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Evidence for decreasing impact-evoked pressure (UHP) conditions during frictional fusion along different shear planes in the Tsergo Ri (Langtang Himal, Nepal) rockslide

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The Tsergo Ri rockslide represents one of the world`s biggest rockslides in crystalline rocks (original volume: 1,010 m^3). The mass movement comprises migmatites, leucogranites, biotite-feldspar orthogneisses and paragneisses (Weidinger et al., 2014). During mass-wasting, frictionites and microbreccias formed at the base of the rockslide (Heuberger et al., 1984). The frictionite is mainly composed of a glassy matrix containing sparsely biotite, quartz, and abundant plagioclase and K-feldspar. Biotite locally shows a transformation to spinel + glass in highly glassy microdomains. Fe-rich layers in the glass indicate complete melting of biotite-rich layers of the protolithic biotite-bearing orthogneiss. Locally, quartz grains are rimmed by a thin layer of SiO_2 glass (lechatelierite). In the course of this study, micro-Raman spectroscopy was performed on deformed quartz grains from temporally different shear planes within the rockslide. Investigations by McMillan et al. (1991), Fritz et al. (2011) and Kowitz et al. (2013) have shown that shocked quartz shows a shift in the major Raman modes towards lower numbers with increasing pressures. Related to this samples containing quartz crystals with and without lechatelierite rims in the Tsergo Ri frictionites have been investigated. Raman mapping of quartz grain areas was prepared using a HORIBA Jobin Yvon LabRam HR800 micro-spectrometer equipped with a 30 mW He-Ne laser (633 nm emission). Weidinger et al. (2014) describe a temporal sequence of shear planes within the rockslide. Basal or primary shear planes formed during rockslide motion. Secondary shear planes formed because of transient differential motions dictated by inner shear and these secondary shear planes formed within the weaker unit of the Tsergo Ri rockslide in Nepal. Tertiary shear planes occur as sub-vertical internal discontinuities within the deposit of Tsergo Ri rockslide and are attributed to form upon collision of the moving rockslide mass with large topographic obstacles such as mountain flanks. Micro-Raman spectroscopy of `normal` quartz yielded an intense A1 Raman mode at 464 cm^{-1}, whereas quartz without lechatelierite rims shows a shift of this band down to 461.5 cm^{-1}. The highest shifts down to 460.5 cm^{-1} occurred in relict quartz grains rimmed by lechatelierite from the primary shear plane. It is also noteworthy that these grains show an internal gradient of Raman shift of up to 3 cm^{-1} from the core (463.5 cm^{-1}) to the rim (460.5 cm^{-1}) to just below the lechatelierite rims. Slightly less shift occurred in quartz from the secondary shear plane down to 462 cm-1 and almost no shift occurred in the tertiary shear planes. The completely molten granitic matrix and the breakdown of biotite to spinel + melt indicates minimum temperatures of 900–1,000 °C and Sanders et al. (2020) showed that the shifted A1 mode of quartz is stable only below 1,100 °C, thus giving an upper limit of the temperature range. The observed Raman shift of the A1 mode and the presence of lechatelierite strongly suggest that a pressure of possibly > 26 GPa was attained in the primary shear planes and 22–26 GPa in the secondary shear planes and most likely pressures < 1 GPa in the tertiary shear planes.