THE VOLCANIC ERUPTION AT DECEPTION ISLAND, DECEMBER 1967

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ABSTRACT. A volcanic eruption began at Deception Island, South Shetland Islands, on 4 December 1967, and continued until at least the evening of 7 December 1967. The activity occurred at two centres located at the northern end of the island where at least six vents were active. A new island composed entirely of ash and scoriaceous debris was created in Telefon Bay; eruptions at the other centre, 1,500 m. north-east of the new island, caused substantial morphological changes in the vicinity of an old crater on the mainland part of Deception Island. No lava flows were associated with the eruption whose highly explosive nature probably resulted mainly from the contact of the rising magma with sea-water. On the second day of activity the eruption cloud reached a height of 8,000 m. Most of the eruption products are andesitic in composition and highly scoriaceous.

DECEPTION ISLAND (lat. 62°57′S., long. 60°38′W.) (Fig. 1A) is an almost circular volcanic island situated at the south-western end of the South Shetland Islands and north-west of the Antarctic Peninsula. Volcanic rocks of Tertiary–Recent age are present on some of the other members of the South Shetland Islands group but only Deception Island has been observed in eruption. Following a detailed geological survey of Deception Island, Hawkes (1961) concluded that, subsequent to an early phase of volcanism, the central part of the island collapsed along a series of arcuate faults forming a broad caldera to which the sea gained access. The locations of later eruptions have apparently been determined by the disposition of major arcuate and radial faults associated with the caldera collapse. The last of the three post-

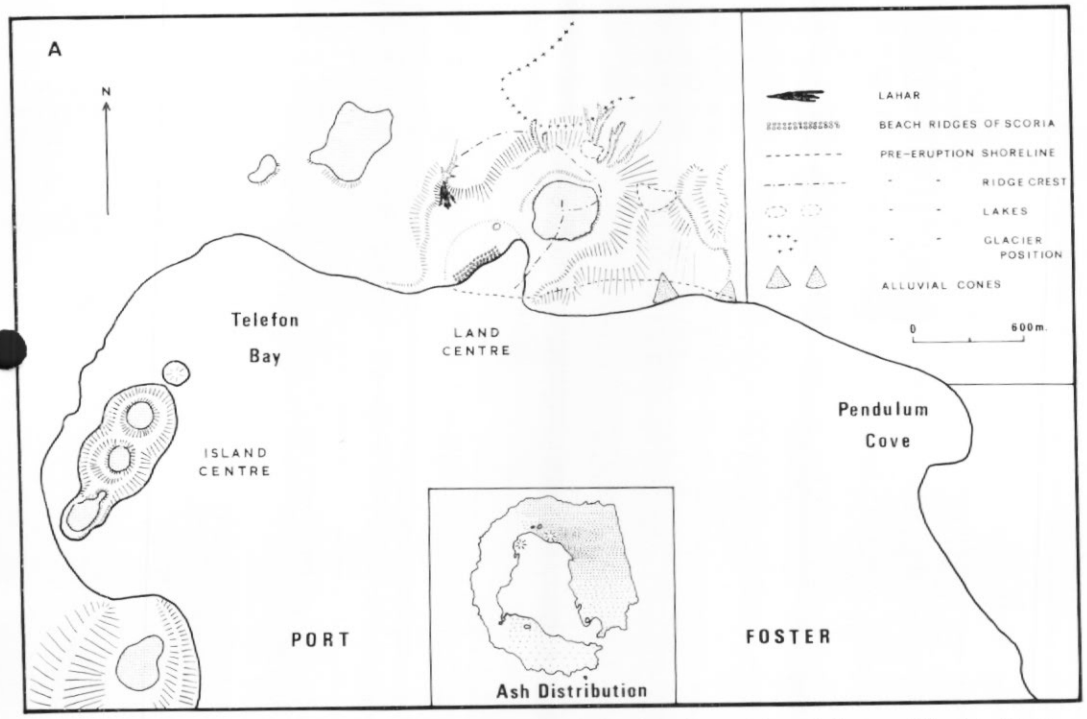

Fig. 1. A. Map of the northern part of Deception Island showing the position of the new island in Telefon Bay and morphological changes in the vicinity of the land centre to the north-west of Pendulum Cove. The inset indicates the density of ash distribution by the intensity of stipple.

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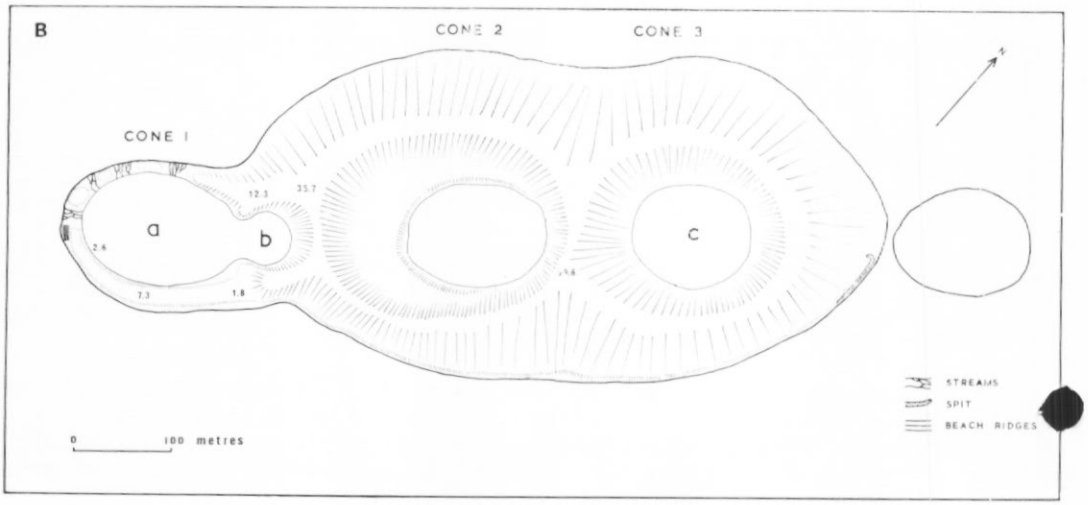

Fig. 1. B. Map of the island centre showing the relative positions of the cinder cones and the small low islet to the north-east of the new island.

caldera phases of eruption (Whalers Bay Group) was characterized in places by scoriaceous basaltic lavas erupted on to thick moraine and fluvioglacial deposits.

At 22.45 hr. G.M.T. on 4 December 1967, a volcanic eruption occurred at Deception Island. The activity was confined to the northern part of the caldera, where a new island (Fig. 2) was formed at the western side of Telefon Bay and new craters were created in the floor of an old one near the shore on the eastern side of the same bay (Fig. 3). The eruption products were ejected from a series of vents that are probably aligned along the fault lines believed to be present around Port Foster. When R.R.S. *Shackleton* visited Deception Island

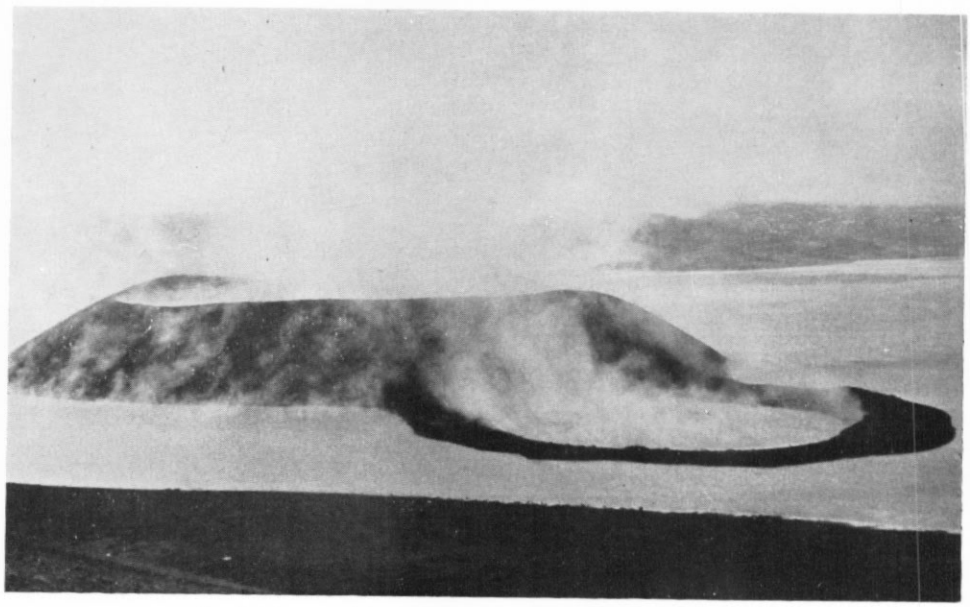

Fig. 2. The new island in Telefon Bay viewed from the west.

on 7 December the land centre was still erupting (Fig. 4) but only clouds of vapour were being emitted from the new island centre.

Arriving at Deception Island on 14 December 1967, the author was able to spend the next 4 days making a preliminary investigation of the results of the eruption. All explosive activity had ceased but there were vigorous fumaroles within and around the craters. The two centres in west and east Telefon Bay will be referred to here as the island and land centres, respectively.

The Island Centre

Morphology

The new island consists of three adjoining cinder cones aligned in a row roughly from south-west to north-east (Fig. 1A). Extending for 987 m. in that direction, the island is 390 m. wide at its broadest part. The highest point is 59·6 m. a.s.l. (taken as high-water mark). Approximately 9 m. offshore at the eastern tip of the island a small islet, rising to about 3 m. above high-tide level, is approximately 110–140 m. in diameter. The three cinder cones contrast considerably in their dimensions and will be described as 1 to 3 from south-west to north-east, respectively (Fig. 1B).

Cone 1 is a low narrow ring of debris with a maximum height of 7·3 m. a.s.l. The wall is breached at high tide in four places, where networks of tiny rivulets drain from the crater lake into the sea at low tide. Cones 2 and 3 are much larger features, their outer flanks rising steeply with convex slopes of 35–20° to heights of 59·6 and 25·6 m., respectively. The inner walls of all three cinder cones descend precipitously to the water-filled craters.

Although it is not enclosed by a separate cinder cone, there is a fourth crater on the island (Fig. 1B, locality b). It is connected to the crater lake within cone 1 by a narrow neck of water and it appears to have been formed relatively late in the eruption for it has been blasted out of the western flanks of cinder cone 2. The prominent bench within cone 2, about mid-way down towards the crater lake on the south-west side, possibly represents the floor of a vent that became disused and disrupted when the vent occupied by the lake came into operation.

While only one crater lake has a surface connection with the sea, all of the crater lakes are tidal. The same phenomenon is present at Kroner Lake near Whalers Bay and this is probably due to the high porosity of the volcanic material.

At both ends of the island, beach deposits form ridges and spits up to a height of approximately 1·5 m. a.s.l. Several small ridges of scoria particles 5–8 cm. in size have been superimposed to make a larger ridge at the south-west end of the island, while at the opposite end a

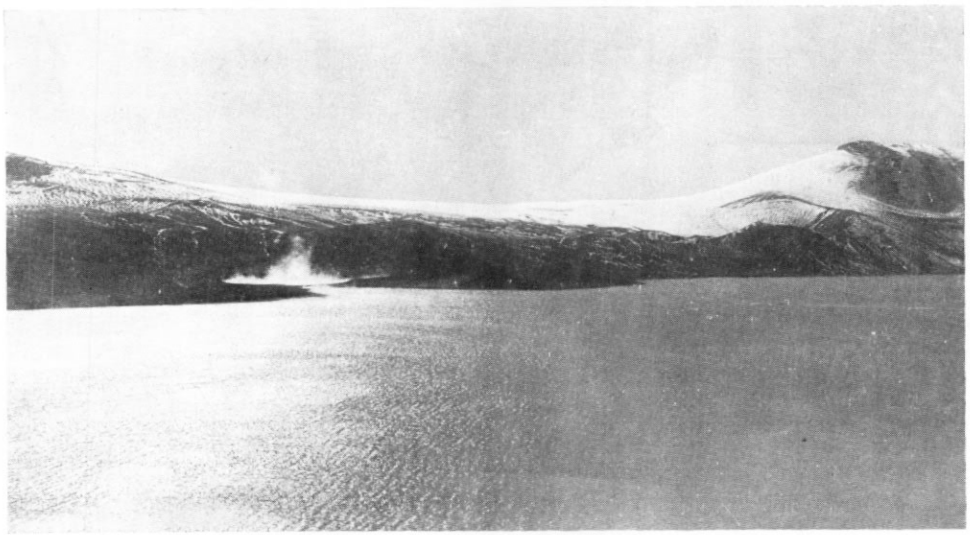

Fig. 3. The land centre viewed from the south-west.

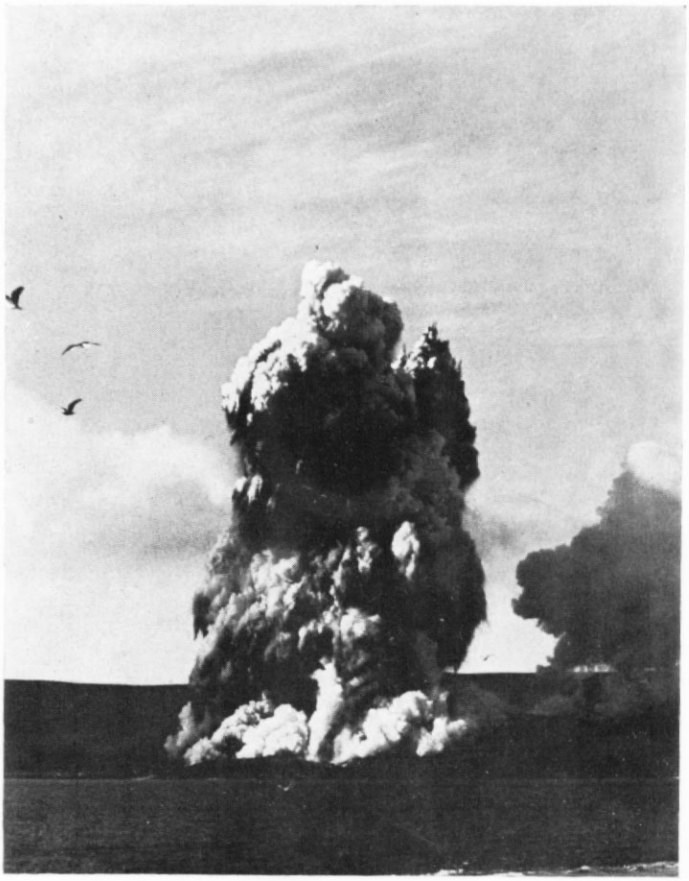

Fig. 4. One of last eruption clouds emitted from the land centre; 7 December 1967. (Photograph by D. Borthwick.)

conspicuous hooked spit curves from south-west to west. These features are presumably related to the abnormally high tidal oscillations in Port Foster caused by the eruptions; the beach deposits are undisturbed by bomb craters.

Materials

The eruption products composing the new island are entirely clastic, consisting primarily of coarsely bedded ash and scoriaceous lapilli. Large bombs of scoria are sporadically contained within the layers and in some places they appear to be more numerous in the basal strata. The island's surface is liberally strewn with scoria bombs from 0·5 to 1·5 m. in length; the largest bomb observed was 3 m. long. The surface of cinder cone 2 very largely consists of such coarse debris, particularly at the low points on the crater rim. There is no evidence within the observed strata indicating that lava flows accompanied the eruption. Predominantly black and brown in colour, the scoria for the most part is high vesicular. Numerous fragments have a decidedly clinkery appearance with spiny needles prominent in the cavities. Blocks of fine-grained grey and pink lava are occasionally present amongst the scoriaceous material, contrasting with the latter in colour, weight, composition and structure.

Since the new island is only a short distance from the western shore of Telefon Bay, it was possible to estimate the maximum distance that bombs had been thrown in that direction. They litter the beach, roughly 130 m. away, but there are few beyond this distance and they do not

occur more than 275 m. from the western tip of the island. The distribution and thickness of ash was also noted on parts of Deception Island but these observations have since been superseded by the detailed studies of a later expedition.

Temperature measurements

These were made at random in the crater lakes and in the fumarole areas; the results are tabulated below. When measuring fumarole temperatures, it was very noticeable that the intensity of the vapour jets varies continually. Because the water temperatures had to be taken round the edges of the crater lakes, they varied according to where the thermometer was placed. The higher temperatures were obtained over the sites of fumaroles bubbling up through the water.

Locality (Fig. 1B)	*Water temperature* (° C)	*Fumarole temperature* (° C)
a	42 (west end)	
	70 (between a and b)	
b	62	
	71	90
	68	91 (outer flank)
		88 (west side)
		98
		77 (outer flank)
		93 (east side)
c	97 (immediately over fumarole)	77 (outer flank, east side)
	55 (away from fumarole)	75 (inner slope, west side)
	99 (bubbling fountain)	100 (inner slope, west side)

Fumaroles

Countless fumaroles occur on the floors of all four craters and round the shore of the island, where they bubble to the surface through the shallow water. At low tide many of these are exposed to the air so that greater quantities of vapour enshroud the island. In addition to those submerged beneath water, a large number of fumaroles is present in various places on the slopes of the cinder cones, excepting those of cone 1. The majority occur on the inner slopes of cones 2 and 3, and on the walls of the crater at locality b (Fig. 1B); those occurring on the outer flanks of the cones do so mainly near the top. The vapour issues mostly from small circular cavities 2–10 cm. in diameter. Many of these lie beneath large bombs, but on the north-east slopes of cone 2 large fissures continually emit fluctuating amounts of vapour; four prominent fissures about 5–8 m. long and 5–12 cm. across descend with these dimensions to unknown depths. Except for the latter, most fumaroles are surrounded by small patches of mineral deposits that have crystallized from the vapour. The sublimate minerals are yellow and white in colour, but they have not been identified.

Although it was not possible to make detailed investigations in areas where fumaroles normally occur on Deception Island, certain relevant observations were made. In general, it was agreed by people familiar with the normal fumarole activity of the island that the intensity of vapour emission had increased. Indeed, personnel at the British Antarctic Survey station reported a rise in sea temperature from $-2{\cdot}2°$ to $+1{\cdot}1°$ C in Whalers Bay a few days prior to the eruption, suggesting increased fumarole activity in that area; unusually large volumes of vapour rose from Kroner Lake and the shallow bay 1,000 m. to the north on 15 December. The most striking fumarole activity was noticed in the vicinity of Telefon Ridge, approximately 1,500 m. west of the new island in Telefon Bay. A row of between 20 and 30 clearly defined jets of vapour rose vigorously to a height estimated at 15–30 m., and they appeared to be located in the vicinity of the col crest. Although they were observed from a distance of almost 1·6 km., the hissing noise accompanying the more vigorous emissions was clearly heard. These fumaroles were seen only on two occasions within a 3-day period and these were both in the late afternoon. At other times there was no obvious sign of vapour and no sounds could be heard.

The Land Centre

The second eruption centre is located on the shore of Deception Island at the eastern side of Telefon Bay, about 2·4 km. north-west of the Chilean station at Pendulum Cove. The site of the eruption is the floor of an old explosion crater, the age and morphology of which was not discussed by Hawkes (1961). Considerable morphological changes were brought about by the eruption (Fig. 1A), particularly round the southern and eastern sides of the old crater. The former shoreline is substantially different, a pronounced bay having been formed. This is separated from a new crater by a narrow neck of land approximately 150 m. wide. The new crater is located partly where a small embayment lay in the inner wall of the old crater rim and partly where there was formerly a ridge up to 61 m. high. Enclosed by vertical walls of scoriaceous deposits 1·5–10·0 m. high, the new crater is approximately 300 m. in diameter. Clouds of vapour continually rise from the edges and surface of the lake contained by the crater. The ridge that enclosed the old crater on its southern side was blasted away by the 1967 eruption, but a new one of similar dimensions has been deposited a short distance to the south. Exposures on the inner side of this new scoria ridge show that the material consists mainly of stratified ash and lapilli; lava blocks up to 1 m. in diameter are present in places. The displacement of the pre-existing topography has also removed two crater lakes and part of a glacier snout (Fig. 1A).

Between the new crater and the west wall of the old one, a plain of volcanic debris slopes seawards at an angle of 5–3°. The surface material is mainly ash but scoria bombs and blocks of old lava litter the ground. Approximately 1·5 m. of ash overlie the snow slopes west of the old crater. In several places the bombs lie broken in craters 15–60 cm. deep but it was impossible to estimate the depth of the material composing the ash plain. Earth tremors immediately preceding and accompanying the eruption appear to have disturbed some unstable slopes on the western side of the old crater. Large debris fans occur where parts of the crater have collapsed and blocks of perennial snow are scattered about the cliff foot, having tumbled down from the crater rim. Torrential hailstorms are reported to have accompanied the early eruptions; these probably caused the fresh gullying observed on the outer and inner slopes about the land centre. A major canyon which is not depicted on the 1956 aerial photographs now cuts into the north-west corner of the old crater. From the mouth of this canyon an extensive fan of ash and cinders has spread out in a series of finger-like lobes (Fig. 5). The micro-relief of the lobes is interesting in that a pronounced rim of coarser material encloses the finer deposits within. The fan-like deposit is almost certainly some sort of mud flow. It probably consists partly of debris eroded from the canyon and partly of freshly erupted ash and lapilli. The water contained by the mud flow was probably derived from precipitation caused by the violent convection of water vapour associated with the eruption and from melting snow and glacier ice issuing from the branch of the east Deception Island ice dome that terminates close behind the crater. It seems likely that the explosions, increased fumarole activity and rising ground temperatures in the vicinity of the snow and ice were responsible for considerable volumes of water. It is, therefore, possible to classify this type of mud flow as a lahar.

It is interesting that the surfaces of the lahars are mostly free of ash deposits, suggesting that they post-date the phase of the eruption when most of the ash was ejected but, since several prominent craters containing volcanic bombs pit the surface of the lahars, it is clear that the mud had ceased to flow before the eruptions had terminated.

Another interesting effect of the eruption is present on the beach where several small ridges of scoria fragments occur up to 1·5 m. above high-water mark. Like those on the new island, they appear to have been piled up by oscillating high tides caused by the submarine eruptions in Telefon Bay and possibly also in the immediate vicinity. The beach ridges are pitted in places by bomb craters.

There is substantial evidence at the land centre indicating that the crater occupied by the lake was not the only centre of explosive activity; the newly created bay also appears to have been the site of an eruption. The evidence for this is:

i. A gently shelving neck of land, approximately 150 m. wide, separates the crater lake from the head of a newly created bay. The bay head noticeably curves like a crater rim

Fig. 5. The proximal part of the lahar derived from the area west of the land centre. Apparent zoning is shown by colour differences between the inner and outer material of the lahar lobe.

for a short distance and this alignment is continued on land by a small escarpment 2–3 m. high.

ii. At one place inside the crater outline described by the escarpment, the surface of the ash plain is broken by a shallow crater which is not more than 10 m. in diameter and only 0·75–1·25 m. deep. Since it does not contain bomb fragments and is much larger than adjacent bomb craters, it is probably the site of minor explosive activity. The fact that vigorous fumarolic activity occurs on its floor lends support to this suggestion.

iii. Very large volumes of vapour were rising from the bay head and from the gullied wall of scoria deposits enclosing the ash plain on its northern side. Yellow and white sublimates liberally occur as small patches around the fumaroles on the gullied crater wall. Similar amounts of vapour and sublimates elsewhere occur only in the new craters.

The above points suggest that at least two vents were active at the land centre. Since the eruption products did not cut off the seaward crater from the open sea, the outline of only the northern perimeter can be readily identified. Because part of the seaward crater is infilled by a bomb-strewn ash plain, it seems probable that the adjacent vent continued erupting after the former one had ceased. The seaward crater also became partly obscured by the development of beach ridges and lahars.

Conclusion

Prior to the 1967 activity, Deception Island had not been seen in eruption since 1842 (Wilkes, 1845). However, this does not necessarily mean that the volcano was dormant for 125 years, because other eruptions could have occurred during periods when the island was uninhabited. An examination of ash deposits within the island's glaciers may help to elucidate the recent volcanic history.

Since tremors were recorded on Deception Island in late April 1967, it may be assumed that the magma column which exploited weaknesses in the caldera fault system took at least 32 weeks to reach the surface. Because the new cinder cones and craters are roughly similar in form to those classified by Hawkes as the youngest on Deception Island (Whalers Bay Group), the 1967 eruption probably illustrates the broad nature of recent volcanicity on the island.

Eruptions characteristically occur at more than one vent and may be aligned along fissures. The activity is explosive, producing high eruption clouds and large quantities of ash and lapilli; large bombs are not usually thrown far from the vents. Because eruptions probably occur frequently in the vicinity of permanent snow and ice, lahars are also a common feature. One major contrast between the 1967 eruption and the previous ones of the Whalers Bay Group is the absence of lava flows. One probable reason for this is the actual siting of the initial vents which were either on the sea bed or close to the shore. The contact of hot magma with considerable quantities of surface and ground water undoubtedly resulted in explosions of scoriaceous debris that built up cones around the vents. Because of these circumstances, it was undoubtedly impossible for the magma column to rise sufficiently high in the conduits to overflow the vents. The scoriaceous and fragmented nature of the eruption products may not have resulted entirely from such explosive activity, however, for it also seems likely that the high volatile content of the magma itself produced ash, lapilli and bombs of a vesicular character. Activity at the land centre appears to have been more violently explosive than at the island centre, producing more finely comminuted debris. The proportion of coarse material is much lower at the land centre, and scoria cones similar to those at the island centre were not formed round the vents. While at least 1·5 m. of ash overlies snow immediately west of the land craters, the greatest amount of deposition was to the south-east where a new ridge composed of eruption products was created; the location of this ridge is probably partly related to the prevailing wind direction during the eruption period.

Because of the soft unconsolidated nature of the volcanic debris composing the new island, the latter is unlikely to remain as a permanent feature of the Deception Island landscape. Wave attack from the south and south-east in particular, where there is a wind fetch of over 8 km. up Port Foster, will very likely destroy the new island in a relatively short time.

Finally, it is concluded that Deception Island should be considered as an active volcano that will continue to erupt periodically. Future outbreaks will also probably be associated with the fault systems linked with the Port Foster caldera.

ACKNOWLEDGEMENTS

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