PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

General Introduction

J. H. Dickson

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PART I. GENERAL INTRODUCTION

By J. H. Dickson
Botany School, University of Cambridge

[Plates 32 to 34]

CONTENTS

1. Biological objectives of the Expedition

Tristan da Cunha and the three neighbouring islands of Inaccessible, Nightingale and Gough support a unique flora and fauna, poor in numbers of species but rich in endemics. Many of the endemics occur throughout the archipelago while others, some of great peculiarity, such as the flightless birds, are confined to single islands.

Knowledge of the environmental conditions which have prevailed during the evolution of such a biota is very much to be desired. It is in this respect that examination of the damage caused by the volcanic eruption which began on Tristan da Cunha during October 1961 is most important. There are over thirty secondary eruptive centres which form very fresh, prominent features of the topography of Tristan. It is highly probable that the biota has suffered from volcanic activity many times in ways similar to, if not more severe than, those which occurred during 1961 and 1962.

Soon after the eruption started, the Royal Society began to organize an expedition to study the new volcano, to make a geological survey of the Tristan archipelago and to investigate the effects of the eruption on the vegetation and fauna. Details of the history of the Expedition and the geological results are given by Baker, Gass, Harris & Le Maitre (1964). The inclusion of a botanist (J. H. Dickson) and a zoologist (D. E. Baird) was made possible by the generous financial support given to the project by the Trustees of the World Wildlife Fund.

The Expedition, which landed on Tristan on 29 January 1962 and departed on 20 March 1962, used the Settlement (figure 4) as its base. Apart from the period 27 February to 5 March when Nightingale and Inaccessible Islands were visited, the biological studies were carried out chiefly in the vicinity of the Settlement and in areas downwind of the new volcano where most of the damage had occurred (figure 4).

The biological aims of the Expedition were fourfold:

1. To study the effects of the eruption on the biota, both alien and native.
2. To investigate the effects, especially on the abandoned livestock, of the absence of the inhabitants, evacuated as a result of the eruption.
3. To attempt to assess conservation needs.

4. To add where possible to the existing biological knowledge of the Tristan archipelago, principally by the collection of specimens of under-worked phyla.

Parts IV and V of this report are full accounts of the results concerning objectives 1 and 2. Reports on conservation have been presented to the Trustees of the World Wildlife Fund. Detailed consideration of the various specimens collected is not possible at present. However, such identifications as are available are included in Parts II and III.

Before 1962, there had been two major expeditions to the Tristan Islands, namely, the Norwegian Scientific Expedition to Tristan da Cunha 1937–38 (Christophersen 1946) which studied Tristan da Cunha, Nightingale and Inaccessible Islands, and the Gough Island Scientific Survey 1955–56 (Heaney & Holdgate 1957) which visited Tristan da Cunha and made the first prolonged study of Gough Island. Modern biological knowledge of the Tristan islands is based principally on the work of these expeditions. Numerous papers have resulted on many aspects of the biology of the archipelago. Nevertheless, much work of a basic nature remains to be done.

Much more collecting of specimens of all phyla, most particularly of inconspicuous groups (the non-vascular cryptogams and invertebrates) is necessary. Only then will it be possible to draw sound taxonomic conclusions which are based on comparisons with material from other regions of the Southern Hemisphere, especially southern South America, the islands of the southern Indian Ocean and New Zealand. Without such studies, the numbers of species in various phyla, the degrees of endemism, and the geographical affinities of many species will remain obscure.

Apart from this fundamental taxonomic research, many promising investigations wait to be carried out. For example, palynological studies combined with radiocarbon dating may be used to elucidate the history of the biota and volcanism; aerobiological studies may be of great value in relation to the means of arrival of the native biota; and the marked impact of man on the biota can be studied by means of ecological investigations of the competition between alien and indigenous species.

The great quantity of information accruing from the Norwegian Expedition, the Gough Island Survey, the Royal Society Expedition and earlier investigations is assembled and assessed for the first time in Parts II and III, which also serve as backgrounds for Parts IV and V.

2. Physiography of the Tristan–Gough group

The Tristan group* takes its name from the largest of three islands which lie in the South Atlantic (37° 05′ 5, 12° 17′ W) almost mid-way between South Africa and South America. Gough Island lies some 350 km SSE of the Tristan group. The position of the islands is shown on figure 1.

Tristan has long been considered to be one of the isolated volcanic islands which lie on or along the flanks of the Mid-Atlantic Ridge. The crest of the Mid-Atlantic Ridge lies some 540 km to the west of the Tristan group and these islands are the uppermost parts of huge volcanic cones which rise abruptly from the relatively gentle outer slopes of the

* To avoid ambiguity in the following accounts, the phrase 'Tristan group' will be taken to include the three northern islands of Tristan da Cunha, Inaccessible and Nightingale (with their offlying islets), while 'Tristan–Gough group' will include the Tristan group and Gough Island. In accordance with local usage, the main island of the Tristan group is hereafter referred to simply as 'Tristan'.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

ridge some 3650 m below sea-level. Even so, the Tristan group lies within a large arc of the Mid-Atlantic Ridge, which is concave to the east, and most probably the volcanic activity is associated with this major earth structure. Gough Island is the summit of a similar cone rising from water of comparable depth.

Bathymetric surveys undertaken by H.M.S. *Owen* in 1961, and H.M.S. *Protector* in 1962, clearly show that Tristan is the uppermost 2060 m of a huge, symmetrical volcanic cone. Figure 2 is a bathymetric chart of the Tristan group contoured at 100 fathoms intervals.

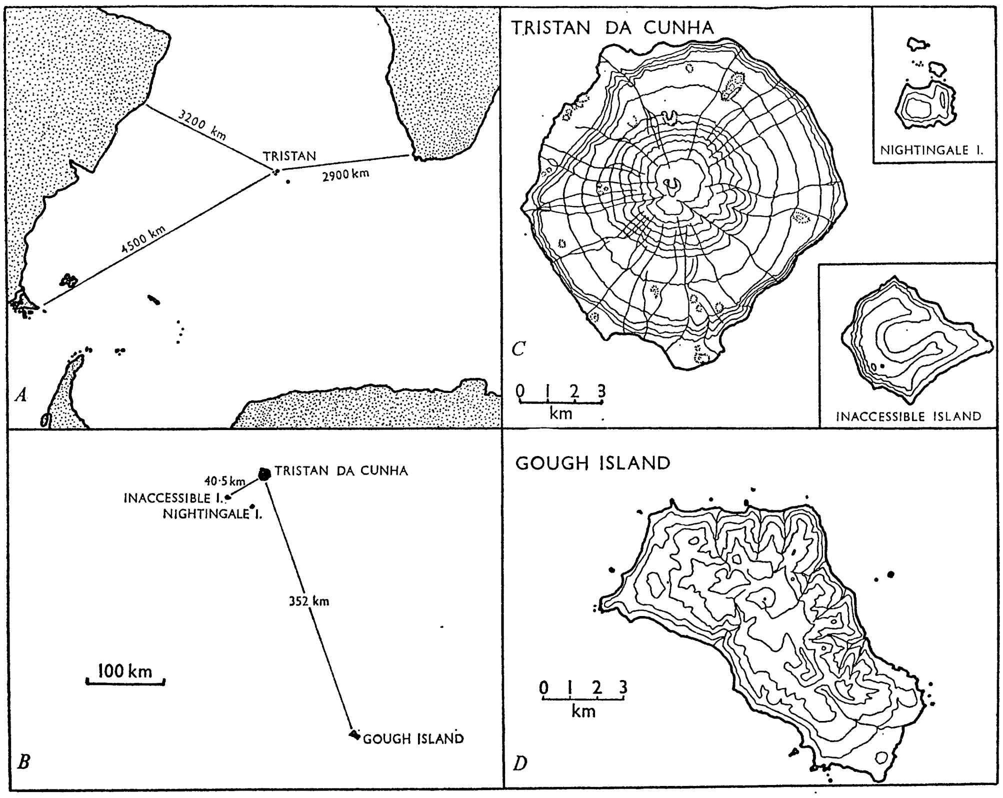

FIGURE 1. The islands of the Tristan da Cunha–Gough Island group. *A*. Position of the group. *B*. Relative positions of the component islands. *C*, *D*. The four islands, drawn to the same scale. Contours at 500 ft. intervals. From Holdgate (1960).

The bathymetric contours around the smaller islands of Inaccessible and Nightingale are more irregular and the presence of an extensive shallow water platform, that surrounds and lies between the islands, suggests that they are eroded remnants of once larger volcanic islands. Between Tristan and the two smaller islands, the water reaches a depth of about 2490 m.

Tristan is roughly circular in plan with an average diameter of between 11·2 and 12·8 km and consists of a central conical peak (2060 m s.m.) from which the land falls away with diminishing gradient to about 600 m. Below this are almost vertical cliffs, often down to the sea. The major topographic features are:

the Peak, for the steeply-inclined, central area above 900 m;
the Base, for the gently-inclined area between 600 and 900 m;
the Main Cliffs, for the 600 m cliffs which bound the island; and
the Coastal Strips, for the low-lying areas between the Main Cliffs and the sea.

The island is made up of interbedded layers of lavas and pyroclastic material. Its conical shape may be considered to indicate youthful age. This is supported by potassium–argon age determinations of approximately one million years (Miller 1964).

Gough, Inaccessible and Nightingale Islands are the eroded remnants of huge volcanic cones. The oldest age determination of rocks from the latter is approximately 18 million years and from the former two, approximately 6 million years.

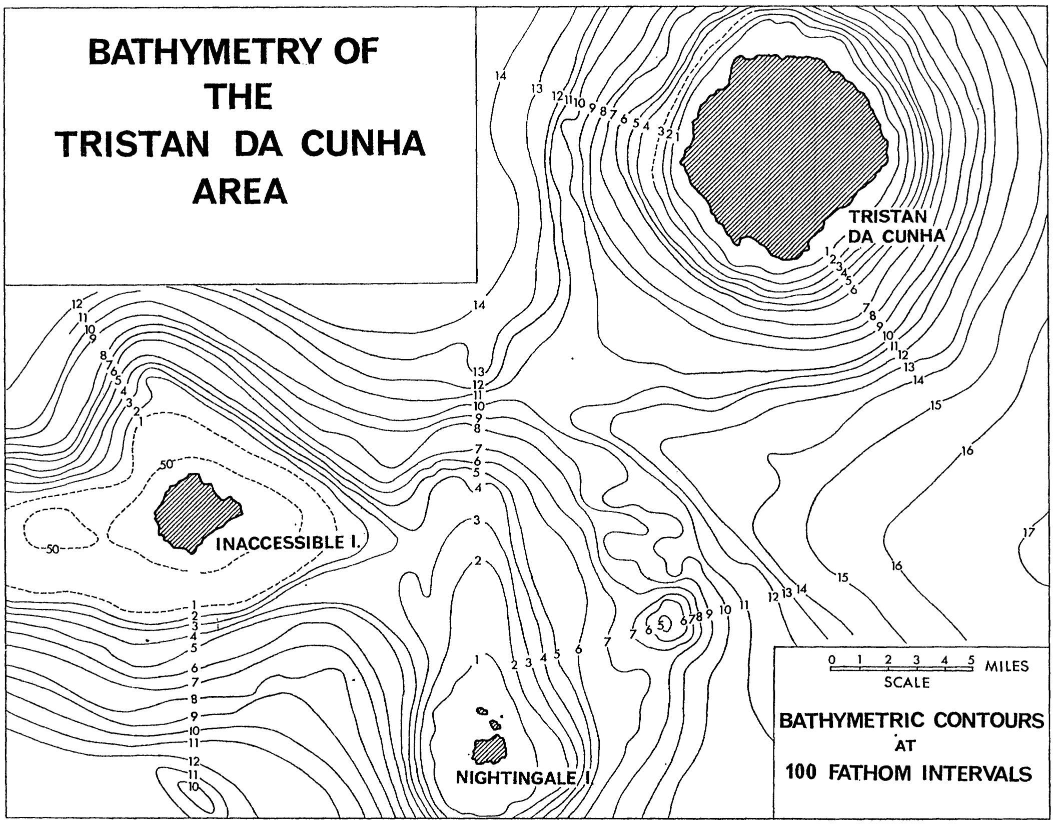

FIGURE 2. From Baker *et al.* (1964).

Under the general term of Nightingale Island (figure 11, plate 33) are the three relatively large islands of Nightingale (planar area 4 km^2), Middle and Stoltenhoff, together with numerous off-shore rocks and islets. All are low-lying, the highest point barely reaching 300 m. Inaccessible Island (figure 10, plate 33) is rhomboidal in shape with a planar area of about 12 km^2 and consists of a relatively flat surface varying in height from 275 m in the east to 550 m in the west surrounded entirely by near-vertical cliffs. Gough Island, which reaches 910 m in height, has rugged terrain 57 km^2 in planar area (figure 9, plate 32). Various islets lie close in-shore around Gough and Inaccessible.

3. THE 1961 ERUPTIVE CENTRE

A series of earthquakes occurred during the 2 months which preceded the eruption. On the night of 9 October 1961 a red-hot plug of lava began to emerge from the Settlement Plain only 275 m from the eastern end of the Settlement. Figures 3 and 4, and figures 12, 13, plate 34 show the position and morphology of the volcano. The plug had reached a height of about 120 m by the last week of October 1961 when it ruptured and lava flowed into

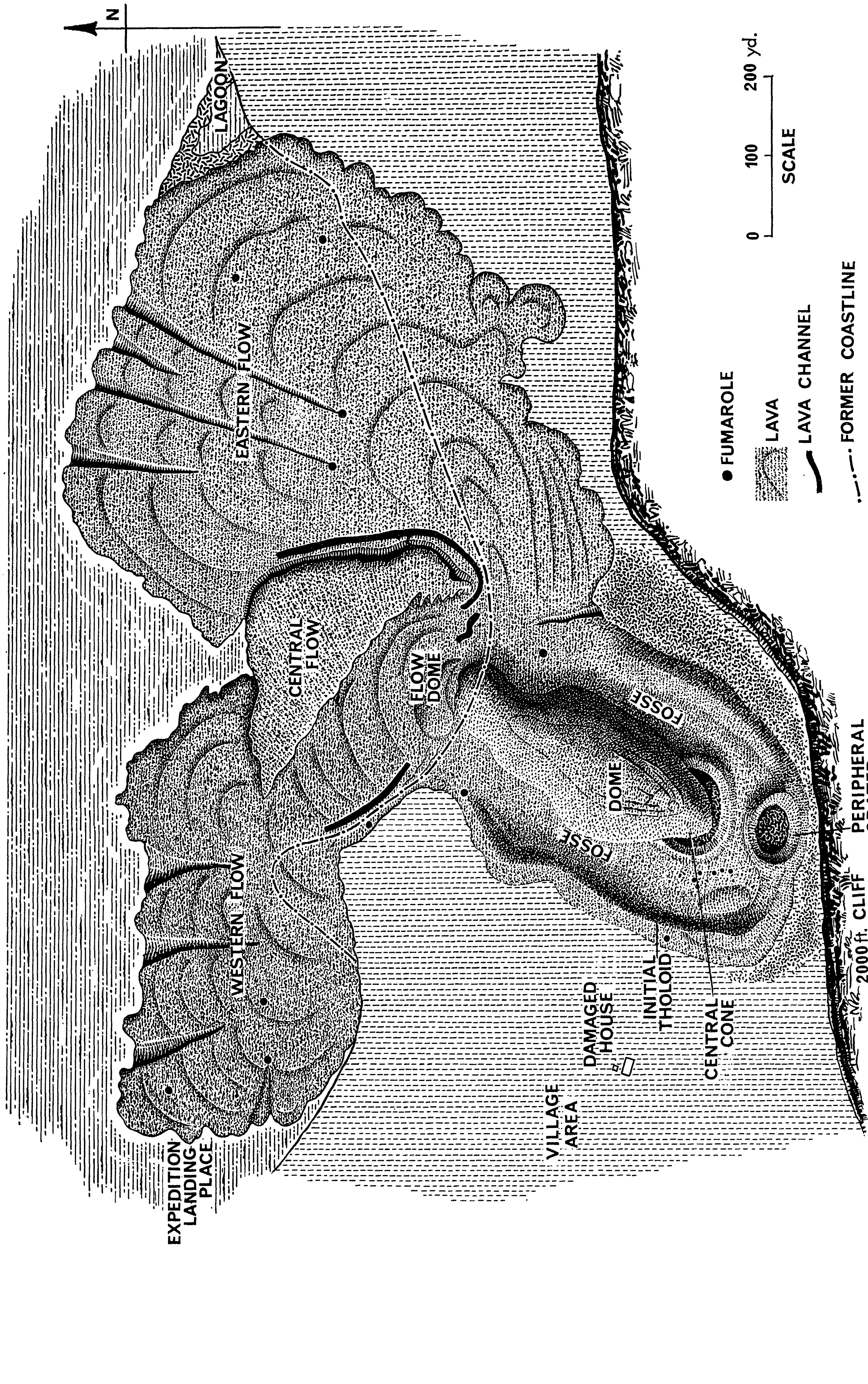

FIGURE 3. The 1961 eruptive centre as it was in February 1962. From Baker *et al.* (1964).

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

the sea. By the middle of January 1962 three flows had formed in east–west alinement and stopped extending. The maximum width of the lava field is 1100 m and its greatest extension in a north–south direction is 914 m. Slab lava makes up the first (central) flow and the second and third (eastern and western respectively) are of the type known as *aa* (lava with a surface composed of angular, jagged blocks; Bullard 1963). The lavas are trachyandesitic in composition.

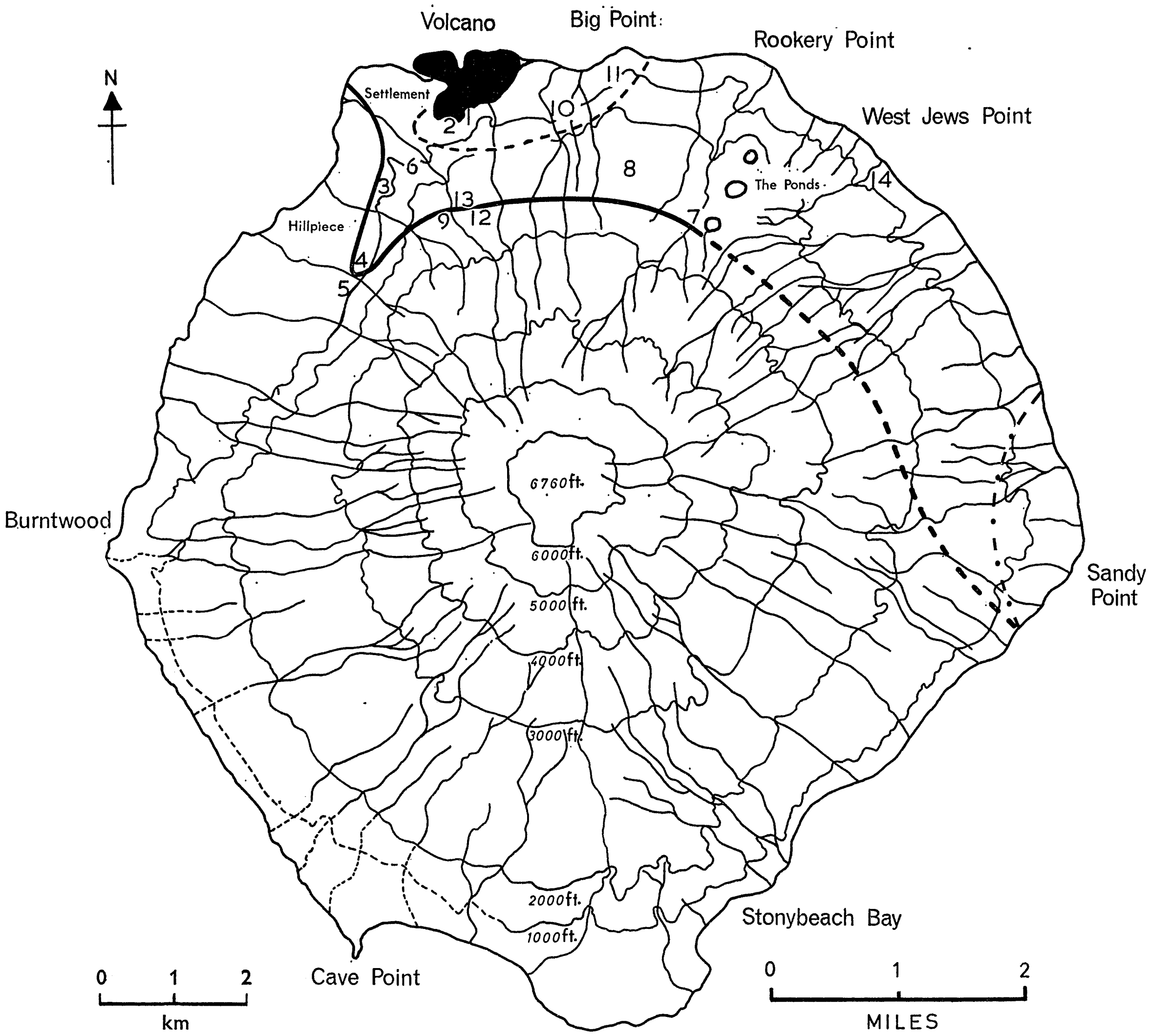

FIGURE 4. The area of fume-damaged vegetation, March 1962. The new eruptive centre is shown in black. The thick (continuous and dash) line delimits the area of fume-damaged vegetation. Between the Settlement, Hillpiece and the Ponds it is accurately placed because the ground was thoroughly covered on foot. Between the Ponds and Sandy Point it is approximately placed because no visits could be made to that region. The dot-dash line shows the area observed from a helicopter of H.M.S. *Protector*. The thin dash line shows precisely the area of maximum fume damage. Numbers 1 to 14 indicate localities studied in detail.

Immediately to the south of the central cone lies a smaller crater which deposited a small quantity of pyroclastics on the lower slopes of the Main Cliffs (figure 3, figure 13, plate 34). By the end of January 1962, all violent activity had ceased. A dome of lava formed over the central cone during February and March 1962.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Not only because of its location, but also because of the small spread of ejecta, the eruption caused minimal damage to the native biota. The solid products of the eruption have an area of 824190 m², two-thirds of which lies beyond the former coastline. The habitat destroyed was poor in species, being made up of sparsely covered beach sand and heavily overgrazed grassland consisting largely of alien grasses. However, especially during its early, violent phases, the eruption liberated toxic gases which caused widespread, though

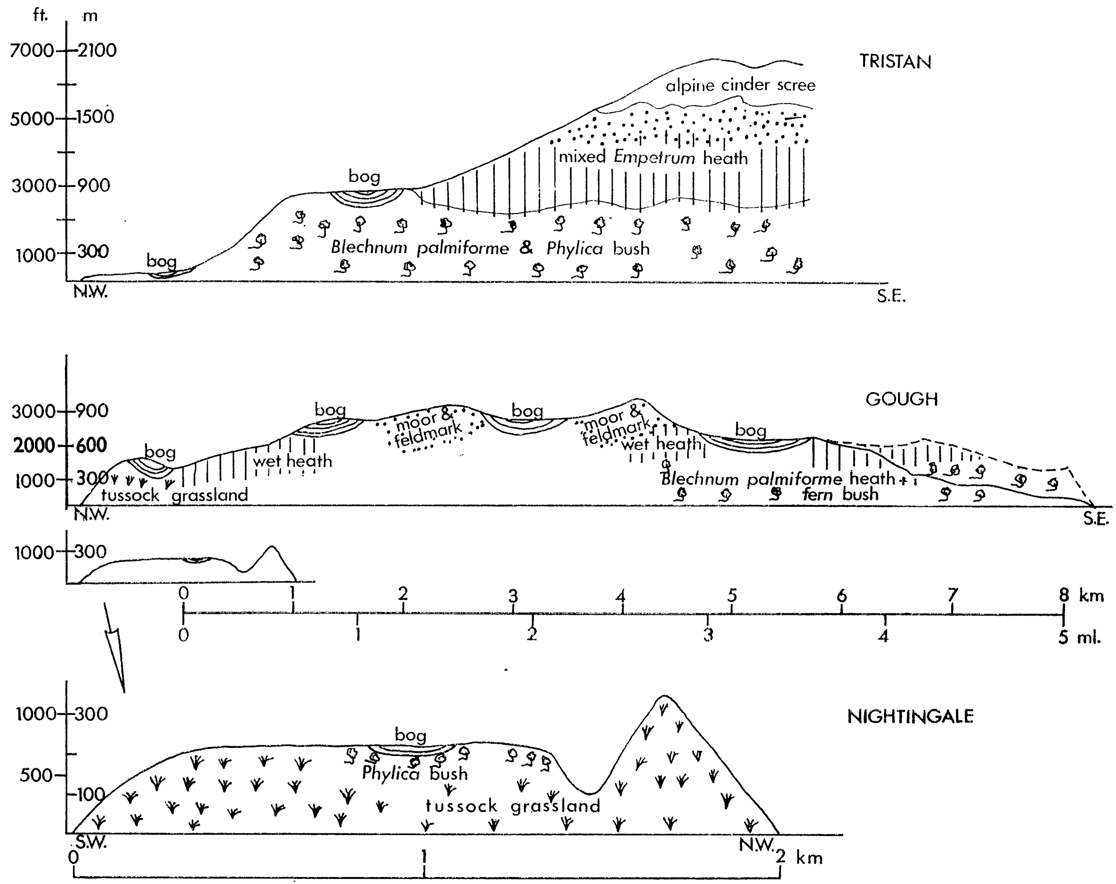

FIGURE 5. Altitudinal zonation of vegetation of Tristan, Gough and Nightingale Islands. Tristan and Gough diagrams taken from Wace (1961).

temporary and selective, damage to the vegetation as far as 9·6 km downwind of the volcano (figure 4; Part IV). The vegetation of Tristan shows a marked altitudinal zonation (figure 5). Fume damage extended to the limit of the *Blechnum palmiforme* communities at about 820 m. The fauna, both alien and indigenous, was little affected by the fumes (Part V).

4. Climate and ocean currents*

The climate of the Tristan group is temperate and highly oceanic, with heavy rainfall, high humidity and narrow range of temperature. The islands lie within the belt of westerly winds which have earned the name 'roaring forties' for the latitudes just to the south. The strongest winds are experienced in the winter months, the actual direction fluctuating

* This and the following section are taken very largely verbatim from the General Introduction in Baker *et al.* (1964).

between north-west and south-west. The weather associated with south-westerly winds is usually cold with squalls and sunny periods, whereas the north-westerly winds bring relatively warm but overcast weather. However, in spite of the frequency of winter gales and storms the climate is basically temperate. From March to December it is largely influenced by depressions which migrate from west to east at speeds of 15 to 20 knots. The frontal systems associated with these depressions bring high rainfall, which is considerably augmented by local orographic precipitation. During the summer months, December to February, the South Atlantic anticyclone belt moves southwards resulting in improved weather, especially when the wind is south-easterly.

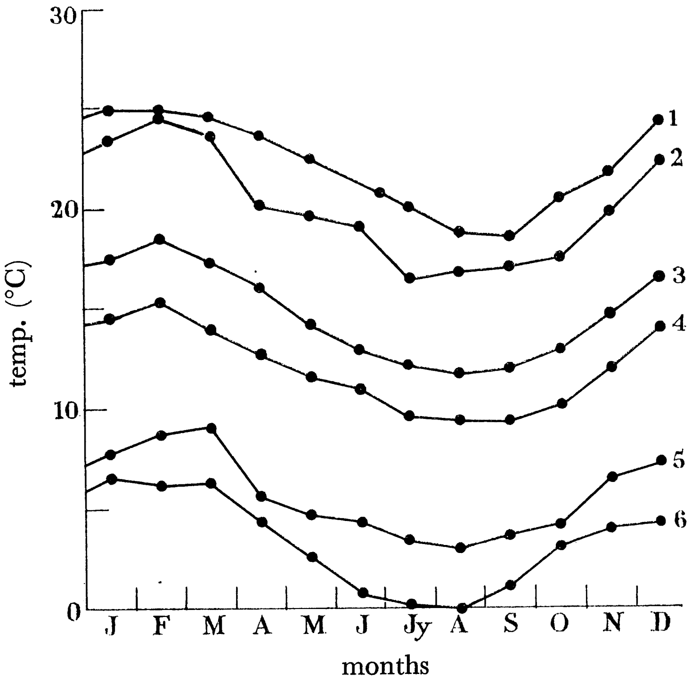

FIGURE 6. Monthly mean air temperatures and monthly extremes at the Settlement, Tristan, for the 15-year period 1943–49 and 1953–60, and at Gonçalo Alvarez, Gough Island, for the 5-year period 1956–60. Tristan, 1, 3 and 5; Gough Island, 2, 4 and 6.

Rainfall, cloud amount and sunshine records are all affected by local orographic factors. The mean annual rainfall for the 15-year period 1943–49 and 1953–60 is 1676 mm at the Settlement.† The average number of rain days is 250. Such figures as are available (Christophersen & Schou 1942) indicate that the Base receives about one and a half times and Peak three times the rainfall at the Settlement. Rainfall is spread fairly evenly through the year, November to March being the driest months. Snow lies on the Peak from May till October and occasionally down to the edge of the Base but not on the Settlement Plain where the temperature never falls to freezing point. Mean annual temperature at the Settlement is 14·7 °C, with a highest daily maximum of 24·9 °C and a lowest daily minimum of 3·0 °C. Relative humidity is high, the average figure being about 80%. Cloud amount is generally considerable, during the north-westerly wind situation

† Rainfall, temperature and sunshine data presented here were supplied by the Weather Bureau, Pretoria, Republic of South Africa.

semi-permanent orographic cloud cover seven-eighths of the sky. The mean of daily hours of bright sunshine is 3·89.

The climate of Gough Island differs mainly from that of Tristan in cooler temperatures and twice as heavy rainfall (figures 6 and 7). Mean annual temperature at Gonçalo Alvarez for the 5-year period 1956–60 was 11·3 °C, with a highest daily maximum of 24·6 °C and a lowest daily minimum of 0·0 °C. Mean annual rainfall was 3397 mm, with an average number of rain days of 296. The mean of daily hours of bright sunshine was 2·81.

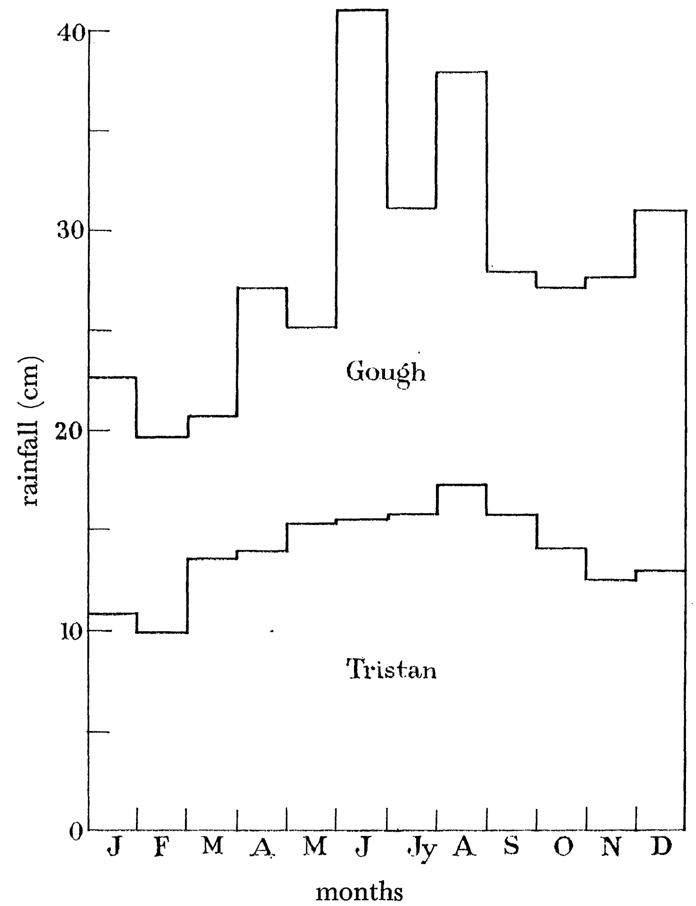

FIGURE 7. Monthly mean rainfall at the Settlement, Tristan, for the 15-year period 1943–49 and 1953–60, and at Gonçalo Alvarez, Gough Island for the 5-year period 1956–60.

The surface ocean currents in the Tristan–Gough area are largely influenced by the wind circulation over the South Atlantic as a whole. The islands are situated on the south side of the South Atlantic anticyclonic belt and in sympathy with the prevailing 'westerlies' the currents have an easterly set. There are three further influencing factors; the north-easterly set of cold water coming up from the Weddell Sea, the movement of the water through the Drake Passage between Cape Horn and Graham Land, and the strong northerly current on the east side of the anticyclone caused by the strong trade winds in the area just west of the Cape of Good Hope. The net result of all these influences is an east-north-easterly set in the Tristan–Gough area. This is maintained throughout the year. Information about these currents is relatively sparse, for the area lies well south of the normal shipping routes. However, examination of British, American and Dutch current charts gives figures which can be resolved as follows:

season	month	direction to	miles per day
summer	December	ENE	17
	January	ENE	17
	February	ENE	18
autumn	March	ENE	20
	April	NE	22
	May	NE	22
winter	June	NE	22
	July	NE	22
	August	NE	22
spring	September	NE	20
	October	NE	20
	November	ENE	17

The values tabulated above are probably maximal rather than mean rates, for Deacon (1960) states that the average daily rate of flow of the southern circumpolar west wind drift is about 8 miles per day.

Observations confirm the strong easterly set, for instance, a ship anchored off the Settlement will usually lie to the eastward of her anchor.

The mean position of the subtropical convergence is generally considered to lie very near to the three northern islands, but this boundary region shows a considerable north–south movement with season and may at times lie well to the north of Tristan. Sub-Antarctic cold temperate and cold temperate mixed water types (Knox 1960) affect the islands, the mean summer temperature of the sea being about 18 °C at Tristan and 14 °C at Gough, while the winter figures are about 13 and 11 °C, respectively.

As far as is known, no systematic tidal measurements have ever been taken at Tristan. The island, being roughly circular, has no bays of any appreciable size and all beaches are 'steep-to'. Tidal movements are therefore hardly noticeable. Casual observations recorded by Lt. Cdr. A. B. Crawford, S.A.N.R., indicate a vertical range of 0·5 m during neap tides, and between 1 and 1·25 m during springs.

5. History of colonization of the Islands

This synopsis deals very briefly with the main events in the history of the Tristan–Gough group; for further details the reader is referred to excellent accounts by Brander (1940), Munch (1945) and Holdgate (1958).

Tristan da Cunha was discovered in 1506 by the Portuguese Admiral, Tristão d'Acunha, after whom it is named, and Gough Island by another Portuguese, Gonçalo Alvarez, at about the same time. Nightingale is named after Captain Gamaliel Nightingale, R.N., who visited the area in 1760.

From 1790, Tristan was periodically visited by small parties of sealers and whalers, who spent periods of weeks or months ashore killing fur seals and 'trying out' elephant seal blubber for oil. Owing to excessive slaughter of the seals, these visits became uneconomic by about 1820 although there was a brief resurgence of sealing in 1880–90 when the stocks had somewhat recovered. Whaling vessels, however, continued to make occasional calls

Figure 8. The northern side of Tristan: taken from H.M.S. *Protector's* helicopter in 1960 before the eruption. The typical volcanic form of the island is well illustrated, as is the Settlement coastal plain.

Figure 9. Gough Island. South Peak (757 m) from Transvaal Bay.

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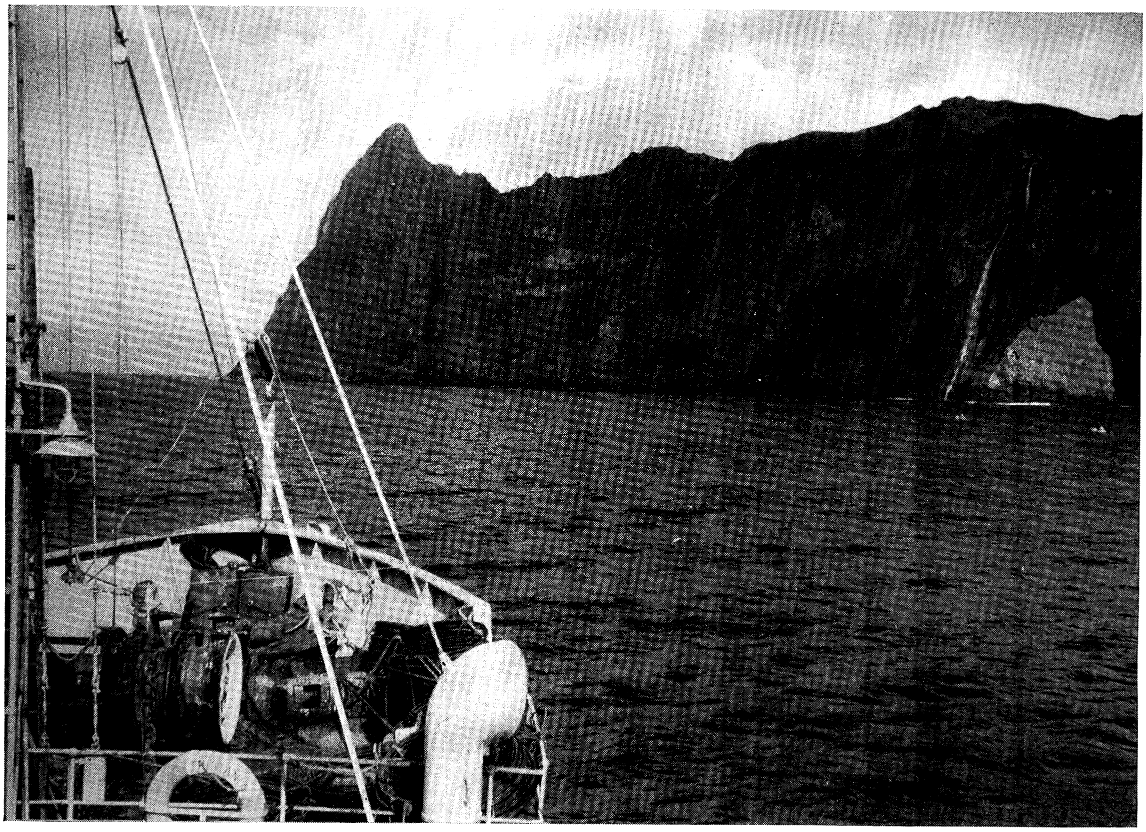

FIGURE 10. South Point of Inaccessible Island seen from M.V. *Tristania*, February 1962.

FIGURE 11. The southern side of Nightingale Island seen from M.V. *Tristania*, February 1962.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

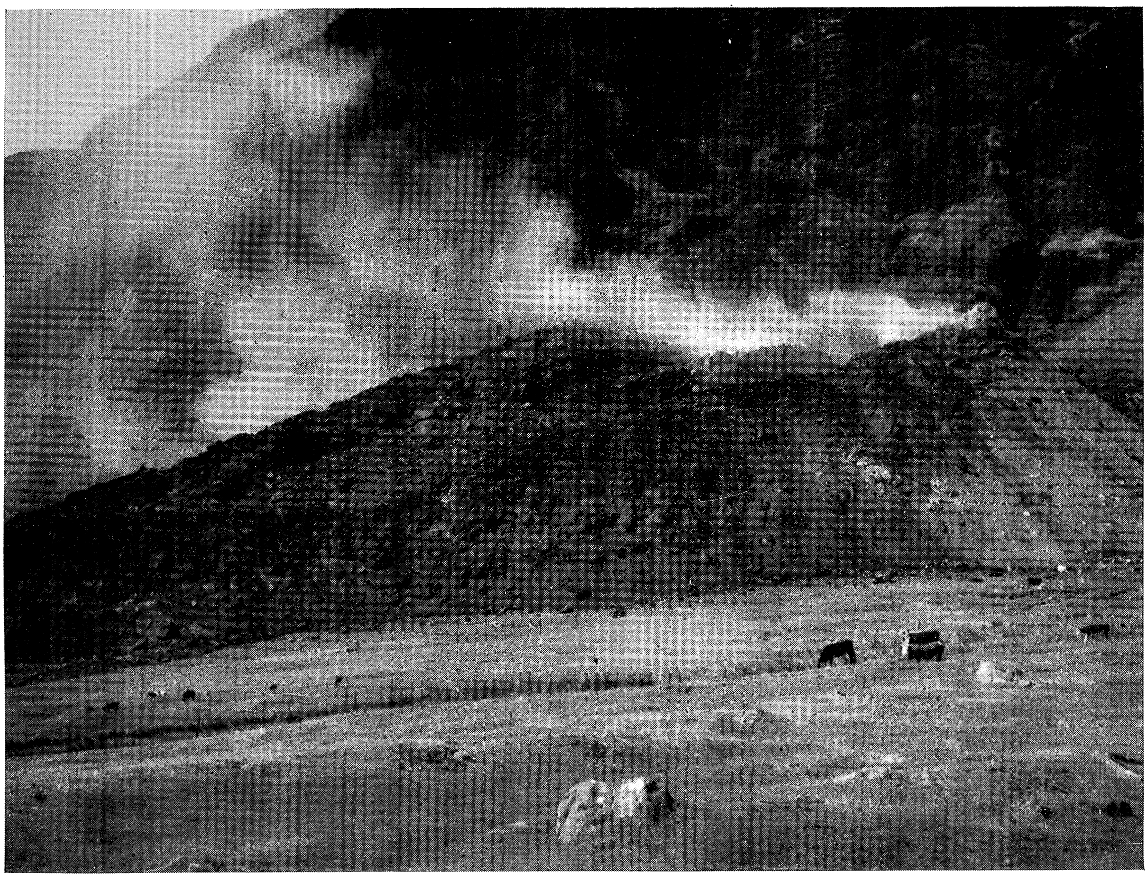

FIGURE 12. The 1961 eruptive centre seen from the west. Fumes blowing eastwards on to the Main Cliffs. Grassland of the Settlement Plain stretches from the foreground to foot of volcano.

FIGURE 13. The 1961 eruptive centre seen from the edge of the Main Cliffs.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

in search of fresh water. The island was sometimes used as a port of call by sailing vessels bound for the Cape of Good Hope, India and Australia; these vessels sailed far into the South Atlantic in order to catch the favourable westerly winds.

It was this situation on a major sea route that led Jonathan Lambert, with two companions, to establish the first settlement on the island in 1810. Lambert proposed to supply fresh provisions to passing ships, and to exploit the natural resources of the islands. His death at sea in 1812 terminated this scheme, but his surviving companion was soon joined by two whalers, and this pioneer colony was in being when a small British garrison landed on the island in August 1816. During the Anglo-American war of 1812–14 American privateers and men-of-war had used Tristan as a base from which to prey on East Indiamen, and the occupation of the island may have been designed to prevent this as much as for the traditional reason of denying the French a base from which to rescue Napoleon from St Helena.

It appears that the British Government soon considered the Tristan garrison to be of little use, for it was withdrawn on the 27 September 1817. However, Corporal William Glass, a member of the garrison, his wife and family and two stonemasons obtained permission to remain, and they were soon joined by a number of other colonists.

Between 1817 and 1836 the population of Tristan fluctuated considerably, recruiting men from shipwrecks and the crews of visiting whalers, and obtaining wives from St Helena. Many of the early settlers left the island, and at least twelve of Glass's sixteen children either took service in or married men aboard American whalers. The island continued to maintain intermittent contacts, and exchange personnel, with the outside world until about 1908, although after about 1886 the isolation of the community, largely through a decline in the number of passing sailing ships, increased steadily. A major exodus, of fifty people, occurred in 1857, and in 1885 fifteen men, the majority of the able-bodied male population, were drowned while attempting to intercept a passing vessel. Between 1885 and 1900 about sixty people left the island although a number of these returned in 1908. This returning population provided the last major influx of new blood to the community. After 1908 contact with the outside world became less frequent, and an increasing population whose agriculture was never very efficient experienced a declining standard of living.

The community never was truly self-sufficient; it was a trading post. Thus, in 1867 a visiting naval captain commented that 'not less than an average of twenty ships annually called at the Settlement for food and water'. Between 1820 and 1850 American whalers maintained very close contact and communication with St Helena. These trading contacts allowed all the goods that the island could not produce to be obtained in exchange for fresh provisions. It was the breakdown in this trade during 1890–1900 that was, in the long run, fatal to the standard of living of the island population, whose mounting numbers, furthermore, consumed an increasing proportion of the agricultural produce of the island and left little surplus for barter.

During the latter half of the nineteenth century and early twentieth century Anglican missionaries stayed on the island for short periods. Since 1923 clergy have been more or less permanently in residence. These churchmen, as well as looking after the spiritual welfare of the islanders, also provided elementary education. In 1942, during the Second

World War, a naval station, H.M.S. *Atlantic Isle*, was established on the island mainly to deprive enemy surface raiders of a watering station. Radio links were established and the commanding officer of the station, a Surgeon Lt. Commander, provided the first medical services. Islanders received wages for duties undertaken, and goods such as flour, sugar, rice and tea could be bought from the naval canteen.

It was during the Second World War that one of the naval chaplains, the Reverend C. P. Lawrence, suggested the establishment of a crawfishing industry on the island. This scheme, financed by a Cape Town firm and by the Colonial Development Corporation, began operations in 1948, when vessels began crawfishing in Tristan waters. In 1950–51 a canning factory was built at Big Beach, 550 yards north-east of the Settlement. The islanders were employed both in the fishing vessels and the factory and wages earned could buy supplies from the company's canteen. In 1950, an Administrator was appointed by the British Government and shortly after he was joined by a doctor, nurse, agricultural officer and teacher. The meteorological and radio stations, installed during the war, continued to operate staffed by South African personnel.

When the volcano erupted on the night of 9 October 1961, the whole population of 264 islanders and 11 officials, their wives and families, was evacuated. By November 1963 virtually the entire population had returned to Tristan.

Nightingale and Inaccessible Islands are uninhabited. A meteorological station has been maintained on Gough Island since 1955. None of the three islands has ever supported a breeding population of man. There have been various sojourns by sealers, prospectors and survivors of shipwrecks.

The biologists of the Expedition wish to express their sincere gratitude to the Royal Society and the World Wildlife Fund for the opportunity of visiting Tristan and to those whose advice and assistance were invaluable, most notably Professor C. F. A. Pantin, F.R.S., Professor H. Godwin, F.R.S., Sir Hugh F. I. Elliot, Dr I. G. Gass and Dr M. W. Holdgate.

The work of many specialists included in this volume is gratefully acknowledged. Botanists who have identified specimens or helped in other ways are: Dr S. Arnell, Mr J. B. Carter, Dr D. M. Churchill, Dr H. Eichler, Mr E. A. George, Dr P. H. Gregory, F.R.S., Dr H. J. Hudson, Professor T. Jimbo, Dr N. T. Moar, Mr P. D. Sell and numerous members of the Botany Department of the British Museum (Natural History) and the Herbarium of the Royal Botanic Gardens, Kew. The following zoologists produced working lists from the invertebrate collections: Mr J. Balfour Browne, Mr R. T. Thompson, Mr R. Pope, Mr E. B. Britton, Rev. C. E. Tottenham, Mr D. S. Fletcher, Mr H. Oldroyd, Dr A. R. Hill, Mr R. A. Crowson, Dr J. A. L. Cooke, Mr J. G. Blower, Mr R. W. Ingle, Dr A. Macfadyen, Dr J. P. Harding and Mr R. W. Sims. We are grateful to Mr H. G. Stableford for the thorough observations he made on our behalf on Tristan during October 1962 and April to December 1963.

We wish to thank the Director of the Weather Bureau, Department of Transport, Pretoria, Republic of South Africa, for supplying meteorological data, and numerous members of Capetown University for their hospitable co-operation, especially Dr G. J. Broeckhuysen, Professor J. H. Day, Mrs M. R. Levyns, Mrs M. K. Rowan and Dr E. A. C. L. E. Schelpe.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Our debt to Dr M. W. Holdgate and Dr N. M. Wace is great. This volume owes much to their knowledge. We are grateful to our fellows on the Expedition for all their help and comradeship. Finally, we extend our thanks to all the many others unmentioned who helped to make the Expedition a success.

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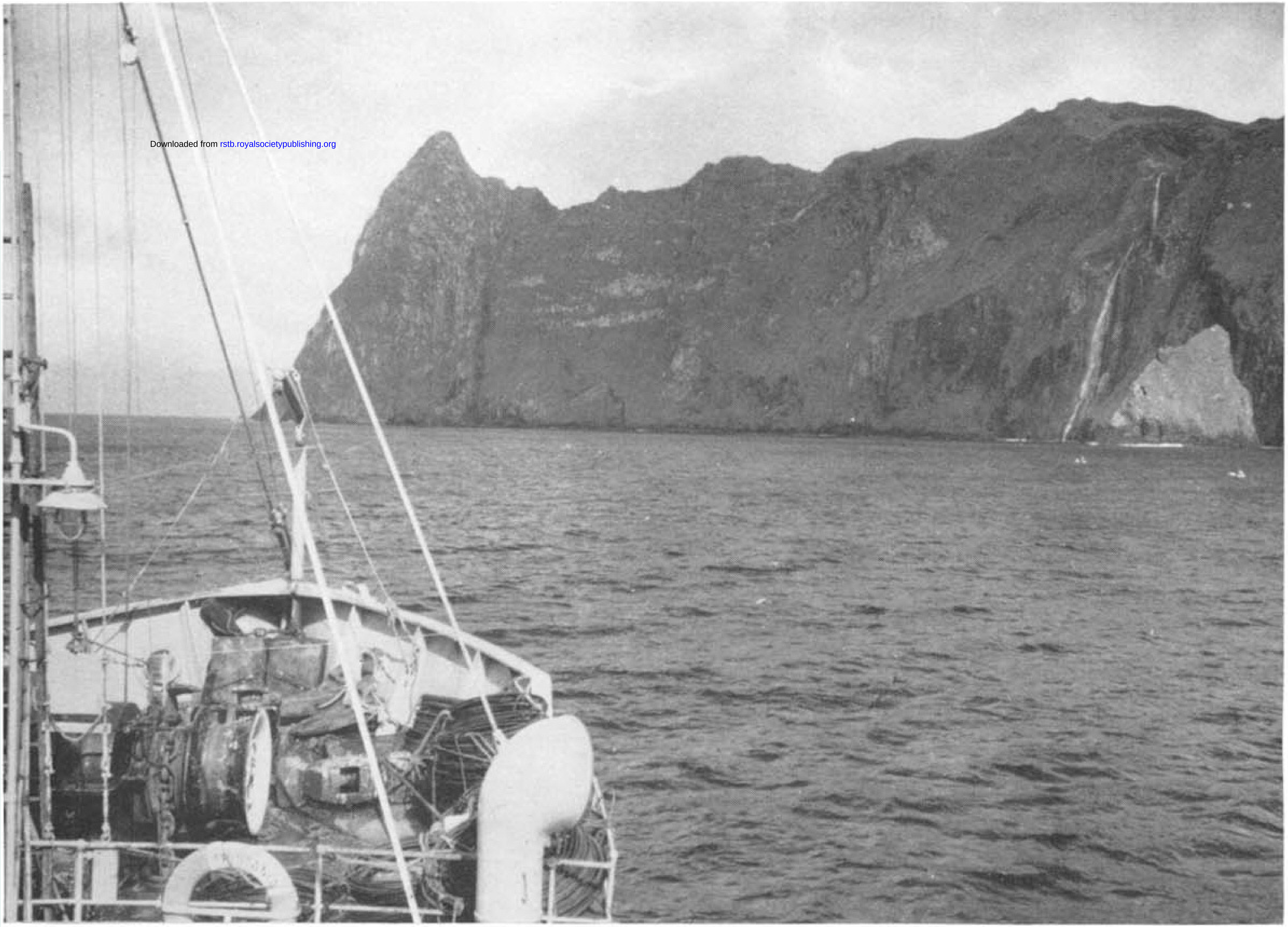
PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

FIGURE 8. The northern side of Tristan: taken from H.M.S. *Protector's* helicopter in 1960 before the eruption. The typical volcanic form of the island is well illustrated, as is the Settlement coastal plain.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

FIGURE 9. Gough Island. South Peak (757 m) from Transvaal Bay.



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PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

FIGURE 11. The southern side of Nightingale Island seen from M.V. *Tristania*, February 1962.

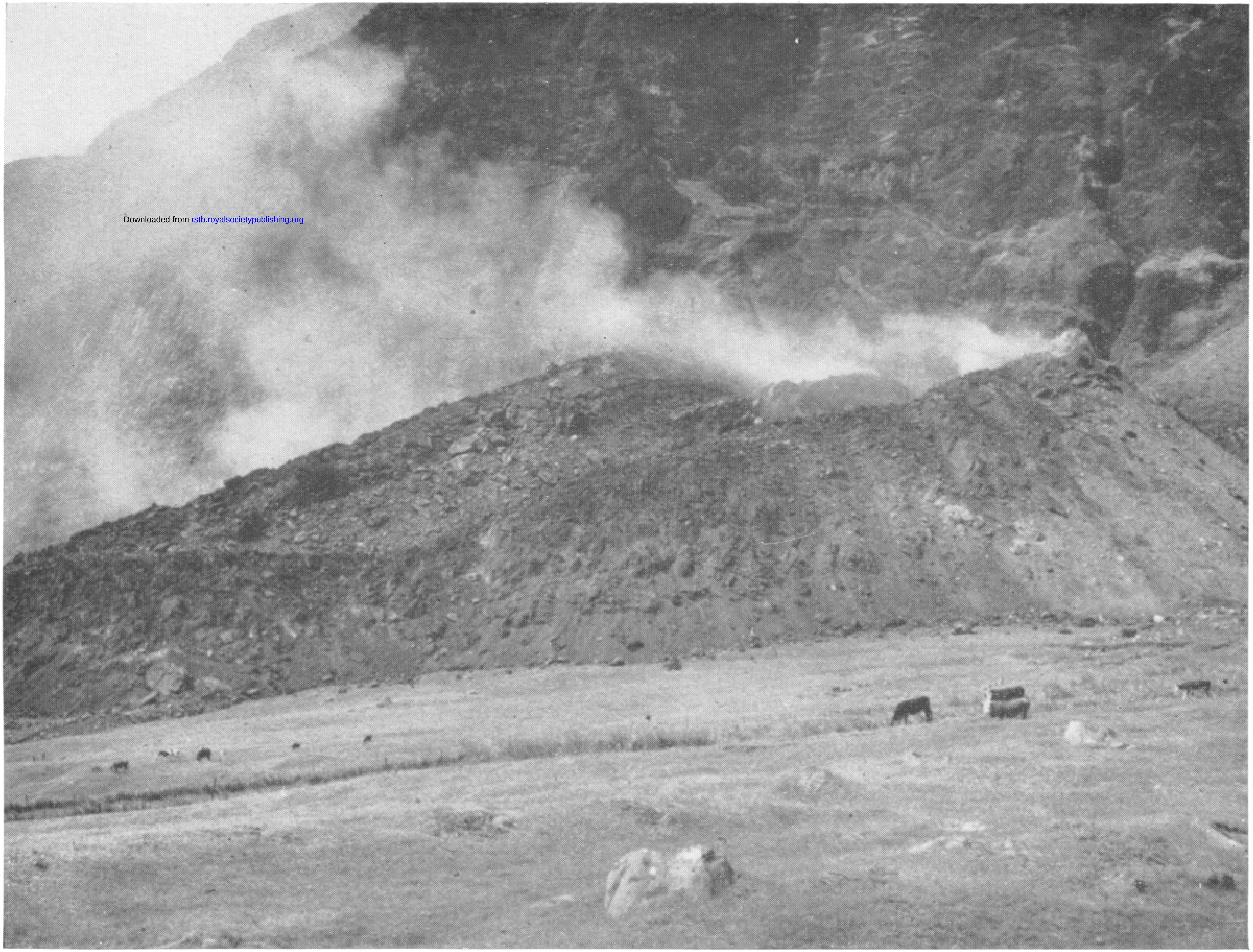

FIGURE 12. The 1961 eruptive centre seen from the west. Fumes blowing eastwards on to the Main Cliffs. Grassland of the Settlement Plain stretches from the foreground to foot of volcano.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

FIGURE 13. The 1961 eruptive centre seen from the edge of the Main Cliffs.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES