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THE ORIGIN AND SIGNIFICANCE OF MUSHROOM STONES IN LOWLAND KARST REGIONS

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Abstract

'Mushroom stones', or 'wave stones', are limestone erratics or protruding bedrock that shows signs of erosion or dissolution suggestive of prolonged exposure to standing water. Fifty-three stones in the central lowlands of Ireland were recorded in a systematic fashion, with accurate lip-height measurements taken for more than half the stones using GPS (Global Positioning System) equipment. The heights of their erosional lips are discussed with reference to estimated pre-bog water tables, lake fluctuations and other possible explanations for this phenomenon. The results suggest that the erosion of the stones now found in the bogs of County Offaly cannot be attributed to erosion by a single large lake as previously speculated, whereas the notching of stones in and around wetlands and lakes in Roscommon and Clare is likely to be due largely to flooding and winter water levels.

Introduction

'Mushroom stones', or 'wave stones', are limestone boulders, erratics or bedrock found in certain bog and wetland sites that are notched and undercut in such a fashion as to suggest prolonged exposure to standing water at some time in the past. In some cases the notching forms a fairly even circle around the stone, hence the name 'mushroom stones', while others have an overhang facing in just one direction.

Wave stones were remarked on by Praeger (1937), who conjectured that they resulted from the solution of the limestone by lake water. According to him, 'evidence of this

higher level is gained from the presence in these flat areas, often far from the present lake, of "mushroom rocks"—large blocks of limestone now shaped like a toadstool. The top is umbrella-like, convex above, flat and horizontal below and rests on a much narrower pillar of the same rock. The flat underside marks the former lake-level, above which the solution of the limestone did not take place.' After this the level of the lake, which in Praeger's case was Lough Corrib, fell substantially—to below that of the present day. This is deduced from the depth to which peat occurs below the present-day water level. Before *c.* 6100 BP the level of the lake began to rise again, with evidence for this coming

from the difference in elevations of the interface between the marl and the organic deposits. Sometime before 2010 BP the rapid change from swamp peat to sphagnum peat took place, which may indicate a lowering of the lake water level again and certainly suggests a cessation of rising water levels. The humification of the peat may indicate a subsequent lowering of the peatland water table with a concomitant drying-out of the peat.

Wave stones are also mentioned by Feehan and O'Donovan (1996), who refer to them as 'lake-edge markers'; the stone near Crancreagh Bridge is interpreted as marking 'the position of what must have been the north-western shore [of Lough Boora]'. Climate variation, palaeohydrology and bog influences on limestone reaction factors are all considered to play a role in how these stones became shaped in such a fashion. Mushroom stones have been found, or reported, in counties Clare, Galway, Offaly, Roscommon and Westmeath (Fig. 1; Dunne 1998).

Aims and methods

The object of this study was to compile as comprehensive a record as possible of the mushroom stones found around the country. All the examples of mushroom stones known by the authors at the time of writing were catalogued, mapped and photographed, and, where possible, the altitude of the erosional lips was accurately measured. It was hoped that a comparison of the altitudes of different stones would provide some clues about the erosional agent that moulded them and thus might help to uncover more details about the post-glacial Irish landscape.

All of the known stones were visited, photographed, measured and named, and a survey card was filled out on each. New stones were discovered, and rumours of stones were investigated and recorded in the same way, but others probably exist that are not yet recorded. Stones that were doubtful or that may have been moved in the past were ignored.

GPS (Global Positioning System) equipment (accurate to 0.01–0.02m or to 0.1–0.3m, depending on satellite information) was used to



Fig. 1—Map of Ireland with positions of mushroom stones.

determine the position and height (to Malin Head) of the stones in and around the bogs, as well as at Clonmacnoise, Birr and Lough Ree. Twelve sites, comprising 31 stones, were recorded, photographed and surveyed in this way. When more than one stone occurred within surveying distance, these stones were measured off each other from the same GPS reading.

A further eleven sites, with 22 stones, were surveyed using only (due to financial constraints) a hand-held Magellan GPS receiver; this is accurate to 10m for positioning but cannot provide reliable data on height above sea level.

Stones were named according to their townland. Where more than one stone occurred in the same townland, each stone was given a number after the townland name. All sites were located on the Crown Series (1:25,000) maps, based on the Ordnance Survey 6-inch series, with reference to the National Grid.

Description

The Turkenagh area in the Ballyeigher wetlands, Co. Clare, has many examples of

notched stones, as well as what appears to be an entire segment of pavement that is eroding and breaking apart into numerous stones. The lips point mostly south-east, but others go in every direction and not necessarily towards the lake. It seems more likely that the water rises every year or that at some point in the past it rose regularly and surrounded the stones to the level of their lips, which range from 0.5m to 0.7m high. Cracks were noted under the lips of some stones, supporting a theory of differential weathering at these points, regardless of water level. Whereas most of the other stones observed seem to be relics, these ones are still developing.

The Clorhane stones are all almost the same height, to within 0.5m, but would be expected to be even closer if the same agent caused the erosion of all three. Some of this difference can be explained by the estimation involved in deciding at what level the true lip is. Although the GPS receiver was only accurate to 0.1–0.3m at this site, only one reading was taken, and the stones were surveyed for heights from this point, so GPS accuracy for the stones is constant relative to each other. The Creevagh stones show a 1.5m difference between the lowest lip and the highest, with the five stones

in between spread out almost uniformly between these two heights. The stones furthest from the river (Creevagh 6 and 7) have the highest recorded lip level. All the lips in this cluster are facing in different directions, suggesting a situation analogous to that of the Turkenagh pavement in the Ballyeigher wetlands.

The Clorhane and Creevagh clusters are both in fields full of large limestone boulders piled in the hedges or in heaps. It is possible that over the years the more fragile stones or the ones with more slender stalks were knocked down to facilitate farming practices. There is a distinct bare limestone platform in a field adjacent to the Clorhane stones, suggesting that the Shannon formerly lapped up to here. However, other erosional processes, such as ice-scouring, may be responsible or involved.

Endrim and Ballylin (Dunne 1998), though quite close to each other (3.5km), have more than a 15m difference in the altitude of their lips.

There are three fields containing clusters of stones on the western shore of Lough Ree. The lip levels of Moyvannan 1–4 are within 0.4m of each other (or only 0.1m if the lower level of the lip on Moyvannan 1 (Fig. 2) is considered



Fig. 2—Moyvannan 1. Location: N 247153.23; E 199577.40. Height of lip: 39.8m, 40.1m OD.

as the lip level), and Moyvannan 5–7, in a different field nearer the lake shore, show 0.5m variation between the highest lip level and the lowest. Between all the Moyvannan stones there is a 0.9m difference, with the lowest lip being closest to the lake. Approximately 1km north of here, the Carrowmurragh cluster is found, with Carrowmurragh 3 and 4 bearing some resemblance to Clorhane 1 and 2, in that they look as if they may have been joined to each other at some time in the past. They are very different from Carrowmurragh 1 and 2, and there is a 0.5m difference between the lips on all four stones. Water records from an Office of Public Works gauge (OPW 1998) at Hudson's Bay, just south of the Moyvannan and Carrowmurragh sites, show modern-day water levels to be 38.5m above sea level during the winter and 37.6m during the summer. The winter level is just slightly lower than the lip levels of the lower stones recorded. This area does not flood in winter at present.

Results

The data pertaining to each stone are presented in Table 1, including their location on the National Grid and their lip height relative to sea level or to the base of the stone (depending on the GPS equipment used). Where stones were discovered in clusters, the position of the first stone is taken as being representative of the others. A combination of the GPS reading and physical features on the map was used to position those stones on which the less accurate GPS receiver was used.

Interpretation

Most of the stones mentioned in this paper were found in wetland areas or areas liable to flooding in a similar way to the Ballyeighter area in County Clare. The clusters of stones found, e.g. the Clorhane and Creevagh stones, may once have looked like the Ballyeighter/Turkenagh pavement, with most of the stones subsequently being knocked down. If the land around the stones became flooded in winter, water would rise and surround the pavement as it stands, eroding the bottom and middle of the limestone.

There are various possible explanations for the notching on these limestone boulders. As many of the stones are close to existing lakes, it has been inferred that the notches were caused by previous water levels. The similarity in form of the stones in and around the bogs but far away from any present-day lakes or rivers (Crancreagh (Fig. 3), Drinagh, Derrinlough, Endrim, Ballylin and Clonkeen) makes it tempting to assume that these stones are a relic of former lakes now drained or obliterated by the growth of raised bogs. However, other possibilities should be considered, in the light of observations, to help ascertain the most likely explanation for the formation of these mushroom stones.

It has been suggested by Feehan and O'Donovan (1996) that the stones found on the bog at Boora (Crancreagh, Derrinlough and Drinagh) are indicative of the early post-glacial extent of Lough Boora. However, the difference in height (they measure 52.9m (the higher lip of Crancreagh), 57.2m and 60.4m OD respectively) between these three stones raises questions about this interpretation. Perhaps the highest stone, Drinagh, which is on an oasis of mineral soil surrounded by bog, indicates the shore of Lough Boora at its highest level. This mineral soil would have been an island in the middle of the ancient lake, and the Drinagh stone an erratic dropped by the retreating ice on the shore of the lake. It is possible that the tower stones, at Derrinlough and Crancreagh, initially were completely submerged but became exposed when the lake level dropped significantly as a result of climate change, the beginnings of the bog or post-glacial isostatic effects. This would leave the Drinagh stone as an isolated relict of an earlier lake level, and the erosional processes would start on the Derrinlough and Crancreagh stones until they were enveloped by the bog encroaching from the margins of Lough Boora.

If the stones in Clorhane are the remnants of an old pavement across the area that was eroded at a bedding plane, it is possible that the plane was not 100% horizontal, hence the height difference between them. All the lips in the Creevagh cluster are facing different directions, suggesting a situation analogous to

Table 1—Location and height of lip of mushroom stones. Stones with more accurate GPS readings are given before those taken with hand-held GPS, and both are arranged alphabetically according to county and then locale. Lip heights for the former are given in metres OD to Malin Head. Lip heights for the latter (indicated by asterisks) are given from the base of the stone.

<i>Stone name</i>	<i>Locale</i>	<i>County</i>	<i>Northing</i>	<i>Easting</i>	<i>Accuracy (m)</i>	<i>Height of lip (m OD/m from base)</i>	<i>Lip direction (if not stated, lip forms a circle)</i>
Crinkill 1	Birr	Offaly	203090.30	205861.06	0.1–0.3	51.3	North/south-east
Crinkill 2	Birr	Offaly	203090.30	205861.06	0.1–0.3	51.5	South
Crinkill 3	Birr	Offaly	203277.70	205707.60	0.1–0.3	50.1	East
Crancreeagh	Boora Bog	Offaly	216465.46	207551.06	0.01–0.02	52.3, 52.9	North-north-east
Derrinlough	Boora Bog	Offaly	215062.67	208561.32	0.01–0.02	57.2	North
Drinagh	Boora Bog	Offaly	215837.89	210611.76	0.01–0.02	60.4	South
Clonkeen	Clonbullogue	Offaly	223098.30	260144.41	0.1–0.3	69.6	North-north-west
Endrim	Ferbane	Offaly	228756.95	208951.85	0.01–0.02	44.9	North-east/south
Ballylin	Ferbane	Offaly	226553.29	211728.16	0.01–0.02	60.4	South-west
Clorhane 1	Shannon	Offaly	228143.60	198825.09	0.1–0.3	38.5	North-north-west
Clorhane 2	Shannon	Offaly	228143.60	198825.09	0.1–0.3	38.4	South-west
Clorhane 3	Shannon	Offaly	228143.60	198825.09	0.1–0.3	38.9	North-west
Creevagh 1	Shannon	Offaly	229463.95	199773.22	0.01–0.02	39.2	South-north
Creevagh 2	Shannon	Offaly	229463.95	199773.22	0.01–0.02	39.4	West-north-west
Creevagh 3	Shannon	Offaly	229463.95	199773.22	0.01–0.02	39.5	North-east
Creevagh 4	Shannon	Offaly	229463.95	199773.22	0.01–0.02	39.5	West
Creevagh 5	Shannon	Offaly	229463.95	199773.22	0.01–0.02	39.8	North
Creevagh 6	Shannon	Offaly	229463.95	199773.22	0.01–0.02	40.7	West
Creevagh 7	Shannon	Offaly	229463.95	199773.22	0.01–0.02	40.5	
Moyvannan 1	Lough Ree	Roscommon	247153.23	199577.40	0.1–0.3	39.8, 40.1	
Moyvannan 2	Lough Ree	Roscommon	247153.23	199577.40	0.1–0.3	39.7	
Moyvannan 3	Lough Ree	Roscommon	247153.23	199577.40	0.1–0.3	39.8	North-east
Moyvannan 4	Lough Ree	Roscommon	247153.23	199577.40	0.1–0.3	39.8	North
Moyvannan 5	Lough Ree	Roscommon	247378.13	199695.30	0.01–0.02	39.7	East-west
Moyvannan 6	Lough Ree	Roscommon	247378.13	199695.30	0.01–0.02	39.2	North-south
Moyvannan 7	Lough Ree	Roscommon	247378.13	199695.30	0.01–0.02	39.5	South
Carrowmurragh 1	Lough Ree	Roscommon	248137.46	199752.29	0.1–0.3	39.3	North
Carrowmurragh 2	Lough Ree	Roscommon	248137.46	199752.29	0.1–0.3	39.4	East
Carrowmurragh 3	Lough Ree	Roscommon	248137.46	199752.29	0.1–0.3	39.0	North
Carrowmurragh 4	Lough Ree	Roscommon	248137.46	199752.29	0.1–0.3	38.9	North
Loughandonning	Athlone	Westmeath	224067.30	205584.22	0.01–0.02	41.2, 41.6	North
Gortlecka 1	Burrin	Clare	194990	132020	10	0.9*	South-east
Gortlecka 2	Burrin	Clare	194990	132020	10	0.9*	South-east
Turkenagh pavement	Burrin	Clare	192430	133870	10	0.5–0.7*	
Ballykinnora North	Corofin	Clare	188480	128650	10	1.1*	
Elmvale 1	Inchiquin Lough	Clare	191700	125850	10	n.d.	
Elmvale 2	Inchiquin Lough	Clare	191600	125860	10	1.1*	
Crossard	Inchiquin Lough	Clare	190750	126880	10	0.7*	
Coad 1	Inchiquin Lough	Clare	191390	127250	10	0.9*	
Coad 2	Inchiquin Lough	Clare	191390	127250	10	0.7*	
Coad 3	Inchiquin Lough	Clare	191390	127250	10	0.7*	
Coad 4	Inchiquin Lough	Clare	191390	127250	10	0.6*	
Coad 5	Inchiquin Lough	Clare	191390	127250	10	0.6*	
Coad 6	Inchiquin Lough	Clare	191390	127250	10	0.5*	
Coad 7	Inchiquin Lough	Clare	191390	127250	10	0.5*	
Coad 8	Inchiquin Lough	Clare	191390	127250	10	0.5*	
Killinaboy	Inchiquin Lough	Clare	191330	127200	10	0.7*	
Rinnamona	North of Inchiquin Lough	Clare	194220	129600	10	n.d.	
Sraheen	Quin	Clare	179640	142860	10	0.9*	
Menlough 1	Lough Corrib	Galway	228980	128440	10	0.6*	
Menlough 2	Lough Corrib	Galway	228980	128440	10	0.9*	
Menlough 3	Lough Corrib	Galway	228980	128440	10	0.7*	
Tullin	Lough Ree	Westmeath	224436	205519	10	0.5*	South



Fig. 3—Crancreagh. Location: N 216465.46; E 207551.06. Height of lip: 52.3m, 52.9m OD.

that of the Turkenagh pavement in the Ballyeigher wetlands, with again perhaps the bedding plane either not being quite horizontal or flooding every year (or every year for a number of years at some time in the past) to a certain level. The stone would thus be immersed at its base more often than further up. This prompts the question of why almost all the stones widen out again at their bases. Some soil erosion may have occurred to uncover the previously protected bases, or the water surrounding their bases may have been less erosively aggressive than the surface water.

The Endrim and Ballylin stones, though quite close to each other (3.5km), have more than a 15m difference in the altitude of their lips. If we assume water erosion to be the cause of the lips, two separate bodies of water with distinct water tables may have existed that together contributed to the raised bog around Ferbane, which extends right to the edge of the town. The nearby Brosna River running through Ferbane shows present-day water levels of 42.98m OD and 42.12m OD for winter and summer respectively. However, one or both

stones could have been eroded solely as a result of immersion in peat at some time and therefore be independent of standing water level.

Although superficially similar features are seen around the lakes at Killarney, those in the splash zone of Lough Leane are very different from those that have been observed on the other stones in this survey. At upper lake level in the splash zone there tended to be sharper and discrete linear grooving forms in all directions of varying sizes, as well as a pitted surface all over the stone, in contrast to the usually smooth undersurfaces of the mushroom stones. It is possible that the mushroom stones looked this way while still in a splash zone and were smoothed out by other erosional factors over the years.

According to Priesnitz (1985), the maximum lake level fluctuation in Lough Leane over the preceding 20 years was 2.2m, which is exactly the same as the maximum height of the hohlekehlen (eroded holes) on the lake edges. This is, however, a different situation, possibly with different limestone, and it seems that the limestone at Muckross has been subjected to more deformation than the midlands rocks.

Moyvannan 6 has a number of similar ridges running from the lip level to the top of the stone. These may be rillenkarren, formed by surface run-off from the top of the stone while the lake water was eroding the lip, which at a later date weakened the protruding lip to such an extent that it fell off. The existence of these microforms supports the water hypothesis.

The difficulty in determining how long it took the limestone to dissolve means that it is impossible to date when this notching effect took place.

Conclusions

It is plausible, but scientifically unsound from the available evidence, to attribute the formation of the mushroom stones to water erosion alone. Findings from other research may be applied to the study in question, and they yield alternative ideas.

It is not necessarily true that the undercut morphology of all the stones investigated was caused by the same phenomenon. Although the notches on some stones may reflect former lake or river levels (e.g. the Moyvannan stones), on others they may be the result of a different erosional agent, with their apparent similarities merely a coincidence. Many of the stones are very near the edges of bogs. Run-off water from peatlands would have a much higher dissolving capacity and could affect the pH of the water eroding the stones. Commonality of height provides the strongest indication that the notching is due to water levels, but the notches may be related instead to former soil or peat levels.

Alternatively, the position of the notch may relate to a property of the limestone itself, e.g. the position of a bedding plane or other fracture or differences in solubility at various levels. For instance, the Derrinlough stone is significantly more fractured and pitted than the Crancreagh stone. To discount this possibility, properties of the limestone at three levels (the top, the area of highest erosion, i.e. the lip or notch, and the base) of each stone would need to be examined at microscopic level for contrasts in homogeneity. Before the limestone

within a stone can be found to be homogeneous, it is impossible to theorise confidently about external effects upon it (Trudgill 1976).

If mushroom stones can be proved to be caused by water erosion, they can be seen as keys to a vanished landscape, an Ireland covered by water much more extensively than now, the waves of giant lakes lapping up against storm beaches, shaping the mushroom stones (by mechanical erosion as well as solution) and retreating over the years, whether owing to climate change, post-glacial isostatic rebound, drainage, bog formation or a combination of all these factors. Evidence found under Lough Boora shows a storm beach, indicating the existence of a lake sufficiently large to produce such a substantial beach. The beach ridge consists of bouldery moraine from which finer material had been washed out by the waves and is situated at a fairly constant level of 52m, which is similar to the lip height of the Crancreagh stone. In the pre-bog landscape a lake with its surface at this level would have covered an area of at least 320ha—large enough to have allowed the build-up of waves that was responsible for the storm beach (Feehan and O'Donovan 1996).

Regarding conservation considerations, the stone at Athlone (Loughandonning) is perhaps under the most immediate threat and is a good example of a mushroom stone. It is standing in the last remaining farm close to a dense residential area, and it seems unlikely that this field will remain without housing for much longer. The best example of these stones recorded to date may be Moyvannan 1 (Fig. 2) on the western shore of Lough Ree, as it has the most distinctive mushroom shape, but it is less likely to be under threat from any imminent developments.

In the future it would be advisable to attach legal protection to these enigmatic but valuable indicators of our past landscape. The Crancreagh (Fig. 3), Loughandonning and Moyvannan sites have all been recommended to Dúchas for National Heritage Area status. More stones must exist, and it would be hoped in time to find and catalogue these and thus increase our understanding of mushroom stones.

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