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Characteristics of micro-earthquakes caused by deep-seated mass movements

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Mass movements in brittle rock geology are expected to produce or enlarge fractures, or to display stick-slip motions along existing shear planes. Both processes generate seismic energy. Since 2005 several short term monitoring campaigns have been accomplished at four different locations in the Austrian Alps (Gradenbach, Hochmais-Atemskopf, Niedergallmigg-Matekopf and Gries-Steinlehen). A fully developed basal sliding surface, episodic high creep velocities in the past (about 6 m during 1976) and application of state- and velocity-dependent friction laws to the temporal development of the mass movement make Gradenbach (Schober range, Carinthia) to a potential candidate for transition to rapid/catastrophic sliding. Therefore a permanent monitoring network has been installed there. Deformation has been monitored by a GPS network since 1999. Since February 2007, a seismic monitoring network (5 Reftek 130-01 recorders with GS-11D 4.5 Hz 3-component geophones; 1 Guralp 6TD broadband seismometer) has been operating continuously at Gradenbach. The data is automatically processed using spectrogram calculations and image processing techniques to extract the micro-earthquakes from the large amount of recorded events. The events showing a sufficient S/N ratio and a clear first-break are localized using travel-time calculations and grid search algorithm (provided by the software NLLoc). During a one-year observation period, we detected approx. 15 micro-earthquakes per month caused by the mass movement. Frequency contents (above noise level) of up to 50Hz, durations of 5 - 20 seconds and magnitudes < 1 (down to -2) are typical. Several types of events were classified (e.g. multi-event, low frequency, etc.). Potential energy release of the moving mass has been estimated from GPS data and the well known

structure of the Gradenbach mass movement. This quantity will be compared to seismic moment and seismic energy release. We discuss the potential of the integration of seismic and geodetic data to characterize deformation and friction.