plying a substantial melting rate at the sole of the glacier in this region. The August 1970 eruption also deposited an ash cover averaging about 1 meter in thickness that blankets the lower part of the Bynon Hill glacier, including all of the ablation zone and 20 percent of the accumulation zone of the pre-eruption glacier. At present, net ablation occurs only around the ice crater walls and on the glacier sole, and net accumulation occurs only on the upper slopes of Bynon Hill and the caldera rim. Hence, the August 1970 eruption has fundamentally and perhaps permanently altered the mass balance regime of the Bynon Hill glacier.

In addition to mass balance studies, the ice crater closure investigation is studying shear bands that formed around the ice crater immediately after the August 1972 eruption and are still active today (Hughes, 1971). This study has led to the first verification of glacial flow confined to discrete, discontinuous bands alined at high angles with respect to the usual flow direction. It supports the idea that thermal convection in polar ice sheets may be via discontinuous flow confined to narrow diapiric columns or pipes in which hot basal ice is extruded upward by the great weight of the overlying cold ice descending en masse between the diapirs (Hughes, 1972). This mechanism would require that each diapiric pipe be surrounded by a narrow shear band sheath.

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Figure 2. The types and locations of field studies relating to the ice crater through the Bynon Hill glacier snout. Primary (P) and secondary (S) surface strain network stakes are at the corners of the triangular grid lines, absolute velocity stakes are at the circled red dots and at the centerline stakes of the surface strain networks, and interior strain network stakes are located in the ice tunnels dug into the ice crater walls at the indicated absolute velocity stake sites. All 20-meter contour interval lines in the plan view date from the 1956 photometric aerial survey. Subsequent eruptions caused partial alterations of the dashed contour lines. The profile view is along an extension of the axis of the primary strain network. The 1956 equilibrium line separates clean ice from dirty ice, buried and exposed. Today buried ice extends uphill beyond the 180-meter contour line.

Glaciology and glacial chronology in the South Shetland Islands

NORMAN W. TEN BRINK *and* JAMES E. CURL

Institute of Polar Studies
The Ohio State University

Field work on Deception and Livingston Islands (fig. 1) from December 16, 1972, to January 28, 1973, extended glaciologic and geologic investigations in the South Shetland Islands that have been conducted by members of the Institute of Polar Studies during each field season since 1968-1969. Two major results from the previous studies provided the basis for the 1972-1973 field work: (1) determination of a threefold sequence of glaciation and interrelated periods of raised beach formation on Livingston Island (Everett, 1971), and (2) determination of mass-balance and inferred paleotemperature variations on Deception Island from 1780 to 1970 (Orheim, 1971, 1972, in press; Orheim *et al.*, 1972). A major objective of the 1972-1973 field work was therefore the logical next step of determining the history of variations in extent of the glaciers so that it could be related to the mass-balance (paleotemperature) variations.

Field work was in three phases. The first was to collect ice samples from selected horizons exposed in walls of the volcanically formed glacier crater and fissure on Deception Island (fig. 2). These samples were collected from sections that have been stratigraphically dated by Orheim (1972) so that their oxygen-18/oxygen-16 content, when analyzed, will provide an independent check on Orheim's paleotemperature reconstructions based on mass-balance data.

The second phase consisted of mass-balance studies on glacier G-1, Deception Island (fig. 2), and on Rotch Dome and Charity Glacier, Livingston Island (fig. 3). The stake networks maintained on glacier G-1 since 1968-1969, and on Rotch Dome since 1970-71, were remeasured, and stakes were reset where possible. In addition, new networks of stakes were set on glacier G-1 and on the Charity Glacier.

The third phase of field work was the most extensive, consisting of investigations with the common goal of determining an absolute glacial chronology for Livingston Island. Three methods of dating moraines were used: tephrochronology, lichenometry, and radiocarbon dating.

The tephrochronologic method consisted of collecting several tephra samples from both stratigraphically dated layers in the Deception Island glacier crater and pyroclastic strata within or on Livingston Island glacial deposits. These samples are being analyzed petrographically and chemically to determine whether correlations can be made between tephra in the glacial stratigraphy and the ice-crater stratigraphy. If so, the ages of stratigraphically dated tephra layers from the glacier crater may be used to place limiting ages on those glacial deposits that contain correlative tephra layers.

Lichenometric dating of glacial deposits was attempted by measuring the maximum diameters of selected species of crustose lichens growing on boulders on moraine surfaces. An internally consistent set of measurements was obtained for sequences of moraines of several different glaciers, and this will permit a system of relative moraine ages to be established; however, absolute ages cannot be derived from the lichen measurements until lichen growth rates are determined on the basis of either tephrochronologic or radiocarbon dating.

Radiocarbon dating of moraines was attempted by determining the stratigraphic and/or morphologic relations between moraines and raised beaches and then searching for datable material buried in the beaches. We were successful in both aspects of this investigation with the following results.

Clear moraine-beach relationships were found on Livingston Island indicating that—(1) The youngest moraines in the area were deposited before the formation of 2.5- to 3.0-meter beaches, which are developed on the moraines, but after the formation of 3.5- to 5.0-meter beaches, which are overlain by the moraines. (2) The next older set of moraines (the "False Bay" moraines of Everett, 1971) were formed contemporaneously with or possibly just prior to a 6-meter beach, into which the moraines grade in a transitional manner. (3) The third and oldest glacial advance(s) (the "Livingston" glacial

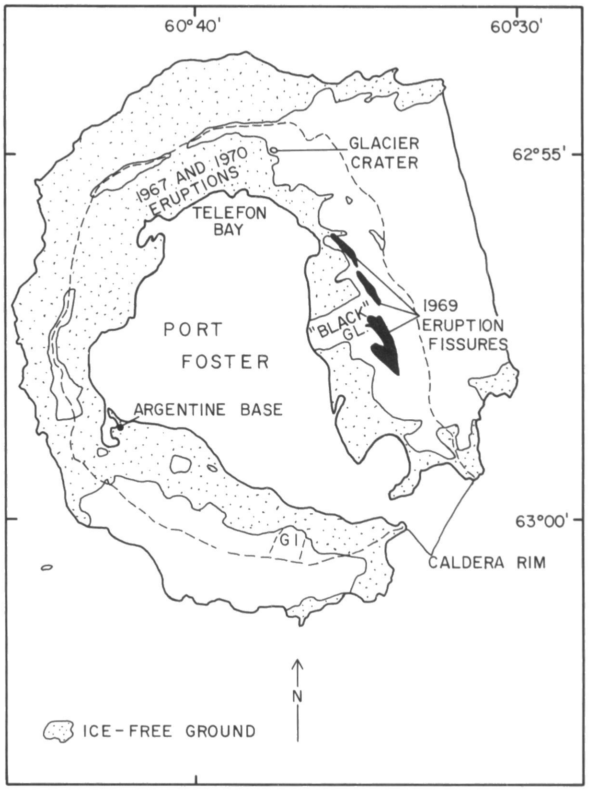

Figure 2. Index map of Deception Island.

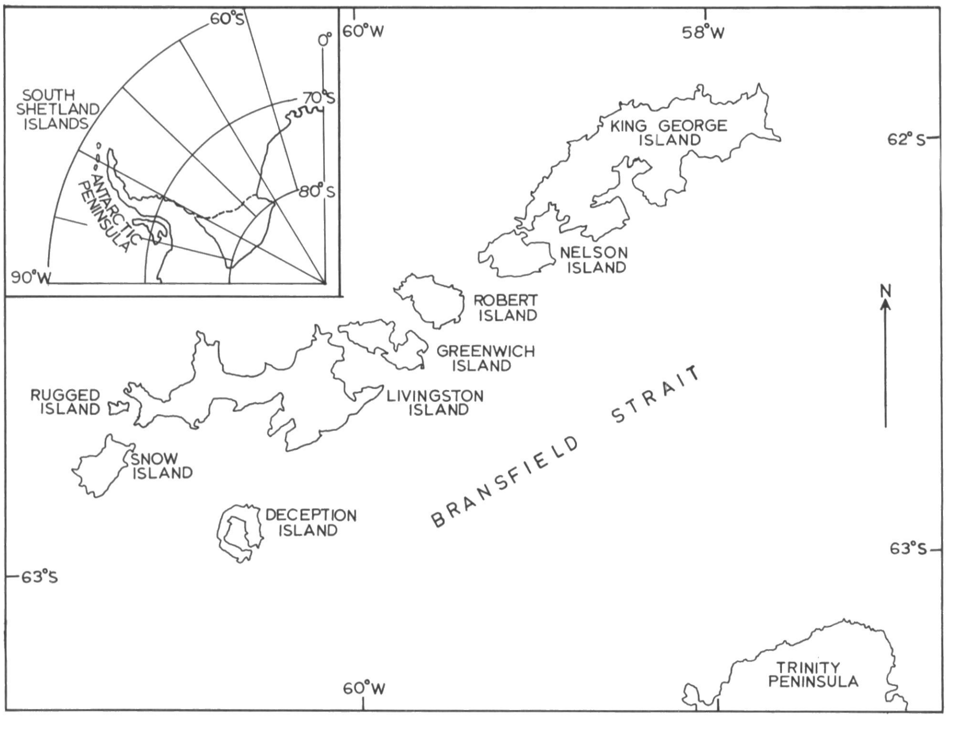

Figure 1. Location of the South Shetland Islands.

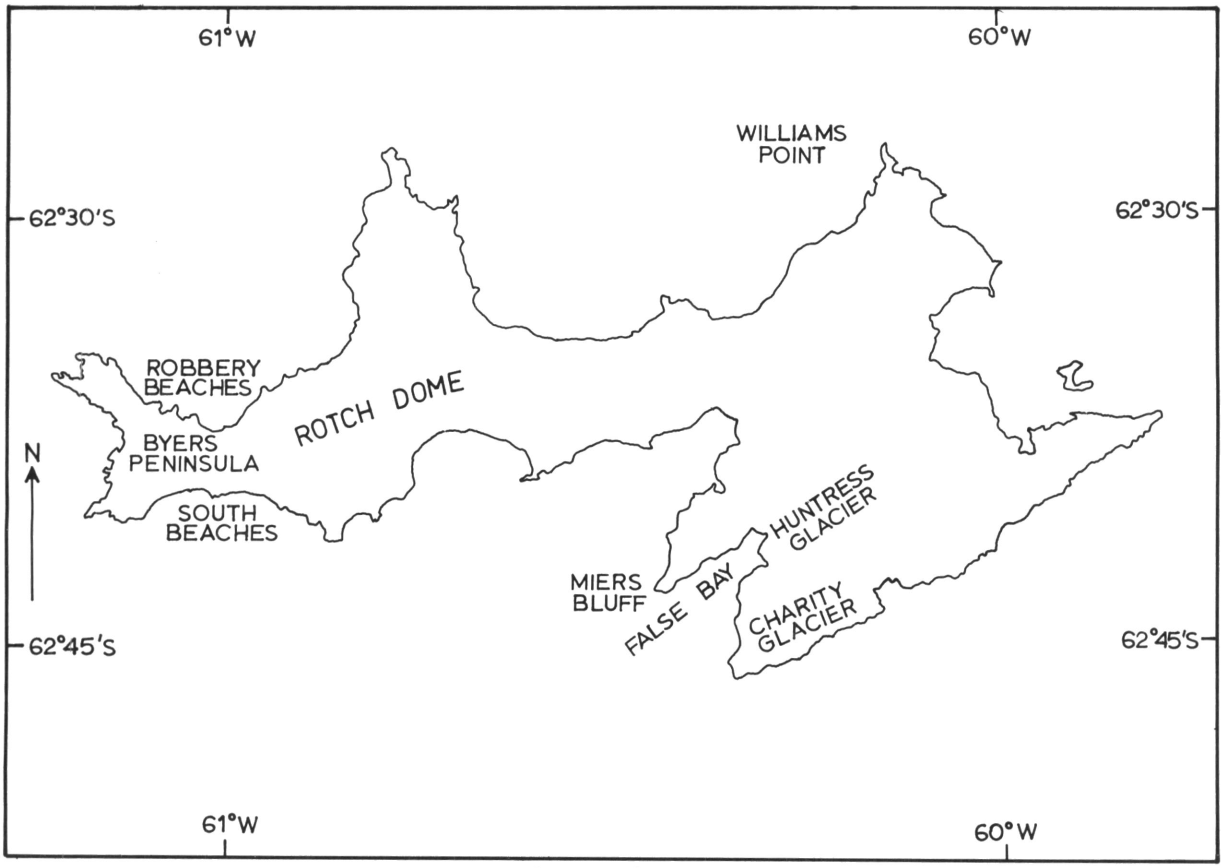

Figure 3. Index map of Livingston Island.

event of Everett, 1971) occurred before the formation of 9- to 12-meter and possibly even higher beaches. Whale bones were collected from *in situ* deposits in each of the beach levels mentioned above. Therefore, radiocarbon dating of these bone samples should provide the framework of an absolute glacial chronology for the South Shetland Islands area. (Samples of whale baleen and seal bones were collected from recently living animals in the area to check radiocarbon dating error due to the radiometrically "old" antarctic water in which the animals lived.)

The Instituto Antártico Argentino provided housing and food through their base on Deception Island for us as well as for four members of another research team from the Institute of Polar Studies and two Romanian geologists, Dr. George Istrate and Dr. Ioan Teodoru. Thus, the 1972-1973 Deception Island work was indeed internationally cooperative, including six U.S. participants, two Romanian geologists and the following six Argentines: Mr. Francisco R. Martinez (meteorologist), Dr. Antonio Igarzabal (geologist), Mr. Felipe R. Rivelli (geologist), Mr. Hugo Spairani (assistant), Mr. Ricardo Sureda (geologist) and Dr. Jose Viramonte (geologist). For making possible a productive field season, highlighted by a spirit of camaraderie, we express our most sincere gratitude to our Argentine hosts.

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