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Long-term development and decoupled kinematics of two adjacent rock glaciers in the Swiss Alps

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Rock glaciers are key landforms of the Alpine periglacial environment that transfer large amounts of debris. To improve our knowledge of the variation in permafrost creep rates over the Holocene, we combined data on current surface movements with surface dating on two adjacent rock glaciers in the Western Swiss Alps, the so-called Yettes Condjà B and C rock glaciers (hereafter YC-B and YC-C). Surface movements have been monitored since 2000 using GNSS measurements, and since 2016 by complementary UAV surveys and daily oblique photographs taken by a webcam. Furthermore, we used Optically Stimulated Luminescence (OSL) for dating block samples in the front of both rock glaciers and Schmidt hammer exposure-age dating (SHD) on different transects.

YC-B is a very active landform that has developed on a steep and regular slope directly at the foot of a rock wall. Surface velocities display substantial interannual variations, from 0.4 m/a between 2005 and 2007, up to 3.5 m/a in 2015 and 2020. Cumulative displacements reached up to 49 m in 21 years. During the last decade, the rock glacier has been separated into two distinct parts by the progressive appearance of a scar in the steepest part of the landform. This suggests the onset of a destabilization phase of the rock glacier. In contrast, YC-C is much less dynamic, and its morphology and topography are more complex than YC-B. Its roots are occupied by a small debris-covered ice patch, and geophysical surveys suggest a high ice content in the landform. Velocities are much lower than in YC-B, with values between 0.1 and 0.4 m/a in the lowermost active sector. During the last 21 years, the cumulative displacement has been up to 6.5 m.

SHD revealed ages of around 7.00 to 9.00 ka towards the front of both rock glaciers, while OSL dating in the front yielded ages of 8.00 to 12.00 ka. Thus, the two rock glaciers would have started to develop during the Early Holocene (11.70–8.24 ka b2k), i.e. before the Holocene Thermal Maximum which, in the Alps, is dated between 9.55 and 6.35 ka b2k. Combining these ages with the length of the rock glaciers, we obtain a mean Holocene velocity of 0.3 m/a for YC-B and 0.4 m/a for YC-C. There is thus a strong discrepancy between the rock glacier ages and the current surface velocities, especially for YC-B. Indeed, the estimated mean velocities during the entire Holocene are two orders of magnitude lower than the current velocities for this rock glacier. This indicates a considerable increase in velocities in recent decades and that current creep rates are probably unprecedented. More generally, this raises several questions about the velocity variations of rock glaciers on a Holocene timescale.