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Kettle holes formed by glacial outburst floods: identification when their surface expression has been removed?

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Kettle holes and obstacle marks formed by the transport, deposition and burial of ice-blocks during glacial outburst floods (jökulhlaups) are a common geomorphological feature on proglacial outwash plains. Indeed, they represent one of the few features which can unequivocally identify glacially-sourced flood deposits in the geomorphological and sedimentary record. Despite an abundance of work on the surface expression of jökulhlaup-generated ice-block structures, descriptions of the subsurface expression of these features in the sedimentary record are limited. There is currently no comprehensive model of the sedimentary characteristics of these features. This is a major gap in our knowledge, as the positive identification of ice-block features constitutes an unambiguous criterion for the identification of former jökulhlaup deposits in the Quaternary sedimentary record. We address this by describing several examples of ice-block impact in the sedimentary record from southern Iceland. Our work recognizes key criteria for the identification of ice-block impact in the sedimentary record, enabling them to be identified in sedimentary sections where their geomorphological expression has since been removed or buried. These key criterion combine: (1) structures formed by the interaction of water flow with the ice-block body during transportation and immobilization; (2) distinctive sedimentological features of surrounding deposits; and, (3) the post-burial mechanical disruption on the deposits. Formulating a suite of key criteria with which to positively identify the sedimentary impact of ice-blocks limits the possibility of misidentification in the sedimentary record, and provides a means of identifying previously unrecognized Quaternary catastrophic glacial floods.