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A complex subglacial clastic dyke swarm, Sólheimajökull, southern Iceland

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Abstract

A complex network of clastic dykes dissects loosely consolidated Holocene sediments along the east flank of the proglacial braid plain of Sólheimajökull, southern Iceland. The dykes comprise downward-bifurcating intrusions up to 0.5 m thick and several metres in length and are intruded into glaciogenic deposits (sandy gravel, gravelly sand, interlaminated silt and sand, and diamicton). The dykes were sourced from a clast-poor sandy diamicton, interpreted as a subglacial till, and were intruded downwards beneath Sólheimajökull glacier during a previous phase of advance. As the glacier advanced southwards, it loaded the sediment column resulting in the intrusion of dykes with a consistent south–southwest dip (with rare northward-dipping examples). The dyke fills are characterised by laminated sediment, with laminae oriented parallel to the dyke margins and comprise interlaminated clay, silty clay, silt, sand, sandy gravel and diamicton. In some dykes, high concentrations of pebble- to boulder-sized clasts occur in association with rotated pods of the laminated sediment. The laminae are thought to have evolved by a slow, long-lived intrusion process that involved the repeated fracture and expansion of the host sediments followed by viscous smearing-on of subglacial material onto the dyke walls, rather than rapid injection of fluidised sediment.

Keywords: Clastic dykes; Glacial sedimentology; Subglacial loading; Iceland

1. Introduction

Clastic dykes occur in a wide variety of glacial, fluvial, lacustrine, shallow marine, deltaic, shelf, deep water and volcanic environments (Maltman, 1994). Depending on the setting, triggers for clastic dyke injection include seismic activity, tectonic stress; rapid sediment deposition including slumping; and the upward influx of deep basin waters into shallow sands (Jolly and Lonergan, 2002). Compositionally,

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clastic dykes are highly variable and gravel, sand and mud-dominated examples occur (e.g. Chown and Gobiel, 1990; Tipper et al., 2003). These form swarms which have sheet-like, anastomising or reticulate (mesh-like) geometries (Jolly and Lonergan, 2002). The rheology of both dyke material and the host sediment exerts a strong control on the morphology of these dyke swarms. A forceful emplacement mechanism is normally suggested for their intrusion (Cosgrove, 2001), and it is commonly assumed that sediments are fluidised when emplaced because clastic dykes often exhibit massive or chaotic fills (Jolly and Lonergan, 2002; Jonk et al., 2003). However, these processes may not necessarily explain the mechanism of intrusion for those intrusions that are characterised by a well-defined internal stratification. Understanding the intrusion of clastic dykes has great implications for the understanding the nature of fluid flow through hydrocarbon reservoirs (Jolly and Lonergan, 2002), together with applications in waste disposal and groundwater remediation (Pearce et al., 2001).

This paper examines a clastic dyke complex preserved within loosely consolidated proglacial sediments along the eastern bank of the Jökulsa Fulilækur outwash plain,1 km south of the terminus of Sólheimajökull, southern Iceland (Fig. 1A–B). The high quality of the exposure allows detailed 3-D documentation of dyke morphology to be made and for their composition and relationship to their host sediments to be evaluated. Their present geographical context, in the forefield of a retreating glacier, provides an excellent opportunity to evaluate the mechanisms by which the dykes were emplaced. This paper aims to (1) describe the sedimentology, stratigraphy and genesis of the host sediments, (2) provide detailed descriptions of morphology and sedimentological composition of the intrusions, (3) discuss sediment rheology during injection and (4) establish the trigger mechanism for dyke intrusion.

2. Geological and topographical setting

Sólheimajökull is a 15-km-long temperate outlet glacier that drains the Mýrdalsjökull ice cap in south-central Iceland. The study site lies along the eastern banks of the proglacial braidplain, currently c.1 km south of the glacier snout (Fig. 1A). The glacier ranges in altitude from ~100 m above sea level (a.s.l.) at the snout to 1500 m a.s.l. in the upper accumulation area, covering an area of approximately 44 km^2. Since 1970, the glacier has had a positive mass balance, resulting in an advance of nearly 1 km (Dugmore, 1987; Mackintosh et al., 2002). The lower ablation area is characterised by transverse and longitudinal ice-cored moraines; the proglacial area domi-

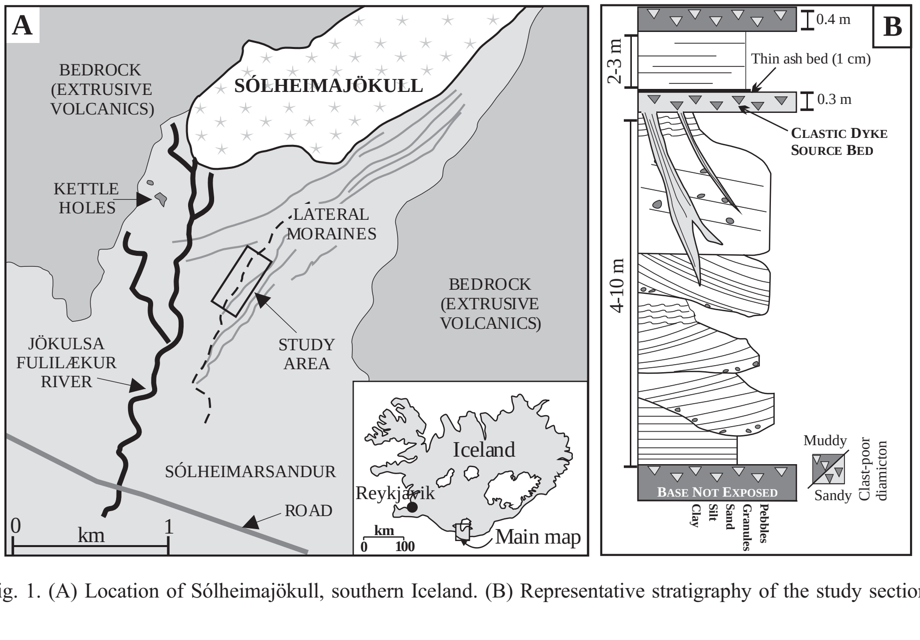

Fig. 1. (A) Location of Sólheimajökull, southern Iceland. (B) Representative stratigraphy of the study section.