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Shift of basin subsidence due to oblique subduction along the Northern Austroalpine margin during the Late Cretaceous-Tertiary of the Eastern Alps and the Western Carpathians

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Subsidence within the Late Cretaceous to Early Tertiary basins at the northern margin of the Austroalpine microplate (Austroalpine Units of the Eastern Alps, Tatric and higher units of the Western Carpathians) shows a regular time shift from the West to the East. Rapid subsidence into bathyal depths within the northwesternmost part of the Northern Calcareous Alps (NCA) began already in the late Turonian. Other basins of the Gosau Group of the NCA (WAGREICH & FAUPL 1994) and the western part of the Inner Western Carpathians (WAGREICH & MARSCHALKO 1995) indicate a shift of this subsidence pulse predated by short uplift and deformation from the Santonian in the west to the Maastrichtian in the southeast. This eastward youngig in the beginning of major subsidence is continued within the Centralcarpathian Paleogene, e.g. the Sulov Conglomerates (Paleocene) and turbiditic formations of the Eocene/Oligocene, partly also early Miocene in eastern Slovakia (see also KOVÁC et al., 1994).

This time shift of subsidence can be interpreted as a result of diachronous oblique subduction processes to the north of the active leading margin of the Austroalpine microplate (including the NCA and the Tatric units of the Western Carpathians). This margin was characterized by southward subduction of the Penninic Ocean from the Cretaceous onwards The short deformation and following rapid subsidence may be due either to tectonic erosion or subduction roll-back, or a combination of both processes. Tectonic erosion due to collision and subduction of an oceanic asperity is more probable in the Eastern Alps based on structural evidence and sedimentological reasoning such as the elimination of an accretionary ridge north of the NCA (WAGREICH 1993, 1995). Within the Western Carpathians a combination of tectonic erosion and later subduction roll-back is more likely, especially for the subsidence of the Centralalpine Paleogene basins, which postdate accretion of the Pieniny Klippen Belt to the north.

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Alpine thrust and subthrust structures below the Vienna Basin and along its adjacent borders.

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The segment of the Alpine Carpathian belt, which passes the Vienna basin from one border to the other below the Neogene basin fill, are mainly the Flysch Zone, the Calcareous Alps with their Palaeozoic base, the Greywacke Zone and the Central Alps.

The Alpine structural style has been studied by detailed surface mapping and by deep wells situated at the borders and within the basin. In the area of the Matzen-Schönkirchen oil fields further information has been obtained by 3D seismic surveys. Correlation between the Austrian and the Slovakian part of the Vienna Basin and the Carpathians on surface show in general a continuation of the main elements and their stratigraphic characteristics from the Alps into the Carpathians but some changes in the structural arrangement.

The Semmering-Leithagebirge system representing the Lower/Middle Austroalpine units seems to be replaced by a more heterogeneous structural and facial complex in the Male Carpaty mountains.

The overriding of the deeper Carpathian and Central Alpine units by the Calcareous Alps is evident in the Alps and Carpathians as well as the overthrust of these units over the Flysch or Klippen Zones. The Greywacke Zone disappears in the Vienna Basin toward NE.

The structures of the Calcareous Alps are strongly compressed especially along their frontal part. Steeping, overturning and backthrustings are the consequence. The narrowing of the Calcareous Alpine Zone toward NE could be a tension effect, but the steep structures point to a stacking of tectonic elements because of subsiding conditions during overthrusting. The main nappe systems are from N to S the Bajuvaricum, Tirolicum and Juvavicum, mostly separated by Cretaceous to Palaeogene synclines, which are overthrust lateron, in the case of the Gießhübl syncline during Paleocene time.

In the Carpathians the tectonic subdivision is similar to that of the Calcareous Alps, but facial arguments suggest that the outcropping Krizna nappe system is the former frontal part of the Bajuvaricum, which has been left behind, whereas the main part has been thrust further toward NW, as the Slovakian drillings show. On surface the Tirolicum covers this northern part carrying a segment of Gosau at its frontal part (Brezova Gosau).

With the Neogene sediments in the Vienna Basin the nappe systems were also lowered down by faulting. In general no horizontal displacement along the faults is evident and the pull apart mechanism, which causes the tension is obviously caused by lateral slipping along the Alpine thrust planes either during or after thrusting.

Below the Alpine thrust complex the autochthonous subthrust floor is known by some deep wells. East of the Crystalline spur of the Bohemian massif Jurassic and Cretaceous sediments in a distinct facial arrangement are extending eastward, covered by Molasse.

The basement dips downward under the orogene in a moderate manner in the south of the basin and to a larger amount toward its northern part. Signs of a rifting within the Middle Jurassic are evident showing synsedimentary half graben tectonics, which ceased in the uppermost Middle Jurassic.

The geodynamic evolution of the Alpine-Mediterranean region: from structure to dynamics

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The geodynamical evolution of the Alpine-Mediterranean region is generally considered in the context of the interaction (convergence) of the Eurasian plate and the African plate. In analyses of this interaction the distribution of earthquake hypocentres and the focal mechanisms of earthquakes - in particular those occurring in subduction zones - have been an important source of data. New information concerning the nature of this interaction has been obtained by the application of seismic tomography techniques (Spakman, 1988, 1991; Spakman, Van der Lee, and Van der Hilst, 1993). The resulting three-dimensional seismic velocity structure provides insight into the history of plate convergence in the region on a time scale much beyond that contained in the distribution of present-day seismic activity. This new information allows for new ways of exploring the kinematics and dynamics of the geodynamical evolution of the region.

First, the 3D structure enables us to investigate the merits of various (published) regional aleogeographic/tectonic reconstructions. To this purpose we investigate the quantitative agreement between such reconstructions and the structure of the upper mantle, as obtained by seismic tomography. This is done by forward numerical modelling - on the basis of kinematic reconstructions - of the temperature distribution in the upper mantle, converting the calculated temperature distribution into seismic velocity structure and comparing these model results with the tomographic results (de Jonge, Wortel and Spakman, 1993,1994).

Secondly, from the seismic velocity structure we have inferred that - in the depth range of about 100 to 200 km - deeper parts of subducted slabs have become detached from lithosphere near the surface and we hypothesize that this detachment process has migrated laterally along the strike of the subduction zones. This process is referred to as: lateral migration of slab detachment (Wortel and Spakman, 1992; see also Yoshioka and Wortel, 1995). The process of lateral migration of slab detachment is envisaged to have geodynamical implications on a variety of scales. In particular, the formation and evolution of island arcs and their back-arc regions are adequately accounted for.

With slab detachment as a key element we presented a hypothesis for the Cenozoic evolution of the Alpine-Mediterranean region, with emphasis on the dynamical basis for observed kinematic patterns (Wortel and Spakman, 1992). On the basis of this hypothesis quantitative predictions can be derived for several areas in the Alpine-Mediterranean realm which can be tested against geological and geophysical data. Examples of some tests will be given. Of special interest in this respect are the spatial and temporal variations - implicit in the model of lateral migration of slab detachment - in state of stress, in vertical motions and in volcanic activity along the strike of convergent plate margins.

Analysis of pertinent observables (Miocene to recent) supports our hypothesis of slab detachment (including lateral migration) in the Hellenic and the Apenninic-Calabrian arcs and also in the Carpathian arc, and leads us to conclude that these three arcs are in different stages of evolution (Wortel and Spakman, 1993). The advancement of the slab detachment process and the associated