morphs and other eukaryotic forms, multi-walled and colonial forms, organisms with complex morphologies. Examples include *Leisphaeridia* and *Lophosphaeridium*, the latter showing cysts encased in thin-walled vesicles interpreted as original vegetative cell walls – evidence of eukaryotic organisms living in these Torridonian lakes.

The best preservation of these microfossils occurs in phosphatic nodules within the Diabaig Group. Cell membranes and cell contents are well preserved. Explanations of phosphogenesis include a biotic origin within microbial mats for instance, the result of seasonal anoxic conditions in the deeper lake environment or the breakdown of seasonal microbial blooms. The phosphates in the Diabaig Group are found in green sands and mud suggesting a reducing environment.

This brings us back to the first paper cited in the introduction to this article. A new organism *Bicellus brasieri* has been identified within Diabaig phosphate nodules (Fig. 4). Bicellus consist of a solid, spherical ball of tightly packed roughly spherical shaped cells surrounded by elongate cells. Some examples appear to show the development from a spheroidal cluster to one showing the elongate outer cells. There is an absence of cell walls suggesting that these cells did not originate from algae but are more consistent with a holozoan origin. The simple cell differentiation and morphogenic processes are similar to those of present-day metazoans. It is then concluded that *Bicellum* shows that differentiation and morphogenesis occurred in freshwater protists as much as a billion years ago.

Summary

The evidence is clear that the Torridonian Group formations were laid down in terrestrial, freshwater lacustrine environments. Microbial mats and microfossils showing eukaryotic characteristics are found in facies ranging in depth and exposure above the water line. The further examination of these, perhaps unique Torridonian rocks may suggest a revised view on the evolution of eukaryotes on land.

Built from the oldest metamorphic and sedimentary rocks in Britain, the North West Highlands are among the most scenic and well worth a staycation. While the resources available to a mid 1970's undergraduate geologists undertaking a mapping exercise were somewhat limited in comparison to today's generation of geology students and not capable of coming close to consider or identify holozoan genesis within the studied rocks, the experience lingers and still engages. The advantage of newsfeeds ensures a continuing source of new material to entertain and enlarge upon these youthful experiences. I am also pleased to record that it was due to suggestions by my sedminentology lecturer and field trip leader Sandy Stewart and my tutor Roland Goldring at Reading University that the work on Torridonian microfossils began.

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Machair – a gaze across deep time

by Charles Hiscock

In 1788, the eminent pioneering Scots geologist James Hutton made one of the most profound statements in the history of geology. He wrote "we see no vestige of a beginning, no prospect of an end". He had visited the localities in Scotland that are now famous sites, Hutton's Unconformity on Arran, at Jedbergh and elsewhere, culminating in his visit to Siccar Point in 1788. From his observations he recognised the huge passage of time in the formation of the earth, "deep time" as he called it. He is justly called the "Father of Geology".

I was standing on the sand dunes looking out over the beach and sea at Seilebost on the west coast of the Isle of Harris. In front of me, the beach was a very pale creamy colour, bright and glistening in the sunshine while the sea was a brilliant turquoise blue, graduating at the shallows from a pale hue to a deep, intense blue away from the shore (Fig. 1). Gentle wavelets broke over the sand while the brisk breeze scattered dry sand grains along the beach. I walked along the sand with the wind in my back and the dunes rising up from the back of the beach, capped by abundant marram grass.

Fig. 1: Seilebost beach

My walk took me along the firm sand until I came upon an extensive area where it seemed more consolidated, cemented into a flat, slightly raised platform. At the same time, I noted that the dunes, which had up to that point been steep gradients rising at the back of the beach, were fronted by low cliffs showing patterns of lower, older dunes and with large numbers of bare marram grass roots just hanging in the air. I remembered that the north of Scotland, in particular the Outer Isles, had experienced severe storms during the previous winter. Clearly, the storms had eroded large quantities of the dunes in this area, exposing the grass roots and the platform of cemented sand fronting the dune cliffs. Close examination of the cemented sand showed it to be composed of comminuted minute shell fragments with some larger pieces and almost complete molluscs. What I was standing on was a modern day 'hard ground' in the making; the lime content of the shells being leached out by the action of percolating water through the dunes to form the hard, crusty surface which had been exposed as the storms removed the dunes (Figs. 2 and 3).

Fig. 2: Calcified sand surface, Seilebost

Fig. 3: Dunes showing old dune formation

Behind the dunes the land was mainly flat and fertile with abundant flowers in the grassy sward. Nesting oyster catchers and redshank called in alarm as I walked across this wildflower extravaganza while, in the distance, a few cows and sheep grazed on the lush grass. However, not much further inland the mountains of Harris rose steeply up, virtually devoid of vegetation. Across the deep blue sea, other mountains provided a hazy backdrop to the scene (Fig. 4).

Fig. 4: The machair at Seilebost and Lewisian gneiss mountains

I was walking across the machair, the fertile land which has been cultivated by the crofters of the Outer Hebrides, the west coast of Ireland and some Scottish mainland coasts. Composed of the shell material washed and blown in by the Atlantic winds and seas, it has provided a precarious living for the farmers over many centuries as well as being the habitat for rare flowers and birds like the corncrake. Standing on the grassy bank, looking out over the platform of exposed cemented sand, my mind dwelt on the interminability of the earth and the processes that have formed it. Here I was considering a newly forming hardground with, to my back and in the distance in front of me, rocks of the Lewisian gneiss that were 1.7 to 3.0 billion years old. I admit that I did not think of the words that Hutton used in 1788 but, nevertheless, the same sentiments passed through my mind. I remembered that I had seen ‘hardgrounds’ and fossil assemblages over the years in the rocks and specimens that I had collected, all from different periods of geology; Jurassic of the Cotswolds at North Nibley quarry, Silurian Wenlock limestone and Llandovery sandstone beds of the Tortworth inlier, Carboniferous limestone of the Forest of Dean, a modern one on the beach of red Mercia Mudstone at Sidmouth bored by piddock shells. Here, on this deserted white shell beach in the far north west of the United Kingdom was a fossil assemblage in the making.

The machair, which is Scots Gaelic for ‘fertile plain’, is the recognised name for the land which lies behind the dune systems on the western coasts of the Outer Hebrides, the west coast of Ireland and some of the coast of the Scottish mainland. In the Outer Hebrides the largest development of machair is on the southern islands of the Uists, Benbecula and Barra, but nevertheless on Harris and to a lesser extent on Lewis, there are some fine machair. It is a precarious and rare habitat subject to the harsh winds and storms which regularly blow in from the Atlantic, particularly in latter years as global warming has intensified the severity of the storms. It is this combination of wind and tide that provides the continual feed of shell fragments onto the western shores and the development of the dune systems. Behind the dunes the land is well drained and becomes covered in grass and abundant flowers such as Sea Pink, Bird’s Foot Trefoil, Daisy, Scabious, Milk Wort (ranging from deep blue to white), and during June, carpets of Buttercups giving the machair a glorious yellowness. Also abundant are orchids - tall spikes of purple Northern Marsh Orchid, pale pink Early Marsh Orchid, Early Purple Orchid and Spotted Orchids (Figs. 5 to 7). At Seilebost on the edge of the machair bordering the dunes was a rare Frog Orchid. At the same beach a small river, water the colour of strong black tea from the peat, enters the sea behind the machair which gradually evolves into a salt marsh on which oyster catchers, lapwing and redshank nest. Meadow pipits were everywhere while skylarks rose into the sky with their distinctive song.

Fig. 5: Frog Orchid (Seilebost, West Harris) 20.6.19

Fig. 6: Early Marsh Orchid (Taobh Tuath) 20.6.19

Fig. 7: Machair flowers

Farming, or more correctly, crofting on the machair has been a way of life for centuries. In Lewis, evidence of Bronze age dwellers can be seen on the headlands, Pictish brochs such as Carloway, the Norse mill and kiln at Shawbost and medieval cultivation strips provide evidence of the long association humans have had with this harsh environment. The fertile land provides rich grassland for the small herds of dairy and beef cattle that range freely across the machair, often accompanied by flocks of sheep. It is this combination of fertile grassland and gentle cropping by the animals that provides the ideal habitats for the nesting birds. At Seilebost and Carbost lines of cultivation strips show where the islanders were forced to retreat during the infamous Clearances in the late 18th and 19th centuries. The sea eroded dunes at Seilebost and the cemented hard ground in the foreground are a stark illustration of the precarious and vulnerable nature of the machair. Photographs of the mollusc shells, sea urchin test and crab’s leg are typical of the elements that are broken down to produce the lime sand of the beaches, dunes and machair (Figs. 8 to 10).

Fig. 8: Assorted shells

Fig 9: Shell sand (x10)

Fig. 10: Sea urchin test

In the photographs that accompany this article we see the machair at Seilebost (Fig 4), and in the shadow of Chaipaval (365m), at Taobh Tuath (Fig. 11).

Fig. 11: Machair, near Chaipaval

Since the early 20th century geological research, techniques and investigation has advanced our science to a stage that Hutton could only dream about to the extent that we now know the age of the planet Earth to be 4567 billion years old. We even have an inkling of how long the Earth will exist and how it may meet its end. But there, on that windy beautiful spot of 'God's creation', Hutton's words seem wholly appropriate – 3.0 billion year old rocks around me and new rock being formed in front of me. It felt and was timeless!

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IMPACT MARKS ON BATH STONE (JURASSIC OOLITE): WW2 BOMB AND BULLET DAMAGE ON BUILDINGS IN BATH

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Impact structures observed in geological strata record a range of completely different processes, operating on vastly different scales: from the potential devastating consequences of a meteorite strike with shatter cones in the country rock at the impact site, the imprints of rain on a muddy shoreline, the landing of volcanic bombs and the dropping of stones from melting icebergs on to the deep seafloor disturbing the strata. Marks from pebbles and fossils bouncing across the seafloor carried by a turbidity current and the footprints of dinosaurs impressed into soft sediment are other types of impact mark. Following Cardiff University's Professor Tom Blenkinsop's fascinating talk to the Bath Geological Society on 4th February 2021 on impacts from meteorites and comparisons with ballistic damage from bullets and shrapnel in conflict zones, I visited the former Labour Exchange building in Bath (Fig. 1). This is a Grade II listed building preserving the damage from the German air-raids during WW2 on 25th to 27th April 1942. There are some really interesting features of detail to be