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Lithological and structural controls for glacial valley development in the Valais, Swiss Alps

P. G. Valla (1), F. Herman (2), and J.-D. Champagnac (3)

(1) Laboratoire de Géodynamique des Chaînes Alpines, Université Joseph Fourier, Grenoble, France (pierre.valla@e.ujf-grenoble.fr / Fax: +33 4 76 51 40 58 / Phone: +33 4 76 63 54 64), (2) Geologisches Institut, ETH Zürich, Zürich, Switzerland, (3) Intitute for Mineralogy, Leibniz University, Hannover, Germany

Quaternary glaciations affected most modern mountain ranges and shaped glacial landscapes including U-shaped valleys, overdeepenings, cirques and ridgelines. Glacial valley formation has been explained using qualitative morphometric evidence or small-scale models (e.g., MacGregor et al., 2000); however glacial erosion rates and the timing of glacial valley formation are presently poorly understood. Glacial erosion is often approximated by scaling erosion rates to the basal sliding velocity of ice (e.g., Herman and Braun, 2008); and several studies show that the faster erosion occurs at the Equilibrium Line Altitude (ELA, e.g., Anderson et al., 2006). Furthermore it has been proposed that lithology and structural control influence glacial erosion (Harbor, 1995).

The Valais in the Swiss Alps is an ideal natural laboratory to better understand these issues. This area is mainly drained by the Rhône valley, a large and overdeepened U-shaped valley; with several high relief transverse valleys. The geology of the area is contrasted, most transverse valleys cut into Penninic metamorphic rocks, whereas the Rhône valley lies mainly on soft Mesozoic sedimentary sequences, highly fracturated by the long-lived Rhône-Simplon fault zone (e.g., Hubbard and Mancktelow, 1992; Champagnac et al., 2003). This context is thus ideal to test potential lithological and/or structural controls on glacial valley formation.

We used a 2D numerical model (Herman and Braun, 2008) that is calibrated using the sediment budget record since the Last Glacial Maximum (Hinderer, 2001), LGM ice-surface geometry (Kelly et al., 2004), and field observations. We first explore the effects of initial topographic conditions on the computed erosion patterns. Using a uniform lithology, the predicted glacial erosion patterns do not enable explaining the contrast between the overdeepened Rhône valley and its lateral tributaries. Lithological dependent erosion law is therefore necessary to explain these spatial variations. These results clearly indicate that glacial erosion can be highly modulated by structural and lithological conditions.

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