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The causes of unexpected jökulhlaups, studied using geothermal reservoir modelling

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Jökulhlaups (glacier outburst floods) are considered the most common type of volcanic hazard in Iceland, and result from the accumulation of meltwater during long-term geothermal activity beneath glaciers, or very rapid melting over a short period of time. Jökulhlaups may occur without visible precursors or prior warning, varying in size from being persistent leakage to floods that have caused considerable damage like the jökulhlaups in Múlakvísl and Kaldakvísl in July 2011. Little has been known about the onset time of water accumulation/melting, whether water accumulated before it was released, and how these events are related to intrusion of magma. This study categorises known ice cauldrons within Icelandic glaciers based on their volume, rate of formation, and longevity. Geothermal reservoir modelling was then used to explore possible heat sources which generate the cauldrons. Five scenarios were simulated: (1) Subglacial eruption – freshly erupted magma in direct contact with the ice at the glacier base; (2) Intrusion into homogeneous bedrock - magma intrudes into a bedrock of homogeneous properties; (3) Intrusion into high permeability channel – similar to scenario (2) but a high permeability channel extends from the intrusion to the glacier-bedrock boundary, e.g. zone of high permeability at a caldera fault; (4) Sudden release of pressure – a hot reservoir is topped by caprock, with a high permeability pathway from depth up to the glacier-bedrock boundary, representing a sudden breach of a pressurised reservoir; and (5) Intrusion into a very hot reservoir – similar to scenario (3) but the reservoir is near boiling point, from previous repeated intrusive activity. This work improves our understanding of sudden and unexpected jökulhlaups, which is helpful for hazard assessments and response plans for unrest in glaciers near inhabited areas, tourist spots, and power plants.