Vp/Vs ratio and seismic activity structure of Ulaanbaatar area, the capital city of Mongolia

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ABSTRACT

Variations in seismic velocities and Vp/Vs ratio can be used to identify precursory activity which may precede large earthquakes and as well as volcanic eruptions. The observation of such variations before large earthquakes has been observed several month or years prior to before large earthquakes. Anomolously high seismic activity occurs around the Ulaanbaatar capital city of Mongolia since 2005. This area, which could be one of most seismic active zone around Ulaanbaatar, dramatically increases the seismic hazard of the capital of Mongolia where is concentrated about of 1/3 of the Mongolia population and the majority of industries of the country. Since the beginning of this high seismic activity in middle of 2005, more than 3000 earthquakes with magnitude between 0.5 and 4.2 have been observed by our network through this area. Since 1994, we have a better detection and location of the seismic activity around Ulaanbaatar when a seismic network has been installed around the capital in collaboration with DASE France. Later on it was upgraded by PS25 seismic array which is located on the area of main structure (Hustai Fault) reactivating, in frame of CTBTO activities. Therefore, it gives unique chance to us to control evaluation of clustering and spatial distribution of those seismic activities in real-time. We analyzed seismic velocity variations of earthquakes recorded at the permanent stations of the Ulaanbaatar Network, which is located just above the seismic activity. Beside this, we investigated data from quarry blasts located around Ulaanbaatar city waiting 5-300 km away. We present result of study Vp/Vs variations with related seismic events and clusters area as well as methods that we used.

Seismic activity around Ulaanbaatar city

The high seismic activity of Ulaanbaatar area starts from middle of 2005 and it is still continuing up to now. During this period, moderate size earthquakes (M4.2) occurred in the last 500 yrs while instrumental seismicity shows regular activity with five M > 4 since 1974, some of which were actually felt by inhabitants.

Active faults around Ulaanbaatar

The nearest fault to Ulansbaatar considered was the Hustai fault with its northeast tip located 10 km from the city of Ulaanbaatar. This 92 km long fault may produce, if it breaks at once, a magnitude about 7.5. No known historical earthquake occurred on the Hustai Fault in the last 500 yrs while instrumental seismicity shows regular activity with five M > 4 since 1974, some of which were actually felt by inhabitants.

Active faults around Ulaanbaatar

In 2005, we observed a very strong increase in seismicity below the International Airport of Ulaanbaatar and north of it, over the Emeelt area. This change dramatically altered our view on the relative seismic quiescence observed until then in region. Immediate field observations revealed a new active fault–now called the Emeelt fault–located less than 15 km from western main and northern part of the airport area. First earthquake associated with the Emeelt fault was recorded on May 2008. Future investigations over the Emeelt fault area in 2008 and 2010 include morphotectonic mapping, near-surface geophysical imaging (magnetic mapping, GPR), microseismography (differential GPS) and paleoseismic trenching. Our results show that 1) the fault is weakly segmented, 20 its trace can be mapped over more than 40 km, 3) the deformation zone is relatively wide and 4) earthquake ruptures have reached the surface in the recent past. The recurrence time of events, their size and 3D analysis of the seismic area are under process.

The Gunjiin active fault located north-east of Ulaanbaatar around 5 km, surface rupture was traced on space images available now for about 15 km. Accordingly recent result of geophysical survey, the Gunjiin fault traces until Ulansbaatar basin were crossing Ulaaslay valley. Morphological evidence of right-lateral movements were found as well and cumulative displacement is around 25 m.

Result and Discussion

The availability of high-quality arrival data (especially unambiguously S arrivals) from three-component digital recorders permitted temporal and spatial variation of P- and S-wave velocities to be accurately determined. We used the method of Vp/Vs–1 in which P-S times are plotted against P-arrival times for a particular event, was followed. The slope of the line, fitted by least squares, gives an estimate of the average value of (Vp/Vs)–1 for the region containing the ray paths between the vertical while S was clearer on the horizontals.

The seismic swarm around Ulaanbaatar area began on May 2005, close to the capital city of Mongolia, where is covering about 100 km square area. Over 3000 earthquakes have been recorded by the RCAG’s permanent and temporary seismic network since the swarm initiated, and activity continues to the present. The arrival time date of these swarms are used to estimate Vp/Vs ratio. Seismic wave velocity studies indicate that significant temporal and spatial variations of seismic wave velocities are present. The Vp/Vs ratio ranges from as low as 1.5 to as high as 1.91 with the majority of values falling between 1.60 and 1.80. Also the Vp/Vs values show very clear spatial and temporal variations during this swarm activity time.

In order to improve resolution of variation of the seismic velocity change we used explosion data ranging from 2005 to 2011. About 150 km to the East of Ulaanbaatar, the Baganuur coal mining company frequently quenches blasting. Around 500 quarry blasts used for this study and we have selected those events with correlation coefficient is more than 0.98. Anomalous low value of Vp/Vs ratio are found between time range of 2007 and 2008, prior to the major 2009/2010 swarm activity. Also, an increase of Vp/Vs for this path observed to 1.75 to 1.85 during 2010.