Geomorphology 201 (2013) 512–519

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Discussion of 'Field evidence and hydraulic modeling of a large Holocene jökulhlaup at Jökulsá á Fjöllum channel, Iceland' by Douglas Howard, Sheryl Luzzadder-Beach and Timothy Beach, 2012

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ARTICLE INFO

Article history:
Received 14 March 2012
Received in revised form 1 June 2012
Accepted 23 October 2012
Available online 30 October 2012

Keywords:
Jökulsá á Fjöllum
Iceland
Outburst flood
Landscape
Hydraulics

ABSTRACT

This paper discusses Howard et al. (2012) who reconstruct the peak discharge of a glacial outburst flood, or 'jökulhlaup', for part of the Jökulsá á Fjöllum in north-central Iceland. They propose that this flood was the largest on Earth. We consider that the magnitude of the jökulhlaup proposed by Howard et al. (2012) warrants much more robust field evidence and demands more carefully parameterised hydraulic modelling. For these reasons we firstly (i) present their study in the context of previous research (ii) highlight issues with attributing landforms and sediments to jökulhlaups, and (iii) consider uncertainty regarding the timing and magnitude of jökulhlaups along the Jökulsá á Fjöllum. We argue herein that whilst a range of landforms and sediments that are attributable to jökulhlaups can be observed along the Jökulsá á Fjöllum, these are not necessarily diagnostic of jökulhlaups. Secondly, we critically discuss (iv) the major underlying assumptions of their study, and (v) their calculations and subsequent interpretations. These assessments lead us to consider that the proposal by Howard et al. (2012) of the largest flood on Earth is highly unrealistic, especially when due consideration is given to a possible source area and a trigger mechanism.

1. Introduction

Howard et al. (2012) suggested that a glacial outburst flood or 'jökulhlaup' that routed along the Jökulsá á Fjöllum in northern Iceland during the early Holocene was the largest flood to have occurred on Earth. They present field data, most importantly large boulders, that they attribute to deposition by this flood and they use the elevation of these boulders to drive a hydraulic model that they suggest reasonably represents the characteristics of this flood. However, we feel that the field data as presented in their paper is both ambiguous and insufficient. We therefore briefly review the field evidence for, and research into, Jökulsá a Fjöllum jökulhlaups. Given the emphasis placed on the exceptional magnitude of the flood and on the applicability of the work for studies on Mars, we also feel that it is very important to question several assumptions that Howard et al. (2012) relied upon for their calculations. This paper therefore proceeds to discuss these assumptions, namely that: isolated large 'erratic' boulders are the product of jökulhlaup deposition, that the position and location of the boulders are sufficient to parameterise a step-backwater hydraulic model, that a hill named 'Ferjufjall' must have been overtopped, that Manning's n can be treated as a fixed quantity, that modelling a single reach of the Jökulsá á Fjöllum can generate meaningful results, and finally that the volume of water implied by such a large peak discharge could have been sourced from northern Vatnajökull.

2. Discussion of research on Jökulsá á Fjöllum jökulhlaups

Attributing landforms and sediments to jökulhlaups (Table 1), particularly those jökulhlaups that occurred millennia ago, is far from straight forward and has occupied many major research efforts focused along the Jökulsá á Fjöllum (Table 2). In light of the claim by Howard et al. (2012) of new and extraordinary evidence, the most important of which is 'large boulders', we will herein firstly critically review the landscape upon which evidence of Holocene Jökulsá á Fjöllum jökulhlaups is superimposed. We will then highlight the production and redistribution

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0169-555X/$ – see front matter
http://dx.doi.org/10.1016/j.geomorph.2012.10.024

Table 1
Summary of previous research identifying landforms and sediments along the course of Jökulsá á Fjöllum interpreted to be the product of jökulhlaups.

Author/publication year	Landforms and sediments presented as evidence of Jökulsá á Fjöllum jökulhlaups	
	Erosional	Depositional
Alho et al. (2005)	• Streamlined hills • Scoured and plucked lava • Large potholes • Longitudinal grooves	• Giant gravel bars • Giant expansion bars • Extensive surfaces of well-rounded heterolithic gravel • Wash limits: erratic imbricated boulders
Knudsen and Russell (2002)	N/A	• Large-scale sandy trough cross-bedded units capped by a boulder-rich unit, interpreted as the product of a hyperconcentrated flow
Waitt (1998, 2002)	• Anastomosing water fluted and half pot-holed stripped basalt surfaces • Small-scale scabland, dry cataracts • Anastomosing distributary cols through moderate relief landscape	• Huge boulders • Long gravel bars • Giant current dunes • Graded gravel beds in channel • Sand–silt backflood facies
Malin and Eppler (1981)	• Tear drop-shaped islands up to 5 km long • Cataracts, scabland • Broad lemniscate forms	• Occasional megaripples • Depositional tails • Boulder fields • Wash limits: 'debris lines' • High water line overtopping large obstacles
Tómasson (1973)	• Ásbyrgi cataract • Scabland • Eroded crater rows	• Shorelines • Gravel-buried crater rows • Large gravel bars
Sæmundsson (1973)	• Grooving and striations on smoothed lava surfaces beyond the glaciation limit	N/A

of large boulders in the landscape and then we will discuss the derivation and use of criteria to distinguish the genesis of jökulhlaup landforms amongst several key land surface processes.

Geological research along the Jökulsá á Fjöllum in Iceland was initiated to consider hydroelectric development (Thórarinsson, 1950, 1959; Helgason, 1987). Investigation of the Dettifoss canyon and of

Table 2
Summary of previous research suggesting timing and magnitude of jökulhlaups along the Jökulsá á Fjöllum.

Author/publication year	Identified floods (years ago)		Estimated peak discharge ($m^3\ s^{-1}$)	Proposed source/generation mechanism	Acquired data/Interpretation method	Techniques
Kirkbride et al. (2006)	4100 3500 − 2900		$>7\times10^5$	Kverkfjöll Grímsvötn	14C AMS dates from Betula macrofossils within peat	Field visit and laboratory analysis
Alho et al. (2005)	N/A		0.9×10^6	Barðabunga caldera	PSIs: imbricated boulders and washed bedrock (i.e. bedrock with exotic well-rounded clasts)	Step-backwater modelling
Waitt (2002)	$1\times2500-2000$ $1\times9000-8000$ $16\times8000-4000$		0.7×10^6 N/A	Kverkfjöll caldera	Stratigraphy and tephra (H5)	Field visit, 1986 and 2000 Geomorphological mapping Step-backwater modelling
Waitt (1998)	2000 9000 − 8000		1×10^6	N/A	 Tephra (H5)	N/A
Tómasson (1973, 2002)	2500		$0.4-0.5\times10^6$	1973; Kverkfjöll caldera or Grimsvötn by subglacial melting, but most likely ice-dammed lake south of Kverkfjöll 2002; the Barðabunga caldera	Tephra (H3)	Aerial photograph interpretation and field visits Manning equation, flood-filled canyon and measurement of present-day topography
Sæmundsson (1973)	Earliest post-glacial Less than 2900		N/A	N/A	Lava striations location relative to moraines of maximum glacial extent	Field visit Geomorphological mapping
Thórarinsson (1959)	1490, 1655; Spring/early winter 1684; early November 1711/1712; early winter 1716; September/October 1717; early September 1729; August			Subglacial volcanic bursts in the Kverkfjöll area and/or Dyngjujökull	Historical witness accounts from Axarfjordur and Keldhuverfi	N/A
Thórarinsson (1950)	1655, 1684, 1711, 1712, 1776, 1717, 1729		Not likely to be >15,000 1–1.5 km^3	Dyngjujökull caldera/volcanogen	Historical witness accounts from Axarfjordur and Keldhuverfi	Field visit, 1946 to Kverkfjöll
Helgason (1987)	Catastrophic	7100 4600 3000 2000	400,000	Ice-dammed lake 'Volcanism'	N/A	N/A
	Hstoric	Perhaps 10 floods within a 'flood period' of 20–40 years	10,000	Volcanic	N/A	N/A
	Minor	Approx. 2 per century	1500	Rapid spring thaw or other 'special circumstances'	N/A	N/A