Strain precursors of the 2008 Wenchuan, China, earthquake

Zehua QIU[1]

[1] ICD, CEA

The tenth Five-Year Project of China Earthquake Administration installed about 40 YRY-4 type high-resolution borehole strainmeters over the mainland China in order to enhance its capability of earthquake-forecasting attempt. The strainmeters are installed in rocks at a depth around 40m and resolve strain changes to the order of 10-11. Measurements are sampled every minute.

Among the new borehole strainmeter observatories, Guza is located the nearest (about 130km), at the southwest end of the seismic fault zone, from the epicentral area of the Wenchuan earthquake. The rest sites are at least nearly 300km away. Even months before the earthquake, it had already been noticed at Guza that the initially smooth curves had become badly interfered from time to time by minor steps or unsymmetrical pulses with periods of minutes˜hours. The interferences were dominantly compressional and mostly on the order of 10-9, less than the size of Earth tide. They were not corresponding to weather changes. Meanwhile other sites did not observe such anomalies.

Given measurements of the four gauges in an YRY-4 strainmeter, denoted as Si (i=1, 2, 3, 4), they should always satisfy the equation

S1 +S3 = S2 +S4 +B, (1)

where constant B comes from arbitrary base values of the measurements. Equation (1) provides a criterion for the self-check of data quality even without in-situ calibration. The similarity of the two curves of S1 +S3 and S2 +S4 of Guza recordings gives sufficient credit to the data for our study.

We define

Sa =S1 +S2 + S3 +S4 (2)

as a target time series for analysis, whose variety is proportional to that of areal strain, and decompose Sa by means of Discrete Wavelet Transformation of dyadic scales. Changes of the interferences of short-periods get stronger before the quake and decay after the quake. Moreover, by comparing the component graphs of different levels we see a strengthening and a movement of weight center of the interferences towards the shock instant along with the increase of period. Since small fractures of rocks in the earthquake preparatory process can be reasonably referred to for explanation of the interferences, the strengthening and the movement of weight center can be readily attributed to the increase of fracture scales.

We put forth an Overrun Rate Analysis (ORA) to give out a quantitative description of the interferences. The analysis is applied to the assembly of the period-bands of signals, which it is obtained by means of Fast Fourier Transform of Sa with a cut-off period. The high-pass interferences can be depicted as positive or negative big values overrunning the normal level. The Overrun Rate of Numbers, denoted as Ron, is defined as the total number of overrun points in one day. The curve of Ron demonstrates more clearly the relevance of the interferences to the quake. It is quite similar to the count rate curve of Acoustic Emission (AE) in rock failure experiments. According to Kaiser effect, the increase of Ron before the quake should reflect the increase of stress level.

We separate Ron into positive and negative portions, denoted as Ronp and Ronn, respectively, and make a time series of Ronp-Ronn. For aseismic normal situation, as the stage before March of 2007, Ronp-Ronn statistically varies symmetrically about the level of zero and close to it. After then, Ronp-Ronn scatters over a much wider region and mostly below zero level while the compressional interferences are developing until the earthquake occurs on May 12, 2008. That during the aftershock stage Ronp-Ronn soon returns to not deviating to any side and recently close to aseismic level should be owing to the vanishing of the compressional interferences.

Our new finding reveals that the strain changes can be observed on the seismic fault zone and founds an approach for the attempt of forecasting major quakes several months in advance.