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Tidal Effects to Earthquake Swarms

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We have analyzed the effect of earth tides upon an intraplate strike-slip fault typical by periodical occurrence of earthquake swarms. In general triggering of earthquakes is attributed to the interplay between the tectonic stress changes, pore-pressure increase and other effects as atmospheric pressure changes and earth tides. Compared to the tectonic stress, which is stable over a long time period, the tidal stresses represent a short-period effect, which may contribute to approaching the critical state on the fault plane and is easy to be determined. Due to the large distance from the ocean we neglect the stresses resulting from the ocean load and account for the solid earth tides only, which are calculated by the Wahr-Dehant-Zschau global elastic earth model. We use the tidal stress tensor, fault orientation and slip direction to calculate the normal and shear traction on the fault plane and evaluate the tidal contribution to the stress state on the fault by the Coulomb failure criterion. We analyzed the dependence of the Coulomb stress on the fault orientation and found that the maximum tidal load is produced for faults striking approximately 130˚, while the minimum occurs at about 30˚. Nevertheless, for any fault orientation the normal stress predominates the shear one, thus the cyclic change in normal stress results in cyclic clamping and unclamping of the fault in the 12-hours period. The lunar period of 14 days produces a modulation of the maximum amplitudes of the Coulomb stress in the range from 400 to 1500 Pa for the optimally oriented faults; the phase shift between the maxima of tidal potential and of Coulomb stress depends on the fault orientation.

We have tested the potential of tidal stresses to trigger and modulate the earthquake activity using the swarm earthquake data from NW-Bohemia/Vogtland. We examined the tidal contribution to reaching the critical state by correlating the onset times of the 7 latest earthquake swarms with the 14-days tidal cycle and found that the onset times of 5 swarms fall within an interval from -1 day to +3.5 days around the tidal maximum.

The possible modulation effect of the polarity of the tidal stress upon the already running earthquake swarm was analyzed by comparing the hourly rate of events and energy release with the current polarity of the Coulomb stress. Non-unique results were obtained indicating that there is no clear relation between the seismicity rate and Coulomb stress. On contrary, our data indicate that tidal stresses are able to disturb the stable stress field on the fault and trigger the onset of an earthquake swarm.