The first evidence of trace fossils and pseudo-fossils in the continental interlava volcaniclastic sediments on the Faroe Islands

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Pokorný, R., Krmíček, L. & Árting, U.E. 2015. The first evidence of trace fossils and pseudo-fossils in the continental interlava volcaniclastic sediments on the Faroe Islands. © 2015 by Bulletin of the Geological Society of Denmark, Vol 63, pp. 45–57. ISSN 2245-7070. (www.2dgf.dk/publikationer/bulletin). https://doi.org/10.37570/bgsd-2015-63-05

Interlava volcaniclastic sediments, mostly sandstones, from the Palaeogene Faroe Islands Basalt Group (Malinstindur and Sneis Formations) contain rare ichnofauna and well-preserved pseudo-fossils in the form of linear structures. Five specimens of two ichnogenera have been identified, which include *Helminthoidichnites* isp. and ?*Palaeophycus* isp. The linear structures are interpreted to be desiccation cracks. This association indicates an environment with low to moderate hydrodynamic energy, which confirms a mosaic landscape of floodplains with rivers and shallow lakes.

Received 20 May 2015
Accepted in revised form 13 October 2015
Published online 11 November 2015

Keywords: Faroe Islands, trace fossils, pseudo-fossils, volcaniclastic sediments.

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The Faroe Islands are a 1400 km^2 remnant archipelago of the extensive Palaeogene subaerial volcanic succession that covers large parts of the eastern margin of the North Atlantic. Beds of volcaniclastic rocks, generally sandstones and conglomerates, are often intercalated with the lava flows in the succession, and Palaeogene fossil material on the Faroe Islands occurs almost exclusively in these volcaniclastic beds. The fossil material is not rich, and trace fossils have not been recorded before. This study describes and interprets some structures, believed to be trace fossils and pseudo-fossils, that were recently discovered at two localities, Eiði and Hundsarabotnur, during a survey of intra-volcanic sedimentary rocks at 32 localities across the Faroe Islands (Fig. 1).

Geological setting

The term Faroe Islands Basalt Group (FIBG) covers the basaltic lava succession onshore as well as the offshore continuation on the Faroe Platform, the Faroe–Shetland Channel, and the banks south of the Faroe Platform (Jolley & Bell 2002). The onshore parts of the FIBG are presumed to rest on a continental crust consisting of Precambrian metamorphic rocks (Casten 1973; Bott *et al*. 1974; Gariépy *et al*. 1983; Holm *et al*. 2001). Passey & Jolley (2009) described the FIBG as comprising both the onshore parts and the offshore continuation of the lava succession to the east and southeast into the Faroe–Shetland Basin, covering an estimated area of *c*. 120 000 km^2. Their work was based on the study of both borehole material and subaerial exposures. Passey & Jolley (2009) also re-defined and renamed the formations originally described by Rasmussen & Noe-Nygaard (1969). Seven lithostratigraphic formations are now formalized with a total thickness of 6.6 km. The formations, in stratigraphic order, are as follows: Lopra Formation, Beinisvørð Formation, Prestfjall Formation, Hvannhagi Formation, Malinstindur Formation, Sneis Formation and Enni Formation (Figs 1, 2). Noe-Nygaard & Rasmussen (1968) distinguished three major petrological types of subaerial lava flows, and subordinate interlava units within the Faroe Islands. The lava flow types are aphyric basalts that lack phenocrysts and typically have a fine-grained groundmass; plagioclase-phyric basalts that also typically have a fine-grained groundmass in which the phenocrysts sometimes form stellate clusters; and olivine-phyric basalts with small, typically stout, olivine phenocrysts. Radiometric data from Waagstein *et al.* (2002) and Storey *et al.* (2007) provide an age range of 60.5 Ma to 55.2 Ma. These data are however in disagreement with the biostratigraphic ages from the FIBG (Jolley 2009). For further discussion, see Passey & Jolley (2009).

Beds of volcaniclastic rocks, generally sandstones and conglomerates, are often intercalated with the lava flows of the FIBG. Mudstone and coal also occur here, but in smaller amounts (Ellis *et al*. 2002; Passey 2004; Passey & Jolley 2009). Frequent intervals of fine-grained clayey sandstone are recorded in the lower and upper part of the Lopra Formation in the Lopra-1 borehole on Suðuroy, where up to several tens of metres in thickness of such rocks were recorded (Ellis *et al*. 2002; Boldreel 2006). Thin beds up to 2 m thick of laminated sandstone or conglomerate are present mostly in the lower and middle part of the Beinisvørð Formation (Hald & Waagstein 1984). In the upper 200 m of this formation, there are abundant layers of mudstone that are sporadically accompanied by coal seams and sandstone (Rasmussen & Noe-Nygaard 1970; Passey 2004; Passey & Bell 2007; Passey 2008).

The Prestfjall Formation is a 3–15 m thick sedimentary succession comprising coal-bearing layers along with clay, shale, and occasionally sandstone and conglomerate. Palaeo-depressions created after the deposition of the Prestfjall Formation were consequently filled by sediments from the Hvannhagi Formation. This mostly volcaniclastic facies also comprises poorly sorted mudstone, conglomerate and sandstone, with rare coal clasts (Rasmussen & Noe-Nygaard 1970; Passey 2004; Passey & Jolley 2009).

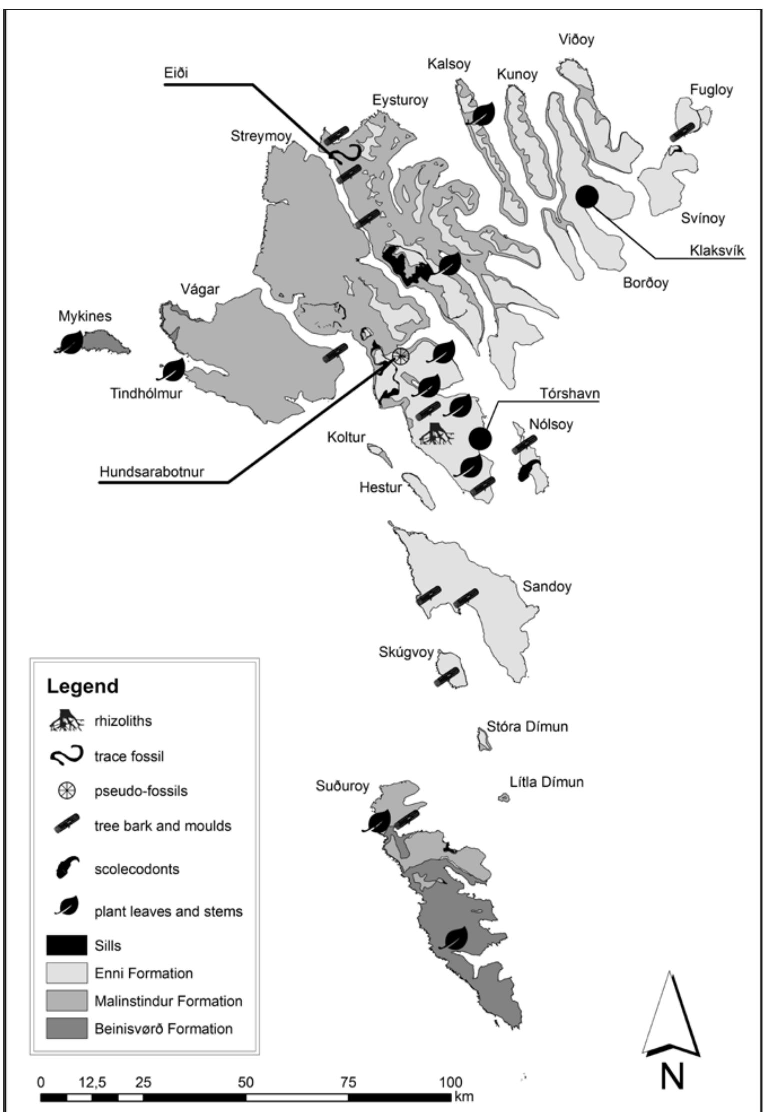

Fig. 1. Simplified geology and evidence of Palaeogene macrofossil localities on the Faroe Islands. Modified and supplemented after Hartz 1903, Noe-Nygaard 1940, Rasmussen & Koch 1963, Rasmussen & Noe-Nygaard 1990, Ellis *et al*. 2002, Passey 2004, Passey 2008 and Passey & Jolley 2009.

The Malinstindur Formation overlies the upper erosional base of the locally occurring Prestfjall and Hvannhagi Formations. Volcaniclastic sandstones and mudstones, generally several metres thick, are present throughout the lava succession, but they are most abundant in the upper part of the Malinstindur Formation (Passey 2004; Passey & Jolley 2009). Passey & Jolley (2009) defined a significant, up to 7 m thick horizon named the Kvívík Beds. The Kvívík Beds are located approximately 780 m above the base of the Malinstindur Formation. They consist of a red basal sandstone and, in the upper part, coarse-grained conglomerate and grey-coloured mudstone (Passey & Jolley 2009; Passey & Varming (2010).

The Sneis Formation comprises a laterally extensive, up to 30 m thick sandstone and conglomerate sequence. A distinct sediment horizon, the Sund Bed, can be found at the base of the Sneis Formation and marks a major hiatus in the volcanic activity. It is up to 1 m thick and composed of coarse-grained volcaniclastic sandstone and clasts of zeolitised wood. This layer is overlain by greenish-grey conglomerate (Passey 2009; Passey & Jolley 2009).

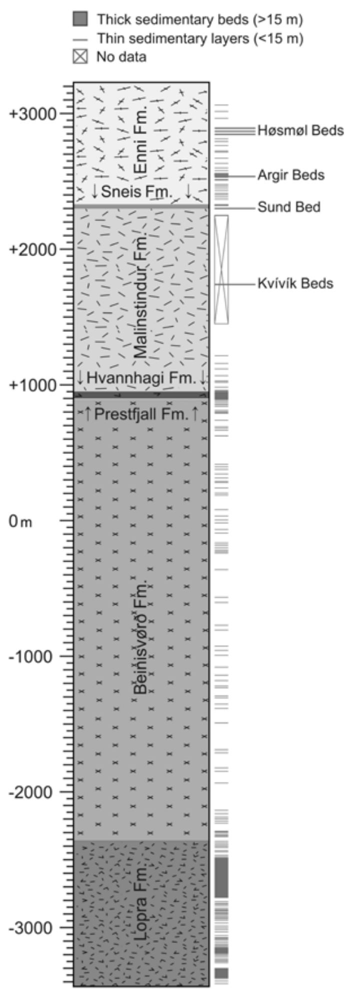

Fig. 2. Schematic stratigraphical log of the Faroe Islands with volcaniclastic sediment layers indicated to the right. The vertical scale is the stratigraphic height in metres; the part of the succession below the 0 m level is only known from drilling. After Rasmussen & Noe-Nygaard 1969, Hald & Waagstein 1984, Waagstein & Hald 1984, Waagstein 2006, Passey & Jolley 2009 and personal communication from S. Passey.

The youngest lithostratigraphic unit of the Faroe Islands is the Enni Formation. It often contains sediment horizons similar to the Malinstindur Formation. The best-developed horizon, the Argir Beds, is situated approximately 250 m above the base of the Enni Formation. The Argir Beds are 1–13 m thick and consist of thinly laminated fine-grained claystone and mudstone in the lower portion, which passes upwards into coarse-grained conglomerate (Passey 2009; Passey & Jolley 2009; Passey & Varming 2010).

A distinct sediment horizon of volcaniclastic sandstone, approximately 15 m thick, occurs on Nólsoy. Passey (2008) referred to it by the working term the Høsmøl Beds. Its stratigraphical position is 200–250 m above the base of Argir Beds, and the Høsmøl Beds are potentially the youngest significant sedimentary unit of the Faroe Islands (Fig. 2).

Review of the palaeontological record and palaeoecology

The preservation of fossil organisms on the Faroe Islands is almost wholly associated with the volcaniclastic rocks. These can form as part of the volcanism (e.g., tuffs), but they mostly represent quiescent periods during which there was sufficient time for sedimentation to take place between the lava flows (Passey 2004; Passey & Jolley 2009). The interval between single volcanic eruptions is commonly characterised by reddened tops of subaerial lava flows, where subaerial weathering of volcanic soil occurred to form the soil profile and sedimentary layer in the humid subtropical climate (Parra *et al*. 1987; Passey 2004).

The variability of the Paleocene to Eocene palaeoecosystems of the FIBG was studied in detail by Laufeld (1965), Lund (1981, 1983, 1989), Ellis *et al*. (2002), Jolley (2009) and Passey & Jolley (2009). They identified a number of fungal spores, water algae, acritarchs, dinoflagellates, bryophyte spores and flowering plant pollen grains, which predicate sedimentation in a wide range of palaeoenvironments from estuarine and shallow marine, littoral to rivers and lakes to wetlands and swamps with coal development.

Macrofossils are represented by coalified and zeolitised plant fragments that usually cannot be specified taxonomically because of missing or badly preserved morphological features (Passey 2004, 2008; Passey & Jolley 2009).

The amount of identified fossils is relatively small (Fig. 1). Fragments of *Metasequoia occidentalis* Chaney 1951 found in the shale, claystone and coal beds of the Beinisvørð Formation on Mykines were described by Hartz (1903), Rasmussen (1925), Noe-Nygaard (1940) and Rasmussen & Koch (1963). Passey & Jolley (2009) described the poorly preserved broadleaved angiosperm *Corylites hebridicus* Seward & Holttum 1924 and the pteridophyte *Equisetites* sp. at the same locality. These same horsetails were also mentioned by Passey (2008) and Passey & Jolley (2009) from the volcaniclastic sandstones of the Malinstindur Formation at several localities on Streymoy, Borðoy and Kalsoy. A well-preserved sample of *Metasequoia occidentalis* foliage was also found in the volcaniclastic sandstone of the Enni Formation on the southern part of Streymoy (Rasmussen & Noe-Nygaard 1990).

Tree moulds, often with preserved shape of the inner imprint of the bark, represent a specific type of the palaeoflora preserved on the Faroe Islands. These are usually cylindrical cavities within a lava flow with diameters of approximately several centimetres to decimetres and lengths of several tens of decimetres. They occur, for example, in lava flows of the Malinstindur Formation on Vágar and Eysturoy, as well as in the Enni Formation on Nólsoy, Fugloy and Streymoy (e.g. Passey 2004; Passey & Bell 2007; Passey 2008). Ellis *et al*. (2002) supposed that the cavities from the Sundshálsur locality on Streymoy, which are situated closely above the layers of volcaniclastic sandstone, could represent moulds of thin trunks or branches.

Ellis *et al.* (2002) described a range of ferrous rhizomorphs, namely rhizoliths and rhizoconcretions, in fine-grained volcaniclastic sediments on the southern part of Streymoy. These are residues of plant root systems that colonised the terrestrial and wetland biotopes during the periods without volcanic activity. Beds of sandstone and siltstone with rhizoliths typically have a mottled appearance.

Animal fossils are extremely rare on the Faroe Islands. Probably the only remnants of fossil animal life in the Palaeogene volcaniclastic sediments are undetermined scolecodonts from the central part of the Enni Formation on Nólsoy (Ellis *et al*. 2002).

Fossils from the period after the end of the Palaeogene volcanic activity on the Faroe Islands are very rare. The unusual find of an 8–10 Ma old rostrum from the beaked whale *Choneziphius planirostris* Cuvier 1824, found at the bottom of the sea shelf north-west of Mykines, has been only roughly described (Post & Jensen 2013).

From the Quaternary period, a well-known and published vegetation succession with a rich palaeobotanic record in lacustrine sediments and peats dates from the late Quaternary after the retreat of glaciers (e.g. Persson 1968; Jóhansen 1975, 1985, 1989; Edwards & Craigie 1998; Andresen *et al*. 2006; Jessen *et al*. 2008; Hannon *et al*. 2010; Olsen *et al*. 2010).

Rasmussen (1972) described frustules of diatoms and wood fragments, probably *Picea* sp. and/or *Larix* sp., in sandy clays of glaciomarine origin from the southern part of Borðoy. Greve (2001), Wastegård *et al*. (2005) and Abbott *et al*. (2014), following the presence of palynological material and tephrochronological analysis, dated them to the end of the Eemian Interglacial, *c*. 120 ka BP. Jóhansen (1989) mentions fragments of *Pinus* sp. from the same locality.

Holocene sand and organic conglomerate from a shallow lake on Suðuroy are interpreted as deposited by a tsunami caused by a large submarine slide, the Storegga slide, dated to 7320–6400 ^{14}C yr BP. These sediments contain small marine shell fragments, foraminifera and marine diatoms (Grauert *et al*. 2001).

A complex of Holocene organic sediment was found in borehole material from the fjord bottom collected in the southern part of Eysturoy. It contained palynomorphs, residues of insects, crustaceans and bryozoans of freshwater origin (Bennike *et al*. 1998), and was covered by clayey silt with marine shells and shell fragments, foraminifera, dinoflagellate cysts, diatoms and acritarch assemblages (Juul 1992; Roncaglia 2004; Witak *et al*. 2005). Holocene insect fauna studies from several localities of the Faroe Islands were produced by Buckland & Dinnin (1998), Buckland *et al*. (1998a, b), Edwards *et al*. (1998) and Gathorne-Hardy *et al*. (2007).

Trace fossils

Probably no trace fossils have been recorded on the Faroe Islands, except for the previously mentioned rhizomorphs from the Enni Formation on Streymoy (Ellis *et al.* 2002). Problematic are thin tubes in ironstones and claystones and the circular micro-cavities in siderite spherules from the Prestfjall Formation on Suðuroy described by Passey (2004, 2014). He considered them as the evidence of bioturbation, i.e. burrows and borings. This assertion, however, requires detailed ichnological analysis and the relationship to trace fossils remains unclear.

In the broad area around the archipelago, fossil expressions of the life processes of organisms were found only in young submarine sediments. Fu & Werner (1994) published a short list of biogenic structures (e.g. *Chondrites*-like, *Planolites*, *Scolicia*, *Teichichnus*-like etc.), probably of Holocene age, coming from the sands and silts on the Iceland–Faroe Ridge slopes approximately 150–300 km west and north of the Faroe Islands. The presence of postglacial bioturbation structures in contourites on the Faroe–Shetland Channel slopes, approximately 250 km southeast of the Faroe Islands, is mentioned by Masson *et al*. (2010). Signs of bioturbation from Holocene marine sediments on the fjord bottom close to Eysturoy of a similar origin are mentioned by Bennike *et al*. (1998) without any details.

Predation traces in foraminifera tests (*Dipatulichnus rotundus* Nielsen & Nielsen 2001) from Holocene sediments on the sea floor, approximately 200 km southwest of the Faroe Islands, were mentioned by Nielsen & Nielsen (2001).

Locality descriptions

Eiði

This exposure is situated in the north-western part of Eysturoy, on the eastern edge of the Eiði village, in a roadside cutting near road No. 23 (62°17′56.8″ N, 07°05′09.4″ W).

A 0.75–1.00 m thick succession of volcaniclastic sediments is situated between two amygdaloidal basalt lava flows of the Malinstindur Formation. The sediments form part of the Kvívík Beds (Fig. 2), and their lithology and mineralogy was described in detail by Passey (2004) who defined two different lithological units that are separated from the lava flows by sharp and planar surfaces at the top as well as at the base.

Brownish-yellow to reddish-yellow, tuffaceous, laminated, moderately sorted sandstone, approximately 50 cm thick, overlies the underlying basalt. The sandstone alternates with coarser-grained layers of darker colour in the lower part of the profile. The darker layers are characterised by highly palagonitised basalt glass and sub-rounded basalt fragments. Lighter, fine-grained layers contain palagonitised glass as well as angular plagioclase crystals, but basaltic clasts are missing. Sandstone fills abundant vertical fissures in the underlying lava flow (Passey 2004).

The lower sediments pass upwards into a reddish-brown, laminated, poorly to moderate sorted, variably grained sandstone up to 50 cm thick, containing a large amount of angular to sub-rounded clasts of palagonitised basalt glass in different stages of alteration (Fig. 3). Some of them contain plagioclase phenocrysts (Passey 2004). Sporadic trace fossils were found in this horizon.

Ellis *et al*. (2002) mention the occurrence of a palynoflora with a dominance of *Inaperturopollenites hiatus* (*Metasequoia*) with *Retitricolpites* species (possibly a riparian plant), *Monocolpopollenites tranquilus* (*Ginkgo*) and bryophyte spores (*Stereisporites* spp.) around Eiði. We found here recently also macroscopic fragments of plant fossils.

Hundsarabotnur

This exposure is in the active quarry of Hundsarabotnur, situated in the western part of Streymoy, on the eastern slope of the Skælingur mountain (767 m a.s.l.), near road No. 50.

Rocks exposed in the Hundsarabotnur quarry belong to the upper part of the Malinstindur Formation, the volcaniclastic sedimentary Sneis Formation, and the lower part of the Enni Formation. The lowest unit in the Sneis Formation is the Sund Bed, the base of which is visible in the quarry floor. The Sund Bed is overlain by conglomerates of the Sneis Formation, with a thickness of approximately 25 m. On the quarry

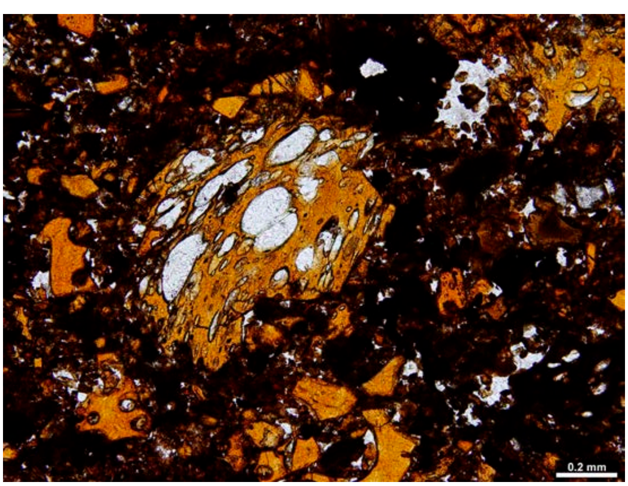

Fig. 3. Photomicrograph of fine-grained laminated sandstone of the Kvívík Beds (Malinstindur Formation) from the Eiði exposure, containing highly vesicular palagonitised basalt glass fragments. Width of picture 1.75 mm.

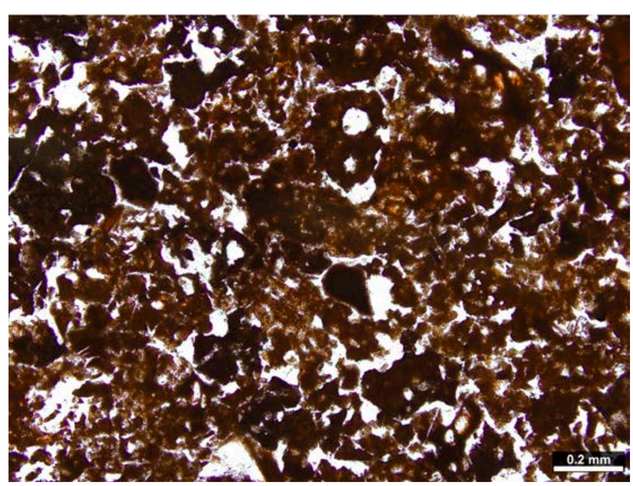

Fig. 4. Photomicrograph of fine-grained laminated sandstone of the Sund Bed from the Hundsarabotnur quarry (the base of the Sneis Formation), showing abundant palagonitised basalt glass. Width of picture 1.95 mm.

wall, the relatively simple stratigraphic arrangement is affected by the intrusion of two segments from the large Streymoy Sill. These apophyses juxtapose the Malinstindur Formation and the Enni Formation (Passey 2008; Árting & Petersen 2012).

Exposure of the volcaniclastic sediments, belonging stratigraphically close to the basal Sund Bed (62°05′36.85″ N, 06°58′44.56″ W), is seen in the local road cutting 750 m north-west of the technical buildings. The sediment horizon is 1 m thick and comprises two distinguishable units. Compact reddish-brown, medium-grained sandstone is situated in the lower part. This layer passes gradually upwards into lighter, ochre-reddish, finer-grained laminated sandstone

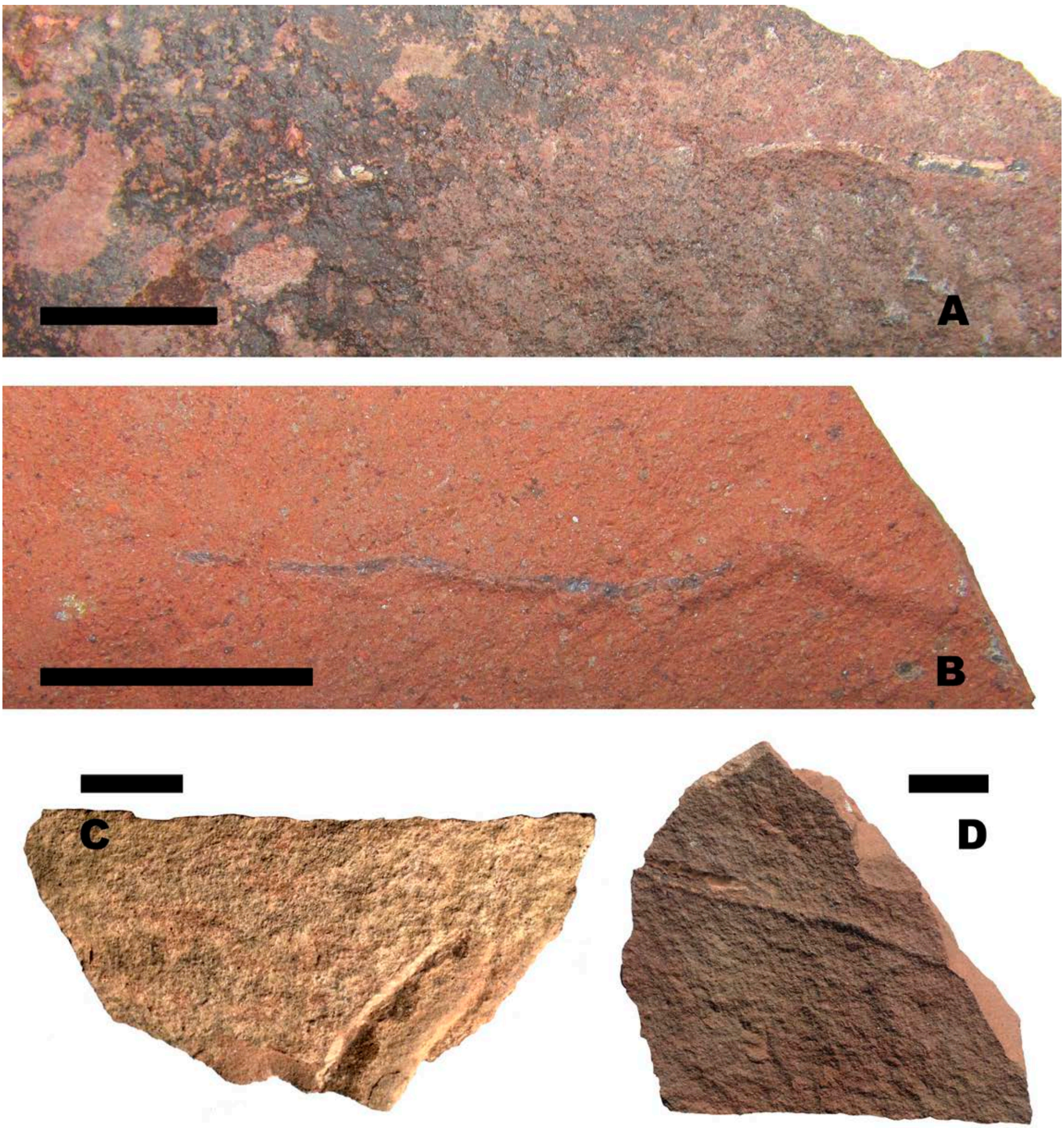

Fig. 5. Trace fossils from the Eiði exposure (Malinstindur Formation). **A**, *Helminthoidichnites* isp.; specimen Eiði2a/1. **B**, *Helminthoidichnites* isp.; specimen Eiði1b. **C**, ?*Palaeophycus* isp.; specimen Eiði4a. **D**, *Helminthoidichnites* isp.; specimen Eiði3a. The scale bar is 2 mm long in all pictures.

predominantly consisting of sub-angular fragments of highly palagonitised basaltic glass and sericitised feldspar accompanied by clay minerals and abundant opaque minerals in the matrix (Fig. 4). The upper layer contains carbonated and zeolitised fragments of plant fossils, and sporadic geometrically straight lines are found on the bedding surfaces. The contacts to the compact lava flows below and above the sediment horizon are not exposed.

Systematic ichnology

***Helminthoidichnites* isp.**
Figs. 5A, 5B, 5D, 6A

Diagnosis: Horizontal, small, thin, unbranched, simple, straight or curved, irregularly meandering or winding trails or burrows with occasional loops that commonly overlap among specimens, but lack self-overcrossing (Buatois *et al*. 1998; Schlirf *et al*. 2001).

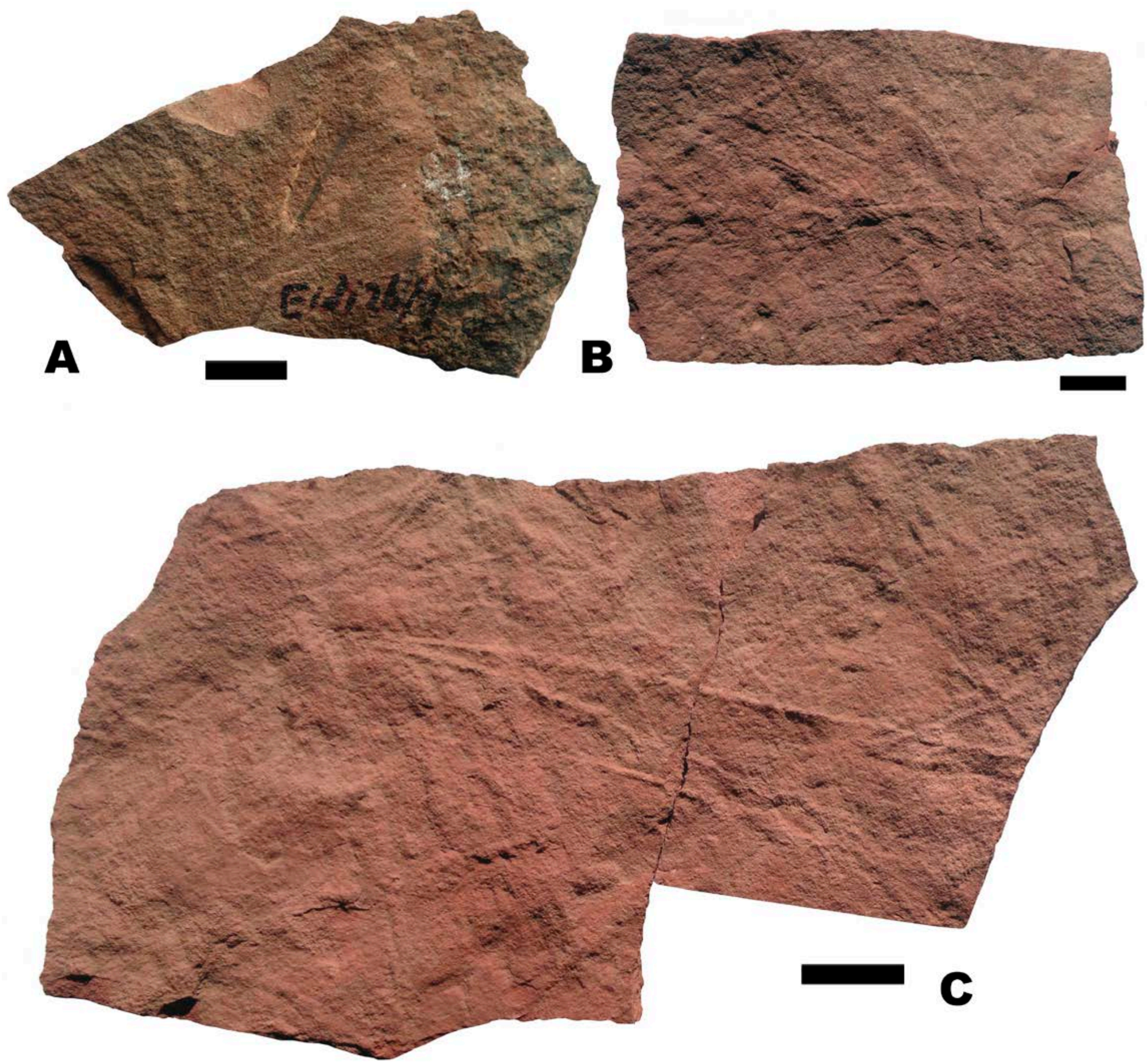

Fig. 6. **A**, trace fossil from the Eiði exposure (Malinstindur Formation), *Helminthoidichnites* isp.; specimen Eiði2b/1. **B**–**C**, linear structures from the Hundsarabotnur quarry (Sneis Formation). **B**, specimen Hund2a. **C**, specimen Hund1a/1+2. The scale bar is 2 mm long in all pictures.

Material: Four specimens – Eiði1a and Eiði1b (upper and lower bedding surface); Eiði2a/1+2 (upper bedding surface), Eiði2b/1 and Eiði2b/2 (fragments of lower bedding surface); Eiði3a and Eiði3b (upper and lower bedding surface).

Description: Thin, slightly winding to almost straight, horizontal, non-branching and non-meandering simple ridges or furrows, without self-overcrossings. The structures are preserved in a weakly convex to almost flat relief on the upper bedding surface and in a concave to flat relief on the lower bedding surface. The trace width ranges from 0.7 to 1.8 mm and is constant over the whole length. Maximal length reaches 150 mm.

Remarks: The traces are poorly preserved, without any detailed or diagnostic features. The structures resemble the segments of *Treptichnus pollardi* Buatois & Mángano 1993 identified by these authors in horizontal view (Buatois & Mángano 1993a), but the pits or nodes at the adjacent segment contacts are missing here. Moreover, the traces only have a two-dimensional character. The gently curved shape of the traces, without a tendency to meander, is different from that in *Helminthopsis* or *Cochlichnus*. The absence of self-overcrossing distinguishes them from *Gordia* (Buatois *et al*. 1997). A detailed overview of morphological differences can be found in the literature, e.g. Jensen (1997), Schlirf *et al*. (2001), Uchman *et al*. (2005) and Baucon & Neto de Carvalho (2008).

Helminthoidichnites probably represents a grazing trace (pascichnia), where the tracemakers are assumed to be unspecified Nematomorpha, Arthropoda, or insect larvae (Buatois *et al*. 1997, 1998). In addition to occurring in marine sediments, *Helminthoidichnites* is mentioned in many freshwater palaeoecosystems, including floodplains (Buatois *et al*. 1997; Schlirf *et al*. 2001; Buatois & Mángano 2002; Uchman *et al.* 2004; Melchor *et al*. 2006), estuaries, lacustrine deltas, shallow lacustrine facies (Buatois *et al*. 1998, 2000; Melchor 2004; Voigt 2005; Melchor *et al*. 2006), glaciolacustrine lakes (Buatois & Mángano 1993b; Gaigalas & Uchman 2004; Uchman *et al*. 2008, 2009), and turbidites of deep lakes (Buatois *et al*. 1996).

?*Palaeophycus* isp.
Fig. 5C

Diagnosis: Branched or, more typically, unbranched, straight to slightly curved to slightly undulate or flexuous, smooth or ornamented, typically lined, elliptical to circular in cross-section, predominantly horizontal structures interpreted as originally open burrows; infill typically structureless, massive, of same lithology or similar to host rock. Where present, the bifurcation is not systematic, nor does it result in swelling at the site of branching (Pemberton & Frey 1982; Fillion & Pickerill 1990; Kim *et al*. 2001).

Material: One specimen – Eiði4a (upper bedding surface).

Description: Short fragment of the horizontal, slightly curved, weakly convex, non-branching trace, 40 mm long and 15 mm wide. The trace is flat-oval in cross section, with a height of 3.5 mm. The surface is smooth, and a wall is faintly visible as a dark coloured thin coating. The burrow-fill is massive and similar to the host rock.

Remarks: A fragment of only one specimen prevents a more accurate determination. The presence of wall coating distinguishes this trace from *Planolites*. Due to the absence of surface sculpture, we suggest a relationship to *Palaeophycus*, probably *P. tubularis* Hall 1847.

Palaeophycus is interpreted as a dwelling or deposit feeding structure (domichnia or fodinichnia), produced infaunally and thereafter passively filled in. The tracemaker may be different types of vermiform animals, probably polychaetes or annellids (Pemberton & Frey 1982; Keighley & Pickerill 1995). *Palaeophycus* is a representative of eurybathic traces in a wide range of marine and freshwater palaeoenvironments including floodplains (Buatois *et al*. 1997; Buatois & Mángano 2002; Kim *et al*. 2002; Krapovickas 2012), rivers (Wang *et al*. 2014) and lakes (Buatois *et al*. 2000; Melchor 2004; Melchor *et al*. 2006). Ekdale *et al*. (2007) and Krapovickas *et al*. (2010) described *Palaeophycus* from aeolian sediments.

Linear structures

Fig. 6B, 6C

Material: Two specimens - Hund1a/1+2 (upper bedding surface); Hund2a and Hund2b (upper and lower bedding surface).

Description: Fragments of sandstone containing numerous simple, straight and thin convex lines, subcircular to Λ-shaped in cross-section. The lines reach up to 100 mm in length and 1.5 mm in width. The lines intersect each other at many places. The infill of the structures is identical to the host rock.

Remarks: Geometrically straight lines usually indicate an abiotic origin. Wetzel *et al.* (in press) describe the trails of modern earthworms with a similar arrangement pattern, but these traces differ from the specimens in the Hundsarabotnur quarry by the not entirely linear trails, and the presence of morphological features such as the imprints of setae, pseudospreiten, blind deviations part of traces and tunnel openings. By studying the thin sections, the lines were found to have the same mineral composition as the surrounding rock. This fact excludes an explanation as pseudomorphs after needle-like minerals formed during diagenesis or due to the low-grade contact metamorphism of sediments by the overlying lava flow. The straight shape of the lines partly resemble the frost cracks arising due to seasonal freezing of sediment, the formation of elongated ice crystals and subsequent infilling of the fissures by sediment after the melting of the ice. Very similar structures were published by Udden (1918) and Fortier *et al.* (2008). Ice crystal marks, however, can be excluded due to the warm character of the Palaeogene climate (Vandenberghe *et al.* 2012). Based on the palaeoenvironment characteristics, the probable process leading to the creation of the structures in the Hundsarabotnur quarry could be described as the gradual drying and shrinking of the sediments in a subaerial environment (e.g. Geoff Tanner 2003; Sadhukan *et al.* 2007). Although the main distinguishing sign of such desiccation structures – a polygonal arrangement – was not observed here, it can be attributed to the fragmentary preservation of the examined specimens. The linear structures are thus pseudo-fossils.

Summary and conclusions

The fine- to medium-grained volcaniclastic sandstones of the Palaeogene Faroe Islands Basalt Group consist mainly of reworked palagonitised basaltic glass and are traditionally associated with fluvial channel environments and their surroundings (Rasmussen & Noe-Nygaard 1970). Based on the lack of brecciation of the overlying lava flows Passey (2004) concluded that the land surface was without deep lakes and was only occasionally affected by seasonal flooding events at the time of lava emplacement. The important evidence of exposure to air in the warm climate is the iron-oxide-rich, red-coloured sedimentary formations and flow tops. This is supported by the occurrence of generally angular to sub-rounded basaltic clasts, indicating short-time/short-distance transport (Passey 2004), as well as the fossil evidence of mostly terrestrial or river- to lake-littoral palynomorphs (e.g. Ellis *et al*. 2002; Passey & Jolley 2009).

The subaerial, occasionally inundated, non-marine moist or wet, soft to loose ground environment corresponds to the *Scoyenia* ichnofacies. This trace-fossil assemblage however, is typically dominated by meniscate burrows, arthropod trackways and simple vertical burrows (cf. Frey *et al*. 1984; Buatois & Mángano 1995).

Helminthoidichnites isp. and ?*Palaeophycus* isp. that were found at Eiði (Malinstindur Formation) indicate a low to moderate hydrodynamic energy environment, which represents suitable conditions for benthic tracemakers (Buatois *et al*. 1997). These ichnogenera are, however, usually present as the diagnostic elements of the *Mermia* ichnofacies, which differs from the previous by occurring in permanently subaqueous zones, represented by the shallow to deep zones of lacustrine systems. Both of the mentioned ichnogenera are occasionally found in the *Scoyenia* ichnofacies (Buatois & Mángano 1995; Buatois *et al*. 1997; Melchor *et al*. 2012).

Based on the above assertions, the new discoveries of trace fossils and possible desiccation cracks confirm that the environmental character of the Palaeogene interlava sedimentary periods of the Faroe Islands was a mosaic landscape of floodplains, interwoven with rivers and wide shore-lined shallow lakes, with the presence of an impoverished *Scoyenia* ichnofacies.

Acknowledgements

The authors gratefully acknowledge Luis A. Buatois and Maria G. Mángano (University of Saskatchewan, Canada) for their constructive comments on the fossil material. Special thanks to Simon R. Passey and Alfred Uchman for their thoughtful and thorough reviews.

Financial support was provided by the J. E. Purkyně University Internal Grant Agency FŽP IG 1/2014: *Ichnological record in young Cenozoic sediments on Iceland*. L.K. was financially supported by project No. RVO67985831 of the Institute of Geology CAS, v.v.i., Prague and by a BUT project No. LO1408 "*AdMaS UP - Advanced Materials, Structures and Technologies*", which is supported by the Ministry of Education, Youth and Sports of the Czech Republic under the "*National Sustainability Programme I*".

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