Geophysical Research Abstracts,
Vol. 11, EGU2009-12127-2, 2009
EGU General Assembly 2009

Regional analysis of knickpoint propagation in bedrock stream long profiles

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Bedrock channel responses to rock uplift may be thought of as 'top-down' and/or 'bottom-up' (Bishop 2007 doi: 10.1002/esp.1493). In the 'top-down' case, high water and sediment discharges enable the development and maintenance of a steady-state long-profile which incises at the rate of rock uplift. When water and sediment discharges are lower and/or rock uplift is intermittent (and/or at very high rates relative to the hydrological characteristics), bedrock rivers respond to base-level fall by knickpoint generation and propagation (i.e., a 'bottom-up' response). In this paper we examine the latter case of bedrock rivers experiencing rock uplift due to glacio-isostatic rebound. The work is part of an ongoing examination of rates of knickpoint retreat and the duration of the corresponding transience.

The results extend our earlier analysis (Bishop et al. 2005 doi: 10.1002/esp.1191) by examining rivers from within the limits of the Younger Dryas Loch Lomond Readvance (LLR) in western Scotland (i.e., the case of Holocene knickpoint retreat) and rivers lying outside the LLR limits (i.e., the case of knickpoint retreat triggered in the Late Pleistocene at deglaciation after the LGM). Substrates cover a wide range of lithologies and structures, including steeply-dipping highly resistant quartzites (Isle of Jura, western Scotland), and flat-lying and dipping sedimentary and meta-sedimentary rocks (eastern and central Scotland).

A statistically significant log-log linear relationship between distance of knickpoint retreat and catchment area (a surrogate for discharge) is confirmed by these data, for drainage areas ranging from 1 km2 to 5,000 km2. This close relationship between distance of propagation and catchment area confirms that the knickpoints are fluvial. There is no indication in the data of a threshold drainage area for knickpoint development. In spite of the diverse substrate erodibility encountered by these rivers, there is also little indication of a lithological influence on rates of knickpoint retreat and so lithology must be a second-order control on knickpoint propagation.