TRANSALP Conference: a crustal section through the Eastern Alps

Trieste, Italy, February 10–12, 2003

The TRANSALP Conference was held in Trieste (Italy) from 10 to 12 February, 2003 and was dedicated to the presentation of the results of the TRANSALP Project, a multidisciplinary international research for investigating the deep structure of the Eastern Alps and the interrelated orogenic and postorogenic processes. The Conference provided a comprehensive forum where the new data were debated within the framework of the entire Alpine mountain belt.

The Alps played a key role in the development of new concepts and theories of mountain building and of continent-continent collision. The former understanding, mainly based on refraction or wide-angle seismic and gravimetry, gained a remarkable progress in the Western and Central Alps by applying the technology of deep seismic reflection profiling. A key structure with a wedge-shaped indenter of Adriatic lower crust and upper mantle splitting up the European crust, peeling and folding its upper part and overriding and pushing its lower part down into the mantle, was revealed.

Conspicuous differences in the Eastern Alps, like the existence of the Austroalpine giant nappe and the northward offset of the Periadriatic Lineament (PL), suggested basically different processes to the east. This concern gave impulsion to the plan of connecting by a transect through the Eastern Alps the deep seismic reflection networks of DEKORP in Germany and CROP in Italy.

The primary objectives were the definition of the continent collision mechanisms. More specific targets concerned: (a) the geometry and reflectivity of the Moho and lower crust; (b) the depth of the crystalline basement beneath the Northern and Southern Calcareous Alps; (c) the extent of potentially hydrocarbon bearing sediments thrust by the Calcareous Alps; (d) the deep structure of the Tauern Window; (e) the dip direction and significance of the PL and (f) possible relationships between seismic structure and seismicity of the Eastern Alps.

The TRANSALP programme focused on a 340 km long and 10 km wide north-south strip between Munich and Venice (Figure 1 and 2). The core of the project is formed by a deep seismic reflection profile, designed for high resolution in the upper crust as well as deep penetration by combining high-fold vibration with high energy but low-fold explosion seismic. The data provided a homogeneous section through the orogene and part of its foredeeps.

The observations along the main seismic line was supported by a variety of imaging techniques, complementary in resolution and depth penetration.

A 3D control was realized by 7 stationary crosslines of 20 km length each at a mutual distance of about 30 km, recording all vibrations and shots on the main line in between the neighbouring cross lines, and thus providing single-fold 3D coverage in a 10 km wide strip around the main line. From these observations clear evidence of seismic anisotropy of the upper crust in the central Eastern Alps was obtained.

Refraction and wide-angle reflection data were also acquired for improving, by tomography, the previous velocity models. To this purpose additional shots were fired along the reflection spread and a mobile array together with a wide-spread stationary network of continuously recording 3-component station (up to 128) was deployed to record all explosions together with the vibrations of the reflection programme to greater distances.

The stationary 3-component network, part of which was maintained in the field for up to 9 months, was also used to gather data for seismological studies, *e.g.,* focal mechanisms of local earthquakes; study of velocity anomalies in the upper mantle by local and teleseismic earthquake tomography; imaging lithospheric mantle discontinuities by means of teleseismic receiver functions.

Figure 1 Vibrators in operation in the Zillertal.

Small-scale high-resolution reflection seismic was acquired in the Molasse basin to increase the correlation with near surface geology.

Other accompanying projects aimed at the re-evaluation of the density structure and isostatic state of the Eastern Alps. Because the spacing and quality of the initially available gravity data were too inhomogeneous in the Southern Alps for discriminating between competing seismic models, 250 gravity stations were acquired and the data exchanged to gain other 215 gravity points from the Brenner Basistunnel Company (BBT-EWIV). The extended data set is deemed now more adequate to solve the open problems.

The actual temperature field is amongst the most important boundary conditions constraining the tectonic and petrogenetic evolution of the Alps. In spite of only few reliable

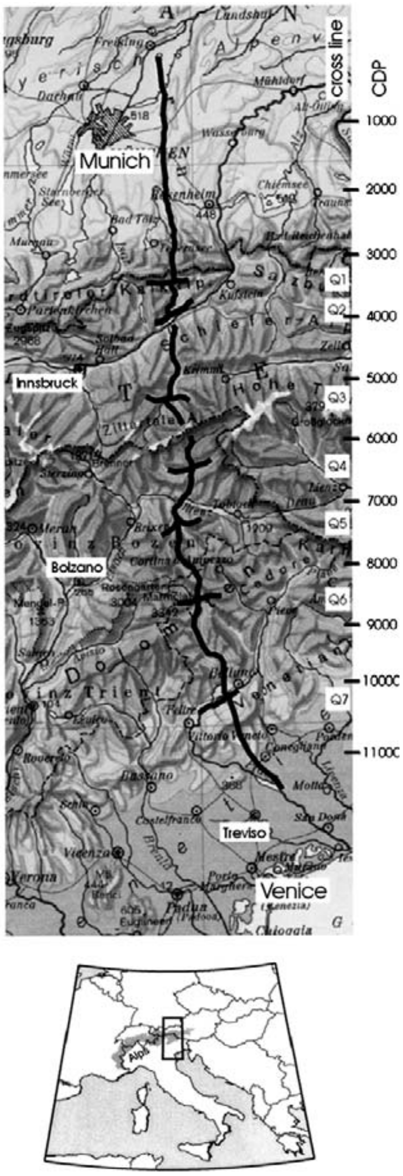

Figure 2 Location of the TRANSALP main line in the Eastern Alps.

heat flow data and uncertainty about the heat production rate in the middle crust it was possible to estimate relatively sharp bounds on the temperature distribution, *e.g.* 900˚C ±30% at 55 km beneath the PL, by steadystate forward and inverse simulation of the conductive heat transport. This implies at least partial anatexis in the deepest parts of the crust and offers explanations for the seismic transparency in that depth range as well as for the origin of young periadriatic igneous intrusions.

In addition TRANSALP was accompanied by geological, petrophysical, geochemical and chronometrical research projects aimed at incorporating the seismic results as constraints and/or at providing support to their integrated interpretation. They include fieldworks as well as laboratory investigations and modelling-supported reconstructions of the East-Alpine chain.

The presented interpretations were based on the entirety of the seismic sections (vibroseis and explosions, stack sections, time- and depth-migrated sections) and the following structural properties can be considered as ultimate products (Figure 3).

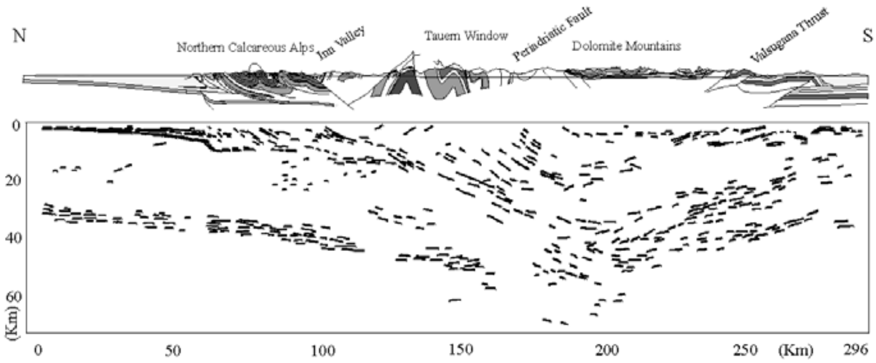

Figure 3   Line-drawing from the seismic sections of the TRANSALP traverse.

The Eastern Alps display a thickened crust related to convergent and slightly asymmetric dips of both the European and the Adriatic plate. Using the Moho (defined in reflection seismic near the base of the reflective lower crust) as marker horizon, the European Moho can be traced from 30 km depth under the northern Molasse foreland to about 55 km depth south of the Alpine main crest and south of the PL, where it disappears in a transparent zone. Remarkably, the receiver functions derived from teleseismics indicate a limited continuation of it to the south of the PL. The Adriatic Moho has to some extent unclear boundaries and disappears as well at 55 km depth near the transparent zone, south of the PL. A thin European lower crust is opposed to a very thick Adriatic lower crust and a prominent transcrustal reflecting zone, dipping from the Inn valley to the south, separates a northern domain with moderate subparallel reflectivity, from a southern domain with strong and complex reflectivity and a conspicuous biverging pattern. The PL cannot be clearly identified in the seismic sections, most likely because of subvertical inclination. Also the successful processing of the neighbouring crosslines has not provided evidence for a northward or southward dip of the PL, which would imply quite different collision scenarios.

These results set new constraints, which should be taken into account in any evolutionary model of the Eastern Alps and the Conference has offered the opportunity for an unified and unambiguous interpretation of the whole chain, opening perspectives for science and practical applications on risks assessment, mineral resources and environment.

The Bundesministerium für Bildung und Forschung (BMBF, Bonn), the Bundesministerium für Wissenschaft und Verkehr (BMWV, Vienna), the Consiglio Nazionale delle Ricerche (CNR, Roma) and the company ENI-AGIP (Milan) financed the Transalp programme. Accompanying projects have been funded in parts also by the Deutsche Forschungsgemeinschaft (DFG, Bonn), the Wissenschaftsfond (FWF, Vienna), and the Swiss National Science Foundation.

The TRANSALP Working Group comprises partners from the universities of Munich, Leoben, Salzburg, Bologna, Padova, Roma, Trieste, ENI-AGIP Division and GFZ-Potsdam. Scientists from research and industrial institutions complement this group. The project benefited from active participation, data exchange and financial contributions from hydrocarbon exploration industry, particularly ENI-AGIP Division, ÖMV, RAG, Forest Oil and German industrial consortia. A cooperation was promoted with the BBT - EWIV in the axial sector of the chain, where important actions have been designed for a 55 km long tunnel.

References

The Extended Abstracts of oral and poster presentations at the Conference are offered in the Special Volume (n˚54) of the Memorie di Scienze Geologiche, Padova, February 2003, with pp. 268, 212 figs, 8 tabs: 33 oral presentations, 35 posters.

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