Continental Tectonics in Central and Eastern Europe

Collision and Extension in the Alpine-Carpathian-Pannonian System;
Siófok, Hungary, 14–16 September 2007

The Pannonian Basin is often cited as one of the major continental basins formed by extension of the lithosphere. Twenty-five years after the classic work in which the subsidence of the basin was quantified using the analytical models developed by D. McKenzie (Earth and Planetary Science Letters, 1978) and L. Royden et al. (Tectonics, 1983), a workshop entitled Collision and Extension in the Alpine-Carpathian-Pannonian System was held in Siófok, Hungary. The workshop, sponsored by The Royal Society, Eötvös Loránd University (Hungarian Scientific Research Fund (OTKA) project NK60455), and the University of Leeds, elicited contributions from specialists working in a broad range of geophysical, geochemical, and geological disciplines.

Extrusion of the Miocene Eastern Alps and Western Carpathians and associated formation of the Vienna and Pannonian basins is now well documented. Analyses of recent controlled-source crustal seismic surveys (e.g., ALP2002 and CELEBRATION 2000) have revealed distinct seismic signatures of the Adriatic, European, and Pannonian crustal blocks. Extension in Pannonia is complex, involving rotations, and possibly governed by preexisting structures. Deep sediment depocenters such as the Makó Trough in southern Hungary are separated by broad regions of more modest subsidence, indicating an inhomogeneous crustal extension field, perhaps attributable to core-complex type behavior of the basement. Gravity features and seismic measurements over the depocenters suggest a locally elevated Moho and upper mantle. The key role of the mid-Hungarian shear zone is emphasized in the gravity field and in the variation of lithospheric anisotropy direction obtained from SKS analyses of a new broadband data set from an array that spans the western part of the basin (the Carpathian Basins Project). Contributions to this workshop show clearly that the upper mantle in the region is pervasively deformed under variable conditions of stress and fluid content.

Magmatism provides essential constraints on the evolution of the basin and the influence of upper mantle processes. Mixing between mantle-derived melts and lower crust is important in the production of silicic and calc-alkaline volcanism of the mid-Miocene Nothern Pannonian region. The end of rifting was marked by the onset of alkali basalt volcanism that continued until recently, and suggests the possibility of future volcanic hazard in the region. Compressive reactivation of the tectonic regime in the Quaternary has sustained the development of recent topography and caused systematic changes in sediment provenance directions.

Considerable discussion has focused on the probable central role of slab rollback in subduction zones in the Carpathians, in creating a back-arc type basin. Analogies between the Miocene Pannonian basin and the present-day Aegean and Tyrrenhian sea basins seem compelling, though the role of subduction in the development of the Carpathian arc is a matter of ongoing discussion. Deep seismicity beneath the southeastern Carpathians continues to be witnessed; e.g., evidence of subducted oceanic lithosphere analogous to the Calabrian arc, through an alternative explanation of the seismicity arising from recent gravitational instability of the continental lithosphere has been proposed, and seems consistent with tomographic and thermal constraints on the present active seismicity.

Integration of these diverse techniques, theories, and data sets is essential, but future regional-scale seismic tomography and geochronological sampling will be of particular interest in further understanding this remarkable system.

The abstract volume to this meeting is available at http://www.see.leeds.ac.uk/~eargah/ACP2007/ACP2007workshop.pdf. In addition, a more detailed version of this meeting report can be found in the electronic supplement to this Eos issue (http://www.agu.org/eos_elec/).

—GREG A. HOUSEMAN, School of Earth and Environment, University of Leeds, Leeds, U.K.; E-mail: greg@earth.leeds.ac.uk; and FRANK HORVÁTH and GÁBOR BÁDA, Department of Geophysics, Eötvös Loránd University, Budapest.
Arctic system model and to develop a suite of high-resolution tools to understand the Arctic as an integrated system, refine model intercomparisons, reduce uncertainty in Arctic climate projections, and provide meaningful tools for stakeholders to plan for future conditions in the Arctic.

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This forum emphasizes the theme of innovative technologies and their application to a healthy and prosperous environment. Through plenary talks, thematic breakout sessions, a technology expo, and exhibits, participants will learn about the role of technology in environmental protection as well as in the United States’s economic success in the global environment.

FORUM

Rationale for a Permanent Seismic Network in the U.S. Central Plains Utilizing USArray

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The eastern two thirds of the coterminous United States (from the Rocky Mountain Front to the east coast) are sparsely equipped with seismic monitoring instruments, with the number of permanent broadband seismic stations per unit area of the order of 5–10% of that in the western U.S. orogenic zone. In this Forum, we use the Central Plains area (CP)—defined here as the four-state area including Nebraska, Kansas, Iowa, and Missouri—as an example to argue that a greatly densified permanent seismic network in the stable part of the United States could significantly improve our understanding of the processes that led to the formation and four-dimensional structure of the continental lithosphere. The network would also serve as an excellent facility for long-term earthquake monitoring and for public education and outreach. This issue is timely because a state-of-the-art, uniform network could be established by simply converting a small portion of the portable stations in the ongoing USArray project into permanent ones without affecting the overall progress of the USArray.

An ideal regional seismic network should have identical instruments, utilizing a single set of data recording parameters with real-time data transfer and professional data archival, and it should be professionally sited and constructed. Stations in the transportable array (TA) component of the USArray, which will occupy a total of 156 sites in the CP region between 2009 and 2013, have all of the characteristics of an ideal network. By converting some of the TA stations after their 2-year deployment to permanent sites, an ideal regional network could be established without removing the TA stations and without the extra cost of reinstallation.

On 4 June 2007, a group of about 20 geoscientists from the four CP states and representatives from EarthScope and the Incorporated Research Institutions for Seismology (IRIS) participated in the organizational meeting of the Central Plains EarthScope Partnership (CPEP) at the University of Missouri at Kansas City. One of the goals of CPEP is to coordinate an organized effort to convert about 10% (~16) of the TA stations to be installed in the CP area into permanent stations. We estimate that these converted stations, together with existing stations and new stations to be installed by various agencies in the next several years, will increase the number of stations per state from the current one or two to seven or eight (excluding the New Madrid Seismic Zone).

Like most other areas of the stable part of the North American continent, the Central Plains area is characterized by a diverse amalgamation of tectonic features developed over the past 2 billion years. Boundaries between three major Precambrian terranes and one of the largest continental rift systems on Earth (the Midcontinent Rift) are located in this area. Preliminary geophysical studies suggest that the mantle transition between the western U.S. orogenic zone and the stable North American craton lies within the western part of this area. In addition, the New Madrid Seismic Zone is the locale for some of the most significant historical earthquakes in the United States (see Figure 1, in the online supplement to this Eos issue; http://www.agu.org/eos_elec/). Therefore, detailed geoscientific studies of the CP will significantly improve our understanding of (1) the growth, modification, and destruction of the continental lithosphere; (2) the nature of the active-to-stable transitional area in the mantle; and (3) the formation mechanism of intracrustal earthquakes. However, the lack of damaging historic earthquakes in most of the CP has resulted in fewer geophysical research efforts relative to the western United States.

Scientific Rationale

The permanent network would significantly expand the USArray’s capability for understanding the formation, dynamics, and structure of the North American continent, as well as expand its capability for seismic hazard mitigation and public education and outreach. Because of the limited duration of recording and the unfavorable location of the CP in terms of the availability of the SKS phase (Pto-S converted phase at the core-mantle boundary) from the world’s major earthquake zones, a low number of high-quality SKS arrivals are expected for the 2-year deployment period of the transportable array. Although such data would be sufficient to obtain a pair of averaged splitting parameters, they would be inadequate for studying complex anisotropy such as multiple anisotropy layers [Marone and Romanowicz, 2007]. In addition, most seismic tomographic techniques using either body waves or surface waves require as many as possible high-quality raypaths from different azimuths and with different angles of incidence to obtain high-resolution images of the Earth’s interior. Thus, a densified permanent seismic network would lead to greater resolving power of virtually all the seismic tomographic techniques.

Although earthquakes have not been a serious public concern for the CP (except for the New Madrid Seismic Zone), damaging historical earthquakes have occurred in this area, which is the home of numerous earth-embankment dams and essential structures such as various types of power stations. In addition, the mechanism that forms intracrustal earthquakes is still unknown. The 2-year recording period of the TA was chosen to balance the need for the TA to progress across the country in a timely manner and the need to record a sufficient amount of data for mapping large-scale structures, and thus the TA was not designed for monitoring earthquakes. A permanent seismic network in the CP would significantly improve the detection threshold of small earthquakes, and consequently would make it possible to identify and characterize potentially active basement faults. This improvement, in turn, would increase our understanding of intracrustal earthquakes, assist in the reduction of earthquake hazards, and vastly improve long-term public planning.

A potential network of permanent seismic stations in the CP area is an excellent facility for educating the next generation of geoscientists and for public outreach. The network would continue the legacy and excitement about geoscience already being created by the transportable array among the general public and in schools [Levy and Taber, 2005]. An improved understanding of the true nature of science and scientific research by the general public is essential for the well-being of the entire