Extensometric researches in Ukraine: methods, instruments, results

© A. Nazarevych[1], L. Nazarevych[2], V. Nasonkin[3], O. Boborykina[3], 2010

[1]Carpathian Branch of Institute of Geophysics, National Academy of Sciences of Ukraine, Lvov, Ukraine
nazarevych-a@cb-igph.lviv.ua
[2]Department of seismicity of Carpathian region of Institute of Geophysics,
National Academy of Sciences of Ukraine, Lvov, Ukraine
nazarevych.l@gmail.com
[3]Taurichesky National University, Simferopol, AR Crimea, Ukraine
b0b04ka14@mail.ru

Extensometric seismoprognostic researches are conducted in Ukraine for over 20 years. They are concentrated in the Transcarpathians and the Crimea as the most seismoactive regions of the country (Figure). In Transcarpathians the quartz extensometers was working [Latynina et al., 1992; 1993; Verbytsky et al., 2003; Verbytsky, Nazarevych, 2005; Nazarevych, 2006]. Now works 3 de-

Points of extensometric researches in Ukraine (marked by red triangle): 1 — RGS "Beregove"; *2* — RGS "Koroleve"; Geophysical Observatory of TNU (AR Crimea, Sevastopol, Cape Chersonese).

vices. At different times they were equipped with various measuring and recording systems [Latynina et al., 1993; Verbytsky et al., 2003; Verbytsky, Nazarevych, 2005; Nazarevych I., Nazarevych A., 1999; 2006]. In parallel in one of the stations for some time the 2 — axis tiltmeter was worked. Recently, we have developed and put into operation in one of quartz extensometers in regime geophysical station (RGS) "Beregove" (see Figure) the computerized measurement and recording system with a noncontact capacitive sensor of micromoving measuring. The system has a primary tool sensitivity 10 nm (about 10^{-9} in relative units) at 2 count per second and can obtain the sensitivity 1 nm in the signal accumulation mode (1 count per 10 s). For temperature control and accounting of parasitic thermoelastic deformation of constructions constituent the system is equipped with a temperature control channel with a sensitivity 0.01 °C.

In Crimea on Geophysical observatory (Sevastopol) of Vernadsky name Taurichesky National University the extensometric laser interferometer complex was created and works [Shliakhovyj et al., 2007; http://www.tnu.crimea.ua/tnu/str_praz/observatory/index.htm]. The complex consists of 2 equal "shoulder" ("shoulder" length is 5 m) two-ray laser interferometers of Michelson type with separated beams using the frequency-stabilized laser as a wavelength standard. Their basic metrological characteristics are following: the sensitivity on strains (ADC LSD unit) — 0.16 nm, the instrumental long-term drift — not more than 2.5×10^{-8} units per year. There is computer registration, measurements are made at intervals 4 s. In the same place 2 — axis tiltmeter which was created in Poltava gravimetric observatory of Subbotin name Institute of Geophysics of NASU also works.

During the extensometric observations the number of more or less intensive predictive deformation anomalies which accompany the preparation of local earthquakes was recorded. In Transcarpathians one of the most intensive was precursor of sensible 1989 Vynogradove earthquakes with M=2.9 (I=5.5) [Nazarevych A., Nazarevych L., 2008; Nazarevych, 2010], which was registered in extensometric station "Muzhiyevo" ("Beregove-1") at the epicentral distance 23 km. Anomaly started 5 months before earthquake and had absolute amplitude 30,8 mkm relative to trend component (11×10^{-7} in relative units). In the period of preparation and after earthquake the nature of deformation processes in rock massifs in observation area was changed: by extensometer **d1** the average annual compression with value $\approx10.5\times10^{-7}$ was changed by expansion with value $\approx4.1\times10^{-7}$, by extensometer **d2** the average annual compression with value $\approx23\times10^{-7}$ decreased to $\approx9.6\times10^{-7}$. Also we can note that there was a similar nature (expansion) and correlated in time changes of deformation (**d1**) and registered on a nearby point of geoacoustic observations acoustic anomalies [Nazarevych, 2010].

An example of deformation precursor of the Crimea — Black Sea region earthquake is recorded in a distance of about 250 km anomaly, which accompanied the preparation of the 07.05.2008 earthquake with a magnitude M=4.9, epicentre coordinates 45.36°N, 30.92°E and focal depth about 10 km. Duration of anomaly was about one and half months, the absolute amplitude relative to trend component was 1,92 mkm ($\sim4\times10^{-7}$ in relative units).

Comparison of values of recorded deformation anomalies with data of theoretical studies on propagation of deformations from the future earthquake emerging focal zone [Dobrovolsky, 1991] shows that registered anomalies are in value by 10—100 times higher than results of theoretical estimations with taking into account the size of the source [Nazarevych A., Nazarevych L., 2009] for earthquakes of corresponding energetic class/magnitude. The reason for this can be features of tectonic structure of these regions lithosphere and the presence here of horizontal tectonic stresses [Nazarevych L., Nazarevych A., 2006]. These results indicate that potential and prospects of extensometric method in seismoprognostic monitoring are substantially greater than it was consider before.

References

Dobrovolsky I. P. The theory of tectonic earthquake preparation. — Moscow: IPhE RAS, 1991. — 219 p. (in Russian).

http://www.tnu.crimea.ua/tnu/str_praz/observatory/index.htm (in Russian).

Latynina L. A., Baysarovych I. M., Brymyh L., Varga P., Yurkevych O. H. Deformation measurements in the Carpathian-Balkan region // Phys. Earth. — 1993. — № 1. — P. 3—6 (in Russian).

Latynina L. A., Yurkevych O. I., Baysarovych I. M. The results of deformation measurements in Beregovo area // Geophys. J. — 1992. — **14**, № 2. — P. 63—67 (in Russian).

Nazarevych L., Nazarevych A. Seismicity and geomechanics of Ukrainian Carpathians region lithosphere // Proc. of XYIII-th congress of the Carpathian-Balkan geological association. September 3—6, 2006, Belgrade, Serbia. — Belgrade, 2006. — P. 402—403.

Nazarevych A. Extenzometric research in Beregovo area in Transcarpathians // Proc. of SSSh. — Lvov, 2006. — Volume XVII. Geophysics. — P. 129—139 (in Ukrainian).

Nazarevych A. V., Nazarevych L. Ye. Deformation precursors of Carpathian earthquakes: separation methods and analysis results // Theoretical and applied aspects of Geoinformatics. — Kiev, 2008. — P. 311—320 (in Ukrainian).

Nazarevych A. V., Nazarevych L. Ye. Scale-energy correlation ratio for Transcarpathian earthquakes sources: some consequences and energetic verification // Theoretical and applied aspects of Geoinformatics. — Kiev, 2009. — P. 279—298 (in Ukrainian).

Nazarevych A. V. Geophysical precursors of some sensible Transcarpathian earthquakes as a reflection of the formation of focal zones // Theoretical and applied aspects of Geoinformatics. — Kiev, 2010. — P. 274—285 (in Ukrainian).

Nazarevych A., Nazarevych L. Optoelectronic measuring channel to quartz extensometer // Geodynamics. — 1999. — № 1(2). — P. 116—120 (in Ukrainian).

Shliakhovyj V. P., Tregubenko V. I., Shliakhovyj V. V., Boborykina O. A., Nasonkin V. A. Some results of digital seismic and tidal observations at Cape Chersonese (Sevastopol) // Geodynamics. — 2007. — № 1(6). — P. 29—36 (in Ukrainian).

Verbytsky T. Z., Gnyp A. R., Malytsky D. V., Nazarevych A. V., Verbytsky Yu. T., Ignatyshyn V. V., Novotna O. M., Narivna M. I., Yarema I. I. Microseismic and extensometric studies in the Carpathians: results and prospects // Geophys. J. — 2003. — **23**, № 3. — P. 99—112 (in Ukrainian).

Verbytsky T. Z., Nazarevych A. V. Extensometric and geoacoustic studies in Transcarpathians // Studies of modern geodynamics of Ukrainian Carpathians / Ed. V. I. Starostenko. — Kiev: Nauk. dumka, 2005. — P. 113—131 (in Ukrainian).

Small-scale convection produces sedimentary sequences

© S. Nielsen[1], K. Petersen[1], O. Clausen[1], R. Stephenson[2], T. Gerya[3], 2010

[1]Aarhus University, Department of Earth Sciences, Denmark
sbn@geo.au.dk
kenni@geo.au.dk
orc@geo.au.dk
[2]Geology and Petroleum Geology, School of Geosciences, College of Physical Sciences, Meston Building, King's College, Aberdeen, Scotland
stephenson@abdn.ac.uk
[3]Department of Geosciences, ETH-Zurich, CH-8092 Zurich, Zurich, Switzerland
taras.gerya@erdw.ethz.ch

It is generally acknowledged that heat transfer in the sub-lithospheric mantle is dominated by convection that maintains an adiabatic temperature gradient close to 0.6 K/km. Transfer of the advected heat to the conductive lithosphere takes place at the base of the lithosphere, which is maintained at a relatively constant temperature in the vicinity of 1300 °C. However, the thermo-mechanical details of this highly dynamic boundary condition at the base of the lithosphere are frequently approximated by a fixed temperature at the assumed long-term equilibrium depth of the base of the lithosphere (the plate model). The present contribution investigates this approximation. We apply a two-dimensional, numerical, thermo-mechanical model of the lithosphere and upper mantle [Petersen, 2010] to asses the effects resulting from a more correct representation of the sub-lithospheric small-scale convection, which is responsible for heat transfer in the sub-lithospheric mantle. Given a particular mantle rheology, our model shows small-scale convection, and converges over time towards a self-consistent, quasi-steady-state with a stable lithosphere, the thickness of which depends on the chosen creep