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Shallow high-resolution seismics and reprocessing of industry profiles in southern Bavaria: The Molasse and the northern Alpine front

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Abstract

The purpose of this seismic investigation in the Upper Bavarian Miesbach area, as part of the international TRANSALP project, was to study the tectonic contact between the autochthonous Foreland Molasse and the allochthonous Folded Molasse marking the tectonic front of the Alpine orogen. Another specific target was the dip of the frontal emerging main thrust of the tectonic units Helveticum/Ultrahelveticum and Rhenodanubian Flysch overriding the Folded Molasse. Twelve seismic profiles obtained from the hydrocarbon industry were reprocessed. From the Foreland Molasse southward to the Autochthonous Molasse in the subsurface of the overthrust Folded Molasse conspicuous features such as steep normal faults at the Molasse base, S-directed thickening of Molasse sediments or sedimentary discordant base of Upper Marine Molasse can be recognized.

Shallow high-resolution seismic measurements were conducted along two profiles across the tectonic contact between Foreland Molasse and Folded Molasse, as well as along a profile across the frontal emerging main thrust of the Helveticum/Ultrahelveticum and the Rhenodanubian Flysch. Geological structures could be identified in the top 300–500 ms two-way traveltime interval, which is hardly possible with the usual deep-seismic method. The method thus provides a bridge between deep-reflection seismics and surface geology.

In contrast to the western Bavarian Molasse zone, the tectonic boundary between the Foreland Molasse and the Folded Molasse in the investigated area is not characterized by a large blind-thrust triangle zone but by a simple south-dipping thrust plane. Adjacent to the S follow several steeply south-dipping inverse Molasse thrust slices and the Miesbach syncline. The inverse thrust slices are interpreted as the overturned and sheared northern limb of a fault propagation fold, which linked the Folded Molasse to the Foreland Molasse during a final orogenic phase.

The main thrust of the Helveticum/Ultrahelveticum and the Rhenodanubian Flysch are well imaged in the near-surface interval of the high-resolution reflection seismic data. In contrast to previously published results, these thrust planes show a gentle dip to the S from the surface down to at least 500–1000 m depth.
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Keywords: Upper Bavaria; Northern front of the Alps; High-resolution reflection seismics; Tectonic structures; Foreland Molasse; Overthrust Autochthonous Molasse; Folded molasse; Helveticum/Ultrahelveticum; Rhenodanubian Flysch

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1. Introduction

The investigation of deep structure and evolution of the Eastern and Southern Alps along a seismic transect was the main focus of the international TRANSALP research project (TRANSALP Working Group, 2001; Gebrande et al., 2003). Beginning near the city of Freising NE of Munich, the TRANSALP transect crosses the southern part of the Alpine foreland and the frontal zone of the Eastern Alps. Within the scope of a complementary project, we aimed at investigating by shallow high-resolution seismics tectonic structures in the top 300–500-ms two-way traveltime interval, which are not imaged in TRANSALP deep seismic sections. The northern part of our study area along the TRANSALP transect allowed to analyze tectonic structures at the contact between autochthonous Foreland Molasse and allochthonous Folded Molasse. For this purpose, we reprocessed earlier seismic profiles from the exploration industry additionally to our new shallow high-resolution seismic measurements (Figs. 1, 2). Combining these methods, moreover, yielded some additional findings on the run of the base thrust of the Folded Molasse to greater depth. The target in the southern part was the dip of the frontal emerging main thrust of the tectonic units Helveticum/Ultrahelveticum and Rhenodanubian Flysch overriding the Folded Molasse (Figs. 1, 2). Only the most essential sedimentary and tectonic features were examined, i.e., marked by line drawings; whereas details in the seismic profiles outside the scope of our project are not discussed here. Quaternary sediments concealed the geologic structures of interest.

The tectonic boundary between the autochthonous Foreland Molasse and the allochthonous Folded Molasse marks the contact between the Bavarian Alpine foreland as part of the autochthonous South German block and the Alpine orogen. The Folded Molasse forms the outermost unit of the Alpine thrust stack. Thus, the tectonic boundary at the front of the Folded Molasse represents the northernmost Alpine main structure along the TRANSALP transect. From Switzerland to Bavaria to the extent of the meridian of Munich, this boundary is marked by a large blind thrust triangle zone at the front of the allochthonous Folded Molasse (Vollmayr and Wendt, 1987; Müller et al., 1988; Vollmayr, 1992; Schwerd et al., 1995; Pfiffner et al., 1997; Berge, 2003; Schwerd and Thomas, 2003). The triangle zone forms a passive roof duplex made up of a wedge-like antiformal stack of hinterland dipping blind thrust horses of Molasse sediments northward thrust into the autochthonous Foreland Molasse (i.e., Müller et al., 1988). Such triangle zones detected also in other fold and thrust belts may be prospective for hydrocarbons (Berge, 2003). In the area east of Munich up to current time it was not clear if there is a continuation of this triangle structure or an along-strike change in tectonics at the front of the Folded Molasse (Berge, 2003). The results of our investigations contribute to the solution of this question.

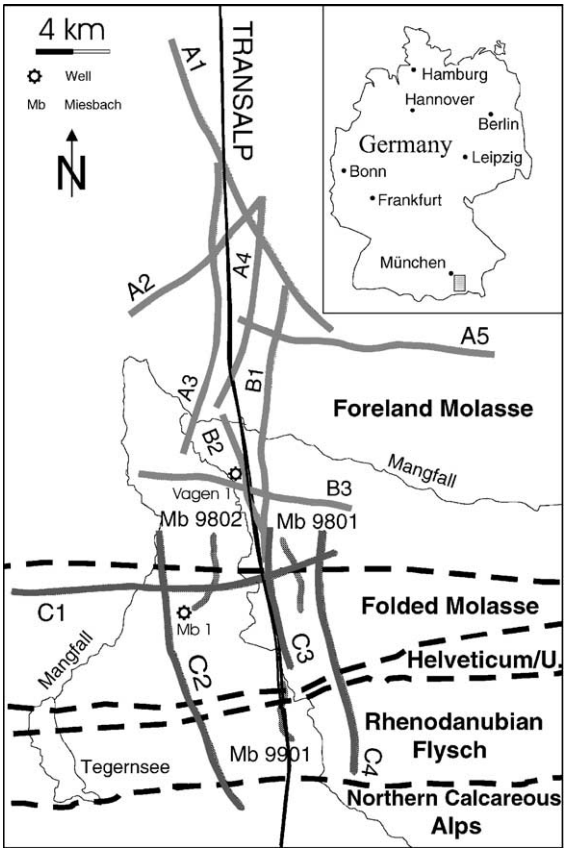

Fig. 1. Location of the investigated area, reprocessed seismic exploration profiles A1–A5, B1–B3, C1–C4, high-resolution seismic profiles Mb 9801, Mb 9802, Mb 9901 and a segment of the TRANSALP reflection seismic profile; U.=Ultrahelveticum.

In the area of the TRANSALP transect, the frontal emerging main thrusts of the tectonic units Helveticum/Ultrahelveticum and Rhenodanubian Flysch overriding the Folded Molasse were shown by Pflaumann and Stephan (1968a) to dip steeply to the S. Instead of to the N emerging simple thrust planes, alternatively, a steeply inclined transcurrent fault system created at the southern border of the Folded Molasse during neoalpidic orogeny could be assumed here. The findings of our research contribute also to the solution of this issue.

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