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Syn-eruption vegetation dynamics, paleosurfaces and structural controls on lava field vegetation: An example from the Palaeogene Staffa Formation, Mull Lava Field, Scotland ☆

David W. Jolley [a,*], Brian R. Bell [b], Ian T. Williamson [c], Iain Prince [d]

[a] Department of Geology & Petroleum Geology, King's College, Meston Building, Aberdeen, AB24 3UE, United Kingdom
[b] Department of Geography and Earth Sciences, University of Glasgow, Gregory Building, Lilybank Gardens, Glasgow G12 8QQ, United Kingdom
[c] English Nature, 'The Maltings', Warf Road, Grantham, Lincolnshire, NG31 6BH, United Kingdom
[d] Statoil, Ltek-Pe, Postboks, N4035, Stavanger, Norway

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ABSTRACT

Lavas and sedimentary rocks of the Palaeogene Staffa Formation are exposed in the south-west of the Island of Mull in the Inner Hebrides, Scotland. Here, we present the results of an extensive programme of analysis of palynofloras from intravolcanic sedimentary rocks across this, the oldest part of the Mull Lava Field. This analysis has been allied to field and aerial photograph mapping, which have provided evidence that the earliest flows and sediments of the Staffa Formation were emplaced into two NW–SE trending fault controlled valleys. This extensional structural regime was also utilised by the NW–SE trending Mull dyke swarm. Early syn-depositional movement on graben margin faults is indicated by anomalously thick alluvial sediments, and ponded lava flows on the downthrown sides. Sedimentary and palynofacies data indicate an overall southeasterly drainage direction for the Staffa Formation paleo-valley system, the palynofloras reflecting this in increased dominance of mire vegetation communities, in the wetter, lower reaches of the catchment. The palynofloras are subdivided into four ecological groupings. Mid to late succession communities dominate the two youngest depositional sequences of the lava field, reflecting the filling of the valley structures, and the development of an increasingly stable environment. The youngest surface includes the renowned Ardtun Leaf Beds, which are shown to be atypical of much of the Staffa Formation flora, being located on a graben margin alluvial fan. This youngest surface also provides evidence for the subsequent inversion of the original graben structure across the south of the area, while active eruption continued in the north. Inversion is attributed to the emplacement of the oldest members of the nearby Mull Central Complex, and heralds the eruption of the trap-forming Plateau Group lavas.

1. Introduction

The occurrence of a well-preserved leaf fossil flora at Ardtun, on the island of Mull, Inner Hebrides, Scotland (Fig. 1), has attracted paleobotanists since the nineteenth century (Argyll, 1851). Interpretation of the ecology and age of this flora has concentrated on the macrofossils, with the first examination of the accompanying pollen and spores being some time later (Simpson, 1936, 1961; Srivastava, 1975). More recently, Boulter and Kvacek (1989) described both the macrofossil and microfossil elements of the Ardtun Flora. This study suggested that a stable north-eastern Atlantic margin flora existed through the latest Paleocene–earliest Eocene, based on the floras of Spitzbergen, Mull, and Antrim. The environmental interpretation of the Mull flora by Boulter and Kvacek (1989) was hampered by a lack of depositional facies data and temporal control, in particular, the influence that structural controls, and lava field processes exerted on the environment. Similarly, the stratigraphical interpretation of Srivastava (1975) and Boulter and Kvacek (1989) are limited by restricted palynological analysis from few localities.

A re-appraisal of the Paleogene flora of the Mull Lava Field is therefore timely. In this study we demonstrate the temporal and spatial restriction of the leaf macrofossil flora known from the island. In doing this we show the linked development of the earliest eruptive phase of the Mull Lava Field, the Staffa Group, the structures that control its geometry and the vegetation community dynamics.

2. Structure of the lava field

The principle structural features of the Mull Lava Field are best seen on the south coast of Brolass (Fig. 2, and see Bell and Williamson, 2002), where the lavas are unconformably underlain by thin

☆ Taxonomic note: The pollen and spore nomenclature used here follows that of Jolley (1996) and Gruas-Cavagnetto (1978).

* Corresponding author.
E-mail addresses: d.jolley@abdn.ac.uk (D.W. Jolley), brian.bell@ges.gla.ac.uk (B.R. Bell), Ian.williamson@English-Nature.org.uk (I.T. Williamson), IPRI@statoil.com (I. Prince).

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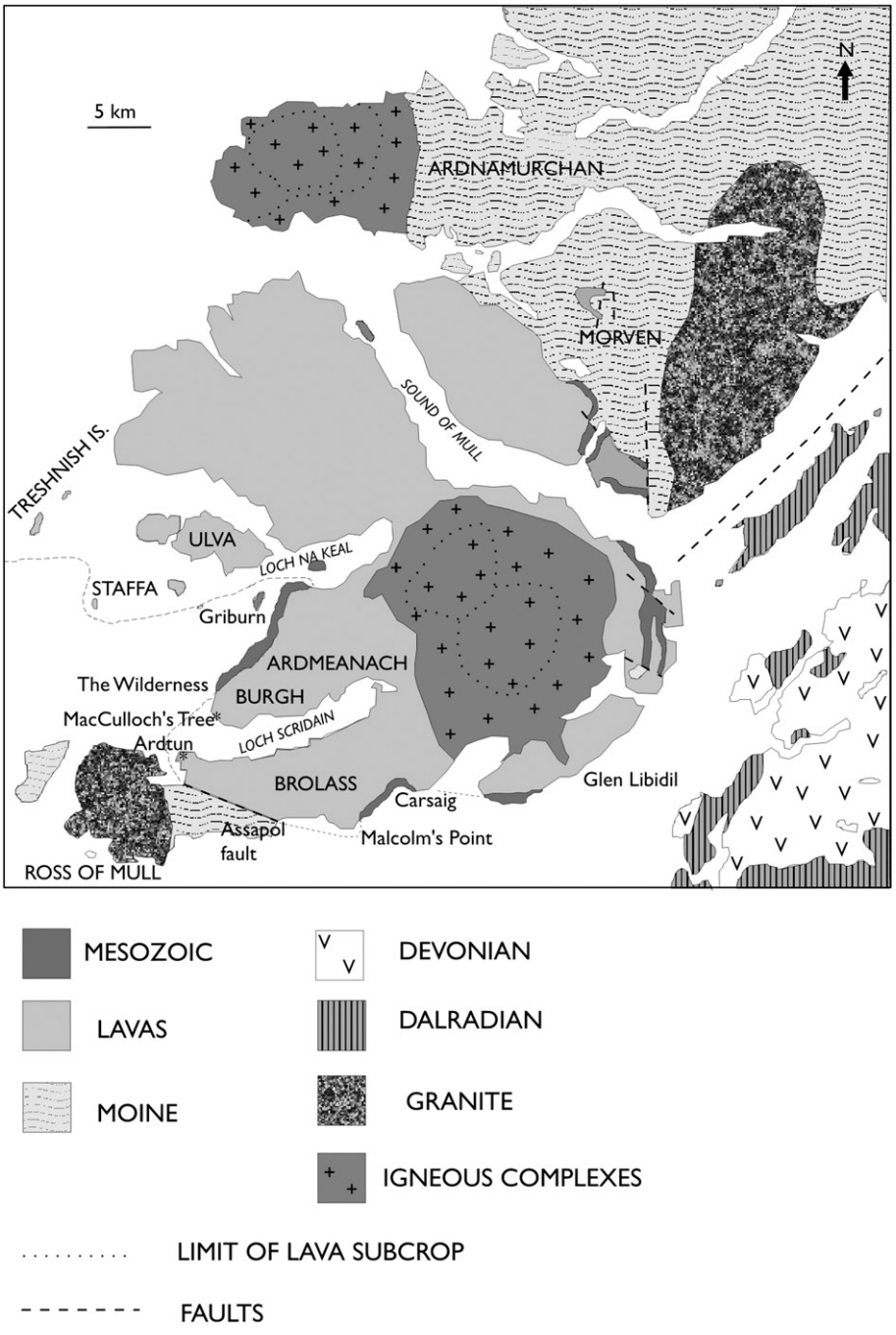

Fig. 1. Location map.

Cretaceous carbonate and Middle Jurassic clastic marine rocks. Here, the Staffa Formation lavas are downthrown against Moine rocks by the NW–SE trending Assapol Fault in the south-west, and thin dramatically against faults east of Malcolm's Point (Fig. 2). These NW–SE trending faults are marked by prominent topographic features evident from aerial photographs, topographical maps, and on the ground, where they are represented by abrupt changes in slope and gullies at the coastline. Evidence for the syn-eruption activity of these faults is provided by localised concentrations of intervolcanic conglomerates (Fig. 3), in which clasts of Cretaceous flints dominate.

The oldest Staffa Formation lavas are thickest in the Malcolm's Point area, with their eastern extent being limited by a group of north-west-trending faults with small downthrows to the northeast (Fig. 2). To the east of these faults, only younger, thin lava flow units occur, suggesting that the topographic expression of these faults controlled the dispersion of lavas and sedimentary systems. Consequently, volcanism was concentrated within the NW–SE trending, down-faulted area between the Assapol Fault and the faults east of Malcolm's Point (Fig. 2), referred to here as the Beinn an Aoinidh Graben. Further evidence of faults controlling sedimentation is provided by the development of thick intravolcanic basalt and flint-flake clast conglomerates, which occur to the west of the faults at Malcolm's Point.

Formation of the downfaulted area between the Assapol and Malcolm's Point faults was initiated by an extensional structural regime, possibly related to the intrusion and emplacement of the Mull Dyke swarm. The distribution of uncharacteristically thick lava and sedimentary units against the west side of the Malcolm's Point faults (Fig. 2), and the distribution of recycled lithoclasts and palynomorphs (Fig. 3), both confirm an early extensional history (Allen & Allen, 1990). The present anticlinal structure resulted from reversal of the direction