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# Structure and englacial debris content of a Himalayan debris-covered glacier revealed by an optical televiewer

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Himalayan debris-covered glaciers contribute to the discharge of some of Earth's largest river systems, shaping the seasonal water supply to millions of people. The supraglacial debris layer heavily influences the pattern of surface melt, producing a range of unique surface features that make it challenging to collect any data, particularly from the interior of such glaciers. Models of debris-covered glaciers therefore lack calibration and validation data, which are needed for accurate predictions of future glacier geometric change and contributions to river discharge, water resources and ultimately sea level. In 2017 and 2018, we logged four boreholes drilled using pressurised hot water into the debris-covered Khumbu Glacier, Nepal Himalaya, with a high-resolution optical televiewer. The boreholes were located at four sites across the lower glacier's debris-covered area, down-flow of the Khumbu Icefall. The resulting logs, ranging in length from 22–150 m, produced a 360° geometrically-accurate full-colour image of each borehole at ~1 mm vertical and ~0.22 mm (1,440 pixel) horizontal resolution. The logs reveal three material facies: i) steeply-dipping ice layers, some including debris; ii) steeply-dipping sediment-rich layers; and iii) clusters of sediment and debris dispersed through the ice. On the basis of these facies, we present reconstructions of the glacier's structure and historical flow paths and the first measurements of the englacial debris concentration of a Himalayan debris-covered glacier. From the latter, we additionally infer both the sources of this englacial debris and of the supraglacial debris layer present across much of the lower ablation area of Khumbu Glacier.