A Mechanism Causing the Temporal Variation in b-values Prior to a Mainshock

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Observations exhibit the temporal variation in b-values prior to a mainshock. The b-value starts to increase from the normal value at time \(t_1\), reaches its peak one at time \(t_2\), then begins to decrease from the peak one at \(t_2\), and returns to the normal one at time \(t_3\). As \(t>t_3\), the b-value varies around the normal one or rightly decreases with time until the occurrence of the forthcoming mainshock at time \(t_4\). The precursor time, \(T=t_4-t_1\), of b-value anomalies prior to a forthcoming mainshock is related to the magnitude, \(M\), of the event in a form: \(\log(T)=q+rM\) (\(T\) usually in days) where \(q\) and \(r\) are two constants. In this study, the mechanism causing b-value anomalies prior to a mainshock is explored. From numerical simulations based on the 1-D dynamical spring-slider mode proposed by Burridge and Knopoff (1967), Wang (1995) found a power-law correlation between \(b\) and \(s\), where the parameter \(s\) is the ratio of the spring constant (\(K\)) between two sliders to that (\(L\)) between a slider and the moving plate. The power-law correlation are \(b\sim s^{-2/3}\) for the cumulative frequency and \(b\sim s^{-1/2}\) for the discrete frequency. Since \(L\) of a source area is almost constant for a long time period, \(b\) directly relates to \(K\). Lower \(K\) results in a higher b-value. Wang (2012) found \(K=\rho_A v_p^2\), where \(\rho_A\) and \(v_p\) are, respectively, the areal density and P-wave velocity of a fault zone. Experimental results show that \(v_p\) is strongly influenced by the water saturation in rocks. The water saturation in the source area varies with time, thus leading to a temporal variation in \(v_p\) as well as \(K\). This results in the temporal variation in b-values prior to a mainshock. The modeled result is consistent with the observation.

Keywords: earthquake precursor, b-value, precursor time, earthquake magnitude, water saturation, spring-slider model