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EVIDENCE OF CIRQUE GLACIATION IN THE FALKLAND ISLANDS

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ABSTRACT. The presence of 49 cirques on the Falkland Islands indicates that glacial conditions were prevalent during the Pleistocene. Cirque moraines and glacially eroded valleys also occur. There appear to have been three phases: a period of cirque formation, the growth of local ice caps and subsequent cirque development. Periglacial landforms such as stone runs, stone terraces and stone lobes also developed during the Pleistocene and attained very large dimensions because of the lithology, the relatively small scale of glacierization and the presence of rotted bedrock.

RÉSUMÉ. *Les marques de glaciation de cirque dans les Falkland Islands.* L'existence de quarante neuf cirques sur les Falkland Islands indique qu'il régnait des conditions glaciaires au Pléistocène. On trouve aussi des moraines de cirque et des vallées creusées par le glacier. Il semble y avoir eu trois phases successives: une période de formation du cirque, la constitution de petites calottes glaciaires et le développement ultérieur du cirque. Des formes topographiques periglaciaires telles que des bandes de pierres, des guirlandes de pierres et des croissants de pierres se sont également constituées au cours du Pléistocène et ont atteint de très grandes dimensions en raison de la lithologie, du fait d'une glaciation relativement réduite et de l'état de decomposition de la roche de fond.

ZUSAMMENFASSUNG. *Zeugnisse einer Kar-Vergletscherung auf den Falkland Islands.* Das Vorhandensein von 49 Karen auf den Falkland Islands zeigt an, dass während des Pleistozäns glaziale Verhältnisse vorherrschten. Kar-Moränen und von Gletschern geformte Täler kommen ebenfalls vor. Es scheinen drei Phasen stattgefunden zu haben: eine Periode der Karbildung, das Wachsen kleiner Eiskappen und die darauf folgende Karentwicklung. Periglaziale Bodenformen wie Steinbänder, Steinterrassen und Steinloben wurden ebenfalls während des Pleistozäns gebildet und nahmen wegen der Lithologie, des verhältnismässig geringen Ausmasses der Vereisung und des Vorhandenseins von brüchigem Grundgestein sehr grosse Dimensionen an.

INTRODUCTION

Situated in the South Atlantic Ocean between lat. 51° and 52° 30′ S. and long. 57° 30′ and 61° 30′ W., the Falkland Islands consist of two large islands fringed by a myriad of smaller ones (Fig. 1). The nearest mainland is the coast of Patagonia almost 600 km to the west; the heavily glacierized island of South Georgia lies over 600 km to the east. Although Pleistocene ice caps covered extensive areas of Patagonia (Flint, [1957]) and buried most of South Georgia, it has generally been considered that the Falkland Islands did not support permanent glaciers. Believing that even during the glacial maxima only periglacial conditions occurred in the islands, Maling (1960, p. 183) stated "It must be emphasised that there is no evidence of permanent glaciation in the Falkland Islands at any time during the Pleistocene". A recent visit by the present writer to West and East Falkland, and the examination of vertical aerial photographs of the islands has enabled the identification of 49 prominent cirques, many of which have contiguous moraines.

The Falkland Islands are composed almost entirely of Palaeozoic and Mesozoic sedimentary rocks with quartzites and sandstones predominant. The general summit level of the hills is from 500 to 625 m, but some rise over 700 m on both islands. Mount Usborne (710 m) on East Falkland is the highest hill. Rounded and broad-crested summits predominate and steep slopes generally separate the main hill masses from adjacent lowlands.

CIRQUES, GLACIATED VALLEYS AND MORAINES

All of the cirques in the Falkland Islands are on hills rising above 540 m. Varying from well-developed semi-circular forms to small embayments in continuous bedrock cliffs, the sharp outlines of the cirques contrast strikingly with the smooth slopes of the mountains (Fig. 2). Most of the cirques have cliffed back and side walls, and many contain tarns. Some of the tarns occupy glacially eroded rock basins but others may be entirely ponded up by the adjacent moraines. The majority of back walls are from 75 to 125 m high but the

range in height is from 15 to 190 m. Small aprons of scree have formed at the bases of most cliffs. The cirques are so similar in form and dimensions to cirques in Britain and other formerly glacierized lands that there is little doubt that those of the Falkland Islands were also created during a period or periods of glacierization.

There are 49 well-defined cirques and at least 13 nivation hollows (Fig. 3). Only five cirques are present on East Falkland, where they scallop the northern slopes of Mount Usborne. The other 44 cirques and the nivation hollows are all located on the principal hill masses of West Falkland.

46 of the cirques and nivation hollows are orientated to the north-east and south-east but none face in westerly directions. These preferred orientations are probably related chiefly to two factors: 64% of the winds in the Falkland Islands blow from the quadrant

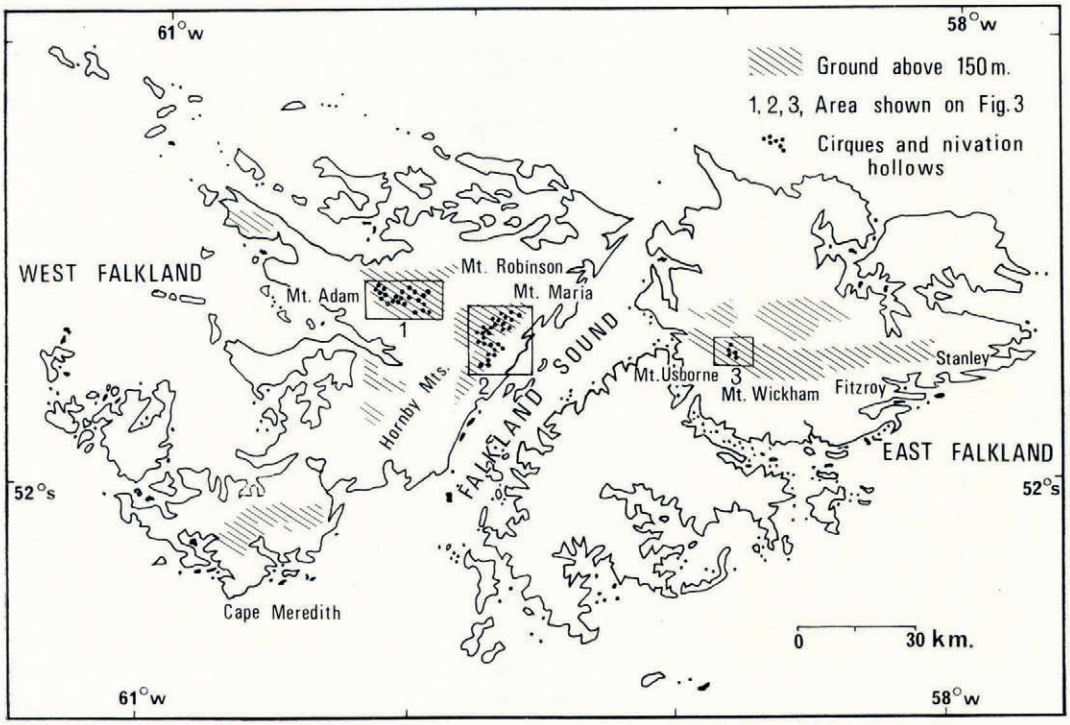

Fig. 1. Distribution of cirques and nivation hollows in the Falkland Islands.

between south-west and north-west (Maling, 1960). Snowdrifts would therefore have been greater on the eastern sides of the hills. The alignment of topography explains why the cirques face predominantly towards the north-east and south-east rather than towards the east (Fig. 3).

Although north-east-facing slopes on the Falkland Islands probably receive more insolation than south-east-facing ones, they carry 41% of the cirques; 35% occur on the south-east-facing slopes where considerably less insolation is received. This contrasts with the well-known situation in most parts of Europe where cirques tend to be most numerous on slopes of low insolation (Flint, [1957]). The anomaly in the Falkland Islands is possibly accounted for by the alignment of the topography and a predominance of south-westerly winds in glacial times.

The floors of 78% of the cirques lie in the altitudinal range of 400–480 m, strongly suggesting that a firn line lay near that range for some time. The floors of the remaining cirques occur at various altitudes between 300 and 585 m. Cirques on West Falkland are too close together to have been noticeably influenced by the rain-shadow effect but it has been important on East Falkland. The floors of four out of the five cirques on Mount Usborne are over 555 m a.s.l. This contrasts with West Falkland where the floors of only two out of 44 cirques exceed 555 m.

A study of the disposition of the cirques and related moraines strongly suggests that there has been more than one phase of glacierization in the Falkland Islands. The nature of the evidence is as follows.

Fig. 2. The cirques on Mount Usborne, East Falkland.

The floor of the largest cirque on Mount Usborne lies approximately 170 m lower in altitude than those of the four adjacent cirques. It is difficult to believe that they all relate to the same firn line. Similarly, the cirques on the northern slopes of Rocky Mountain and Clay Mountain and on the south-east flank of Shingly Mountain are much larger than any of the nearby cirques and their floors are 170 m lower. The upper slopes of these large cirques on West Falkland are clearly truncated by prominent secondary cirques. Two periods of cirque development have thus occurred and they may relate to separate periods of glacierization. For example, the large cirques formed when the firn line was as low as 385 m on East Falkland and 300 m on West Falkland. The secondary cirques developed when the firn line was not lower than 550 m on East Falkland and 450 m on West Falkland.

Small ice caps possibly formed during the more extensive period of glacierization. This is suggested by certain valleys in the Mount Adam–Mount Robinson area. The trough-like form of the valleys is very similar to that of valleys in glacierized lands and they contrast

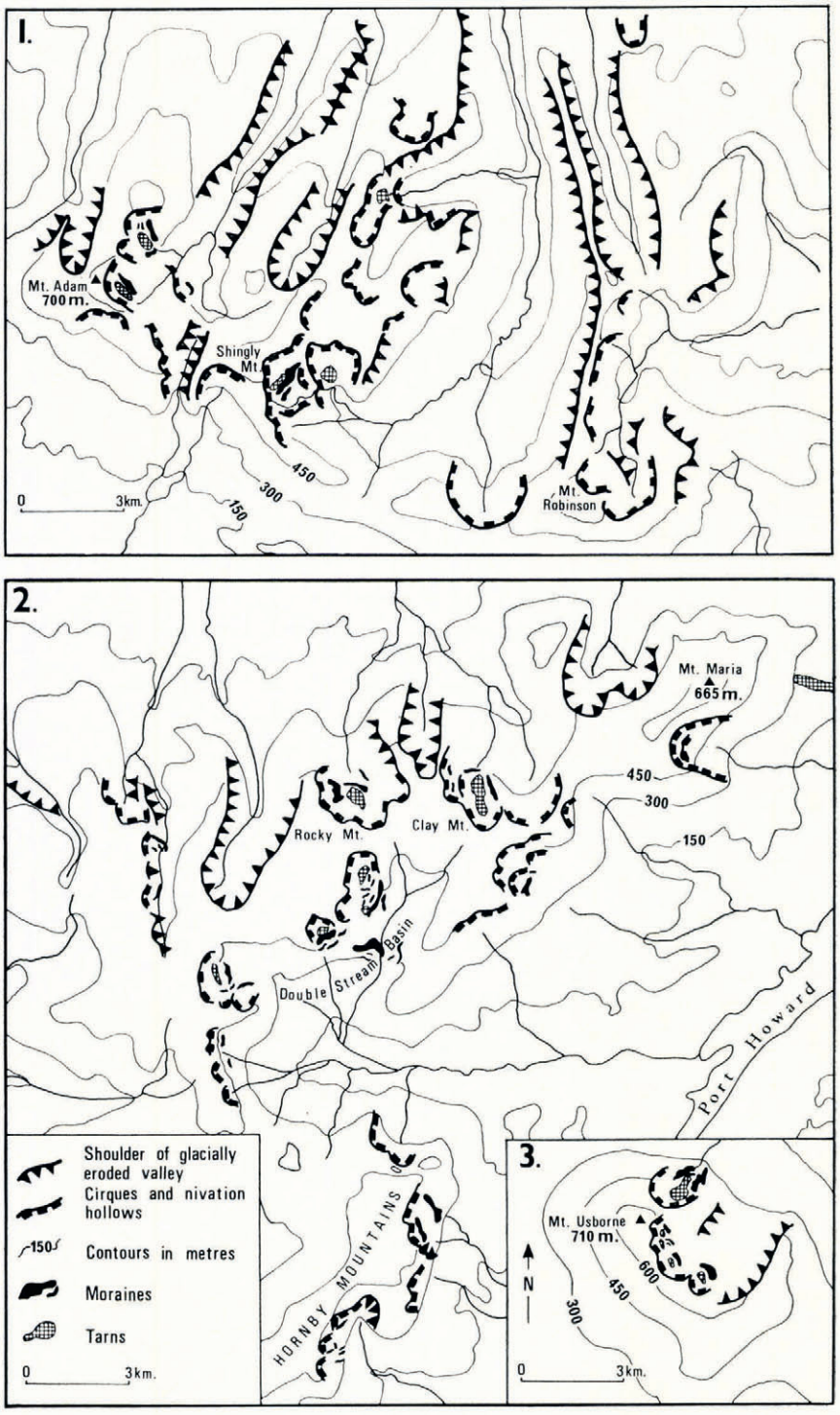

Fig. 3. The glacial landforms of the Falkland Islands. For locations see Figure 1.

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with all of the other valleys in the Falkland Islands. The troughs are unlikely to have been created by small cirque glaciers and they probably developed beneath local ice caps. Because small cirques are present on the upper parts of some of the troughs, at least one period of cirque development post-dates the ice-cap phase.

Conspicuous moraines varying from large single ridges to complex multiple ridges are present at 35 of the cirques. Some of the moraines are small features only a few metres high but many are steep-sided sharp-crested ridges rising over 15 m above adjacent tarns. Many of the moraines are crescent-shaped and curve across the lips of the cirques. The extremely steep sides of the ridges suggest that the morainic debris is very coarse. The size of most moraines seems to be proportional to the volume of debris removed from the parent cirque but some cirques have no moraines and others possess very small ones.

Significance of the periglacial landforms

Although the stone runs of the Falkland Islands have been discussed by several authors (Andersson, 1906; Baker, [1924]; Joyce, 1950), the contiguous and equally abundant and prominent stone lobes and stone terraces have received little attention. Like the stone runs, the latter testify to former periods of intense mechanical weathering and rapid down-slope movement of debris, probably during periglacial conditions. All of the exposed stones in the runs, lobes and terraces are lichen-covered and are no longer in motion; the edges of the stones have been rounded by weathering. The forms are thus relict.

If the cirques had been exposed to the climatic conditions responsible for the development of the stone runs, their walls would be severely degraded by frost-shattering and the accumulation of massive screes. This is not so. The cirques are strikingly fresh and even the moraines have not been modified by stone runs. On Mount Usborne, stone runs and related features abundantly occur on the mountainside below the cirques and contiguous moraines. Similarly, stone runs are notably lacking and are poorly developed until well beyond the cirques on the mountains of West Falkland. The cirque areas thus appear to have been covered by snow and ice when the lower hills were subjected to intense periglacial weathering. Because some stone runs and other debris forms occur on the oversteepened valley sides of the Mount Adam–Mount Robinson area, they must post-date the ice-cap glaciation but those occurring outside the cirque areas probably represent more than one period of Pleistocene periglacial conditions.

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