



## **Pre-seismic changes in ground tilt and strain associated with the 2010 Yushu earthquake**

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The Yushu Ms7.1 earthquake on April 14, 2010 in Qinghai, was a catastrophe earthquake after Wenchuan earthquake in China, and it caused 2698 deaths. The pre-seismic changes in ground deformation were recorded with sampling per minute by a tilt meter and a borehole strain meter, two instruments installed at the Yushu station that is less than 2 km away from the earthquake rupture zone or Yushu fault. As the power supply can not be guaranteed the observation was sometimes interrupted, but generally does not affect the trends, and the trends may be recovered by means of Interpolation, connections and filtering. The obtained data showed that anomalous signals of ground tilt and strain were not observed in 2 years before the event.

The main measurement interference factor for the ground tilt was rainfall except for the power supply. The EW-tilt was varying in an annual period form, and the annual variation remained until the earthquake occurrence, and no precursory signals were observed; The NS-tilt before and after July of 2009 was shown as an anomaly, but the anomaly was mainly related to the load-unload changes of river water flowing nearby the Yushu fault that located in the southern part of the Yushu station. This relation can be proved by the measured ground water level change at the station. After this term the NS tilt was smoothly varied up to the earthquake occurrence.

The borehole strain meter was installed at about 50m depth, and main measurement disturbances are the atmosphere pressure and rainfall. The atmosphere pressure was often rapidly varied, and the strain tides were unstable. During the same period of load-unload changes of river level in July 2009, 3 components of the borehole strain meter synchronically changed with compression-tension, the other one was on the contrary. The area strains (channel 1+3 and channel 2+4) were correlated with a coefficient more than 0.95 with the characteristics of compression then tension, so the strain meter was operated in good status before the earthquake. After this period, the 4 components were normally varying up to the event.

This measured phenomenon of tilt and strain prior to Yushu earthquake nearby the earthquake rupture zone is consistent with the results from other major earthquakes, such as 1989 Loma Prieta earthquake, 2004 Parkfield earthquake, 2009 L'Aquila and 2008 Wenchuan earthquake, and it is difficult to explain with the current rock fracture nucleation process model. The common phenomenon maybe proved that the difference between laboratory results and natural measurements, and crust medium nearby earthquake source prior to earthquake was of high strain with small change. We proposed a possible mechanical model for the forthcoming earthquake source area.

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