HISTORIC VOLCANIC ACTIVITY AT DECEPTION ISLAND

By M. J. ROOBOL*

ABSTRACT. A British expedition to Deception Island in 1829 produced an accurate map of the island and detailed descriptions. A comparison of these with the 1956 air photographs, the 1959 topographic map and a field visit in 1968 reveals local morphological changes. Youthful craters, which in 1829 were open to the sea, have been infilled with water-transported and pyroclastic material. Eruptions resulting in new craters and pyroclastic deposits occurred between 1829 and 1956. Much of the topography described here and visited has since been destroyed or buried by the eruptions of 1967, 1969 and 1970.

DECEPTION, Penguin and Bridgeman Islands are subaerial volcanic centres situated in Bransfield Strait between the South Shetland Islands and the Antarctic Peninsula. The December 1967, February 1969 (Baker and others, 1969), and August 1970 eruptions (Baker and McReath, 1971) at Deception Island have created much interest in the area, culminating in an international volcanological expedition in 1970 (Orheim, 1971*a*). Deception Island is by far the largest of these centres, measuring 14 km. north–south and 13 km. east–west, with a striking horseshoe plan due to the large flooded caldera of Port Foster. The above three eruptions occurred on the elliptical fault zone bounding the caldera and have added to the broad belt of pyroclastic cones previously there (Hawkes, 1961). This belt is now incomplete only at Fumarole Bay in the west and at Neptunes Bellows in the south-east—the only sea entrance to Port Foster.

EVIDENCE OF PREVIOUS HISTORIC ERUPTIONS

One of the first questions raised after the present eruptions is that of how active is Deception Island. The only previously recorded sighting was reported by Wilkes (1845, p. 149) as a much abbreviated letter from a sealing captain, William H. Smiley.

> ". . . Captain Smiley, who mentions in his letter to me, that in February 1842, the whole south side of Deception Island appeared as if on fire. He counted thirteen volcanoes in action. He is of the opinion that the island is undergoing many changes."

Andersson (1906) and Adie (1957) regarded this description as exaggerated, since Wilkes also reported that Captain Smiley sailed into Port Foster at this date, searched for and found a self-registering thermometer left there by the *Chanticleer* expedition. It may be that what Smiley saw were 13 unusually active fumaroles, suggesting that he had just missed an eruption a few months earlier.

Orheim (1971*b*, *c*), in a study of the walls of the chasms produced in the Deception Island glaciers by the 1969 and 1970 eruptions, has recognized pyroclastic deposits within the ice. He has reported six in the walls of the 1969 fissure and eight in the walls of the 1970 chasm. He concluded that there has been a cyclic pattern of eruption over the past 200 years. His study is continuing.

THE 1829 STUDY OF DECEPTION ISLAND

On the evening of 9 January 1829 His Majesty's Sloop *Chanticleer* entered Port Foster and remained there until 8 March 1829, engaged in scientific studies. During this time Lieut. E. N. Kendall constructed the topographic map shown in Fig. 1 (Kendall, 1831). His comments on his work will be of interest to the recent investigators:

> "It was, however, cheerless work. The fogs were so frequent that, for the first ten days, we saw neither sun nor star . . . we did our work; and, being allowed a boat and four men, I surveyed the island, sleeping at night on the cindery beach, with no other covering than a canvas tent."

Captain Henry Foster, in command of the expedition, commented in his hydrographic

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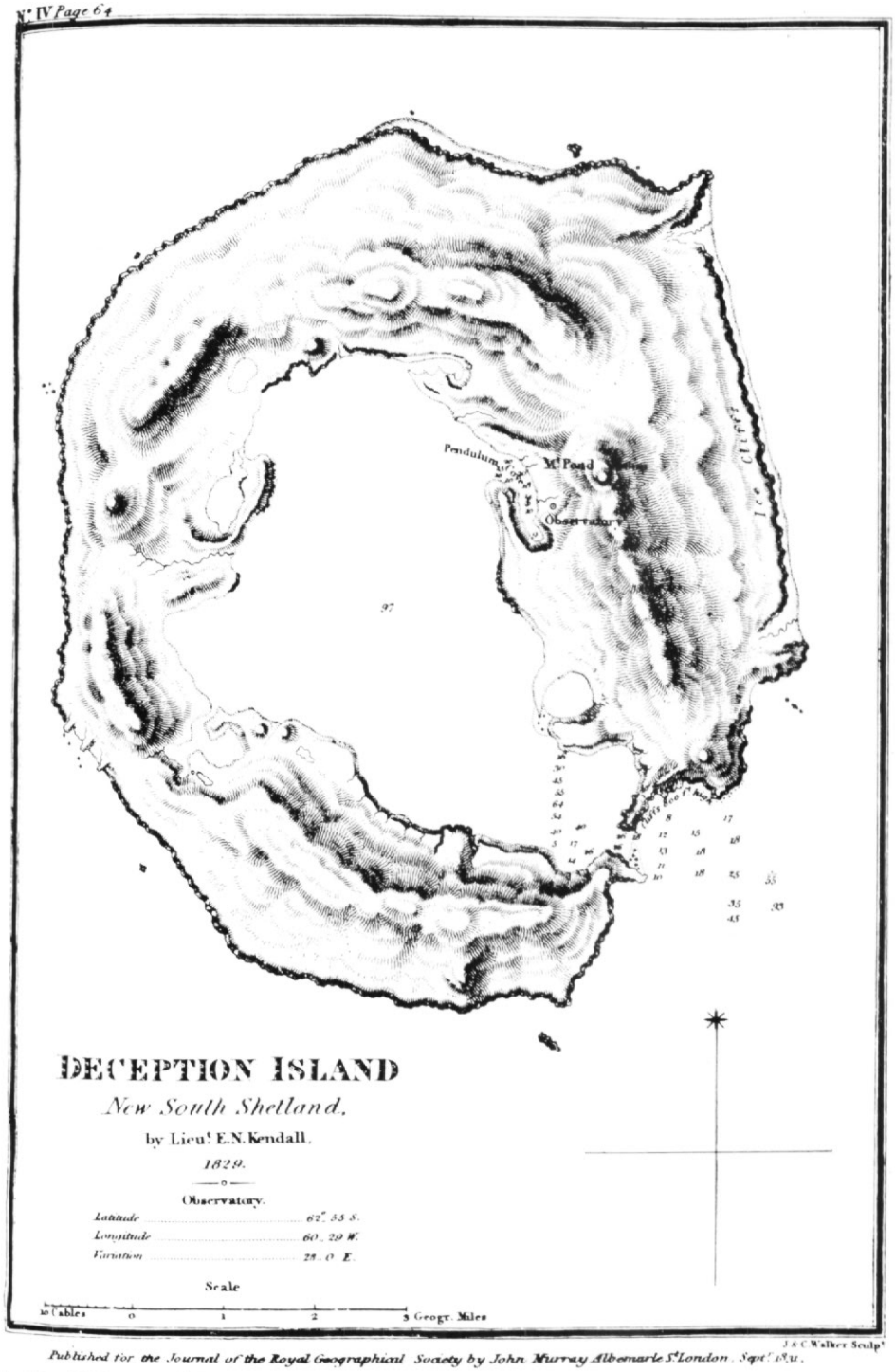

Fig. 1. The 1829 map of Deception Island by Lieut. E. N. Kendall (original scale). (Reproduced by kind permission of the Royal Geographical Society.)

report, published in the account of the voyage by the ship's surgeon, W. H. B. Webster (1834, vol. 2, p. 279):

> "In the event of this island being hereafter visited by persons furnished with proper instruments for surveying, it would be highly interesting to ascertain to what extent the present form of this island may have changed by the active agency of rivulets, or the more powerful action of volcanic eruptions, for which purpose the careful survey made by Lte. Kendall will prove very valuable."

It is proposed here to make such a comparison, the results of which locate several craters which have formed during the past 200 years. These results complement those of Orheim.

Modern Studies of Deception Island

An excellent set of vertical air photographs exists, and these were flown by Hunting Aerosurveys Ltd. in December 1956. From these the 1959 topographic map (scale 1 : 25,000) of the island was produced (*in* Hawkes, 1961). Fig. 2 is a reduced outline of this map, which when compared with Fig. 1 provides a remarkable fit. In particular, the shores of Port Foster appear more accurate than the outer shores of the island. This presumably reflects the small-boat work of Kendall which would have been restricted to the safer waters of Port Foster.

There are striking local differences between Kendall's map and that of 1959. As some of the localities were described in detail by Kendall, Foster and Webster, the possibility of poor coastal mapping can be ruled out. The author first visited Deception Island in December 1968 as a member of the British Antarctic Survey–Royal Society Expedition. Copies of the original map and accounts were carried there and the changes were investigated. At that time, with the exception of the 1967 island and land centre, there were few morphological changes of the island since the 1956 air survey. A thin veneer of pyroclastics was mapped (Baker and others, 1969, fig. 2) but this was rapidly being removed by melt water. The 1969 and 1970 eruptions have since obliterated much of the 1956 topography which can still be seen on the air photographs of that date and the 1959 map.

Comparison of 1829 and 1956 Topographies

Two groups of altered features can be recognized:

A. Youthful flooded craters, which became infilled due to sedimentation from annual melt waters and younger pyroclastic material.

B. Craters which do not exist on the 1829 map and therefore formed between 1829 and 1956. Most of these probably formed before 1912 when the whaling station was constructed in Whalers Bay (Hydrographic Department, 1943). The occupation of this station was not continuous, hence some of the eruptions might have been missed.

A1. Pendulum "Cove"

In 1829, H.M.S. *Chanticleer* was moored here in 14 fathoms [25·6 m.] of water. By 1956 the cove no longer existed and had been almost completely infilled by transported pyroclastic material, leaving only a small lake termed Relict Lake by Hawkes (1961). The original Pendulum "Cove" was situated due east of Crimson Hill. The name Pendulum Cove today refers to that part of Port Foster immediately north of Crimson Hill. Captain Foster (*in* Webster, 1834, vol. 2, p. 279) gave a lengthy discussion of another cove (Fig. 3, A2) which had been used by early sealers, but in 1829 it was largely infilled and blocked by a sand bar at shallow depth. The preference of the sealers for this less sheltered cove, rather than Pendulum Cove, suggests that the latter may only have formed during the first quarter of the nineteenth century. Relict Lake was infilled by material from the 1969 eruption.

A2. The sealers' harbour to the north of Pendulum Cove

This was situated immediately below the caldera wall in the north-eastern part of Port

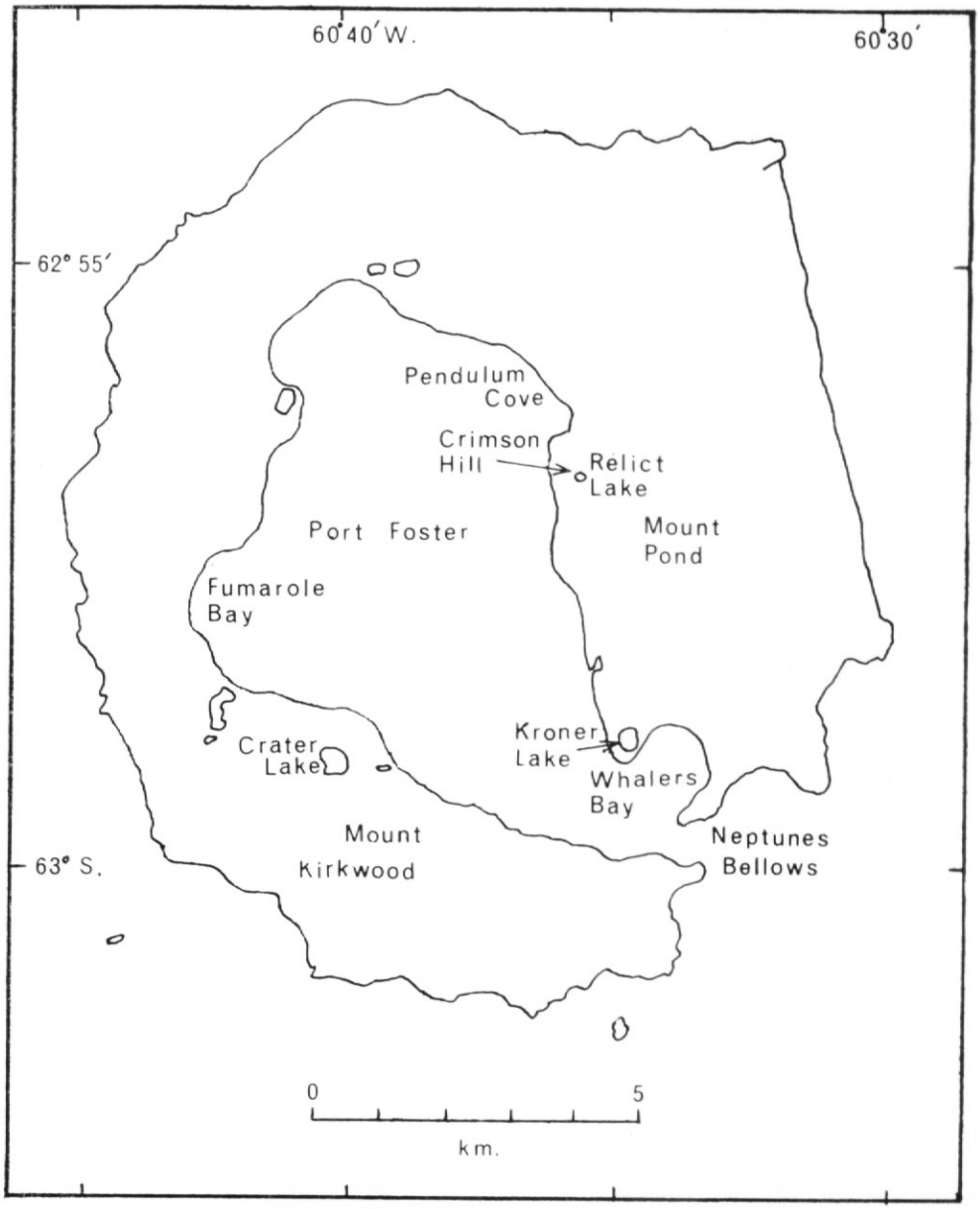

Fig. 2. Reduction of the 1959 map of Deception Island (*in* Hawkes, 1961).

Foster. It was known to Captain Foster and identified by him from the debris of the sealing industry scattered there. Captain Foster concluded (*in* Webster, 1834, vol. 2, p. 279):

> "and from all these circumstances I am induced to believe that the cove in question is the one which is stated as capable of affording anchorage for five or six vessels in four or five fathoms of water over a bottom of good clay, the entrance into which is now nearly blocked up by a spit that has extended itself right across the entrance, and in some places is dry at low water."

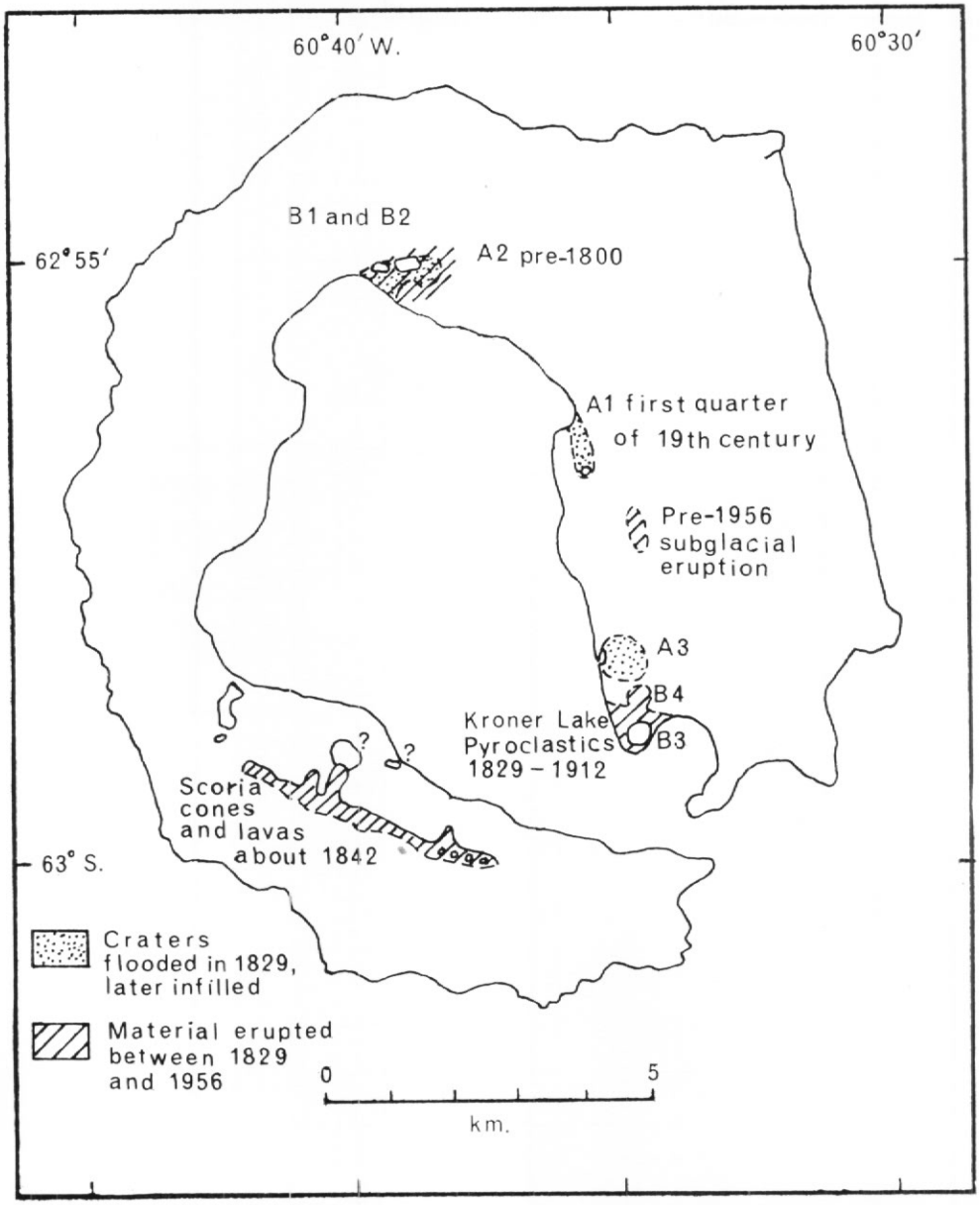

Fig. 3. Suggested historic eruptions at Deception Island.

In 1956 and 1968 there was no evidence here of a silted-up crater as the one behind Crimson Hill. Rather, two young maars were present on this site and these were separated from the sea by a bank of pyroclastic material 13 m. high. These appear to have formed by a volcanic eruption between 1829 and 1956 (marked in Fig. 3 as B1 and B2). This same site was blanketed by pyroclastic material during the 1970 eruption and the maars were infilled.

A3. The north shore of Whalers Bay

One of the most striking differences between the 1829 map and the 1956 air photographs is the north shore of Whalers Bay. In Kendall's map the two shores of Whalers Bay diverge

at an angle of about 60°, whereas in 1956 and at present they are almost parallel. A very impressive, circular, flooded crater open to the sea (A3 in Fig. 3) lay immediately north of Whalers Bay, whereas on the modern maps there is no evidence of this. A study of the 1956 air photographs very clearly shows the 1829 crater A3 (Fig. 4). It has been largely infilled by a blanket of younger pyroclastic material, glacial outwash material and in part by the snout of a glacier. In 1968, a small inlet of the sea marked the seaward side of this crater and its northern wall deflected the 1969 jokullhlaup* which left a "tide mark" of ice-cemented ice fragments and blocks on the wall up to 3 m. above the floor.

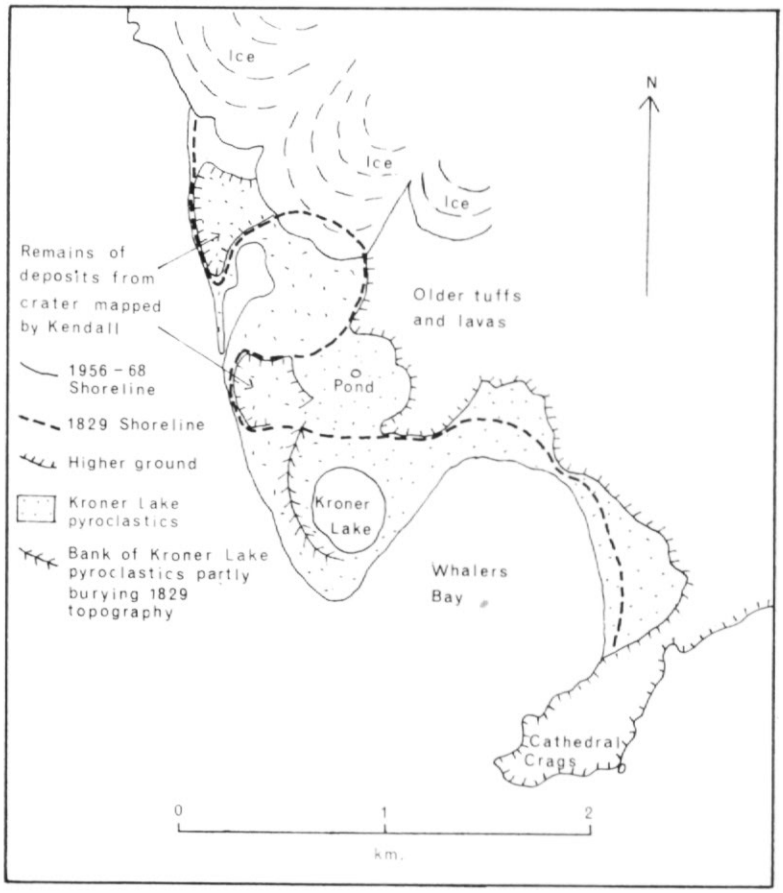

Fig. 4. Map showing changes in topographic features in the Whalers Bay area, 1829–1956.

The reduction in area of Whalers Bay is due to the Kroner Lake peninsula (Fig. 4), which consists of fresh, unconsolidated, air-fall pyroclastic material. A bank of this material on the western side of the crater (Kroner Lake; B3 in Fig. 3) partly blankets the 1829 topography. The Kroner Lake pyroclastics must have been erupted between 1829 and 1912 as the shore around Whalers Bay was littered with whale bones in 1968—evidence of the early wasteful days of the whaling industry. There appear to have been two vents during this eruption, Kroner Lake (B3) and the depression (B4) immediately to the north. The latter formed in the 1829 peninsula (Fig. 4), and in 1968 it was occupied by a small pond. The vent B4 may

* Jokullhlaup: the Icelandic term for the flood of melt water and ice blocks released in a subglacial eruption. The term is used extensively and the phenomenon has been described by Thorarinsson (1958).

have closed before that of Kroner Lake and was blanketed by later material, leaving only the depression with a small pond in the centre.

The area A3, B3 and B4 (Fig. 3) was washed by the 1969 jokullhlaup. The small inlet in the A3 crater was completely infilled, the depression B4 formed a temporary lake, the pond was infilled, Kroner Lake was breached on its southern side, and the whale bones around the bay were largely buried.

B1, B2, B3 and B4

The young explosion craters B1 and B2 have been described under the heading "A2. The sealers' harbour to the north of Pendulum Cove", and the craters B3 and B4 under the heading "A3. The north shore of Whalers Bay".

The Mount Kirkwood vents

Hawkes (1961) drew attention to the correlation between Smiley's observations and the line of young scoria cones with short lava flows on the northern slopes of Mount Kirkwood (Fig. 3). There is no reason to suggest that these are not the cones of about 1842 age. A careful study of Kendall's map and the 1956 air photographs reveals that the shore north of Mount Kirkwood is smoother today. The conspicuous hills marked by Kendall cannot be seen today; also the edge of a lava flow forming a conspicuous headland is today buried. Kendall's map lacks Crater Lake which is partly infilled by one of the 1842 flows. The smoother features suggest that this pyroclastic blanket is younger than 1829. This could have originated from the Mount Kirkwood cones, some of the vents of which are hidden beneath the permanent ice cover, or from Crater Lake. As the latter cannot be seen from the sea nor the shore, it is possible that it was overlooked by Kendall and for the present it is assumed that only the Mount Kirkwood vents are post-1829. This area is still accessible for more detailed studies.

A vent on Mount Pond

In 1968 the snout of the "black" or "dirty" glacier in Port Foster, mid-way between Whalers Bay and Pendulum Cove, contained a 2 m. thick bed of red scoria. Although the ice there was sheared and somewhat contorted, the scoria was clearly contained within the ice. The deposit was similar to those erupted on to the ice during the 1969 eruption and has migrated down-slope with the ice. The age of this subglacial eruption is unknown.

Conclusions

Comparisons of the map and descriptions of the 1829 *Chanticleer* expedition to Deception Island, the 1956 air photographs and field observations made in 1968 reveal evidence of a rapid morphological evolution around the shores of Port Foster. Two youthful flooded craters of 1829 were infilled with sedimentary and pyroclastic material by 1956. In 1829, Captain Foster described the silting up of a third crater at that time. At least four craters and their accompanying deposits appeared around the shores of Port Foster between 1829 and 1956. The young cones and lavas of Mount Kirkwood are probably of around 1842 age. There is evidence of a subglacial eruption similar to that of 1969 on the inner slopes of Mount Pond at some considerable time before 1968. As Kendall's map lacks detail of the dry craters, it is only possible to compare the shoreline changes between 1829 and 1956. It is probable that several dry craters have also formed during the past few hundred years. However, enough has been recognized to place Deception Island among the more active volcanoes on Earth. These conclusions support the study of ash layers within the glaciers at present being carried out by Orheim.

Acknowledgements

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