OBSERVATIONS ON THE GEOLOGY AND MINERAL RESOURCES OF ST. HELENA

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Abstract

THE WRITER VISITED ST. HELENA IN APRIL, 1951, WITH THE PRIMARY OBJECT OF investigating deposits of manganese ore. These have been known for many years, and specimens have been received at the Imperial Institute from time to time, but they had never previously been seriously examined by an economic geologist. The article deals with the history of this most interesting oceanic island, its physiographic and geological structure, mineral occurrences and problems of soil conservation and water sppply.

St. Helena, situated far out in the South Atlantic Ocean, with the nearest land the still smaller island of Ascension, 750 miles to the north-west, is the deeply-eroded summit of a composite volcano of central type, which rises from the ocean floor at a depth of 13,860 ft. The highest point on the island is nearly 2,700 ft. above sea-level, making a total height of over 16,500 ft. The exposed part of the volcano consists of a lower series, mainly tuffs and agglomerates with weak lava flows, and an upper series of thicker flows with interbedded tuffs. Later than these, and forming domes, crater fillings, irregular injections and occasionally dykes, are intrusions of phonolite and phonolithic trachyte. The main mass of the island is basaltic, and both olivine-rich and olivine-poor basalts occur. There were two main centres of eruption, the most important being in the south of the island. Myriads of basaltic dykes intrude the lavas and tuffs and are concentrated mainly in the south and in the north-east, in and near the original main centres of eruption. The island is entirely surrounded by forbidding cliffs, which conceal the pastoral aspect of the interior, and intense erosion has produced valleys of immense depth and steepness.

The manganese deposits, although consisting of good-quality ore in part, are not extensive enough to justify exploitation, and other minerals mentioned are suitable for local use only.

Introduction

The popular conception of St. Helena is one of a barren rocky island far out in the Atlantic Ocean, upon which Napoleon was confined and which issues stamps much sought by collectors. The writer must confess that, when requested to visit the island to investigate deposits of manganese, his own conception held little more substance, the little extra being recollections of the voyages of Darwin and of the island's significance in geological arguments about the permanence of ocean basins, Wegener's hypothesis, and the internal constitution of the earth. Enquiry showed that an extensive literature, both historical and scientific, exists, but as the scientific literature at any rate is not readily available, it is thought that an account of a visit to the island, written mainly from the geological and mineral point of view, will be of interest to readers of *Colonial Geology and Mineral Resources*.

St. Helena is certainly remote, lying in the South Atlantic 1,200 and 1,800 miles from the nearest parts of Africa and South America re-

spectively. The nearest land is the still smaller island of Ascension, some 750 miles to the north-west, and Daly (13)[1] mentions the striking fact that these two tiny specks form the only dry land in an area of nearly 6,000 sq. miles, or 3 per cent. of the earth's surface.

The writer spent three weeks on the island in April, 1951, primarily to examine the manganese deposits which had been known, from the literature and from samples received in this country at intervals, for many years, but which had never been investigated by an economic geologist. The opportunity was taken to enquire also into mineral possibilities generally and to advise on questions of water supply and of soil erosion and conservation. The geological observations were incidental to these investigations, and will be supplemented in these notes by drawing on the works of others, particularly of the American geologist Daly (12; 13) and of Oliver (6) and Mellis (7). Daly visited the island in 1922, and was solely concerned with problems of petrology and structure, and philosophical considerations arising from his study of this and other oceanic islands. Oliver was an officer in the Royal Artillery stationed on the island in the sixties of last century, who wrote his excellent geological observations in the form of a pamphlet published in Jamestown, the island's capital, in 1869. The best comprehensive account is a book by J. C. Mellis published in 1875, with the ponderous title of " St. Helena: a Physical, Historical and Topographical Description of the Island, including the Geology, Fauna, Flora and Meteorology ". A list of these and other works which have been consulted will be found at the end of this article.

General

St. Helena was discovered by the Portuguese navigator João de Nova Castella in 1502 and named after the mother of Constantine the Great. It was then unpopulated and said to be covered with thick forest. The Portuguese, as always, planted fruit trees and vegetables and introduced partridges, pheasants and turkeys, goats and pigs, but did not occupy the island permanently. The goats and pigs ran wild and began the devastation of the natural vegetation which has been vigorously continued by the human inhabitants, and has resulted in the desolate wastes of the island's fringes.

St. Helena's position on the route to the Cape of Good Hope and the Far East gave it key importance as a watering and victualling station, which continued until the opening of the Suez Canal. Its turbulent and romantic history from its discovery until the seventeenth century is bound up first with the struggles between the British, Dutch, Portuguese and Spanish, and afterwards with the fortunes of the East India Company who, with the final expulsion of the Dutch in 1673, were given a second Charter[2] by Charles II and continued in possession until 1836, when the island was taken over by the Crown. The Crown were also in control during the period of Napoleon's incarceration from 1815 to his death in 1821.

[1] Reference is made by number to the publications listed on page128.
[2] The island was recaptured by the Dutch after the grant of the first Charter in 1661.

The present inhabitants, called Islanders, whose language is and always has been English, are the descendants of the employees and slaves of the East India Company, (European, Indian and Far Eastern in origin,) and of Chinese coolies who were brought there early in the nineteenth century, mixed to some extent with the West African negro blood of slaves taken to live in camps near Jamestown from ships captured during the suppression of the slave trade. They are a peaceable people of quiet and courteous manners, and many of them have sought a wider horizon in South Africa or in Britain, as domestic servants and farm workers. In addition to some 5,000 Islanders, there are about 50 Europeans—Government officials, traders (one or two of whom have a long ancestry on the island), Church dignitaries and retired persons.

St. Helena is 10½ miles long and 6½ miles wide in maximum dimension, with an area of 45½ sq. miles. It is bounded on all sides by impressive but forbidding-looking cliffs, which effectively conceal from the sea the beautiful, pastoral aspect of the interior. The cool, mild and equable climate is due to the influence of the south-east trade winds, which blow throughout the year[1]. Although mosquitoes can be a source of irritation, there are no tropical diseases. Sheep and cattle are kept, and donkeys are the main means of transport of the Islanders. Goats are confined to a restricted area. The only indigenous bird is a plover (*Aegialitis Sanctae Helenae*), locally called the wire-bird, but canaries, mynahs, pheasants, partridges, pigeons, turkeys, guinea-fowl, fowls, ducks and geese have been introduced, and the first five are wild, as are a few rabbits. Snakes are absent and the only reptiles are lizards. A particularly virulent type of white ant is one of the problems of the island, and is said to have been introduced in the timbers of a Brazilian slaver dismembered at Jamestown.

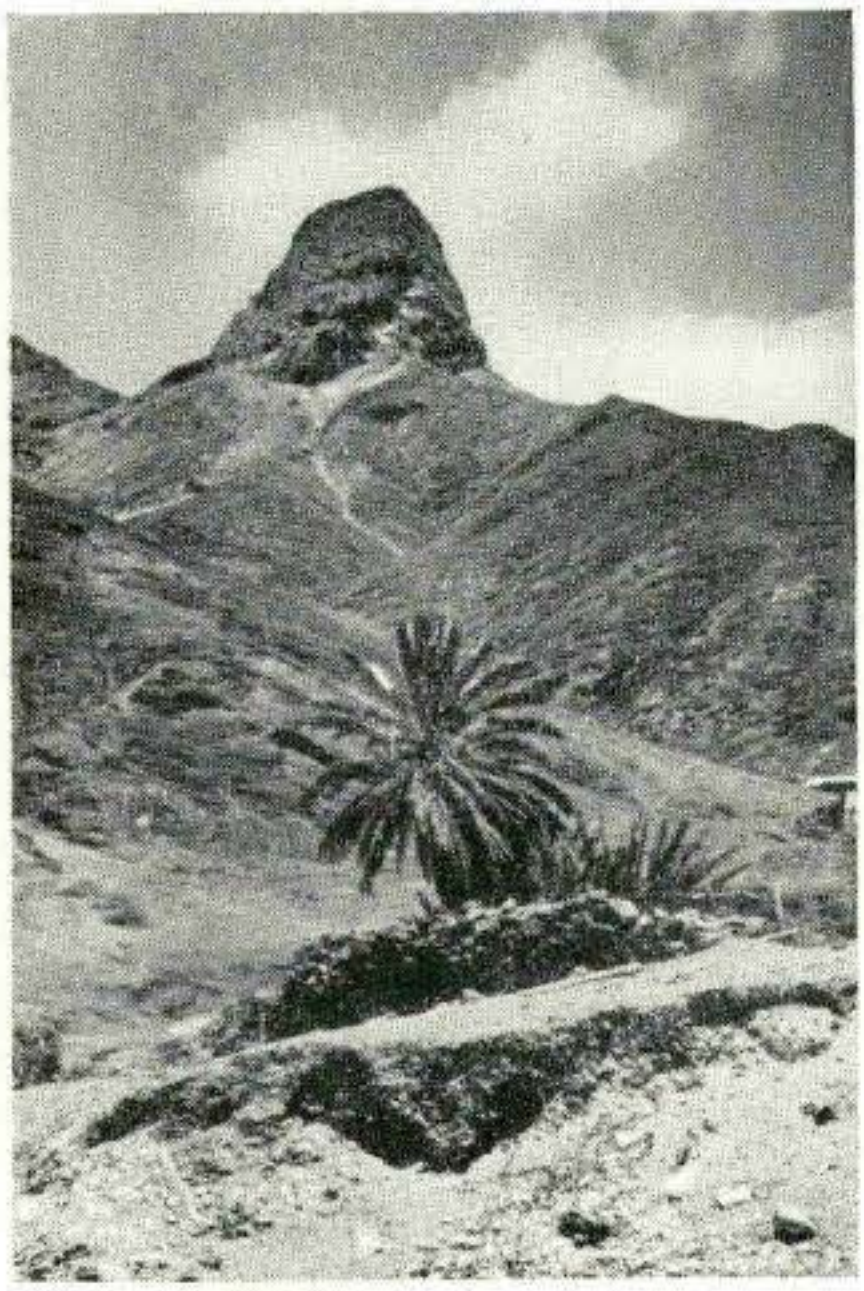
The indigenous forest[2] has entirely disappeared, and the greater part of the green belt is covered with New Zealand flax (*Phormium tenax*), interspersed with pasture. In the grounds of private houses, especially Plantation House (Government House), trees and shrubs from all over the world flourish, but apart from such plantations there is but little timber, and even firewood is a problem. Agaves apart from Phormium, such as sisal and aloe, grow well. The thorn tree (kaffirboom of South Africa) is common along the roadsides and often grows to a great size, and there are scattered clumps and plantations, mainly of pines and firs, wattle, Port Jackson willow and Cape yew, the results of what have been hitherto rather desultory afforestation schemes.

Quite 75 per cent. of the island land, inside the barren Crown Waste Lands, is in the possession of three landowners, who own the greater part of the flax, and graze sheep and cattle under ranching conditions over the remainder of their domains. Consequently not a great deal of land is left for cultivation of foodstuffs, and there is an anomalous situation in which, although the sheep and cattle population is by no means

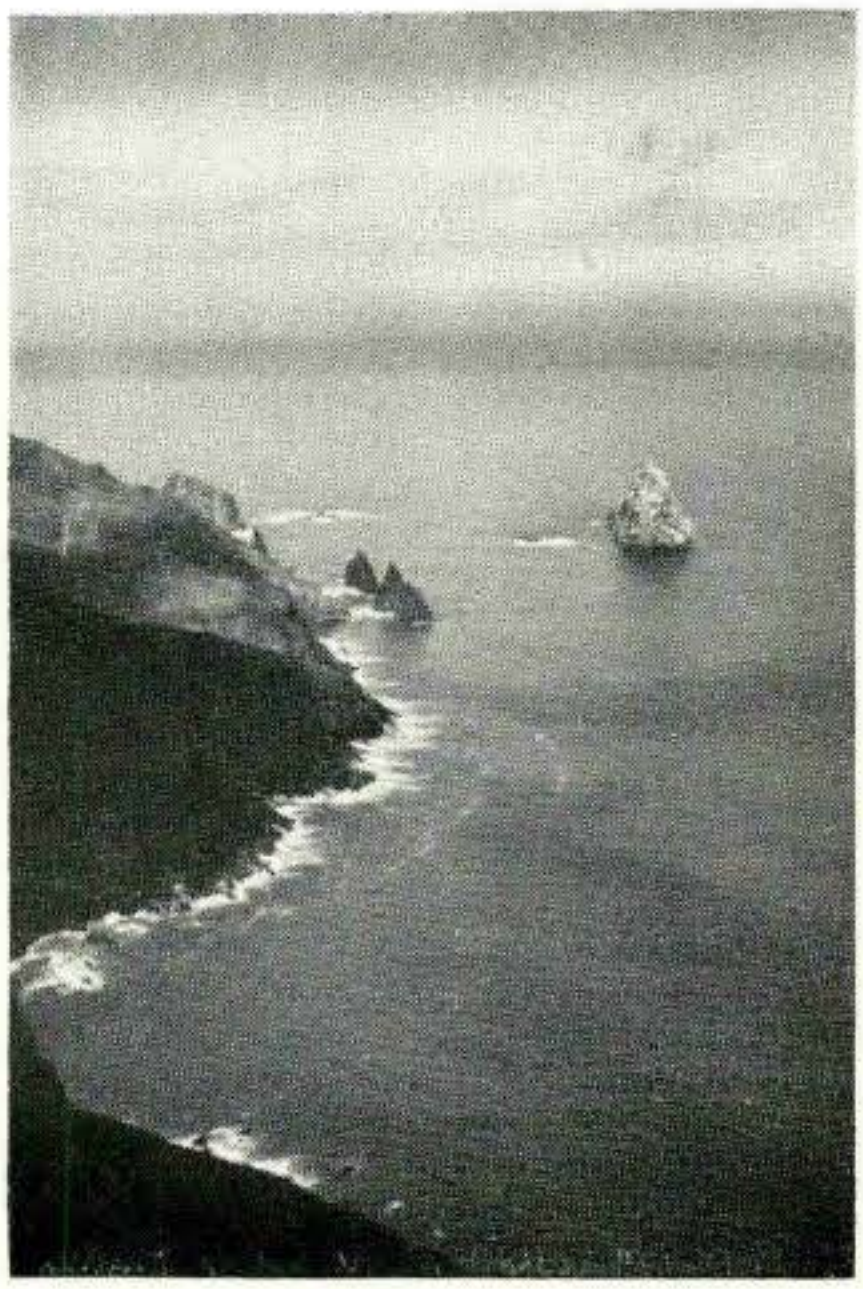
[1] Mr. Cecil Rankin, Government Secretary, St. Helena, has also pointed out, in a letter to the writer, that none of the warm currents of the South Atlantic approach the island.

[2] Gumwood, ebony, redwood, white cedar and tree-ferns are said to have been prominent in the indigenous flora.

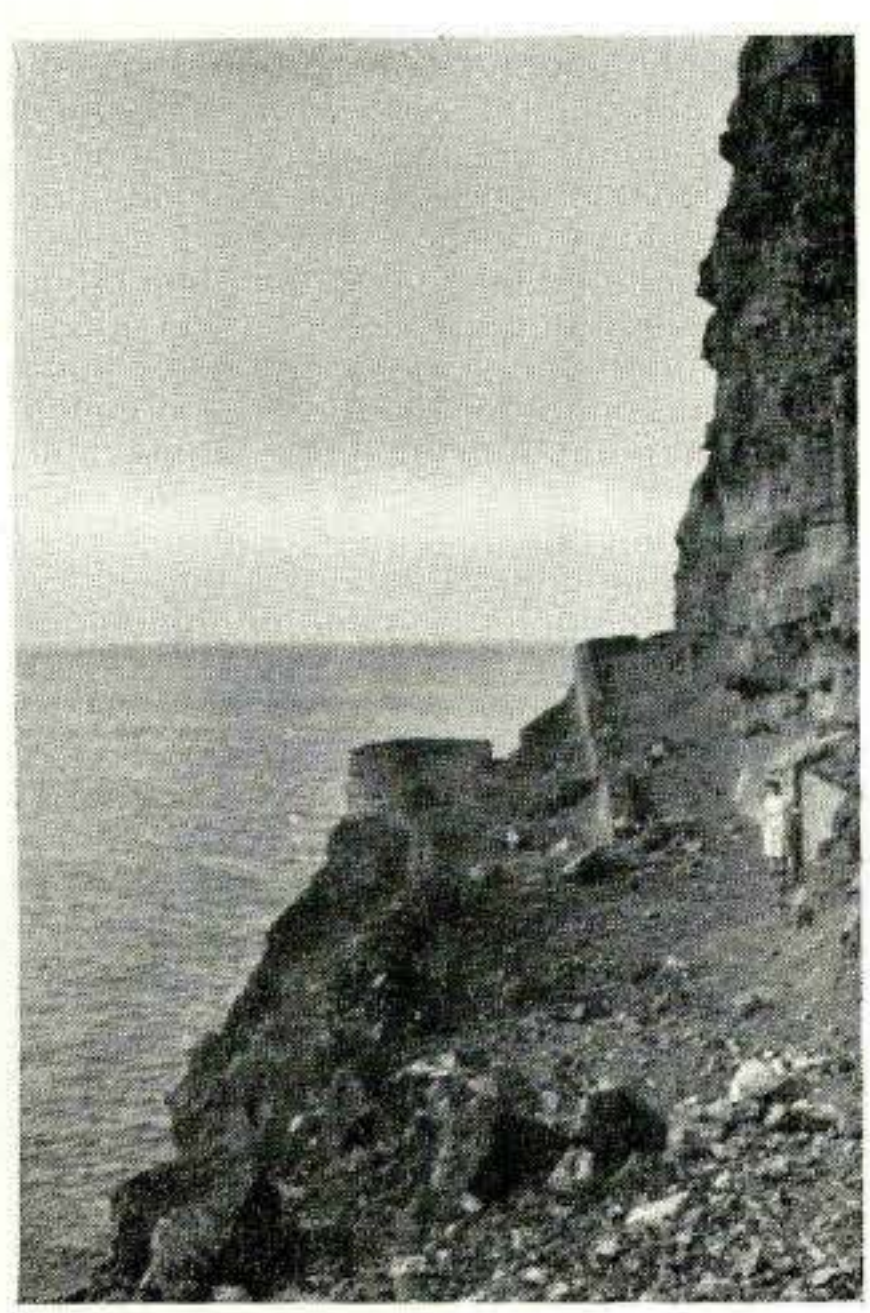
PLATE I.



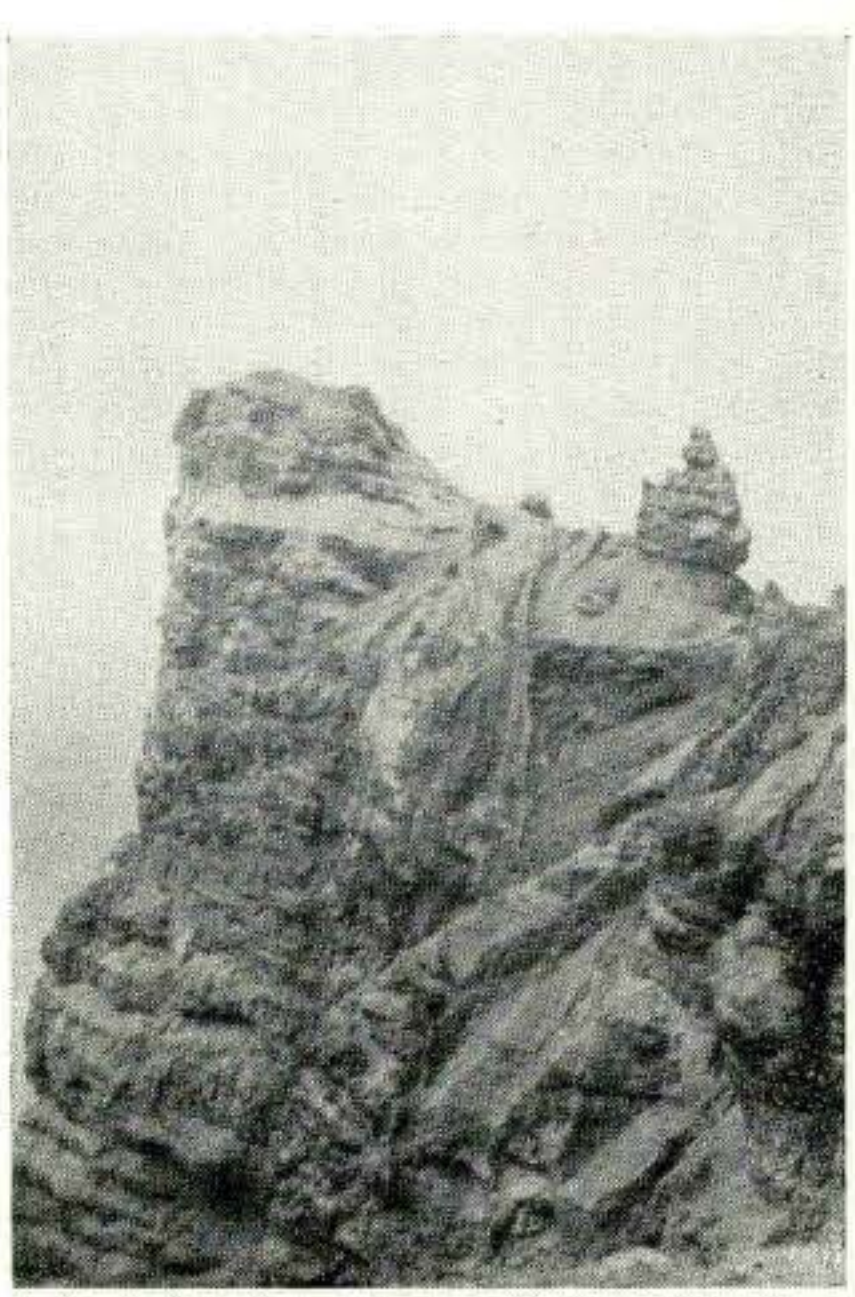
Lot, a phonolite plug, Sandy Bay Hollow.



Speery Island, viewed from Joan Point.



Munden's Battery, near Jamestown.



King and Queen Rocks, Prosperous Point.

[*Photos: G. F. Gammer, Miss E. R. Salmond and J. H. Jacobs*

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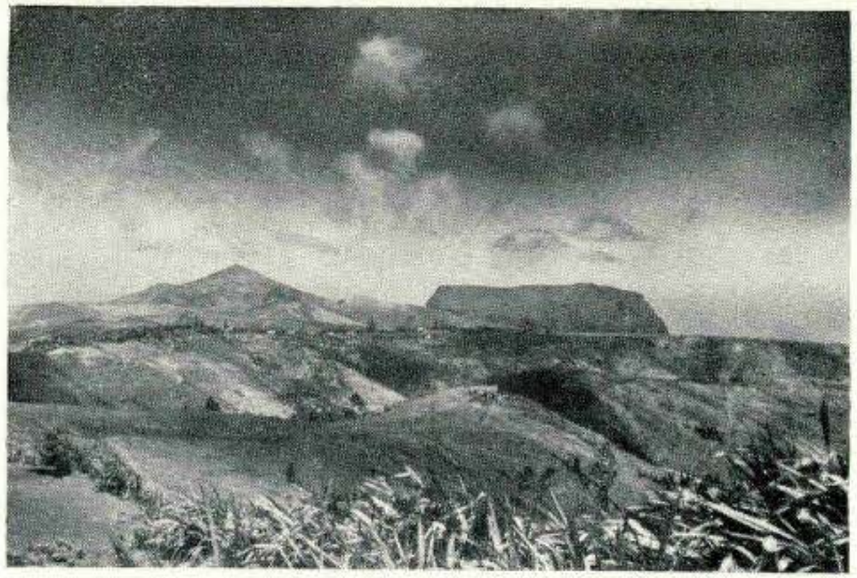
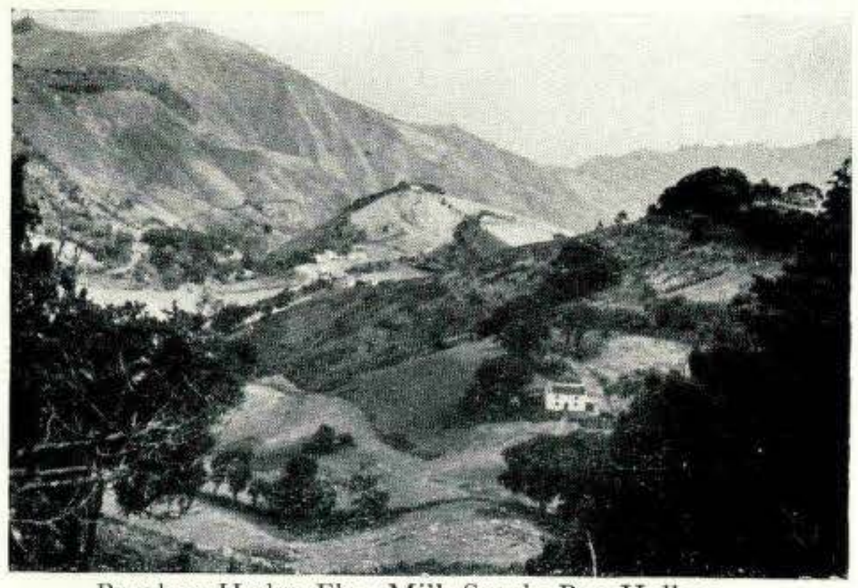
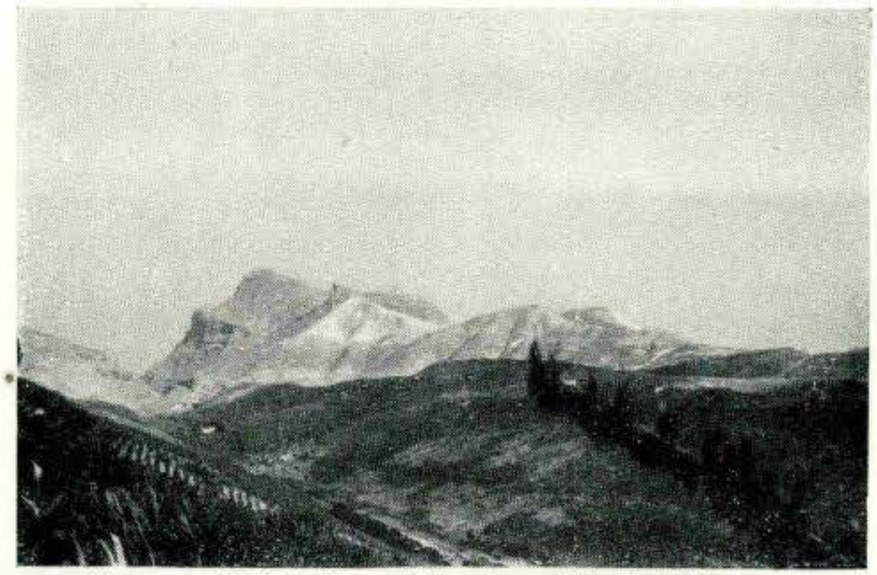


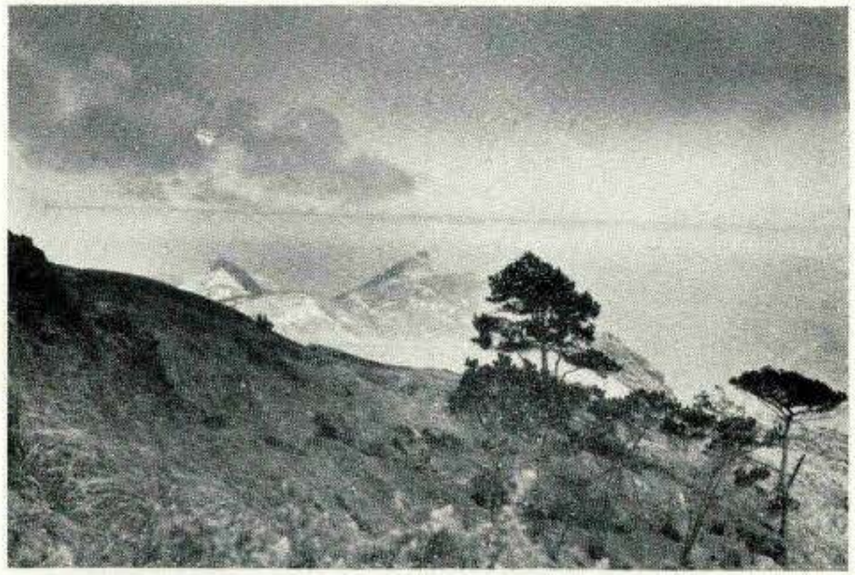
Flagstaff Hill and The Barn. Longwood Plain in middle distance.



Bamboo Hedge Flax Mill, Sandy Bay Hollow.



Great and Little Stone Top, from Woody Ridge.



Great and Little Stone Top, from Rock Rose.

[*Photos: G. F. Gammer, Miss E. R. Salmond and J. H. Jacobs*

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as large as it could be, the former in particular do a great deal of erosional damage by uncontrolled grazing. Potatoes and vegetables are expensive and meat scarce and too dear for the Islanders' means. Fish is the mainstay of their diet, and much of this is obtained by spare-time line fishing from the rocks, after the traverse, often in the night, of cliff "roads" and tracks around talus-strewn slopes that make even a hardened rock-climber shudder.

The climate is agreeable for the reason already stated. In summer the temperature ranges at sea-level from 68°-84° F. and in winter from 57°-70°. In the higher interior it is 5°-10° cooler. Rainfall varies according to altitude; it is some 60 in. on the central ridge, about 45-50 in. at the elevation of Longwood (Napoleon's residence, 1,750 ft.) and less than 10 in. at Jamestown. Summer rains are heavier but less continuous than those of winter, when mists descend continually from the central ridge and create a somewhat damp and chilly atmosphere.

The coastal belt, 1-1½ miles wide, with a low rainfall, is devoid of vegetation except cactus, the prickly shrub lantana, Cape fig and similar xerophytic species. Where volcanic ashes or tuffs are prominent in this belt, subsidiary valleys (locally called "guts") and channels are cutting rapidly back into them to form "badlands". These valley sides show remarkable colouring effects in shades of red, blue, purple and white, due to the state of oxidation of the iron and manganese content of the decayed rocks.

An intermediate zone, in and around the central portions of the stream courses rising in the central ridge, has a higher and more consistent rainfall and consists of steep slopes covered with flax or grass, and inland cliffs where harder lava flows or phonolitic masses outcrop.

The central zone, on each side of the sickle-shaped central ridge which forms the backbone and main watershed of the island, is often concealed from view by mist and cloud, especially in winter. Vestiges of the indigenous forest remained on the higher slopes until quite recent times, but flax plantations now extend to the summit ridges, and a few tree-ferns, pines and patches of grass form the only other vegetation.

Physiography

St. Helena island is the deeply-eroded summit of a composite volcanic cone which rises from the ocean floor at a depth of 13,860 ft. The highest point on the central ridge, Diana Peak, is nearly 2,700 ft. above sea-level, making a total height of 16,560 ft. To the east of the island is the Buchanan Deep, with a maximum known depth of 18,400 ft., and nearly 600 miles to the west is the summit of the mid-Atlantic swell, at a depth of less than 8,000 ft. Daly (13) calculated that the base of the volcano is more than 10 times the area of the base of Etna, the largest volcano in Europe.

In addition to intense erosion of the surface, with the production of valleys of stupendous depth and steepness, the island has undergone a great amount of marine denudation. It is bounded on all sides, even the leeward, by the most awe-inspiring cliffs, a phenomenon which, together

with the fact that the marine mollusca most resemble those of the West Indies, led Daly (13) to speculate whether in the Quaternary there was a different set of winds and currents at St. Helena. A graded shelf entirely surrounds the island, varying in width, according to Admiralty Charts, from 0·8 miles to 1·87 miles from the present sea fringe to the break-of-slope, near the 300-ft. line. From the 300-ft. to the 1,200-ft. line, the slope varies from 1 : 1 to 1 : 3. It would appear that the inner shelf has been formed by marine denudation and the outer one by the deposition of the material thus removed.

The island is stable, and few earthquakes have been recorded, and those only of minor intensity. Daly's (13) study of a 5-metre wave-cut bench along the leeward side of the island, associated in some places with caves now high and dry, led him to postulate an emergence, due to a world-wide eustatic change of sea-level in post-glacial times. All traces of the bench on the windward side have been removed by marine denudation. There must have been uplift prior to this, as the Sandy Bay stream in the lower part of its course has cut down through more than 20 ft. of coarse boulder beds.

The great valleys draining off the central ridge are, as already stated, steep-sided and narrow at the bottom and are occupied by streams which are only active after much rain. Their tremendous size and depth and the existence of high-level boulder beds in the larger valleys indicates that in the past, possibly in inter-glacial pluvial periods, the streams had much greater power and were perennial. They nearly all reach the sea at grade, but in a few cases, where hard lavas overlie softer tuffs, they have been truncated by backward erosion, a typical example being the so-called Heart-Shaped Waterfall in the valley above Jamestown, below Francis Plain. There is little level ground between the valleys, the most extensive area of flattish ground being the Longwood and Deadwood plains.

Most of the cliff features and the sides of the valleys display basalt lava flows interbedded with volcanic ashes, and scores of flows may be counted in any cliff section. Examples are The Barn, Flagstaff Hill, High Knoll at Jamestown, Sandy Bay Barn, and Man and Horse Cliffs. Others, such as Great Stone Top, Castle Rock, High Hill, Riding Stones, Sheep Knoll and Hooper's Rock are massive and have a light-grey appearance, contrasting strongly with the drab-grey of the basalt flows. These are intrusions of phonolite and phonolitic trachyte, and some of them, such as the superb conical mass known as Lot, and the slender pinnacle Lot's Wife, which is narrower at the base than near the top, are phonolitic plugs.

The most amazing sight in an island in which magnificent views are almost a commonplace, is the view over the Great Hollow of Sandy Bay southwards from the central ridge. This great hollow is in the form of an amphitheatre of which the northern rim is formed by the central ridge containing the highest points on the island, Diana Peak and Actaeon Mountain. In it several streams converge into the main stream running along the axis of the basin, and which flows into Sandy Bay proper. Each stream has cut to a tremendous depth through strongly-cliffed harder lava flows into underlying coloured tuffs and weak flows pene-

trated by myriads of dykes. Projecting through all these are the apparently unscaleable plugs Lot and Lot's Wife, and the great light-grey masses of Riding Stones, Sheep Knoll, and smaller fantastically-shaped remnants such as Partridge Rock. Perched on ledges and inter-valley slopes around the sides of the bowl are small farms and houses and patches of cultivation—pleasant islands of green above the desolation of the lower slopes. Darwin (4) and Oliver (6) considered the Great Basin to be an explosion crater, breached to the south on the seaward side, but there are no signs of the enormous amount of material that would have been ejected in such an explosion, and the existence of similar but smaller hollows, and the general structure of the Great Hollow itself, allow of little doubt that it is an erosional feature.

Main Geological Features

Some of the later phonolitic intrusions, like Lot and Lot's Wife, seem to be the fillings of vents, but others, more widespread, appear to be either endogenous domes poured out of craters, or masses exuded from linear fissures. The fact that they are mainly situated in and around the Great Hollow, together with the countless dykes visible in that area, indicates that this was the great centre of eruption, not from one main crater, but from many small vents and from fissures. Dyke swarms appear also in the Flagstaff Hill-The Barn-Knotty Ridge area in the north of the island and there was here probably a minor centre of eruption. The Sandy Bay centre accounted for by far the larger mass of the island, and eruption seems to have proceeded for a long period to produce tuffs and only weak basalt flows, followed by a period in which the flows were much thicker and more numerous. A similar sequence of events took place in the northern focus, and in both areas a thick lower complex, mainly consisting of tuffs and agglomerates, is overlain by younger lava flows interbedded with only thin tuff beds; in both areas, too, the streams have cut through the harder, more massive upper lavas into the lower and weaker basal complex, and it is in this latter that the " bad-lands " have been developed and are even now being extended. These, with their almost complete lack of vegetation and striking colourings, may be seen best developed in the Sandy Bay district and adjoining valleys, and in the Deadwood, Longwood and Prosperous Bay areas in the north. In the Great Hollow area, the flows dip uniformly outwards at angles up to 15° and are probably roughly in the position in which they were formed. In the neighbourhood of Flagstaff Hill and The Barn, in the northern focus of eruption, dips are much higher and the beds appear to have been upthrust to form an anticlinal structure since their formation, possibly by pressure from magma intruded below the lower complex.

From the dips around the Great Hollow, Daly (13) calculates an original highest altitude of some 4,000 ft., contrasting with the 2,700 ft. of the present highest point of the central ridge.

High Knoll, near Jamestown, on which the Fort stands, formed a small independent centre of eruption of which the neck was filled by trachydoleritic basalt, now forming a mass on top of the hill, overlying

the dozens of flows, interbedded with thin tuffs, which are so strikingly displayed on the steep southern slope of Jamestown (Chapel) Valley.

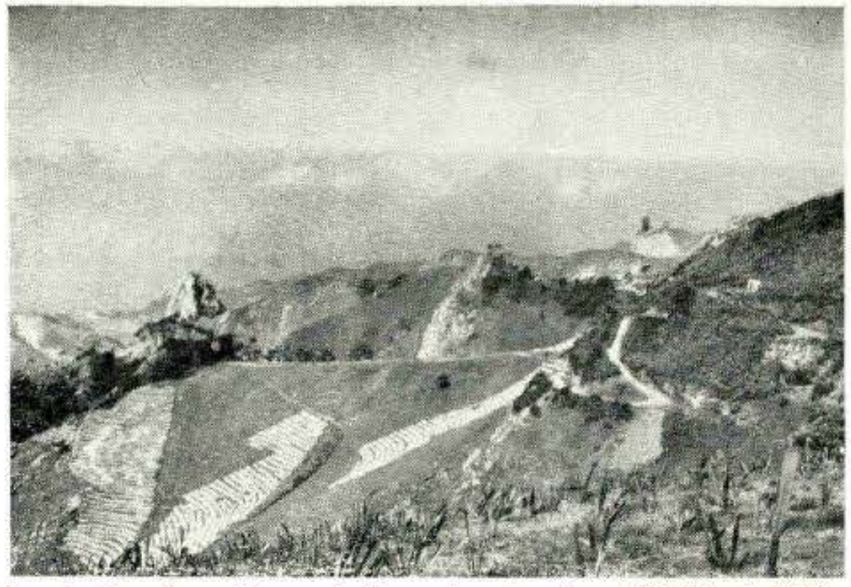
It must be borne in mind that the visible rocks on St. Helena are the youngest products of a great volcano, most of which lies beneath the sea; indeed, Darwin (4) considered that the lower complex, consisting mainly of tuffs and agglomerates, was mainly deposited under the sea. The petrology of the lavas and younger, more alkaline rocks has been studied by Daly (13), who concludes that by far the greatest volume of the exposed rocks is basaltic. Both olivine-rich and olivine-poor basalts occur, the latter being perhaps the more abundant. They are nearly all more or less vesicular, and both zeolites and calcite occur as fillings of amygdales. The trachydoleritic basalt of High Knoll may be considered as being to some extent intermediate between the ordinary basalts and the more salic bodies, which are true phonolites and closely-allied soda-trachytes. In the true phonolites, nepheline never exceeds 12 per cent. by weight, and in the soda-trachytes it is a very subordinate constituent. As stated above, the salic rocks form domes, necks, crater-fillings, irregular injections and occasionally dykes. They often show a columnar structure, which is beautifully displayed for example towards the top of Lot, while such structure is only rarely seen, poorly-developed, in some of the thicker basalt flows.

The dykes are basaltic and represent in part later fillings of fissures along which the lavas were extruded. They trend NE-SW and NNW-SSE, the former being commoner, especially at Sandy Bay.

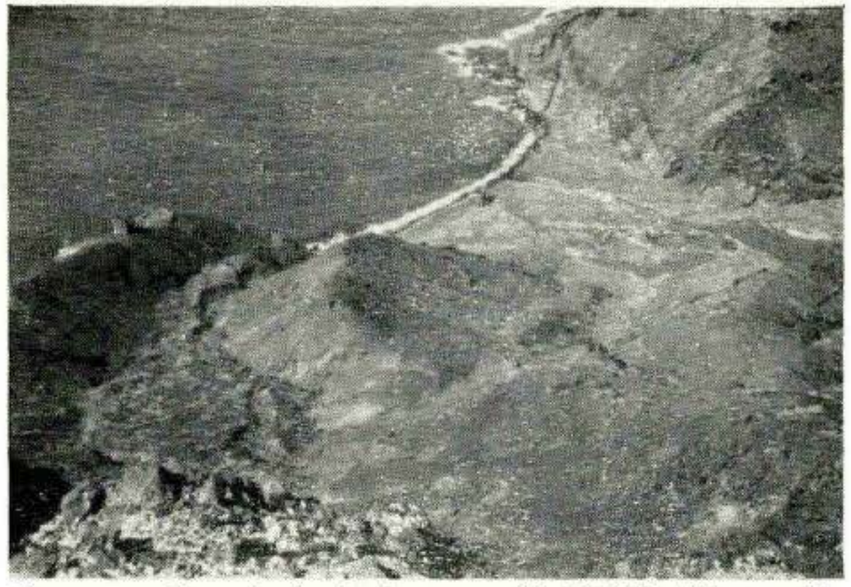
Both Oliver (6) and Mellis (7) record the occurrence of casts of tree-trunks in basalt, notably in the Friars Ridge district near Jamestown, and Daly (13) states that two of these flows of basalt in which they occur are stratigraphically 100 ft. apart. No fossils of diagnostic value have been found on the island, but the depths and widths of the valleys and the heights of the sea cliffs testify to a great age. Wallace (9) after consideration of the fauna and flora, concludes that both are ancient, " perhaps dating back to the Miocene period or even earlier ".

Fragments of granitic and sedimentary rocks and of quartz have been carefully searched for by Darwin (4), Webster (3), Mellis (7), and Daly (13) amongst others, but no trace of them has ever been found during the long human occupation, though granitic and syenitic projectiles have been found at Ascension. Since that island is situated on the mid-Atlantic swell, traces of lighter rocks occasion less surprise.

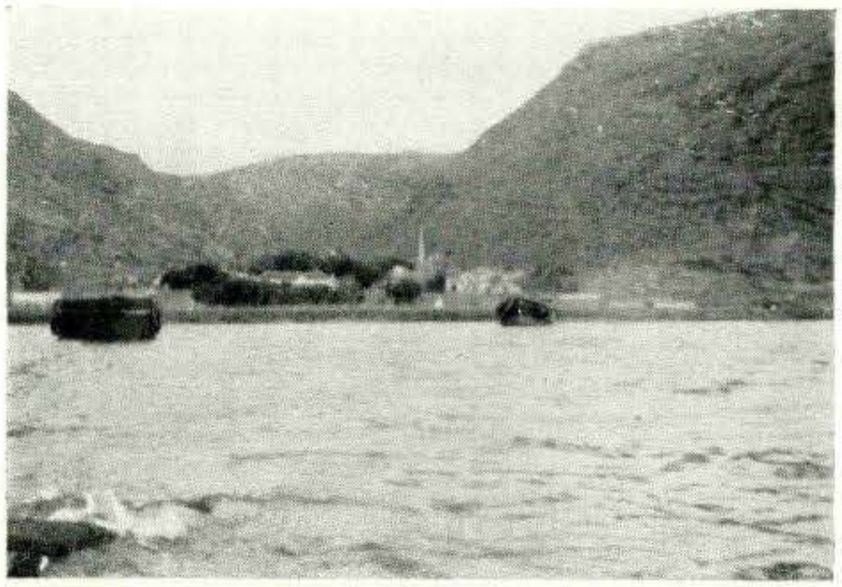
It is surprising that Daly (13) refers to the weathered, variegated tuffs of the lower complex, so well-exposed in the valleys of the coastal belt, as laterite. They bear not the slightest resemblance to the residual laterite so common in tropical countries and they are simply due to the weathering of fine-grained tuffs, showing striking coloration when containing appreciable amounts of iron or manganese. There is no true laterite on the island, but there are some deep red-weathering ferruginous basalts, often with abundant crystals of augite. If true laterite were present, there would not be the difficulty there is in finding a suitable self-binding top-dressing for the roads. Halloysite occurs in thin beds and veins amongst the weathered tuffs as a white or pale-cream clay with a



Sandy Bay from Casson's Gate, showing Lot (left) Lot's Wife (right) and flax drying.



Prosperous Bay. Ledge in foreground is Holdfast Tom, with manganese ore.



Jamestown from the sea.

Central Ridge from Hutt's Gate.

[Photos: G. F. Gammer, Miss E. R. Salmond and J. H. Jacobs

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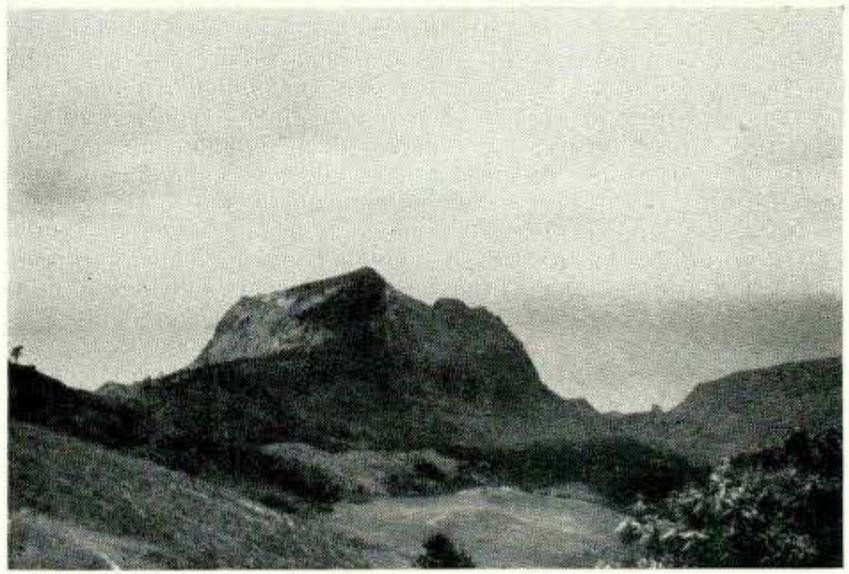
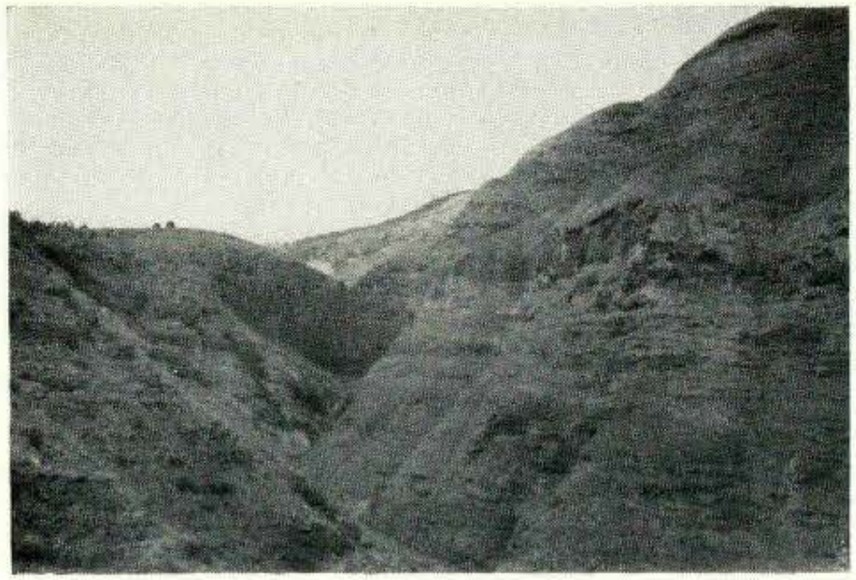


High Hill, a phonolite dome, from Blue Hill.



Heart-shaped Waterfall, Chapel Valley, Jamestown.

Lot's Wife. Sandy Bay in background.

Road to Rock Rose, from Sandy Bay.

[*Photos: G. F. Gammer, Miss E. R. Salmond and J. H. Jacobs*

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soapy feel and a tendency to conchoidal fracture. A similar clay, but pale-chocolate in colour, often occurs in thin veins in weathered basalt, associated with manganese oxide.

An interesting encrustation occurring in cavities in decayed lava at the farm Hermitage, near the Agricultural Station at Scotland, has been determined by Mr. D. F. Livingstone of the Mineral Resources Division as phosphatic allophane. The mineral is yellowish or brownish in colour, with a glassy lustre and conchoidal fracture and is very brittle.

Economic Geology

Manganese

The manganese deposits of the island have been mentioned by many observers, particularly Oliver (6) and Mellis (7), and specimens have been received in England from time to time, mainly by the Imperial Institute. The Annual Report on the island for 1907, by Governor Gallwey (11), notes that they had been examined by a Mr. Herdsman, who reported unfavourably upon them.

Manganiferous occurrences are fairly widespread, but the only deposits of any significance are situated in the north-eastern part of the island. Minor occurrences were noted near Sandy Bay Beach, Gumwood, near Francis Plain, and at Two Gun Saddle, near the Sidepath, consisting of thin manganese veins and coatings associated with the chocolate-coloured clay mineral described above.

The beds, mainly variegated tuffs of the lower complex, which underlie the Longwood and Deadwood plains in the north-east, are dissected by several valleys or guts, fed by numerous subsidiary guts which are rapidly eroding back into the plain. Just below the junction of Netley Gut and Sheep's Pound Gut, both of which drain from Deadwood plain below Flagstaff Hill, anastomosing veins of psilomelane, which often coalesce into nodules and small masses, occur in a whitish decomposed tuff on the south bank of the stream. Weathering of this is proceeding, and manganese ore has been redeposited lower down the slope to occur as " boulders " of soft ore (wad) and in places as a definite band some 2 ft. in thickness and of limited extent, lying in and partially concealed by soft friable chocolate-coloured " sand " washed down the slope.

The two kinds of deposit can be traced at intervals, sometimes in a tuff outcrop and sometimes as " boulders " or a bed of soft ore, along the south side of the valley past the junction with Bilberry Field Gut, as far as the waterfall shown on the accompanying map. It is absent on the north side of the valley where lavas outcrop. The waterfall is caused by a dyke intrusion striking across the stream. The manganese ore appears again below the fall and east of the dyke, but is less prominent and fades out where the stream turns north to fall sharply to the valley between The Barn and Turk's Cap.

In the Springs Valley, between Turk's Cap and Horse Point, white " claystone " (decayed tuff) about 20 ft. thick and overlain by grey lava is prominently exposed in the cliff face. Near the junction of the two small streams which unite to form the Springs Valley at about the

400-ft. contour, the claystone displays thin veins and irregular masses of hard botryoidal ore over a length of about 100 ft. Below it occurs chocolate-coloured friable " sand " with soft manganese ore weathered out of the manganiferous bed and similar in appearance to that in the Netley-Sheep's Pound Gut valley.

The white to bluish decayed tuff or claystone can be traced southwards in the vertical cliff overlooking Prosperous Bay. At Horse Point, on the ledge known as Holdfast Tom, and again in Fisher's Valley and at inaccessible places between these points, the veins and masses of hard botryoidal ore occur prominently at intervals. At Fisher's Valley the host rock is agglomeratic. Between Prosperous Bay and Stonetop Gut, manganese was noted only in Dry Gut, north of Bencoolen, and there only as thin coatings on lava.

Thus, though the tuff bed or beds are continuous over a considerable distance from the Flagstaff neighbourhood round towards Bencoolen, the manganese concentrations are sporadic in occurrence and they have not been noted on the south side of Longwood and Deadwood plains, where the same series of beds is displayed on the flanks of the upper part of Fisher's Valley and Sain (or Seine) Valley (at the head of which is Napoleon's tomb).

The veins and masses of botryoidal ore, harder than the matrix, stand out prominently where they occur, and the hard ore is of excellent quality and could easily be separated from its matrix by crushing and washing. Analyses of these ores, made by the Mineral Resources Division, are as follows:

MANGANESE ORES FROM ST. HELENA

		Per cent.		*Per cent.*
1. Hard botryoidal ore (Springs Valley)	MnO_2	74·48	Mn	52·18
	MnO	6·61		
	SiO_2	3·12		
	Fe_2O_3	0·80	Fe	0·56
	P_2O_5	0·91	P	0·40
2. Hard botryoidal ore (Holdfast Tom)	MnO_2	55·98	Mn	38·56
	MnO	4·12		
	SiO_2	14·49		
	Fe_2O_3	4·40	Fe	3·08
	P_2O_5	0·63	P	0·28
3. Soft ore (Near Junction Netley Gut and Sheep's Pound Gut)	MnO_2	56·16	Mn	40·88
	MnO	6·96		
	SiO_2	6·55		
	Fe_2O_3	4·04	Fe	2·83
	P_2O_5	0·82	P	0·36

Sample No. 1 may be taken as representative of the hard botryoidal ore when cleaned from adhering tuff. The high silica of Sample No. 2 is due to a higher proportion of tuff. The soft ore is that occurring as " boulders " and an indefinite bed formed from manganese washed out and redeposited from the nodules and veins occurring as botryoidal ore in tuff. It is clear that crushing and washing of the hard material would yield high-grade metallurgical ore.

The minor occurrences of manganese, as near Francis Plain Mill, Two Gun Saddle, etc., consist of extremely thin veins and coatings in spheroidally-weathering basalt lava.

The botryoidal ore in the " claystone " is clearly of secondary origin and deposited from solutions derived probably from the breakdown of manganiferous minerals in associated lavas and tuffs.

As an economic proposition, the deposits must be rejected, not on grounds of quality or difficulties of separation from the matrix, but because of insufficient tonnage. Kitson (15) quoting from Oliver (6) infers that " the actual quantity [of ore] buried beneath the surface is probably enormous, since the white claystones doubtless underlie the whole district ". The present writer cannot agree. In the first place, Oliver gives the impression that there are, in the Longwood-Prosperous Bay area, beds of " claystone ", all containing the manganese veins and masses. This is not the case. There are not more than two, and possibly only one, as the bed in the cliff sections may be the same as in Netley Gut, carried down on the dip. Secondly, Oliver assumes that the manganese occurs throughout the claystone, but the concentrations are clearly sporadic in occurrence and, due to the hardness of the manganese ore, stand out prominently wherever they occur. Finally, although it may be agreed that the claystone bed or beds underlie the whole district, since the same series is exposed in the valleys south of Longwood and Deadwood plains, the manganese concentrations do not, as there is no sign of them in the outcrops on the flanks of these valleys. Even if they do occur underground to some extent, as can be expected, there is the question of overburden of the order of 1,000 ft. to be considered, and the concentrations could not yield sufficient ore to justify underground mining, even in the form of adits.

Iron Ore

Nodules of haematite and limonite are thickly strewn over parts of Longwood and Deadwood plains. They are mainly of small size, up to an inch or so, on Deadwood, but larger blocks, up to 6-9 in., occur in places at Longwood and have been used in the past for fencing. The material has also been tried, lightly crushed, as a top dressing for roads but has not proved satisfactory as it is not lateritic and has no binding qualities. The nodules have been accumulated by the weathering of tuff beds in which the iron oxide occurs as veins and nodules in a similar manner to the manganese described above.

Miscellaneous Minerals

A Geiger-Müller ratemeter was used over a wide variety of outcrops. A small reaction was obtained from hard basalt lavas on the Hutt's Gate-Rockrose-Sandy Bay motor road, near Warren's Gut, but from no other locality.

Sporadic small occurrences of iron sulphide in the lavas have been mistaken for gold or copper ore in the past. There are no quartz veins on the island, nor any other geological milieu in which gold might occur.

Kitson (15), following up Darwin's mention of a " compact mass of

greenstone " in the Sandy Bay area, infers the possibility of the occurrence of every possible mineral of magmatic origin, from platinum metals to diamond. It seems certain that Darwin was referring to the phonolitic mass of Riding Stones, which is the largest compact mass of hard rock in the Sandy Bay Hollow and has a greenish colour in the hand-specimen. There is certainly no occurrence of very basic or ultrabasic rock and consequently no trace of magmatic ore minerals.

There are scattered small occurrences of calcareous beds—mainly reconstituted wind-blown shelly " sand ", and tufa derived from this—calcite, gypsum (selenite), zeolites, and phosphate from ancient bird rookeries. The shortage of wood for fuel and the difficulties of transport militate against the use of local calcareous beds such as those near Sugarloaf and overlooking Potato Bay, and the same argument applies to the use of local clays for bricks and tiles. There is no local skill in pottery making. Easily dressable building stone is not common and is found in practice to be more expensive than concrete blocks. The concrete and mortar made by the P.W.D. from crushed stone, beach " sand " (comminuted basalt, rock-forming minerals and shells) and imported cement seems to be adequate for the purposes for which it is required.

Samples of the coloured tuffs have been taken for testing as possible sources of pigments, and some of the phosphate from the Prosperous Bay area as a possible source of fertiliser for local use.

This question of fertilisers is of some importance to the island. The soils are manifestly deficient in lime, and private owners have found importation of lime too expensive. Neither the calcareous nor the phosphate deposits are large, but there would probably be sufficient for local use by direct application after fine grinding. The calcareous " sandstone " and tufa near the top of the cliff 1,000 ft. east of Sugarloaf Hill might be suitable and is not too far from Jamestown, while the phosphatic rock occurs as thin cakes and dust on the surface of Prosperous Bay plain.

Analysis of the phosphate gave the following results.

PHOSPHATE ROCK FROM ST. HELENA

	Total P_2O_5 (%)	*Available* P_2O_5 (%)
1. Solid material (Prosperous Bay Plain)	25·25	11·09
2. Phosphatic " dust " (Prosperous Bay Plain)	18·47	9·58

The available P_2O_5 was determined from material ground to −100 mesh. The material could thus be used by direct application as a fertiliser when finely ground.

A suitable top dressing for the sections of road not yet treated with a bitumen emulsion has not yet been found. It was anticipated, from previous descriptions of the occurrence of laterite on St. Helena, that this problem could easily be solved, but the writer found no true laterite on the island. Some of the lavas and tuffs weather red, but the material is not laterite and has not the binding quality of laterite as a road dressing.

Mr. Gammer, Superintendent of Works, has experimented and continues to do so with local " marls " (volcanic tuffs), but the only satisfactory solution to the problem is the treatment of all the important roads with bitumen emulsion. This would effect considerable savings in maintenance, both of the roads and the vehicles using them.

During his stay on the island, the writer was informed by Mr. Thorpe, flax owner and farmer, of Oakbank, that he was using a cement made by mixing a small quantity of imported portland cement with crushed grey decomposed volcanic tuff outcropping at the back of Oakbank. A test of this and similar tuff from other parts of the island shows that it has no inherent pozzolanic properties and the effect of mixing cement with it can only weaken the cement. The sample handed to the writer by Mr. Thorpe had a decided cementitious property, but it was found that it had already been mixed with imported cement.

Soil Conservation

The soil cover in many parts of the green belt is only thin and once the grass has been removed by overgrazing, especially by sheep, and even by donkey rolling, sheet erosion proceeds apace on such steep slopes. The process may be seen in an advanced stage at Broad Bottom and in the incipient stage on the north slope of Lemon Tree Gut, but there are many other examples.

Gulley erosion and the formation of " badlands " is proceeding rapidly in areas of soft tuffs, as may be seen north and east of Longwood and in the Sandy Bay area.

The reclamation of much of the Crown Waste Land is not impossible, but will take many years if it is ever attempted. In the meantime the preservation and improvement of the green belt is imperative. It will not be difficult, given a consistent policy. The eroded patches such as those at Broad Bottom should be fenced off and re-grassed. Sheep grazing should be controlled, flax planting done strictly on the contour and there should be a systematic programme of replanting of grazing areas by better quality grasses. The steeper slopes should be afforested, and a mixture of Port Jackson willow, Cape yew, wattle and pines would be suitable for this purpose. These matters have been dealt with by Mr. Humphrey, Agricultural and Forestry Officer, in memoranda addressed to Government, and the present writer is in agreement with his main conclusions and recommendations.

Water Supply

The present water supplies are adequate, given proper usage and additional storage. The main watershed of Central Ridge, and subsidiary watersheds, should be delimited and protected by law. The principle is, of course, to preserve the vegetative cover so as to give the rainfall time to seep into the rock beneath and consequently maintain the flow of the springs. There is no objection to flax, provided this is planted on the contour and there is no between-row cultivation. Afforestation of the heads of valleys immediately around and above the

springs would be helpful. There should be a Water Authority to control by permit any proposed large-scale usage of water.

The topographical conditions do not favour the storage of water in dams. The valley bottoms are in general too narrow to yield any considerable areas suitable for irrigation, and for purposes of domestic water supply, impounded water in the valleys would entail costly distribution by pumping to the settlements on the higher ground. There should certainly be much-increased storage of water, but this would be better done by construction of storage tanks at convenient and easily accessible points near the heads of streams, and distribution by gravity feed through pipes, as is done at present.

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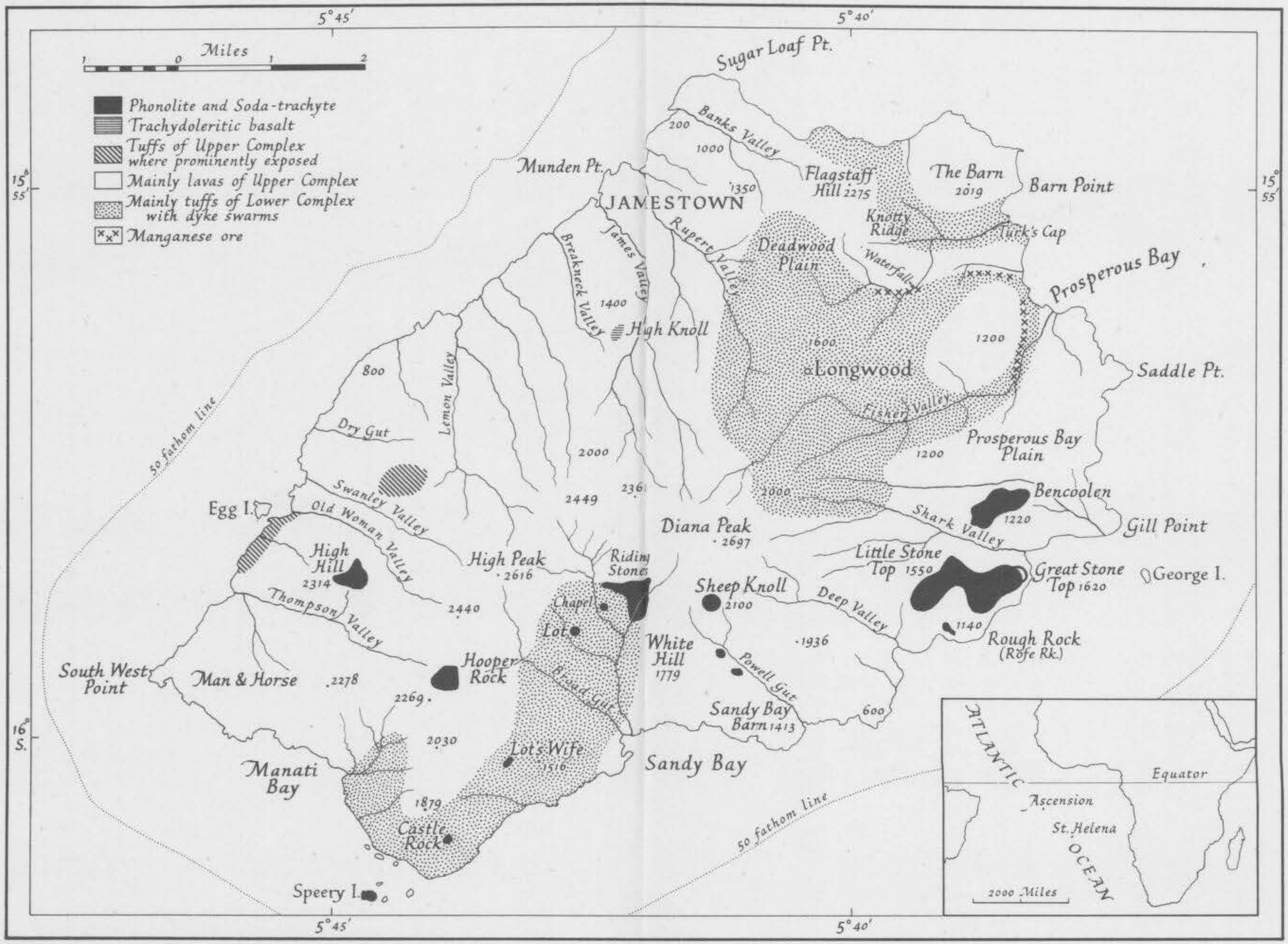
GEOLOGICAL SKETCH MAP OF ST. HELENA

Largely after R. A. Daly (1927)



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