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Editors in chief

(Institute of Astronomy and Geophysics, Ulaanbaatar, Mongolia)

Prof. Demberel Sodnomsambuu

Dr. Odonbaatar Chimed

Dr. Ulziibat Munkhuu

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Editors: Dr Odonbaatar Chimed
Dr Munkhsaikhan Adiya
Mrs Ankhtsetseg Dorjsuren

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FIRST RESULTS OF GPS MEASUREMENTS WITHIN THE LOCAL NETWORKS IN THE CENTRAL MONGOLIA

Miroshnichenko A.I.[1], Lukhnev A.V.[1], Radziminovich N.A.[1], Zuev F.L.[1], Demberel S.[2], Erdenezul D.[2], Ulziibat M.[2] and Ganzorig D.[2]

[1] *Institute of the Earth's crust SB RAS, Irkutsk, Russia*
[2] *Institute of Astronomy and Geophysics of Mongolian Academy of Sciences, Lkhagvasuren street – 42, Maakhuur tolgoi, 5 khoroo, BZD, 13343, Ulaanbaatar, Mongolia*

Contact: *mai@crust.irk.ru*

Introduction

In the frame of the joint Russian-Mongolian project, a system for monitoring deformations of the earth's surface using GPS-geodesy has been designed and implemented since 2010 around Ulaanbaatar. Design and number of the sites of the new local networks "Ulaanbaatar" and "Emeelt" were determined on the basis of the geological-geomorphological structure of the territory, location and orientation of the active faults, the manifestation of paleo- and recent seismicity. Eleven campaign GPS sites were installed during 2010-2011 by the efforts of the staff of the IEC (Irkutsk, Russia) and IAG (Ulaanbaatar, Mongolia). These sites and the permanent station ULAB (Ulaanbaatar), which is incorporated in the IGS, form "Ulaanbaatar" network (Fig.1). Additionally, seven new sites were installed within the seismically active structure "Emeelt". These two networks are connected through two sites, EML7 and ULAB. The networks are located around mountain highland Bogd-Khan-Uul. The "Ulaanbaatar" network is extended in the latitudinal direction by 100km, in the meridional direction by 80km.

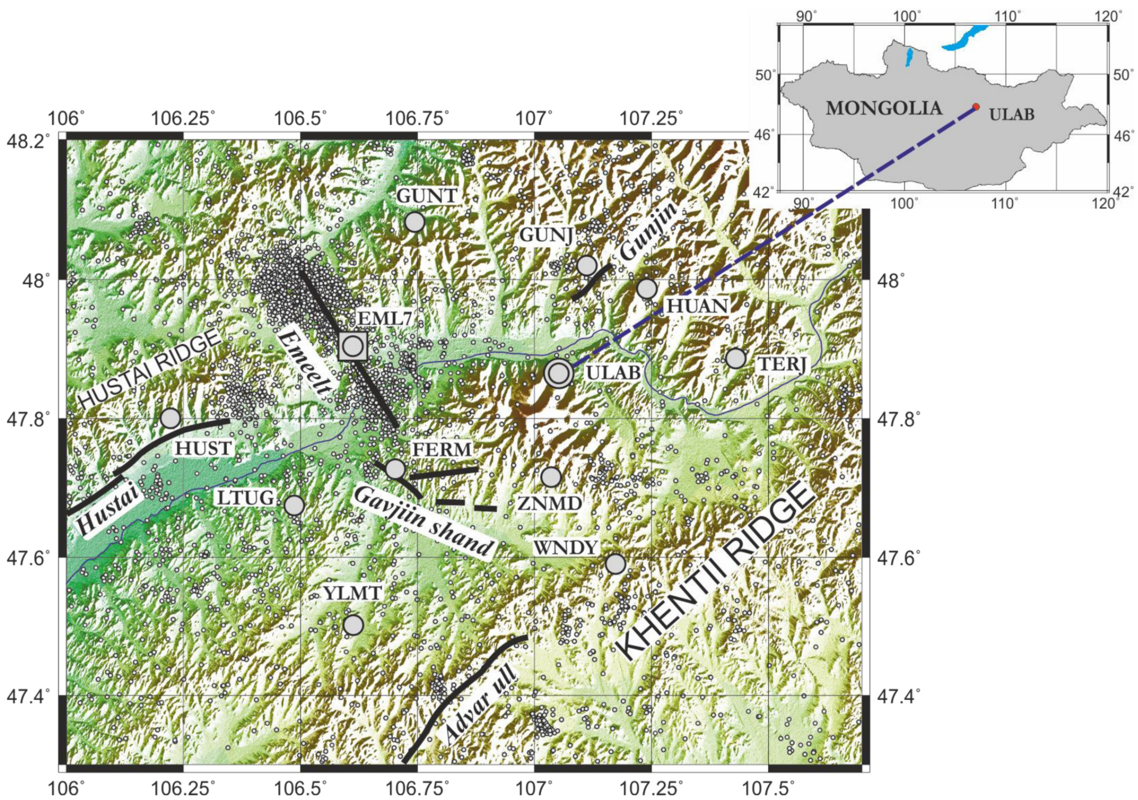

Figure 1: Location of the GPS networks around Ulaanbaatar. GPS sites of the network "Ulaanbaatar" are shown by circles; ULAB is also a station of the IGS. Location of the network "Emeelt" is shown by square with EML7 site in the center. Black lines are active faults considered here. Small circles are epicenters of earthquakes.

Measurements at all sites have been carried out using dual-frequency GPS receivers Trimble 5700 with Zephyr TRM 39105.00 antennas and by multifrequency receiver Sokkia GSR2700 ISX with inner GNSS antenna Pinwheel^{TM}. Since 2012, measurements have been carried out using Trimble NetR9 multichannel GNSS receivers with Choke Ring antennas in the kit, capable of tracking the signals of all satellite systems that exist now. Measurements at the sites of the "Ulaanbaatar" network were carried out for 72 hours or more, while in the "Emeelt" measurement interval varied from 8 to 72 hours. For velocity calculations, data from at least four observation sessions conducted in 2010-2015 were used. Results of GPS measurements were processed with the special GAMIT/GLOBK software packages. GPS velocities and their 95 per cent confidence ellipses for "Ulaanbaatar" network were estimated in ITRF2014, whereas for "Emeelt" ITRF2008 was used as well as we also referred "Emeelt" GPS velocities to the EML8 site to access the local-scale crustal movements. The regional and global GPS network data were correlated using records from 31 IGS stations. The calculation procedure is described in detail in (Lukhnev et al., 2010). We derived also relative strain patterns from horizontal GPS velocities using formulae from (Turcotte and Schubert, 1985).

Results

Velocity vectors calculated from the measurements in "Ulaanbaatar" network for 2010-2015 are shown at Fig.2.

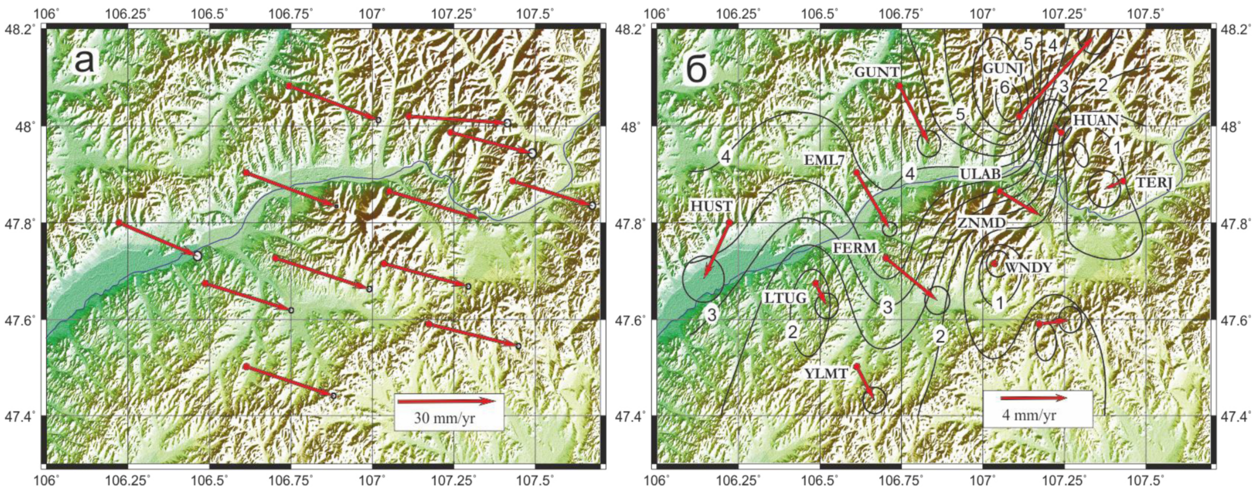

Figure 2: GPS-derived velocities of the sites of the "Ulaanbaatar" network for 2010-2015 in the ITRF2014 system (a) and with respect to Eurasia (b). Ellipses are 95% confidence. Isolines are the interpolated velocity values in mm/yr.

With respect to Eurasia the vectors are slightly turned to the south but in general they are also oriented 130-150° and the values are 2-4 mm/yr. Nonregularity of the velocity distribution results zonal structure of the the field of relative horizontal deformations (Fig. 3).

In the western part of the territory, an elongated in the S-N direction zone is observed with the predominance of the relative deformations of extension whose axes are oriented in a sublatitudinal direction. Here, the majority of earthquakes occur, mainly within the Emeelt fault. The central part of the network is a zone extended from SW to NE where shortening of the crust prevails. Axes of shortening have NW-SE orientation. This zone is also characterized by high values of maximum shear strain.

Results for the "Emeelt" network, both velocities and strain patterns, have been calculated, too (Fig.4). Within this network, significant variation of horizontal velocities is observed. The largest value (11 mm/yr) has been found for EML0 site, which is located just in the central part of the fault zone. This site, as well as the nearbyEML5, moves to the east. EML6 and EML7 have practically equal velocities (7-8 mm/yr) and and azimuths of displacement (120°), though they are located at the different fault sides. Relative deformations within the four distinguished triangular areas show

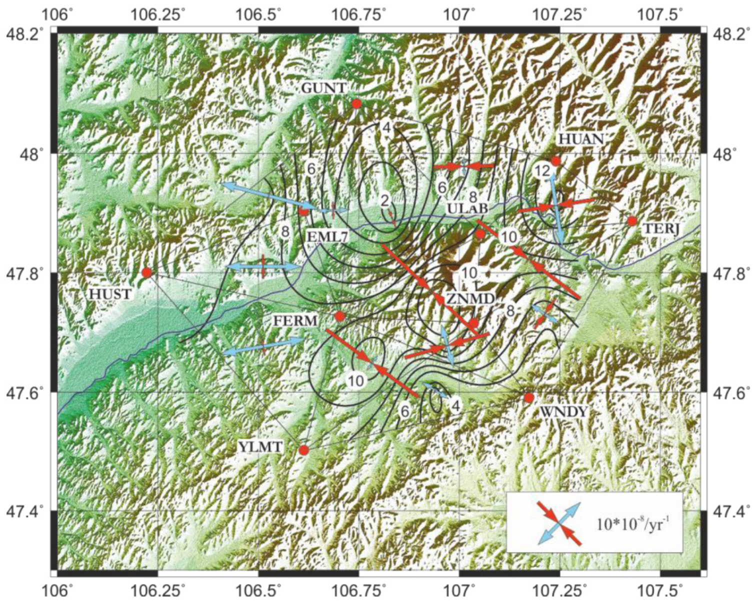

Figure 3: Relative horizontal crust strain patterns. Black and white arrows are principal shortening and elongation rate axes, respectively. Isolines are the interpolated velocity values in mm/yr. Isolines are the interpolated velocity ($\varepsilon_{max} = (\varepsilon_1 - \varepsilon_2)/2$).

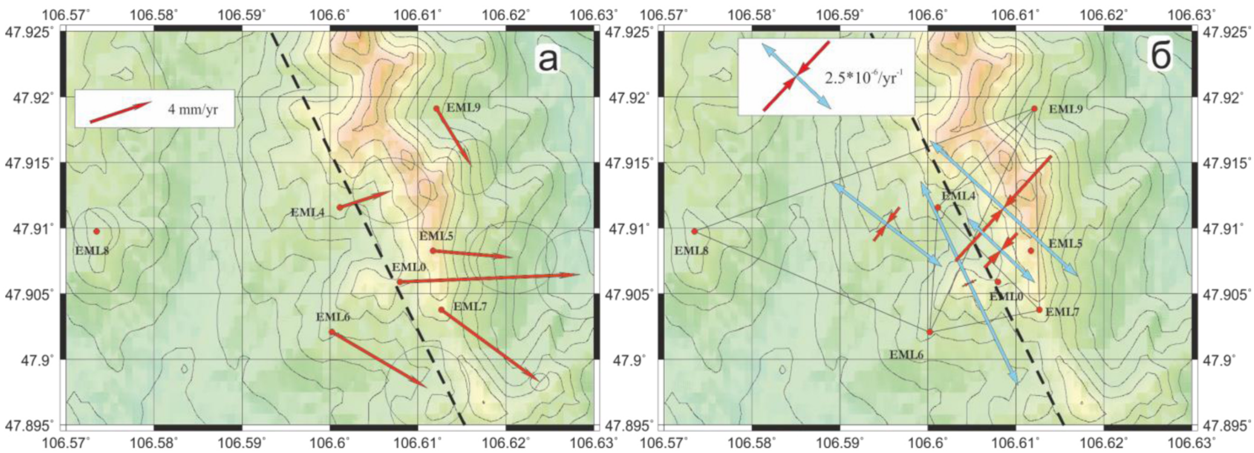

Figure 4: GPS-derived velocities of the sites of the "Emeelt" network (a) and field of the relative horizontal crust strain (b) for 2010-2015.

an elongation of the earth's crust in the SE-NW direction and a little bit smaller in rate shortening in the SW-NE rhombs. The elongation rate reaches 5x10-6 yr-1. The axial part of the fault zone that crosses the network in the NW direction is characterized by maximum deformations.

Discussion

The obtained data are the first results of GPS measurements in the vicinity of Ulaanbaatar. The velocity vectors in the ITRF2014 system show a consistent movement of the sites in the southeast direction that is consistent with the previous results for the ULAB permanent site. Considering the results with respect to Eurasia, we can see that the velocity field is more complicated. The values and orientations of the vectors are more diverse. The sites in the eastern part of the network move slower comparing to the sites in the north-western part. This results in shortening of the crust in the NW-SE direction in the local scale.

The sites of the "Emeelt" network are located directly within the seismogenic structure. The high values of the strain rate obtained are due to the small area of the network. The strain rate of the crust elongation is somewhat higher than the strain rate of the shortening that is in agreement with seismological data (Ganzorig, 2015). Orientation of the principal strain axes obtained from GPS data also coinsides with the stress axes inverted from focal mechanisms, namely shortening (compression) axis is directed NE-SW and elongation (extension) axis is directed SE-NW. At the regional scale, this area is characterized by a subhorizontal compression acting in the northeastern direction with a subhorizontal position of the extension axis oriented SE-NW (eg., Lukhnev et al., 2010; Sankov et al, 2015; Radziminovich et al., 2016; Seminsky et al., 2017).

The kinematics of faults around Ulan-Bator deduced from seismogeological and structural data also corresponds to shearing. As for the orientation of the compression axis, different researchers define it depending on the scale of the territory or individual structures, from SW-NE (Seminsky et al., 2017) to close to W-E or even NW-SE (Smekalin et al., 2013, Battsetseg, Ganzorig, 2017). The latter direction is consistent with orientation of deformation axes from GPS data within the local area.

Conclusions

As a result of the conducted studies, a decrease in the velocities of horizontal movements within the network "Ulaanbaatar" from NW to SE has been established. It causes the deformation of shortening of the crust with the axis oriented NW-SE in the south-eastern part of the network. In the western part of the network, elongation prevails with the axis in E-W direction. Here, the most of the earthquakes recorded around Ulaanbaatar occurs. Results obtained from GPS measurements are in agreement with those from focal solutions.

Our analysis of the GPS data shows that the recent deformation of the crust id determined by the summed effects of geodynamics of the studied area and its geological settings.

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