AN AEROMAGNETIC SURVEY OF ALEXANDER ISLAND AND PARTS OF PALMER LAND: A PRELIMINARY REPORT

By B. J. DIKSTRA

ABSTRACT. An aeromagnetic survey was flown over Alexander Island and parts of Palmer Land in the southern summer of 1975–76. A brief description of the equipment and a discussion of navigational methods is given. The completed flight network is shown.

THE aeromagnetic survey of the Antarctic Peninsula, which was begun by the British Antarctic Survey in December 1973 (Renner, 1976), was continued in the southern summer of 1975–76. B. J. Dikstra, J. L. Martin and R. G. B. Renner carried out the survey using a De Havilland twin Otter aircraft based at the British Antarctic Survey's station at Fossil Bluff (lat. 71°19′S., long. 68°17′W.). A network of flight lines was established, between lat. 69°30′ and 72°30′S., over Alexander Island, George VI Sound and northern Palmer Land (Fig. 1). The survey took 100 hr., flying at 140 kt, between 16 December 1975 and 10 January 1976.

Since many physiographic features and geological formations in this area are elongated north–south, parallel to the trend of the Antarctic Peninsula (Bell, 1975), most lines were flown east–west, at right-angles to the predicted magnetic strike. Most of the survey (15,200 km.) was flown at a constant barometric altitude of 2,500 m. above sea-level. Over Alexander Island, flight lines were about 15 km. apart and most of these were continued eastward across Palmer Land. Lines were more closely spaced between lat. 71°15′ and 71°31′S., where it is eventually hoped to produce a crustal profile across the Antarctic Peninsula by combining the results of this survey with those of previous gravity, radio-echo sounding and geological surveys.

More detailed surveys, flown at the minimum constant altitude allowed by the terrain (1,130 m.), covered parts of south-western Alexander Island. A grid network (2,200 km.) was flown to investigate the relationship between (?) Carboniferous sediments and dolerite and diorite intrusive rocks at Stacatto Peaks (Bell, 1975), and to search for structures which may lie beneath the ice to the east of these peaks. A further 700 km. were flown to determine the extent of Cenozoic volcanic rocks which are exposed on scattered nunataks on Beethoven Peninsula (Bell, 1975).

EQUIPMENT

Total magnetic field measurements in units of 1 gamma (1 gamma $= 10^{-9}$ tesla) were made once each second with a Geometrics model G-803 proton-precession magnetometer. The sensor was toroidal and mounted on one wing tip of the aircraft. The measurements were recorded on a Cipher model 70 magnetic tape recorder for subsequent computer processing in the United Kingdom. The recorder was controlled by a Geometrics model G-704 data-acquisition system. Also recorded each second were: a flight line number, the time and information from the aircraft navigation instruments, viz. the distance along the line, the heading of the aircraft, its air speed and altitude, and the outside air temperature. In case of recorder failure or tape damage, every tenth data record was printed on paper by a Datac model 210 printer. This also enabled the operator to check that the magnetometer system was functioning correctly. A Geometrics model MARS-6 chart recorder produced magnetic profiles in flight so that the magnetic character of an area could be recognized immediately and later lines planned accordingly.

Magnetic compensation of the aircraft was carried out at the British Antarctic Survey station on Adelaide Island (lat. 67°46′S., long. 68°55′W.). Heading-error tests showed that field readings should be accurate to about 5 gammas.

Most of the equipment was housed in a rack 1·03 m. high, 0·49 m. wide and 0·57 m. deep, leaving ample room in the cabin for additional fuel tanks which extended the range of the aircraft to about 1,700 km.

Navigation

In previous airborne programmes of the British Antarctic Survey, navigation has relied on visual techniques using bearings, fixes and time estimates based on maps which were in some cases no more than reconnaissance sketches. Radio direction-finding aids were limited to two beacons, both of limited range, situated at the Survey's stations on the Argentine Islands (lat. 65°15′S., long. 64°16′W.) and Adelaide Island. Recently, much improved maps based on satellite imagery have been published for part of the area, but still the navigator has to contend with a range of scales, projections, accuracies and styles. Over sea, featureless ice or cloud, the navigator had to rely solely on dead reckoning with no means of measuring the wind.

For the 1975–76 season, a Bendix DRA-12 Doppler-navigation system was installed in the aircraft. This system measured the velocity of the aircraft with respect to the ground using Doppler radar in conjunction with a Sperry C-12 gryo-magnetic compass. The system integrated these measurements to calculate the position of the aircraft relative to a starting point. An account of Doppler-navigation systems has been given by Fried (1957).

The system proved to be reliable except when flying over very smooth sea, such as often occurs in open pack ice, but this was to be expected from the way in which Doppler radar works (Fried, 1957). However, when the Doppler radar did fail, the system computer would continue to calculate the track of the aircraft on the assumption that the wind velocity obtaining before the failure did not change.

The Doppler radar displayed ground speed (the magnitude of the velocity of the aircraft) and drift angle (the angle between the direction of the velocity of the aircraft and the heading of the aircraft), and the system computer displayed the progress of the aircraft along a chosen course.

For example, if the pilot had chosen a course of 010° but had flown along 020°, the computer display after 100 nautical miles would have shown 98·5 nautical miles along track and 17·4 nautical miles across track to the right. The form of this display made it simplest to fly lines along a constant magnetic course. The pilot would select the desired course on the computer and would then fly in such a way that the across-track reading on the display remained constant.

So that flight lines could be related to ground features, beginnings of lines would wherever possible be over prominent nunataks or ridges which could be identified on the map. Once on track, it was found better to maintain a constant course, taking navigational fixes as opportunities arose, rather than to fly dog-leg fashion from one feature to another. Fixes were mostly hard fixes (when identifiable features were crossed) and running fixes (taking two bearings from along track to the same feature at different times).

A proper estimate of errors in navigation must await a comparison of positions given by navigational fixes with those given by the Doppler system but such a comparison will be complicated by the variable accuracy of the maps; however, most lines started near George VI Sound where map errors are believed to be small compared with the error in the initial navigational fix. Fried (1957) reported tests which showed that the probable position error of a Doppler-navigation system was $0 \cdot 15D^{\frac{1}{2}}$ km., where D was the distance flown in kilometres. Thus, at the end of a 250 km. line, the error would on average be 2·5 km. before taking into account any navigational fixes. The recent completion of tellurometer-survey networks in Palmer Land and Alexander Island allows the accuracy of the present mapping to be checked and thus it is expected that the positions of most lines will be established to within 1 km.

Throughout the period of the survey, continuous diurnal variation measurements were

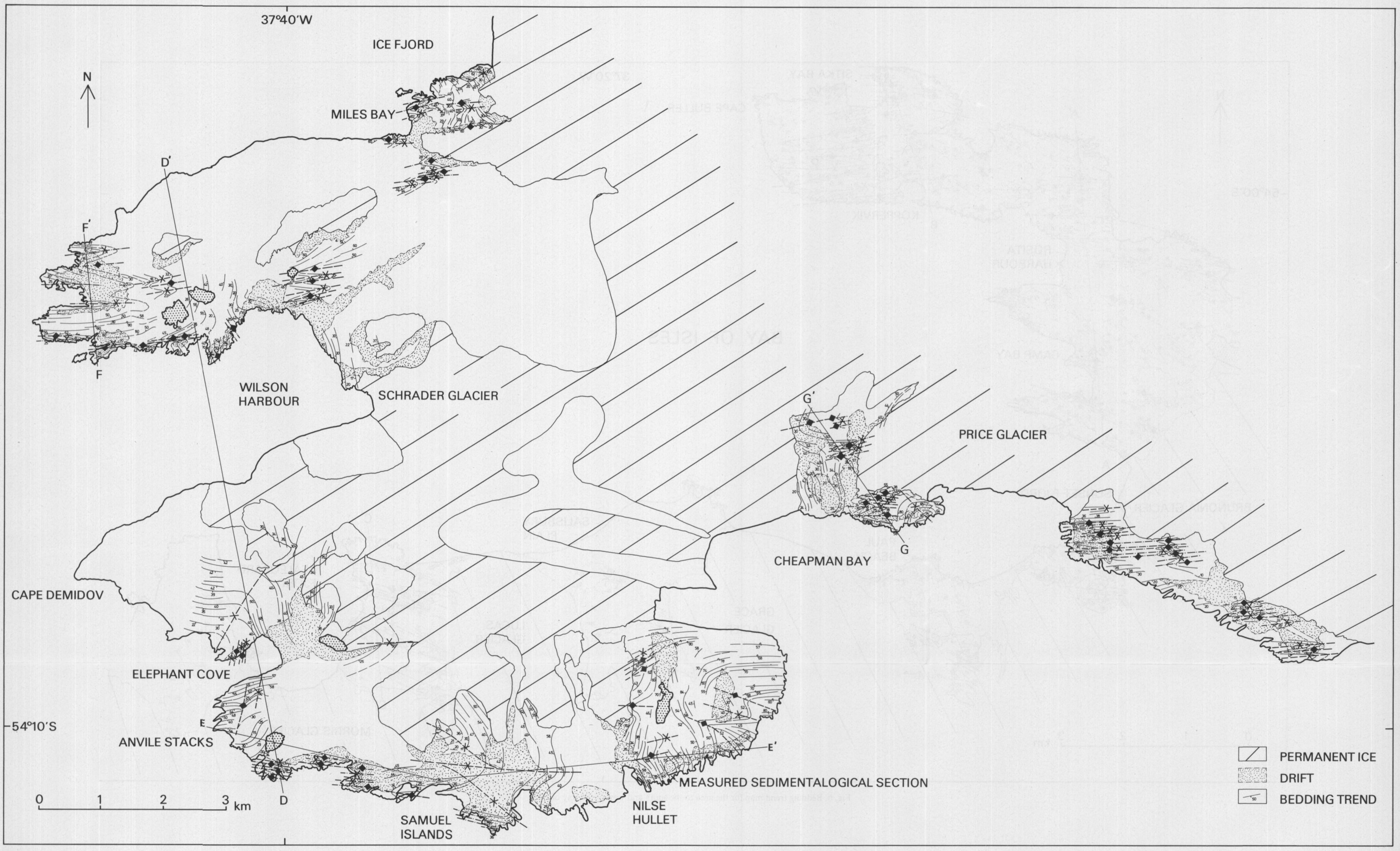


Fig. 8. Bedding trend map for the area bounded by Cheapman Bay, Wilson Harbour and Ice Fjord.

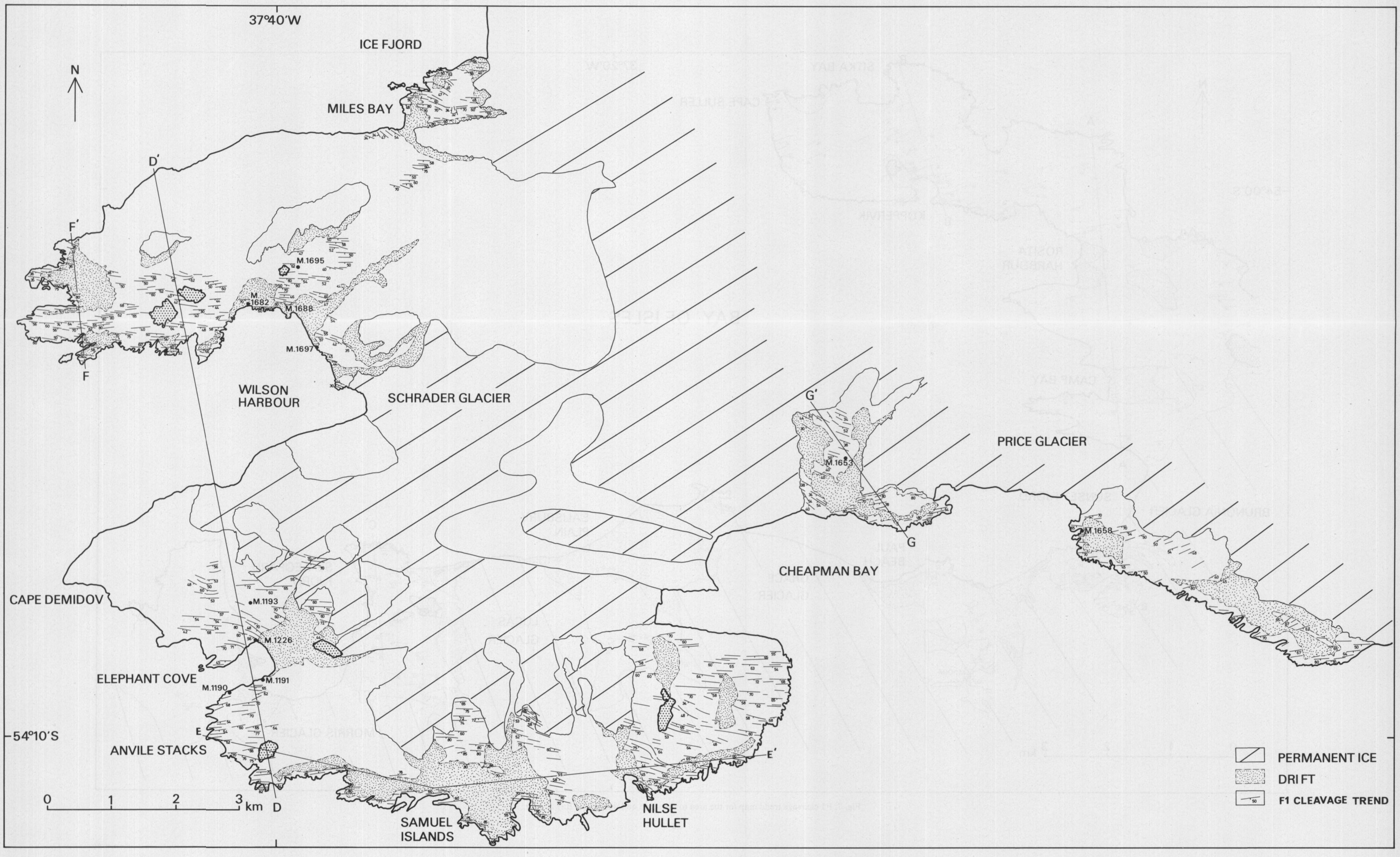


Fig. 9. F1 cleavage trend map for the area bounded by Cheapman Bay, Wilson Harbour and Ice Fjord.

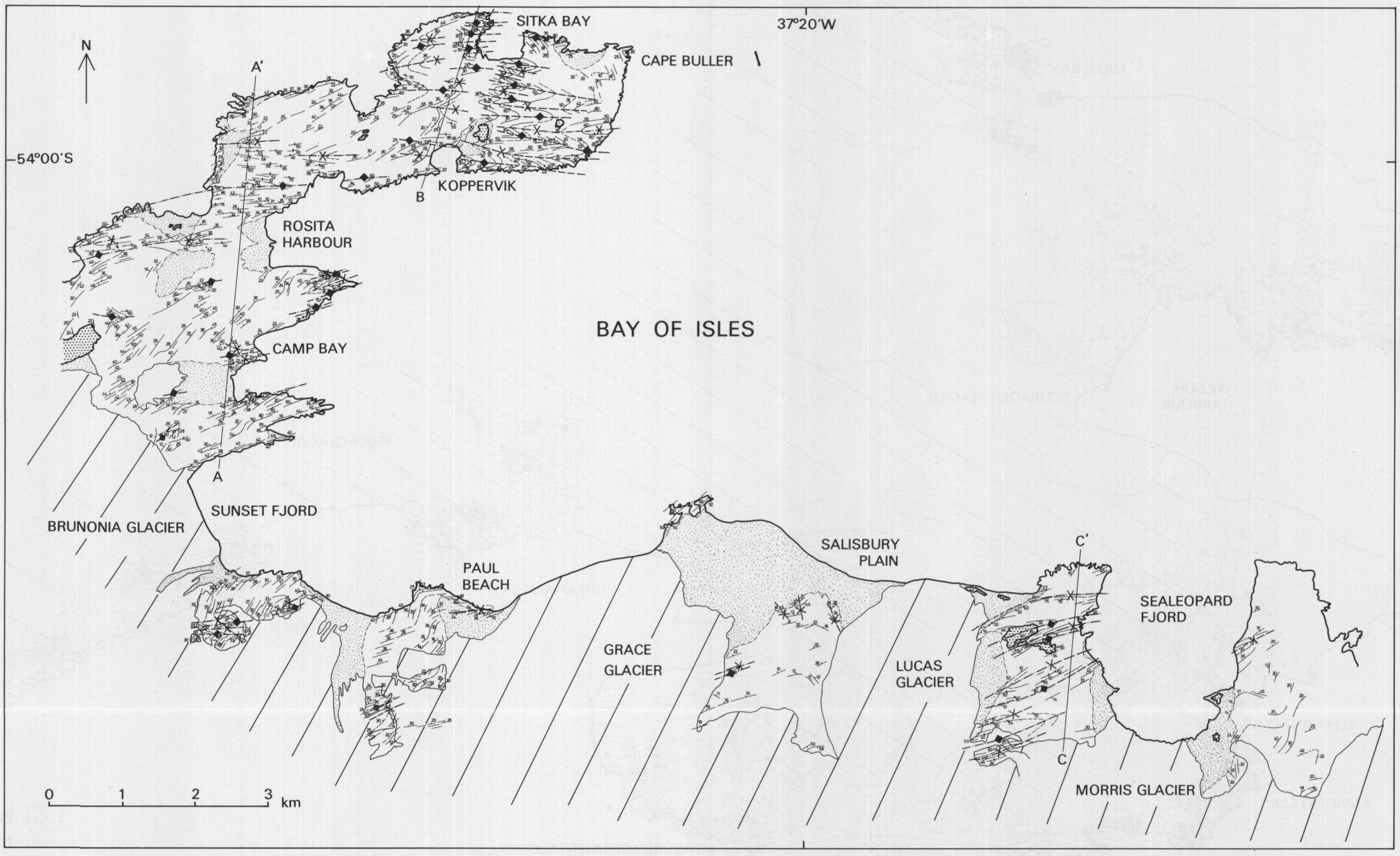


Fig. 6. Bedding trend map for the area to the south and west of the Bay of Isles.

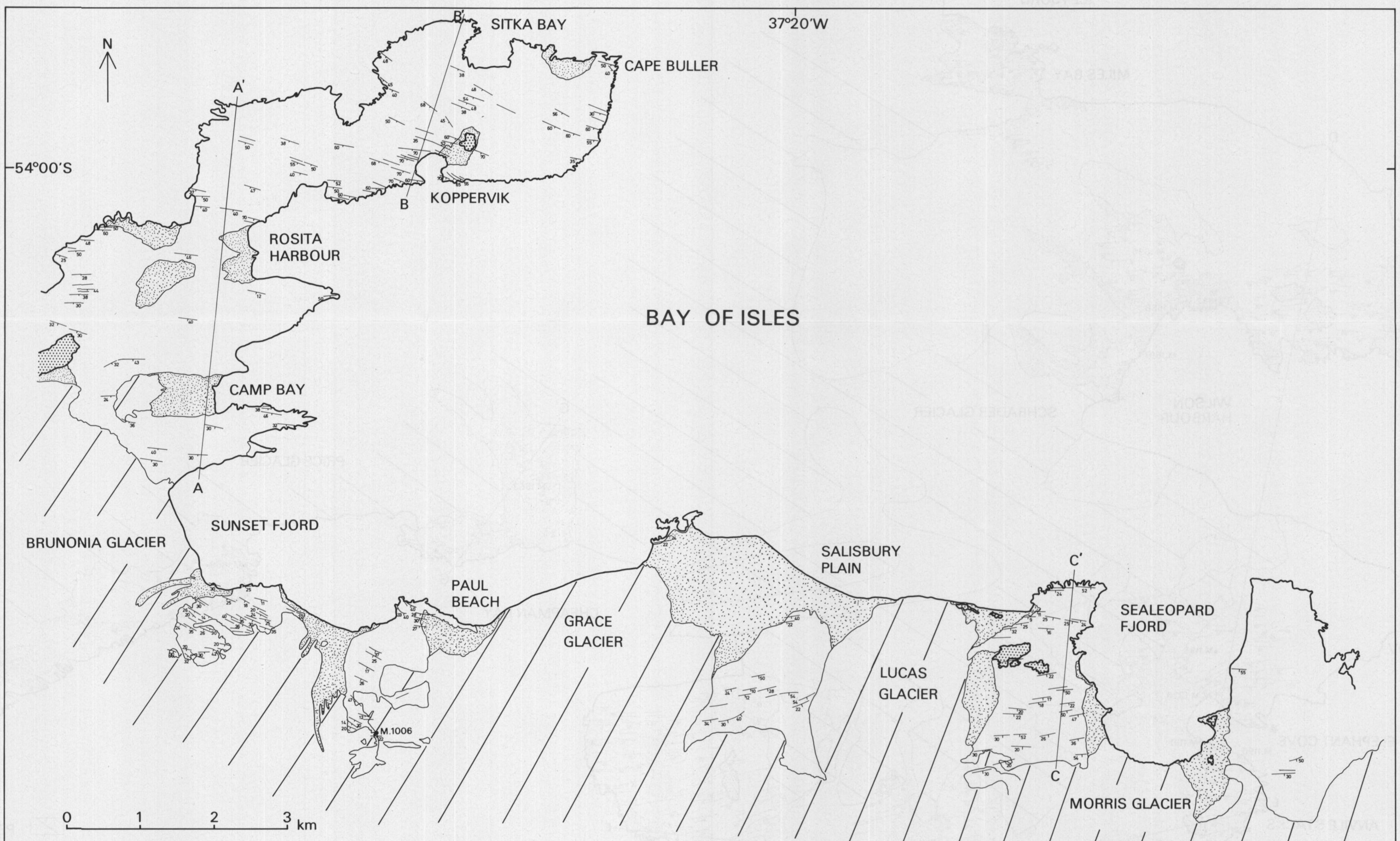
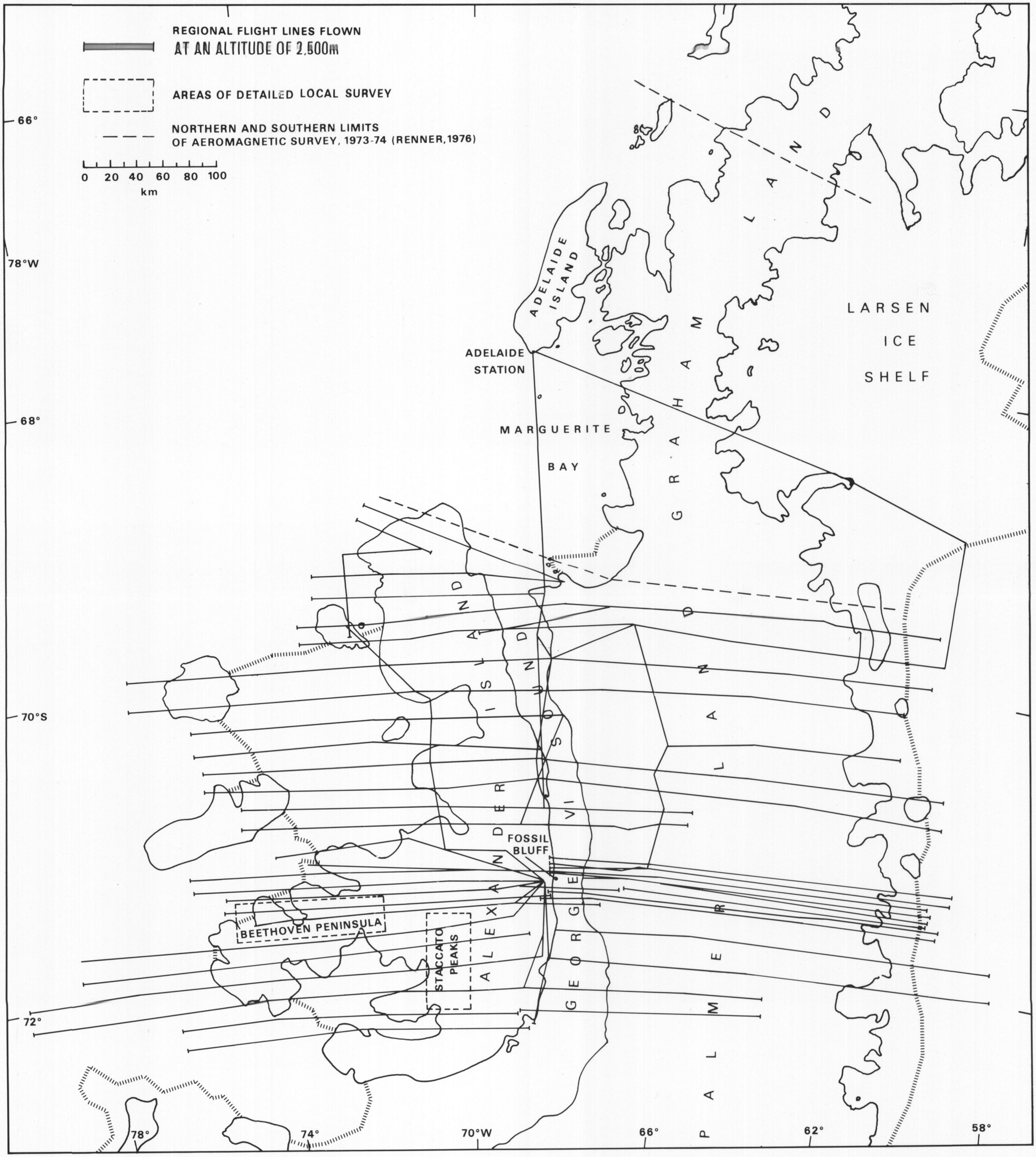


Fig. 7. F1 cleavage trend map for the area to the south and west of the Bay of Isles.

Face page 190


REGIONAL FLIGHT LINES FLOWN
AT AN ALTITUDE OF 2,500m
AREAS OF DETAILED LOCAL SURVEY
NORTHERN AND SOUTHERN LIMITS
OF AEROMAGNETIC SURVEY, 1973-74 (RENNER,1976)
0 20 40 60 80 100
km
66°
78°W
68°
70°S
72°
78°
74°
70°W
66°
62°
58°
ADELAIDE ISLAND
ADELAIDE STATION
MARGUERITE BAY
GRAHAM LAND
LARSEN ICE SHELF
ALEXANDER ISLAND
GEORGE VI SOUND
FOSSIL BLUFF
BEETHOVEN PENINSULA
STACCATO PEAKS
PALMER LAND

recorded at the Survey's geomagnetic observatory at the Argentine Islands and at the station on Adelaide Island.

All of the aeromagnetic data, including that from the 1973–74 summer season, are now being processed and analysed using the IBM 370/165 computer at the University of Cambridge.

ACKNOWLEDGEMENTS

The author wishes to express the gratitude of the survey team to G. Harvey, the pilot, and to A. Forman and A. Simon, who maintained the aircraft and assisted with the installation of the aeromagnetic survey equipment. The support of the members of the Adelaide Island station is gratefully acknowledged.

MS. received 11 November 1976

REFERENCES

ELL, C. M. 1975. Structural geology of parts of Alexander Island. *British Antarctic Survey Bulletin*, Nos. 41 and 42, 43–58.

FRIED, W. R. 1957. Principles and performance analysis of Doppler navigation systems. *I.R.E. Trans. aeronaut. navig. Electron.*, **ANE-4,** No. **4**, 176–96.

RENNER, R. G. B. 1976. An aeromagnetic survey over southern Graham Land; a preliminary report. *British Antarctic Survey Bulletin*, No. 43, 59–61.