Lithospheric studies

Seismic probing of the Pannonian lithosphere: a review

Endre HEGEDŰS*

Keywords: crust, mantle, Békés Basin, refraction, reflection, astenosphere

1. Early results of lithospheric research by refraction and wide-angle reflection methods

During the first experiments in 1955 seismic arrivals were obtained from the crust–mantle boundary. Those first attempts have revealed that the crust is thinner in the Pannonian Basin than the European average (see Fig. 1) [GÁLFI, STEGENA 1955, 1957].

![Fig. 1. Double reflection echoed from the crust-mantle boundary](image)

* Eötvös Loránd Geophysical Institute of Hungary, H–1145 Budapest, Kolumbusz u. 17–23, Hungary,
In the 60’s and early 70’s it became possible to map the crustal thickness in Central Europe by a grid of deep seismic profiles. An example of the international cooperation is the Adriatic Sea–Pannonian Basin–Ukrainian Shield profile (see Fig. 2) [POSGAY 1977].

2. Results of deep seismic reflection investigation of the Earth’s crust and upper mantle: the Pannonian Geotraverse Program

In eastern Hungary seismic velocity measurements have revealed that the upper zone of the asthenosphere is in elevated position, at 53 km depth (see Fig. 3).

Deep seismic profiles in southern Hungary gave first evidence of a domal uplift structure of the lithosphere–asthenosphere boundary [POSGAY et al. 1995]. Beneath the Békés Basin, geomagnetic, gravity, seismic, magnetotelluric and geothermal measurements contributed towards recognizing the uplifted position of the lower crust, the crust–mantle boundary at 20–25 km depth and of the lithosphere–asthenosphere boundary at 40–45 km depth. In some places displacement (shear) zones affecting the whole lithosphere and magmatic intrusions in the upper crust have been revealed. As an example, at the SW end of the PGT-4 profile, a NE dipping major low angle shear zone is shown (Fig. 4). This characteristic feature can be traced downward to several tens of kilometres. The strike direction of this shear zone agrees with the known strike line of the normal fault in the western flank of the Hódmezővásárhely–Makó Graben. Besides the subsidence of the Békés Basin it may have caused a lithospheric scale slipping displacement along the downward sloping shear zone from the west. This process was able to take place along the low angle shear zone. This explains the anomalously thick sedimentary deposition in the Hódmezővásárhely Makó Graben in spite of normal (Pannonian Basin) lithosphere thickness.


Beginning in 1997, a series of large seismic refraction experiments covered Central Europe with an unprecedented network of seismic profiles
Fig. 2. Dubrovnik–Donets international refraction profile

2. ábra. A Dubrovnik–Donets nemzetközi refrakciós szelvény
Seismic probing of the Pannonian lithosphere: a review

Fig. 3. Velocity determinations penetrating the asthenosphere: measured near Karcag and Biharkeresztes

3. ábra. Az asztenoszférán áthaladó sebességmeghatározások: Karcag és Biharkeresztes közeli mérések

with considerable threedimensional coverage and drew the attention of the international community to the crustal and lithospheric mantle structure and tectonics of the area. These experiments—POLONAISE’97, CELEBRATION 2000, ALP 2002, and SUDETES 2003—were only possible due to a massive international cooperative effort. Since the lithospheric structure in the region is very complex, the need for a 3-D approach was recognized early. The first of the new experiments was POLONAISE’97 [GUTERCH et al. 1999] and it showed how much could be learned from even modest 3-D coverage. A series of even larger experiments followed in rapid succession: CELEBRATION 2000, ALP 2002, and SUDETES 2003 [GRAD et al. 2006]. The coverage extends from northern Poland to the Eastern-Alps, Adriatic Sea and the Dinarides. The scientific goals of this effort included attaining a better understanding of the formation of continental Europe in the Paleozoic and the Variscan and Caledonian orogenies, as well as the subsequent formation of the Alps-Carpathian mountain chain and the Pannonian Basin. Apart from producing 2-D models along the many seismic profiles recorded, the ultimate goal was to construct a 3-D model of the lithospheric structure in the area
and provide the structural background for other geophysical modeling (e.g., potential fields, heat flow).

Finally, these 3-D models could be the starting point to evaluate and develop new geodynamic models for the tectonic evolution of the whole region. The crustal structure of the Pannonian Basin is relatively simple. Below the 2–5 km thick Neogene sediments, a layer of low-velocity rocks (5.8–6.1 km/s) with a very small velocity gradient occurs down to 18 km depth. The uppermost mantle is characterized by velocities of 7.95–8.0 km/s, and the Moho lies here at a relatively shallow depth of only 22–23 km (see Fig. 5).

REFERENCES


A Pannóniai litoszféra szeimikus kutatása – áttekintés

HEGEDŰS Endre
Fig. 4. PGT-4 deep reflection profile with MT profile below

4. ábra. Fent a PGT-4 mélyreflexiós szelvény, alatta az MT szelvény
Fig. 5. Lithospheric model with tectonic map along profile CEL05 [GRAD et al. 2006]

5. ábra. Litoszféra modell a CEL05 szelvény mentén készített tektonikai térképpel [GRAD et al. 2006]