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The processes creating blue-ice moraines in the Heritage Range, West Antarctica: implications for interpreting deglacial history

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Blue ice is found in areas of Antarctica where katabatic winds, focussed by steep surface slopes or by topography around nunataks, cause surface ablation. Deeper, older ice then rises to the ice sheet surface, often bringing with it englacial sediment. Prevailing theory suggests that it is this material, once concentrated, that forms blue ice moraines, sedimentary systems that once dated using cosmogenic isotope approaches can be used to constrain deglaciation. To test this model for blue ice moraine formation we visited the Patriot, Marble and Independence Hills in the southern Heritage Range, West Antarctica. Detailed studies of extensive blue ice moraines were conducted using: novel structure-from-motion photogrammetry techniques; Terrestrial Laser Scanning; ground-penetrating radar and ground-based and terrestrial radio echo sounding surveys; differential global positioning surveys and; detailed field mapping, sediment particle size analysis and cosmogenic dating of clasts and bedrock. The aim of this multidisciplinary geomorphological and geophysical approach is to establish the processes creating blue-ice moraines in the Heritage Range. Specifically we link detailed survey of surface form and sediment with the dynamics of ice flow from a surface stake network and radar sounding of structures in the underlying ice. Results suggest a palimpsest landform of complex genesis. Sediment is supplied from: i) the retreating ice sheet; ii) basal erosion, entrainment and subsequent emergence via blue ice englacial route-ways; iii) debris covered hanging valley glaciers and rock glaciers transferring material onto the ice sheet surface; iv) direct deposition from rockfall/slope processes from nunataks and; v) periglacial processes from nunatak slopes. Once sediment coalesces in the blue ice moraine significant reworking occurs through glaciological, slope and periglacial processes. Fully understanding these polygenetic landforms and the ongoing processes involved in sediment deposition and reworking is critical for our interpretation of cosmogenic dates from the moraine surface and has broad implications for our understanding of the deglacial history of the West Antarctic Ice Sheet.