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PRELIMINARY GEOLOGICAL INTERPRETATION OF THE CENTRAL TRANSALP SECTION: INVERTED EXTENSIONAL STRUCTURES AND EXHUMATION OF THE TAUERN WINDOW

Franz Neubauer, Karl Millahn, Gerfried Grassl & TRANSALP Working Group

The Eastern Alps represent the classical example of a double-vergent orogen with an exhumed metamorphic core complex in the centre. The Eastern Alps involves the S-ward subducted European continental lithosphere in a lower plate position and the Adriatic plate in the upper plate position. The Eastern Alps nappe complex comprises from footwall to hangingwall the allochthonous Central Gneis unit, the Penninic oceanic unit and the Austroalpine continental unit, and the Southalpine unit to the south of the Periadriatic fault. The TRANSALP deep seimic line investigated, among other problems, the deep structure of the antiformal Tauern metamorphic core complex within internal zones of the orogen. Recent discussions on the structure of central sectors of orogens focused on double-vergent thrusting leading to vertical extrusion of central, metamorphic sectors of the orogen (e. g. BEAUMONT et al. 1996; BONINI et al., 1998). The principal goal of this study is tconcerned with the crustal structure of the central portion of the Eastern Alps and to elucidate how the structure was formed by processes of convergence and collision and to search for structures inherited from pre-orogenic extension.

The results clearly show a double-vergent orogen with continuous crustal thickening towards the centre of the orogen, with thickest crust beneath the Tauern window (TW). The European basement-to-cover contact can be traced, with some interruptions, from the Molasse zone to beneath the northern TW. This contact displays three major extensional structures, flexures and normal faults, interpreted to represent inherited structures from the extensional stage. The northern margin of the Folded Molasse zone coincides with a sedimentary halfgraben with onlap features of younger sediments. A second halfgraben is supposedly beneath the Inn valley. The contact is gently S-dipping beneath the Inn valley and nearly subhorizontal beneath the Austroalpine basement with traces of possible European sediments in a depth of ca. 13-14 km beneath the Graywacke zone. A major ramp (reflective zone from 15 km, with several breaks, down to ca. 35 km) appears to delimit the continuous European basement beneath ca. the northern edge of the TW. This ramp is likely an inverted normal fault, too, because of the presence of imbricated sedimentary piles along its northern limit. Two major gently S-dipping reflective zones can be traced from beneath the central TW (ca. 20 resp. 30 km) to beneath the Southalpine unit (SA) (ca. 25 resp. 35 km). These structures together are interpreted to represent a major crustal-scale forethrust with several major splays along which basement-cover nappes were stacked towards north.

The TW area display several reflective zones in shallow and intermediate structural levels. These are interpreted to represent basement-cover duplexes. The northern shallow gently N-dipping reflective zones can be interpreted to represent cover schists along the upper margins of the window. A central shallow reflective zone may represent a synform. Major portions in shallow southern levels are transparent (?Variscan Central Gneiss). Some gently north-dipping reflectors occur in ca. 20 km depth (vibroseis) and coincides there with the orientation of the Periadriatic Fault. These are possible buried European sediments. Consequently, the TW Penninic units form a duplex-type structure which is wedged into the Austroalpine units by northward thrusting.

The PF can be traced by a sharp northern, medium-angle N-dipping delimitation of several prominent, gently S-dipping reflectors within the SA. Consequently, the PF has in this interpretation a pronounced component of back-thrusting.

Taking the shallow N-dipping delimitation of the SA, the PF, and the gently S-dipping reflective zones beneath the TW, the SA forms a wedge which caused detachment of the Penninic continental basement from previously extended European continental crust. Together, all these features are interpreted to represent a major crustal-scale fore-thrust with several major splays along which major crustal sectors were transported and stacked towards north.

The European crust is flexured due to thrust loading of the entire Alpine nappe stack onto the European crust. The middle and lower European crust is remarkably unaffected by shortening (except possible duplication of layered lower crust what needs further confirmation). The Alpine nappe stack to the north of the Periadriatic fault shows internally all characteristics of north-directed thrusting with a pronounced ramp-flat geometry where ramps are the loci for major splays and duplex structures which complicate the internal structure of the Alpine nappe edifice, specifically within the Northern Calcareous Alps (see, e.g. EISBACHER & BRANDNER, 1996; ORTNER & REITER, 1999). Among these the duplex-structure of Penninic units exposed within the Tauern window is of particular importance because it shows that the Tauern culmination includes a strong component of N-S shortening, including formation of a flake which intruded into the northern nappe stack ("crocodile structure") (see LAMMERER & WEGER, 1998; NEUBAUER et al., 1999). The overall structure is in clear support of present models of double-vergent orogens where an uniformly subducting slab delaminates and causes back-thrusting starting from a point of singularity (BEAUMONT et al. 1996; BONINI et al. 1998).

As relatively thin sedimentary layers can be followed on the European continental crust, this feature argues that no oceanic rift is present to the N of the Central Gneiss unit. This argument is in line with the recent notion that no separate North Penninic ocean may have existed as recently proposed by WORTMANN et al. (2001). Moreover, the relationships between sediments and basement, and the northward thickening of cover sediments seems to support the presence of a moderately extended passive continental margin. Splays of thrust faults evolved above the tip of previous normal fault structures which controlled, therefore, the structural style of the orogen.

References

BEAUMONT, C., ELLIS, S., HAMILTON, J. & FULLSACK, P. (1996): Mechanical model for subduction-collision tectonics of Alpine-type compressional orogens. – Geology, **24**, 675-678.

BONINI, M., SOKOUTIS, D., TALBOT, CH.., BOCCALETTI, M. & MILNES, A.G. (1999): Indenter growth in analogue models of Alpine-type deformation. – Tectonics, **18**, 119–128.

EISBACHER, G. H. & BRANDNER, R., (1996): Superposed fold-thrust structures and high-angle faults, Northwestern calcareous Alps, Austria. – Ecl. Geol. Helv., 89, 553–571.

LAMMERER, B. & WEGER, M. (1998): Footwall uplift in an orogenic wedge: the Tauern Window in the Eastern Alps of Europe. – Tectonophysics, **285**, 213–230.

NEUBAUER, F., GENSER, J., KURZ, W. & WANG, X. (1999): Exhumation of the Tauern window, Eastern Alps. – Phys. Chem. Earth Part A: Solid Earth and Geodesy, **24**, 675–680.

ORTNER, H. & REITER, F. (1999): Kinematic history of the Triassic South of the Inn valley (Northern calcareous Alps, Austria) – Evidence for Jurassic and Late Cretaceous large scale normal faulting. – Mem. Sci. Geol., **51**, 129–140.

WORTMANN, U.G., WEISSERT, H., FUNK, H. & HAUCK, J. (2001): Alpine plate kinematics revisited: The Adria problem. – Tectonics, **20**, 134–147.

Authors' addresses:

Franz. Neubauer, Inst. of Geology and Palaeontology, University of Salzburg, A-5020 Salzburg, Austria; Karl Millahn, Gerfried Grassl, Dept. of Applied Geophysics, Mining University, A-8700 Leoben, Austria