四成分歪計(SKZ-1)による前兆的変動の検出
Detection of precursory anomalies using the four -component borehole strain meter (SKZ-1)

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High sensitive crustal monitoring has a long history to investigate anomalous precursory variations of earthquakes by means of several kinds of sensors as borehole volumetric sensors (Sacks and Evertson,1971), borehole extension sensor by Gladwin (1984), three component volumetric strain meter by Sakata (2004) and Ishii and Yamauchi (2007). In China the four component strain meter with high performance was developed by Su Kaichi (1977) and has been used in earthquake-prone provinces since 2006.The configuration of four sensing units at intervals of 45 degree provides a simple indicator (consistent factor) of the sensor functioning and regime of the crust assumed to be plain strain in normal state to detect candidates of anomalous variation without little ambiguities. The observation at ten sites in several provinces of China for some 10 years has proved profitable performance of the sensor: high stability and high degree of resolution to detect local and regional anomalous variations near hypocenter. In the normal stage the variations consist of steady diurnal variations due to earth tide, steady trends due to the crustal stress adjustment after construction of the borehole, and installment of the sensors. There are little urban noises with the result of the consistent factor being almost constant value of 0.99.
Here we present analyses of anomalous variations detected by use of the correlation coefficient of two independent plain strain components before two major earthquakes near the network: YiLiang M5.7earthquake and LuDian M6.5 earthquake. In the imminent sage of the Yiliang earthquake, obvious strain anomalies with periods of several days, several weeks appeared simultaneously in four components at the nearest YiLiang site of the epicenter distance15.5km. The correlation coefficients for those anomalies are well below reaching 0.2 compared with the ordinal value 1.0. At DaGuan site of larger distance 30km, there appeared no significant anomalies with the factor remaining the normal value near 0.99 or so. Analyses show that the correlation coefficient can be used to objectively detect anomalies to define the successive stage of earthquake occurrence from normal to relaxation stages.
 A multiple observations using the four component strain meters, groundwater meters and electromagnetic sensor are expected to substantially contribute to investigation of the nucleation process of natural earthquakes. Present finding may contribute to efficient data analysis to detect candidate of anomalies from using big amount of continuous multiple data with higher sampling rate.

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