Frictional behaviors of smectite clay: constraints for the mobility of slow-moving landslides in the cold season

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In Japan, reactivated landslides are distributed on gentle clayey slopes in specific geological settings, such as Neogene soft sedimentary rock areas and hydrothermally altered rock areas around active and inactive volcanoes. These strata are typically composed of smectite-bearing high-plasticity soils. Of all the clay minerals, smectite shows an extremely low residual friction angle. Therefore, landslides consisting of these soils can easily become unstable and be reactivated on very gentle slopes. In many cases, such landslides are likely to be reactivated during certain seasons every year, moving slowly with typical velocities ranging from 0.01 to 0.1 mm/min. According to behavioral data of landslides in the Niigata Prefecture, a well-known landslide-prone area in Japan, some landslides begin to move during the early cold season (late autumn or early winter). Some landslides are activated during the winter, and display continuous movement, while others are activated predominantly during the snow-melting period. These various behaviors cannot be explained solely by fluctuations in pore-water pressure (ground water levels), and this therefore raises the question of what the key controlling mechanisms are. Shallow landslides, less than 10 m deep, are sometimes activated in the early cold season. We inferred that the change in ground temperature may play a key role in activating landslides. In order to verify this, we investigated the effect of temperature on residual shear strength of various clayey soils. Reversal box shear experiments and ring shear experiments were performed on undisturbed slip-surface soils and reconstituted soil samples, respectively. The test results revealed that the shear strength of smectite-rich soils decreases with decreasing temperatures under slow shearing rates of lower than 0.1 mm/min. This finding implies that seasonal fluctuation in ground temperature can influence slope instability, especially for shallow, slow-moving landslides. It is also evident that the effect of temperature on residual strength changes with the shearing rate. We infer that the velocity-dependent characteristic is strongly regulated by the fabric of smectite particles along the shearing plane.

References
1) Shibasaki T., Matsuura S., and Okamoto T. (2016): Experimental evidence for shallow, slow-moving landslides activated by a decrease in ground temperature. Geophysical Research Letters, 43, 13, 6975-6984. doi.org/10.1002/2016GL069604
2) Shibasaki T., Matsuura S., and Hasegawa Y. (2017): Temperature-dependent residual shear strength characteristics of smectite-bearing landslide soils. Journal of Geophysical Research: Solid Earth, 122, 2, 1449-1469. doi.org/10.1002/2016JB013241

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