999) or the serpentinization of the forearc mantle leading to a talc rich layer, which lubricates the plate interface (Hyndman et al. 1997, Peacock & Hyndman 1999).

Fossil subduction channel

The subduction channel of active convergent plate margins can neither be directly accessed by drilling nor through surface observations. Therefore, direct investigation of ancient subduction zones and the comparison with indirectly acquired data from active ones is probably the most appropriate way to get insights into these geodynamic settings. For this purpose we studied an up to 1000 m wide mélange of schists, ultrabasites and felsic rocks as remnants of the South Penninic ocean within the Central Alps, which are sandwiched between the overlying African domain (Austroalpine in working area) and the underlying European domain during convergent plate motion (Bousquet et al. 1998). We regard them to represent parts of a fossil subduction channel.

The examination of seven profiles crossing the South Penninic – Austroalpine boundary allows us to describe the configuration of the fossil subduction channel. The hanging wall of the subduction channel is formed by upper plate basement, i.e. granite, gneiss and partly amphibolite. It is covered by sediments to some extent. The footwall of the subduction channel is made up of remnants of the South Penninic oceanic crust consisting of basalt and serpentinized peridotite. The matrix of the subduction channel is composed of a mélange of metasediments such as carbonate, grey or red shale and sandstone. Their metamorphic overprint increases towards the south of the working area (inferred deeper subduction level). Deformation of the metasediments increases similarly, which is expressed by the increasing dominance of foliation planes, and more pronounced stretching lineation. The matrix of the subduction channel incorporates clasts of different size consisting of upper plate material such as carbonate and gneiss as well as slivers of the oceanic lower plate (basalt and serpentinized peridotite). The clast size varies from a few millimeters to hundreds of meters. We recognized a predominance of upper plate basement clasts within our inferred upper parts of the subduction channel, which changes to a predominance of sedimentary clasts, i.e. dolomite, towards deeper levels of the subduction channel. Clasts of upper plate basement (i.e. granite and gneiss) exhibit only a cataclastic deformation along their rims – internally they still have retained their original texture. At deeper levels of the channel embedded sedimentary clasts are foliated along their outer parts similar to the foliation of the channel matrix.

Pseudotachylytes as evidences for fossil earthquakes (e.g. Cowan 1999) have been found at several localities along a composite synthetic N-S profile immediately above the South Penninic – Austroalpine boundary zone within the hanging wall basement. The first appearance of pseudotachylytes in our composite N-S profile occurred near Davos (Graubuenden, Switzerland), where we identified a small pseudotachylyte vein, which was generated along the boundary between oceanic rocks of the footwall and continental basement of the hanging wall. This pseudotachylyte vein cuts from the fault zone into the hanging wall. Towards the south of the working area the quantity and size of the pseudotachylyte veins increase significantly. Probable pseudotachylytes occur also within remnants of the oceanic plate. We never recognized pseudotachylytes within metasedimentary rocks. However, the metasedimentary clasts exhibit large amounts of hydraulic fractured vein systems. Additionally, we identified chaotic hydraulic fractured veins within gabbroic rocks at deeper levels of the subduction channel.

Conclusion

Convergent plate margins are the most seismically active areas on Earth. Due to the inaccessibility of subduction zones for direct investigations, the study of fossil examples, especially in the Central Alps, may open a new avenue for research to understand subduction zone processes. In the working area we identified characteristically features postulated in subduction channel models (e.g. Cloos & Shreve 1988a,b), like embedded clasts of different origin forming a mélange-type structure. Also pseudotachylytes as evidences for fossil earthquakes occur at a limited depth range within the fossil subduction channel. However, at deeper levels of the subduction channel chaotic hydraulic fractured veins occur. Their relationship to seismic faulting has to be evaluated yet. They may mirror dehydration processes during prograde metamorphism within the subduction zone. To summarize the features of the fossil subduction channel we can conclude, that the deformation as well as the metamorphism increase towards the south of the working area (towards deeper subduction level). The predominance of basement clasts in the upper part of the subduction channel changes into a predominance of sedimentary clasts toward deeper levels. Clasts size, as well as the size and quantity of pseudotachylytes and hydraulic fractured veins increase additionally towards the south of the working area.

Future parts of this study are addressed to the different processes of stable and unstable sliding and their relationship to seismicity in different depths of the subduction channel, as well as petrological and geochronological investigations. The integration of the study's results with new insights from synthetic geophysical, numerical and analogue modelling will offer the chance for a detailed identification of processes within ancient and active subduction channels.

References

Bousquet, R., Oberhänsli, R., Goffe, B., Jolivet, L., and Vidal, O., 1998, High-pressure-low-temperature metamorphism and deformation in the Bundnerschiefer of the Engadine window: implications for the regional evolution of the eastern central Alps. *Journal of Metamorphic Geology*, v. 16, no. 5, p. 657-674.

Cloos, M., and Shreve, R.L., 1988a. Subduction-channel model of prism accretion, melange formation, sediment subduction, and subduction erosion at convergent plate margins: 1. Background and description. *Pure and Applied Geophysics*, v. 128, no. 3-4, p. 455-500.

Cloos, M., and Shreve, R.L., 1988b. Subduction-channel model of prism accretion, melange formation, sediment subduction, and subduction erosion at convergent plate margins; Part II, Implications and discussion. *Pure and Applied Geophysics*, v. 128, no. 3-4, p. 501-545.

Cowan, D.S, 1999. Do faults preserve a record of seismic slip? A field geologist´s opinion. *Journal of Structural Geology*, 21, 955-1001.

Hyndman, R.D., Yamano, M. & Oleskevich, D.A., 1997. The seimogenic zone of subduction thrust faults. *The Island Arc*, 6, 244-260.

Nedimović, M.R., Hyndman, R.D., Ramachandran, K. & Spence, G.D., 2003. Reflection signature of seismic and aseismic slip on the northern Cascadia subduction interface. *Nature*, 424, 416-420.

Oleskevich, D.A., Hyndman, R.D. & Wang, K., 1999. The updip and downdip limits to great subduction earthquakes: Thermal and structural models of Cascadia, south Alaska, SW Japan, and Chile. *JGR*, 104 (B7), 1496514991.

Peacock, S.M., and Hyndman, R.D., 1999, Hydrous minerals in the mantle wedge and the maximum depth of subduction thrust earthquakes. *Geophysikal Research Letters*, v. 26, no. 16, p. 2517-2520.