The Vienna Basin: tectonics, subsidence and thermal evolution of a thin-skinned pull-apart

Kurt Decker[1], Bernhard Grasemann[1] and Anco Lankreijer[2]

[1] Department of Geology, University Vienna, Austria
[2] Institute for Earth Sciences, Vrije Universiteit Amsterdam, The Netherlands

The sediments of the Vienna pull-apart basin unconformably overly Alpine-Carpathian thrust sheets and sediments of an Early Miocene piggy-back basin which were thrust over the European (Bohemian) basement between the Eocene the early Miocene (c. 55 to 17 Ma). The formation of the pull-apart between the Karpatian (17 Ma) and the Pannonian stage (c. 8 Ma) coincides with the transition from post-collisional thrust shortening to the eastward lateral extrusion of the Alpine units. During extrusion, a sinistral transform system evolved which continued from the central Eastern Alps through the Vienna Basin into the Outer Carpathian Flysch nappes. The tectonics which led to Middle Miocene subsidence of the Vienna Basin between left-stepping segments of this transform fault can be described as divergent strike-slip duplexes. Rhomb-shaped duplexes from several hundred meters length up to the size of the entire basin are delimited by NE-striking sinistral faults and by connecting NNE-striking oblique-normal faults. Such duplexes were mapped along the basin margins and by 3D-seismic surveys of the OMV in the basin (Häusler et al., this vol.). Extension and strike-slip faulting was restricted to the Neogene sediments and the Alpine-Carpathian nappes overlying the European basement, i.e., to the uppermost 10-12 km of the crust.

Paleogegraphic maps show that the pull-apart basin acquired its outline in less than 1 Ma (within the Karpatian stage) and that the basin shape did not change during the Middle Miocene. High total basement subsidence, high subsidence rates (up to 5.8 km in 9 Ma), and comparably low finite extension (20-30%) characterise the duplex-shaped basin.

The basement subsidence of a divergent strike-slip duplex mainly is a function of the geometries and the kinematics of the basin boundary faults. Strain rate, duplex size, and depths to detachment determine amount and velocity of subsidence. Basement subsidence curves computed for a duplex of constant volume show that subsidence rates decrease with time, resembling subsidence curves of the McKenzie rifting/thermal cooling model. However, unlike in the McKenzie-model, this decrease is not due to thermal processes during cooling of the basin. Concave-up subsidence curves result from the strain geometry and from isostatic rebound effects.

The thermal evolution of a thin-skinned extensional basin which formed by extension of the uppermost crust has been modelled by finite difference algorithm. The model was set up for a 100 km thick lithosphere (30 km crustal thickness) with an initial steady-state geotherm and constant heat flux at the base of the crust as lower boundary condition. Crustal temperatures were computed for a 50 m grid which gives extremely good spatial resolution. Thin-skinned extension was modelled by a pure-shear velocity field applied to the uppermost 12 km of the crust. The resulting „basin" was continuously filled with sediments and a velocity field was constructed which accounted for synsedimentary deformation. Models were computed for 9 Ma subsidence, constant strain rate, 60% vertical thinning, and different sediment conductivities. The results show that thin-skinned extension hardly changes the initial thermal conditions and that only a very minor downbending of isotherms occurs. Advective downward transport of cool crust in the strained area overlaps and is nearly extinct by heat convection from the base of the lithosphere to the surface.

In sum it can be shown that subsidence of thin-skinned extensional basins is a function of strain geometries, deformation mechanisms, and isostatic rebound effects which result from the substitution of basement rocks by the unconsolidated basin-fill sediments. Thermal processes are not important for the subsidence of such basins. For the description of the Vienna pull-apart basin, the model of a divergent strike-slip duplex with a basal detachment which coincides with the floor thrust of the Alpine-Carpathian nappes seems to be most appropriate.

New geothermal measurements in Transylvanian Depression. Preliminary report on a joint cooperation between the Institute of Geodynamics - Bucharest, Romania, and the Geophysical Laboratory - Aarhus, Denmark

Crisan Demetrescu[1], S.B. Nielsen[2], M. Ene[1], N. Balling[2], D. Ivan[1], G. Polonic[1] and M. Andreescu[1]

[1] Institute of Geodynamics, Bucharest, Romania
[2] Geophysical Laboratory, Aarhus, Denmark

From the heat flow point of view the Transylvanian Depression is well known as a remarkable low, in contrast to other Neogene basins in the Carpatho-Pannonian-Dinaride system. A joint cooperation between the Institute of Geodynamics - Bucharest and the Geophysical Laboratory - Aarhus on the heat flow and lithosphere evolution in the Transylvanian and Pannonian basins started in 1996 as a contribution to the subproject "Paleo Heat Flow and Fluid Flow in the Transylvanian and Pannonian Basins" of the PANCARDI Project of EUROPROBE. Funding is provided by the Romanian Academy and the Danish Natural Science Research Council.

A campaign of borehole temperature measurements was undertaken in August 1996 and the data from 12 thermally stabilized boreholes in unsampled areas of the Transylvanian Basin will be reported in this paper. The logging system built by the Geophysical Laboratory of Aarhus University consists of a quartz thermometer, a winch driven by an electric motor, a two conductor cable of length 1.5 km, a cable counter for depth measurement and a PC for data acquisition. The power is supplied by a generator. The temperature measurement system is based on the counting of the frequency of a quartz oscillator. The advantages of this system over a thermistor based four conductor system are high stability and the requirement of only a two conductor cable. The quartz crystal is cut to produce an almost linear temperature coefficient of about 1 kHz per degree. The frequency of the quartz crystal is about 9 MHz. Because such a high frequency leads to transmission problems over a long borehole cable the frequency is divided using a CMOS divider prior to transmission. At the surface the signal is filtered, amplified and multiplied to yield a frequency of about 28 MHz. The power requirements of the probe is 10 mA which is supplied from the surface via one of the two conductors. As the boreholes were only partially filled with water, the system was used in the continuous logging mode, with a few stops in the air column to obtain the parameters characteristic to the heat transfer from borehole to thermometer. A deconvolution procedure has been used to derive temperature and gradient variations with depth.

Neogene magmatism and tectonics in the Carpatho-Pannonian region

Hilary Downes

Department of Geology, Birkbeck College, London, U.K.

Neogene magmatism in the CPR can be classified into (a) an earliest phase of highly siliceous acidic pyroclastic tuffs and ignimbrites, (b) slightly younger volcanism of calc-alkaline affinity, identical in its petrography and geochemistry to subduction-related magmatic rocks worldwide; and (c) a generally later phase of alkaline volcanism, similar to the late Tertiary/Quaternary intraplate activity elsewhere in Europe. An unsolved problem is the origin of the widespread early acidic magmatism which began in several regions 19 Ma ago. It may be linked with lithospheric delamination, in which hot asthenosphere was brought into direct contact with the base of the crust, heating it and causing melting. Such a hypothesis can be tested using isotopic and other geochemical methods.

The acid magmatism was followed by the formation of subduction-related andesitic stratovolcanoes along the West Carpathian arc at ca. 16 Ma. The majority of these calc-alkaline volcanoes were extinct by 10 Ma, an age which coincides with a major E-W compressional event in the region, possibly related to the entry of continental crust into the subduction zone. Thus, if oceanic subduction were responsible for the calc-alkaline magmatism, then the subducted slab first reached the required depth for magma generation of 100-120 km (the "magma generation window") simultaneously beneath the whole of the Western Carpathians around 16 Ma ago and ceased to generate calc-alkaline magma about 6 Ma later.

However, in the Eastern Carpathians there is significant calc-alkaline magmatism younger than 10 Ma, showing an age-progression along the chain from 10 Ma in the north to 0.2 Ma at the southern end of the chain. If an oceanic slab subducted beneath the East Carpathians then it must have reached the magma generation window at a progressively later and later time. It takes a finite time for a subducted slab of oceanic crust to reach the temperature and depth of the magma-generation window; this time-lag could account for the gap between the cessation of tectonism and the onset of magmatism. The time interval between the beginning of subduction and the arrival of the subducting slab in the magma generation window will be a function of the angle of subduction and the rate of subduction. In the East Carpathians the narrow volcanic zone and fast progressive movement of volcanism indicates that the period of time which the slab spent in the magma generation window was short. This in turn suggests that the piece of oceanic crust which was subducted was of small dimension and sank quickly. Slab detachment in the East Carpathians followed the arrival of unsubductible continental crust of the Tornquist zone or East European Platform at the trench around 10 Ma ago.

The oldest extension-related alkaline magmas are about 9-11 Ma old and were erupted just as the calc-alkaline magmatism was waning. This indicates a "switch" from a collisional tectonic regime to an extensional one. After this, alkali basalts occurred sporadically in time and place up