Middle Jurassic subduction-related volcanism and Cretaceous kinematics in Meliata units of the eastern Northern Calcareous Alps

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A sedimentological and structural study has been carried out on Meliata units of the eastern Northern Calcareous Alps (NCA). There, the Meliata units there comprise Middle/Late Triassic pelagic limestone and radiolarite, and the Doggerian Florianikogel Fm. with dark shale/slate and sandstones where the earlier formations are interpreted to represent olistolites within the Florianikogel Fm. (Mandl and Ondreijickova, 1991; Kozur and Mostler, 1992). Own field lithostratigraphic and structural investigations suggest that the Middle/Triassic and Doggerian formations represent a continuous sequence that is overlain by another tectonic unit with mainly greyish to colored pelagic limestones. The Florianikogel Fm. represents the well-preserved, finely laminated sequence with dark slate, cm-thick feldspar-rich tuffaceous layers, and several cm-thick, volcaogenic graywacke layers. Modal (using the Gazzi-Dickinson approach) and geochemical compositions (major, minor and trace elements following Bhatia & Crook, 1986) suggests a deposition of these graywackes in a arc-related geodynamic setting. Both the graywacke composition and the presence of tuffaceous layers indicate, therefore, provided correct biostratigraphy, the presence of a distal volcanic arc setting in an anoxic sedimentary basin in the Meliata ocean.

The thrusting of Meliata units onto the proximal Tirolic passive continental margin sequences of the NCA occurred under very low grade to low grade metamorphic conditions during pre-Gosau shortening and nappe stacking. Kinematic indicators display, similar to all underlying Austro-Alpine units, a top WNW emplacement of Meliata units under semi-ductile to ductile tectonic conditions. In portions, ductile fabrics were annealed (e.g. within a basal calcite marble), in hangingwall units overprinted by top-SE extensional fabrics.

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P- and S-wave tomography of the Vrancea seismogenic zone

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A set of 2782 P- and 2615 S-wave arrival times from 319 local earthquakes recorded at least at 7 stations were simultaneously inverted for 3-D P- and S-wave block velocity structures, hypocentral parameters and station corrections. The block dimension was 30 km x 30 km horizontally and the layer boundaries were at 20, 40, 60, 80, 100, 120, 150 and 180 km depth. A number of 248 blocks were modelled. The overall reduction in residual variance was 32%, leaving 0.46 s unexplained, mostly due the errors in S-wave picking. In the crustal domain, the results confirm the high velocities directly under the Carpathians and the low velocities in the foredeep region. In the subcrustal domain, the results confirm the seismic gap between 40 and 60 km depth, as well as the very narrow vertical region oriented SW-NE, with maximum 15 km in the SE-NW direction, containing the intermediate depth earthquake foci. There is a tendency of the foci between 60 and 150 km depth to lie in low velocity regions (v_P = 7.5-7.7 km/s). We tentatively explained the presence of these velocities in that depth range by a basalt to eclogit phase transition in the subducted oceanic crust. The foci lie in zones with $v_P/v_S \geq 1.7$ in the crust and between 1.6-1.7 below the depth of 60 km. Higher subcrustal velocities are found in NE (East European Platform) or in NW (Transylvanian Basin) in comparison with the southern regions belonging to the Moesian Platform.

Timing of basement reactivation in the Inner Western Carpathians

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Fault systems formed in the Austroalpine basement of the Inner Western Carpathians during Triassic-Jurassic rifting have been reactivated several times in a variety of tectonic regimes and metamorphic environments. The complex events recorded in the fault rocks of these systems have been locally obscured by overprinting, but the integration of structural data and the pattern of sediment deposition on a regional scale has helped to resolve local complexities into a regionally consistent model. The aim of this presentation is to discuss the significance of the observed repeated selective exploitation of ancient fractures and to speculate on its influence on the depositional pattern on the northern margin of the Pannonian basin.

Sets of steep E-W to NE-SW-trending extensional faults and NW-SE-trending transfer faults dissect the Austroalpine basement to form a system of blocks, which formed the floors of small (locally isolated) sedimentary basins from the Triassic onwards. Sedimentation was intermittent, controlled by reactivation of the bounding faults. As the availability of reliable slickenfibre data in this area is restricted (B.Sperner pers. comm. 1993), and sedimentary control on the timing of fault movements is poor, radiometric dating (Ar/Ar on white micas) proved an invaluable tool in determining the absolute timing of reactivation of the E-W to NE-SW-trending set as sinistral transtensional faults with varying amounts of dip-slip: ca. 85-82 Ma. Deformation was strongly partitioned into the fault zones, and the intervening blocks were only weakly deformed.

At least some of the E-W-trending set functioned sporadically as growth faults during rifting, with the largest sediment thicknesses on the southern i.e. downthrown side. This pattern is preserved as the thrusting related to the Lower Cretaceous compressional event was non-pervasive in the Inner Western Carpathians, in contrast to the Alpine-Pannonian transition zone, where coeval "corner effects" produced a more complex deformation pattern. It is speculated that the basement of the northern Pannonian basin to the south of the IWC similarly escaped major shortening, in which case the reactivated structures dominating the formation and development of Palaeogene and Neogene basins could be extensional faults of Triassic-Jurassic age, with coeval rift infill locally underlying the younger basins, rather than major thrust faults postulated in analogy to the transition zone further to the west. This implies that additional source and reservoir rocks may be preserved in the subsurface of the northern Pannonian basin.

Geodynamic evolution of the Central Dinarides

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As distinguished from the northwestern and southeastern Dinarides, the central parts are characterized by a zoned pattern in the distribution of the large lithostratigraphic units. From the southwest i.e., the Adriatic microplate to the northeast, six main lithological associations originating in different environments can be distinguished.

(1) The carbonate platform (CP) formations of the Alpine passive continental margin (the present External Dinarides) are underlain by Upper Paleozoic formations. Initial stages of CP evolution were predisposed by rifting accompanied by the magmatism of the continental crust origin, which finished in the Late Triassic. Afterwards monotonous carbonate sedimentation continued in stable environments and lasted, with a few hiatuses, unitil the Middle Eocene.

(2) The passive continental margin formations originated by continuous sedimentation on the slope of the CP and its foot. Two main units can be distinguished: (a) Jurassic to Turonian sandstones and limestones, only in some places with flysch signatures, and (b) Senonian - Paleogene (?) carbonate flysch sediments.

(3) The ophiolite formations originated in different environments: (a) Late Triassic to Early Cretaceous radiolarites with shales, micrites and basalts. (b) Graywackes and shales, i.e. an olistostrome melange with fragments of graywackes, basalts, diabases, gabbros, peridotites, cherts and exotic carbonate rocks; the age of the melange is presumably Jurassic to Early Cretaceous. (c) Ophiolites are represented by peridotites with subordinate gabbros, diabases and basalts; the radimetric ages of ophiolites range from 180 to 136 Ma. (d) Late Jurassic to Late Cretaceous overstep sequences represented mostly by clastic and carbonate rocks.

(4) The active continental margin formations, related to the subduction zone, are represented by (a) Upper Cretaceous-Paleogene trench sediments with blocks of blueschists; (b) Tectonized ophiolite melange in which exotic blocks of Upper Cretaceous and Paleocene limestones are also included; (c) Alpine medium-pressure metamorphic rocks originating from the surrounding Upper Cretaceous-Paleogene sediments, and (d) Alpine synkinematic granitoids.

The four formations marked by (2) to (4) are included in the Internal Dinarides.

(5) The allochthonous Paleozoic-Triassic formations are thrust onto the internal units but the frontal parts of the nappe overlie the northeastern margin of the CP. In some areas, below the Paleozoic-Triassic nappe tectonic windows composed of rocks of the ophiolite formations are found.

(6) Post-orogenic Oligocene and Neogene formations accumulated in marine to fresh-water environments in Oligocene intramontane basins, numerous Neogene depressions in the uplifted Dinarides, and in the Pannonian Basin.

Geodynamic evolution of the central Dinarides was related to a sequence of tectonic events which