

Seismicity and slip of Whillans Ice Stream driven by neap- to spring-tide cycles

S. Anandakrishnan, J. P. Winberry, D. E. Voigt, R. B. Alley, M. A. King, R. A. Bindshadler, and I. Joughin

The ice plain of Whillans Ice Stream flows in an episodic “stick-slip” fashion. The slip occurs at high tide and again a few hours later during the falling tide. The magnitude of slip is relatively constant, but there is some fine-structure in the pattern. The flow speed of the ice plain was calculated from GPS position fixes at five minute intervals. Along with the GPS, we deployed a three-component seismometer that recorded seismicity (microearthquakes, referred to as events hereafter). In this talk, we present the results of the seismic measurements. The pattern of seismicity is complex. Bursts of events are always associated with slip events, but not vice versa. In other words, there are some aseismic slips and some seismic slips. The seismic slips dominate during the transition from neap tide to spring tide and the aseismic slips are during the other half of the cycle.

The seismicity is from the base of the ice stream. The accuracy of source location is insufficient to determine whether slip is at the interface between ice and subglacial materials or within the subglacial sedimentary layer. However, the depth accuracy is sufficient to discount surface crevassing. We suggest that the properties of the subglacial material (if that is the source of the seismicity) can be determined by comparing model results from rate- and state-dependent friction laws to this pattern of seismicity. The frictional properties of the bed are balanced close to the failure envelope, with a significant hysteresis associated with the peak high tide (which has a range of close to 2m). At peak high tide, some aspect of the frictional structure of the subglacial sediments is altered to a state that discourages seismic slip, and it takes a few days (4-8 days) before the sediments again exhibit seismic slip. If the slip is at the interface between the ice and sediments, then the hydrology at the bed is the likely cause of this hysteresis.