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Exploring the effects of immobile sediment cover on patterns and rates of bedrock erosion

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Existing mechanistic models of bedrock erosion by particle impacts describe the competing effects of sediment supply in terms of erosional 'tools' or alluvial 'cover' which incise or protect bedrock river beds, respectively (Sklar & Dietrich, 2001). An oversight of this dynamic model is that bedrock channels episodically receive inputs of very coarse sediment from hillslopes (e.g., Dini et al., 2021; Shobe et al., 2016, 2021) and from bedrock detachment (plucking) and transport associated with extreme discharges (e.g., Cook et al., 2018). These coarse, often meter scale blocks or boulders, can persist on channel beds where they may remain immobile for hundreds to thousands of years (e.g., Nativ et al., 2022) and can exceed the maximum grain size that can be transported by typical flow conditions. Our ability to predict erosion rates and patterns are currently limited by complex feedbacks between relatively immobile bed cover, bed topography and bedload transport. Here, we present initial results from a series of experiments in a 2% tilting flume (10 m x 0.4 m) with a polyurethane foam board as an erodible bedrock proxy, 60-100 mm diameter particles as immobile sediment cover, and a constant feed of 5-8 mm angular gravel to drive erosion. Experiments were conducted using variable initial bed states (e.g., smooth/rough topography) and immobile sediment coverages for a duration of 25 hours. Observations suggest that rates and patterns of bedrock erosion are remarkably sensitive to the presence of immobile sediment cover. Erosion often appears locally enhanced around immobile elements, although this is offset to some degree by the cover effect produced by bedload deposited in association with hydraulic heterogeneity generated by the immobile sediment. Self-formed and imposed bed topographies also yield different patterns of erosion, suggesting initial boundary conditions may produce distinct patterns of sediment cover and erosion.