POLISH POLAR RESEARCH (POL. POLAR RES.) POLSKIE BADANIA POLARNE	1	1	29—54	1980

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Geology of Admiralty Bay, King George Island (South Shetland Islands) — An outline

ABSTRACT: Admiralty Bay, which is the largest embayment on King George Island (South Shetland Islands, West Antarctica) has been geologically mapped by the present author between 1977 and 1979. The following rock-complexes have been distinguished: 1) evoic stratiform complex of andesitic and rhyolitic lavas and sediments (Martel Inlet Group and Cardozo Cove Group: probably Upper Jurassic); 2) Andean intrusions represented by gabbroic and dioritic dykes with associated pyrite-mineralization (Wegger Peak Group: approximately Cretaceous-Tertiery boundary); 3) Tertiary stratiform complex of basaltic and andesitic lavas and interstratified sediments, altogether more than 2700 m thick (King Island Supergroup: probably Eocene — Middle Miocene); 4) late Tertiary intrusive complex of basaltic and andesitic dykes and plugs (Admiralty Bay Group: probably boundary of Miocene and Pliocene); 5) late Tertiary effusives: olivine basalts, andesites etc., and sediments, about 600 m thick (Kraków Icefield Supergroup: Pliocene and ?early Pleistocene), with well preserved traces of two subsequent glaciations; 6) Quaternary intrusions (Cape Syrezol Group), Pleistocene) and effusives (Penguin Island Group: Holocene), mainly olivine basalts, related to opening of the Bransfield rift. An outline of structural history of King George Island is also presented.

Key words: Antarctic, geology

1. Introduction

King George Island is the largest member of the South Shetland Islands which belong to the Scotia Ridge linking South America with West Antarctica (Fig. 1). The island lies between latitudes 61°50′ and 62°15′ south and longitudes 57°30′ and 59°00′ west (Fig. 2). To the north, it borders on the Drake Passage, to the south it is separated from Antarctic Peninsula by the Bransfield Strait.

More than 90 per cent of the island's area is covered by ice-caps (domes) and glaciers, the largest ice-domes being the Arctowski Icefield

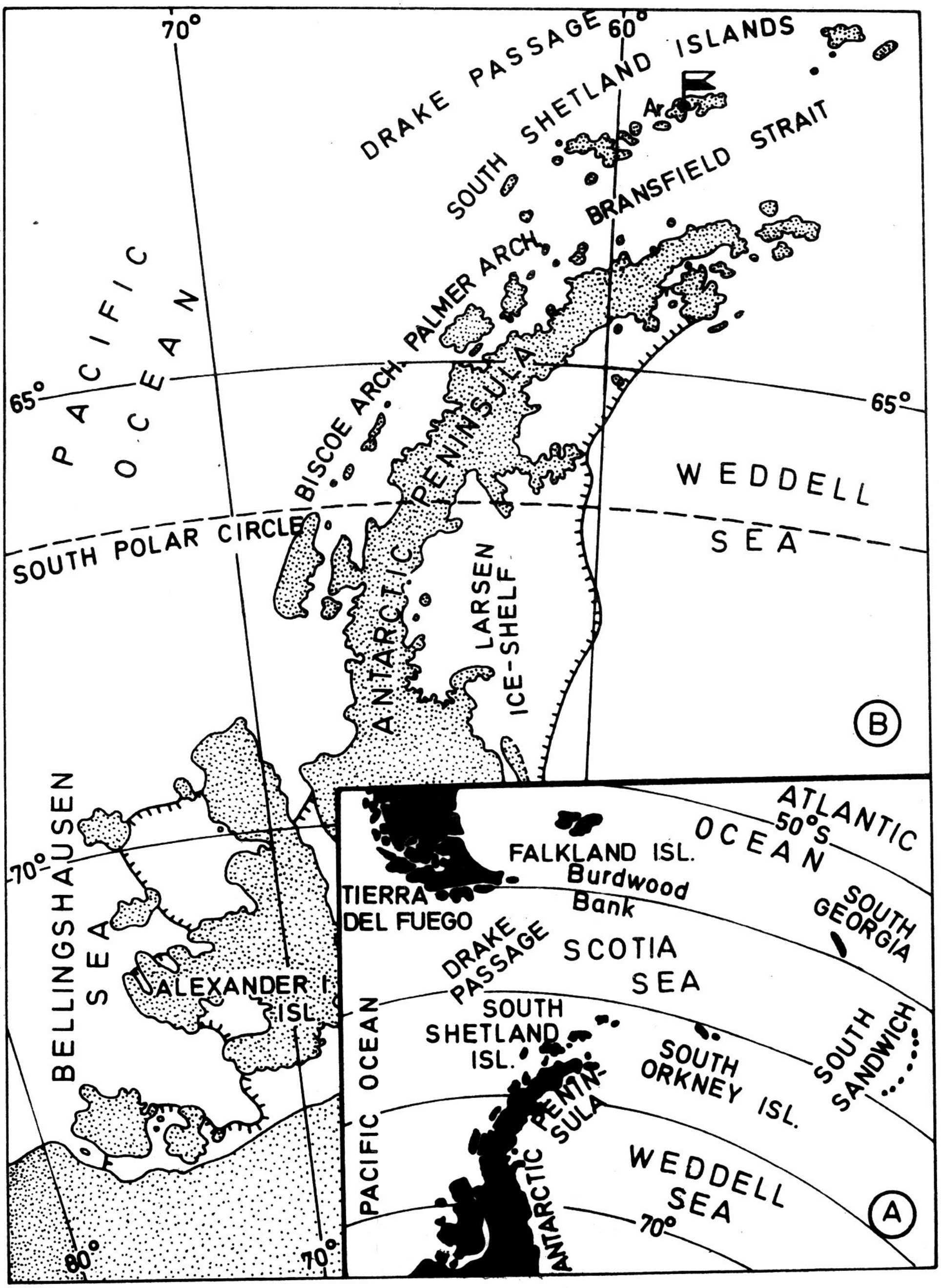


Fig. 1. Key maps to show the location of the South Shetland Islands *(A)* and Arctowski Station (*B*) — marked by flag

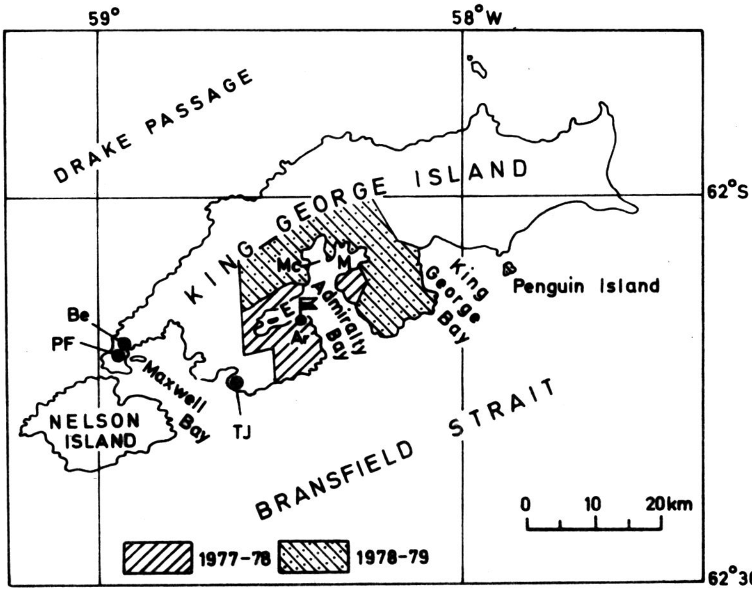


Fig. 2. Area of King George Island geologically surveyed by the author
Ar — Arctowski Station (Poland); *Be* — Bellingshausen Station (USSR); *E* — Ezcurra Inlet; *M* — Martel Inlet; *Mc* — MacKellar Inlet; *PF* — Presidente Frei Station (Chile); *TJ* — Teniente Jubany Station (Argentina)

covering the axial part of the island, the Kraków Icefield (between King George Bay and Admiralty Bay) and the Warszawa Icefield (between Admiralty Bay and Maxwell Bay) — see Figure 16[1)].

Admiralty Bay is the largest embayment on King George Island, incised from the vouth (Fig. 2). It is a fiord whose branches penetrate deeply into the axial part of the island: Ezcurra Inlet (on the west), Mackellar Inlet (on the north) and Martel Inlet (on the east and north-east).

Despite extensive ice cover on the island, numerous rock exposures along the coasts of Admiralty Bay and on nunataks give a good insight into geological structure of King George Island. The bay cuts across a major tectonic feature of the island — the Ezcurra Fault (Fig. 16) which separates the northern Mesozoic domain from the southern Tertiary domain.

In the inner part of Admiralty Bay, numerous good sections of Mesozoic stratiform volcanic-sedimentary succession are available. They are represented by the Cardozo Cove Group (on the west) and by the Martel Inlet Group (on the east and north) which probably belong to the Upper Jurassic (Fig. 3).

[1)]The place names are located in charts, 1:200.000, sheets W 62°58′ (King George Island) and W 62°56′ (Bridgeman Island) published by the Directorate of Overseas Survey (London) in 1968. New names are explained and located on maps by Birkenmajer (1980g).

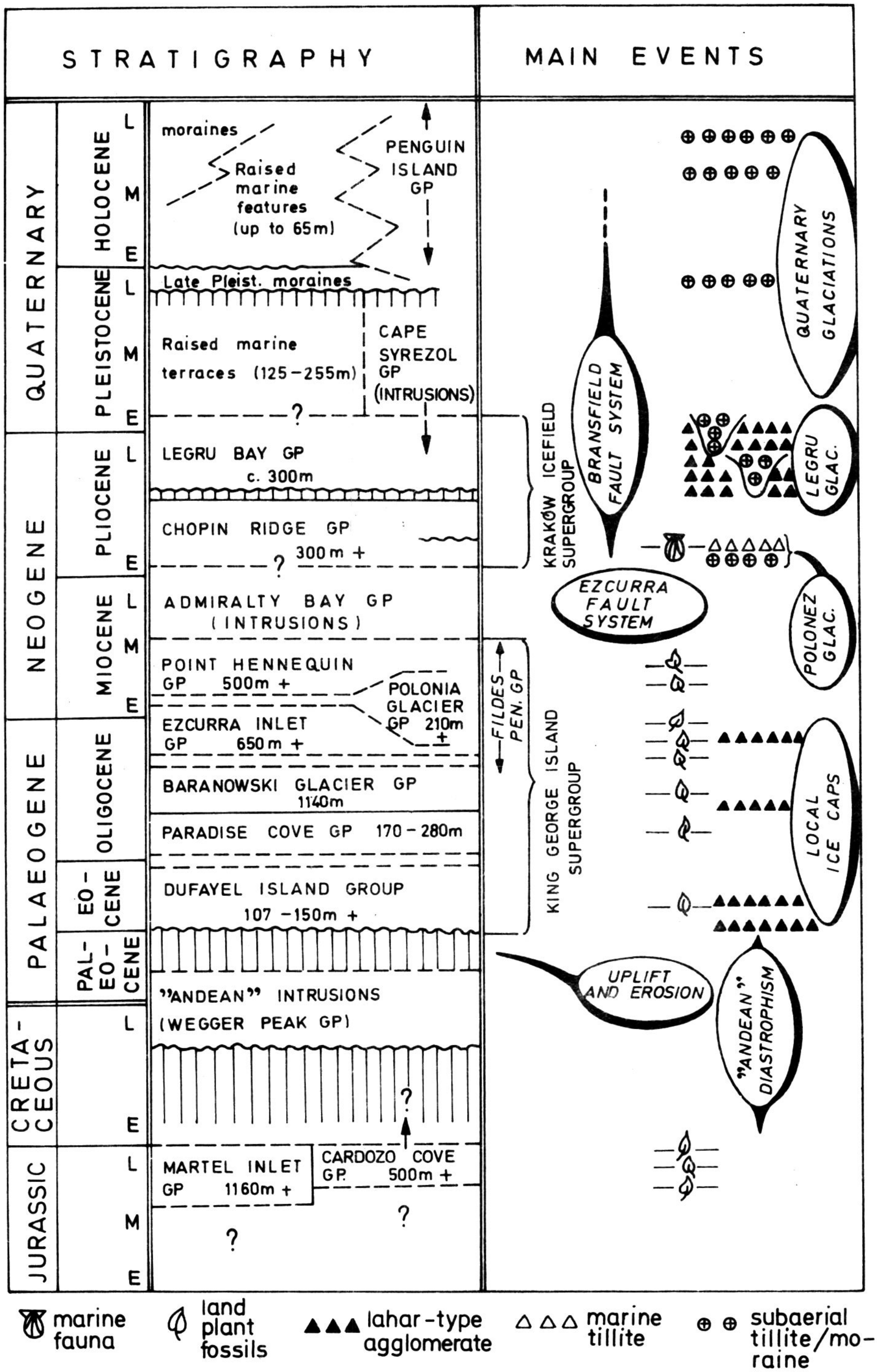


Fig. 3. Simplified stratigraphical standard for the area of Admiralty Bay and vicinities, King George Island

The outer part of Admiralty Bay, between Bransfield Strait and Ezcurra Inlet-Martel Inlet, exposes a comparatively complete, nearly continuous section through the Tertiary (possibly Eocene through Middle Miocene) stratiform-vokanic-sedimentary complex — the King George Island Supergroup (Fig. 4). The main section of the supergroup is along the western shores of

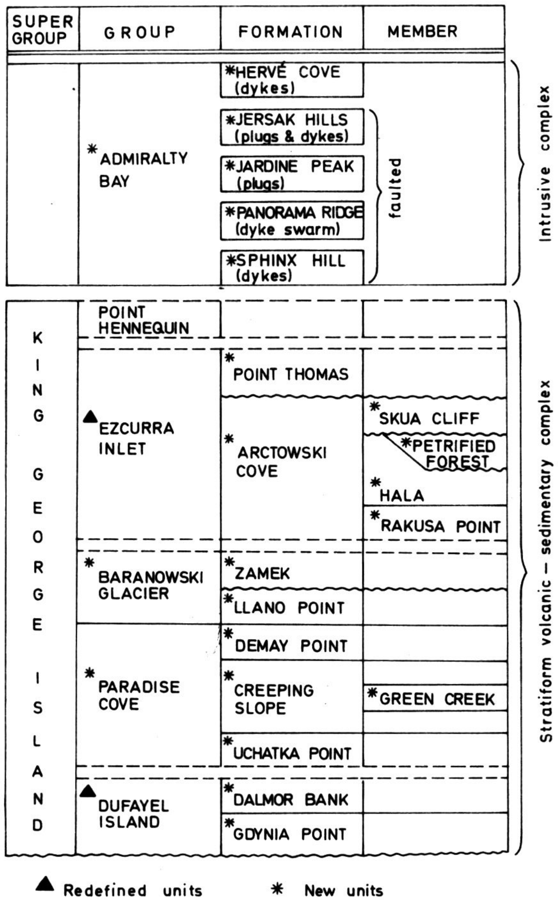


Fig. 4. Lithostratigraphical standard for the Tertiary of Admiralty Bay, King George Island

Admiralty Bay, its base is exposed at Dufayel Island (Ezcurra Inlet), and its top — at the southern coasts of Martel Inlet (Fig. 16).

The coastal area v e Bransfield Strait between the mouths of Admiralty Bay and King George Bay is built of the youngest stratiform sedimentary-volcanic complex — the Kraków Icefield Supergroup (Pliocene and ?early Pleistocene)[2].

Numerous intrusions cut through the stratiform complexes. The oldest group which cuts exclusively through the Jurassic complexes is represented

[2] See Figs. 3, 13 and 14.

by small plutons and hypabyssal intrusions (dykes) of diorite, gabbro and related dolerite and andesite, associated with quartz-pyrite mineralization (Wegger Peak Group). This group correlates with the Andean intrusive suite of Antarctic Peninsula (mainly late Cretaceous — Paleocene).

The next group of small hypabyssal intrusions — andesitic and basaltic dykes and plugs (Admiralty Bay Group — Fig. 3, 4) cuts both through the Mesozoic rocks (Jurassic volcanics and sediments, and Andean intrusions and mineral veins) and through the King George Island Supergroup lavas and sediments, but not through the Kraków Icefield Supergroup. The age of the Admiralty Bay Group thus probably corresponds to the latest Miocene — earliest Pliocene time span.

The third group of intrusives (Cape Syrezol Group) is represented by small plugs and dykes, mainly of olivine basalt, which cut through the Kraków Icefield Supergroup, but may be partly coeval with the youngest formations of the latter. They probably represent a Pleistocene stage of volcanic activity (Fig. 3).

Finally, the youngest intrusives are connected with stratovolcano of the Penguin Island Group (Holocene): they are represented by olivine basalt dykes and a plug.

Besides these discrete groups of intrusions which correspond to significant stages of structural evolution of the South Shetland Islands arc, have been recognized several centres (vents, plugs) — feeders for the stratiform lava complexes, in the Ezcurra Inlet and Point Hennequin groups.

2. Previous work

The first systematic geological investigation of the Admiralty Bay area was carried out between 1913 and 1914 by Ferguson (1921), and his rock samples have been petrographically elaborated by Tyrrell (1921). Ferguson has distinguished an "older series" of dark mudstones and greywackes with interbedded andesite lavas, tuffs and agglomerates (tentatively correlated by Tyrrell (1921) with Jurassic rocks of Graham Land, Antarctic Peninsula), separated by an unconformity from a "younger series" of basalts and olivine andesites (Cenozoic). A third rock-group was represented by plutonic intrusions (stocks, veins) of diorite and gabbro associated with ore-bearing veins which cut through the older series but not through the younger series.

New rock collections made during the *Discovery II* voyages of 1934 and 1937 by Mackintosh and Marr, allowed Tyrrell (1945) to distinguish the youngest volcanic phase of olivine-basalts later referred to as the Penguin Island Group by Hawkes (1961).

A more detailed geological work in the area of Admiralty Bay and its vicinity was undertaken by British scientists based in field station (Base *G*) on Keller Peninsula between 1948 and 1960 (Adie 1958, 1964, Hawkes 1961, Bibby 1961, Barton 1961, 1964, 1965). Hawkes' (1961) synthesis of the geology of King George Island distinguishes five rock-complexes: 5) The Penguin Island Group (Pliocene to Recent): olivine-basalts, tuffs, hypersthene-augite andesites and augite-andesites; 4) the Point Hennequin Group (Middle Miocene): hypersthene-augite-andesites, tuffs, augite-andesites and basaltic andesites; 3) the Fildes Peninsula Group (?early Miocene): basaltic andesites, hypersthene-augite-andesites and augite-andesites (this group has not been distinguished at Admiralty Bay); 2) the Andean intrusive suite (late Cretaceous to early Tertiary): quartz-gabbros, granodiorites and quartz-diorites; 1) the Jurassic volcanics (Upper Jurassic): pyroxene-andesites, tuffs, basalts and rhyolites.

Barton's (1965) synthesis recognizes the following rock-complexes, whose content and areal distribution has been revised with respect to those of Hawkes: 8) The Penguin Island Group (Pleistocene to Recent); 7) the Lions Rump Group (Pliocene); 6) the Point Hennequin Group; 5) the Fildes Peninsula Group; 4) the Ezcurra Inlet Group; 3) the Dufayel Island Group (6–3: Miocene through Upper Cretaceous); 2) the Andean intrusive suite (late Cretaceous to early Tertiary), and 1) the Jurassic volcanic rocks (Upper Jurassic). The stratigraphical ranges of some of these groups have been slightly modified by Adie (1964).

An angular unconformity between the Tertiary and Mesozoic rocks was recognized on Dufayel Island by Argentine geologists Díaz and Teruggi (1956). Studies of raised beaches were carried out in the Admiralty Bay area by John and Sugden (1971) and Curl (1976).

Geological and petrological studies relevant to the geology of the Admiralty Bay area have also been supplied from the Maxwell Bay area by Fourcade (1960), Schauer, Fourcade and Dalinger (1961), Schauer and Fourcade (1963, 1964), Orlando (1963, 1964), Grikurov and Poljakov (1968), Grikurov et al. (1970) and Covacevich and Lamperein (1972), and from the Maxwell Bay and Penguin Island areas by González-Ferrán and Katsui (1970).

Detailed geological mapping, 1:50,000 scale, of the Admiralty Bay area was carried out between 1977 and 1979 by the present author (see Fig. 2, 16). This allowed him (Birkenmajer 1979, 1980a — c, e, g and in press) to revise and supplement the stratigraphical standards of the area in question[3].

3. Mesozoic rocks

The Mesozoic rocks of Admiralty Bay were studied by Ferguson (1921), Hawkes (1961) and, in particular, by Barton (1961, 1965). Petrological characteristics of volcanic rocks were given by Tyrrell (1921) and Hawkes (1961). These rocks were compared with Upper Jurassic volcanics and sediments of Antarctic Peninsula (e.g., Tyrrell 1921, Adie 1964), but neither palaeontological nor radiometric age control were given for the area of King George Island to support that age.

Birkenmajer (1980) has distinguished two lithostratigraphic groups within the stratiform complex in question, the Martel Inlet Group (east

[3] See Figs. 3, 4, 13 and 14.

of MacKellar Inlet) and the Cardozo Cove Group (west of MacKellar Inlet). The mutual relation of these groups has not been solved due to the lack of suitable exposures in the critical area (Mackellar Inlet and Domeyko Glacier).

The *Martel Inlet Group* consists of grey to greenish andesitic and rhyolitic lavas alvernating with green to purple tuff and agglomerate, often with fragments of silicified wood. Mega-scale wedge-shaped cross-bedding has been observed in some thickest agglomerate-conglomerate horizons (Ullman Spur). Flow banding and folds are after characteristic for felsitic lavas. The group consists of four lithostratigraphic formations which will be formally named and described in a separate paper.

The *Cardozo Cove Group* consists of green (metasomatic) or dark-grey andesitic lavas with subordinate, thin, green to purple tuff intercalations. Agglomerates are scarce, wood fragments are very infrequent compared to the Martel Inlet Group. A green tuffaceous zone with numerous *Araucaria* branches and with burrows, found at the top of Admiralen Peak by Barton (1961, 1965) and regarded by him as basal Tertiary (resp. late Cretaceous — basal Tertiary) beds, seems to belong to the top part of the Cardozo Cove Group.

4. Andean intrusions

The Martel Inlet and Cardozo Cove groups are cut by small plutons and veins (dykes) of dioritic to gabbroic composition referred to as the Andean intrusive suite (Tyrrell 1921, Hawkes 1961, Barton 1961, 1965, Adie 1964), and here called the *Wegger Peak Group* (Birkenmajer 1980g (Fig. 3). The intrusions from vertical or steeply inclined rather thick dykes, single (e.g. at Wegger Peak) or in parallel swarms (e.g. Keller Peninsula, Stenhouse Bluff, Precious Peaks), and are often displaced by transversal faults. At Wegger Peak there is a transition from gabbro to diorite in the marginal part of the pluton. Pyrite and quartz-pyrite mineralization is usually associated with these Andean intrusions.

A 55 Ma K-Ar date (i.e. around Paleocene/Eocene boundary) has been given by Grikurov et al. (1970) for granodiorite intrusion of Noel Hill at Marian Cove (Maxwell Bay) which, according to Barton (1965, Fig. 5B), cuts through Jurassic volcanic rocks (mainly tuff and agglomerate) and pyritized volcanic rocks, and belongs also to the Andean intrusive suite.

5. Tertiary rocks

A revised lithostratigraphic standard for the Tertiary rocks of Admiralty Bay (Birkenmajer 1979, 1980a, b, e, g) includes two stratiform volcanic-and-sedimentary successions: the King George Island Supergroup (probably Eocene through Middle Miocene), in are than 2700 m thick, and the Kraków Icefield Supergroup (Pliocene and ?early Pleistocene) more than 600 m thick. These supergroups are separated from one another by a period of transcurrent faulting at the Miocene-Pliocene boundary, associated with intense volcanic activity — the Admiralty Bay Group intrusives (Fig. 3).

King George Island Supergroup. The King George Island Supergroup consists principally of lavas and volcanoclastic rocks of basaltic and andesitic characteristics (Hawkes 1961, Tyrrell 1921, 1945, Barton 1965, Birkenmajer 1980e. The geological age of the supergroup, which is based on still inadequately known plant-fossil assemblages (Barton 1964, 1965, Adie 1964, Orlando 1964), probably covers the Eocene through Middle Miocene time span (Fig. 3). Six lithostratigraphic groups have been distinguished and those subdivided into formations and members (Fig. 3, 4).

A major unconformity recognized at Dufayel Island, separates the King George Island Supergroup from folded and partly metamorphosed (metasomatic) volcanics of the Cardozo Cove Group (Díaz and Teruggi 1956, Barton 1965, Birkenmajer 1980e). The supergroup post-dates the Andean plutonic intrusions but the contact between these two units has not been observed in the Admiralty Bay area.

The rocks of the King George Island Supergroup at Admiralty Bay are gently folded or monoclinal, and only in the vicinity of the Ezcurra Fault do steep folds appear. The supergroup is often strongly disturbed by faulting, usually transversal to the Ezcurra Fault.

The *Dufayel Island Group* (Barton 1964, 1965, redefined by Birkenmajer 1980e) consists of two formations. The lower Gdynia Point Formation (60 m) is composed of coarse to very coarse purple or green andesitic-basaltic agglomerates and conglomerates passing into coarse tuff-sandstone. The upper Dalmor Bank Formation (47 to more than 150 m) consists of grey to bright-green and purple tuffaceous rocks with plant remains (see Barton 1964, 1965), with intercalations of conglomerate and agglomerate and with andesite or basalt lava flows (Fig. 5).

The *Paradise Cove Group* consists of three formations. Green basaltic (tholeiitic) lavas represent the lower unit — the Uchatka Point Formation (more than 50 m thick). Red shales with bright-green tuffaceous and flake-conglomerate horizon in the middle (Green Creek Member) form the Creeping Slope Formation (60 m). Light-coloured, acidic (?) porphyritic lavas and intrusions, tuff-breccias, siliceous pisolites, red conglomerates, agglomerates and lapilli tuffs constitute the upper unit — the Demay Point Formation (60 to more than 170 m). Numerous well preserved silicified wood fragments, often of large dimensions, are usually associated with conglomerates and agglomerates.

The *Baranowski Glacier Group* consists of two formations. The Llano Point Formation (more than 1100 m) is represented by a monotonous sequence of predominantly basaltic (tholeiitic) and subordinately andesitic lava flows (sheets), usually of fairly constant thickness, with pyroclastic intercalations, sometimes with interbeddings of red tuffaceous sandstone. The Zamek Formation (more than 40 m) consists of dark-grey to greenish basaltic and augite-andesite lavas alternating with scoria and tuff, with a horizon rich in plant remains. A characteristic coarse agglomerate forms the base of the formation.

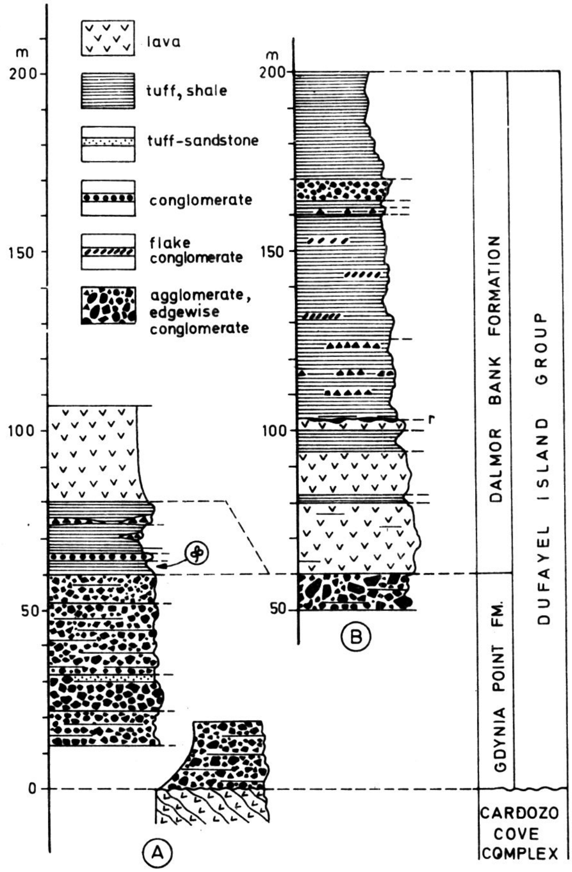


Fig. 5. Lithological columns of the Dufayel Island Group at Gdynia Point, Dufayel Island (*A*), and at Pond Hill-Barrel Point, Ezcurra Inlet, inner part (*B*)
Locality of fossil flora marked by conventional symbol

The *Ezcurra Inlet Group* (Barton 1965, redefined by Birkenmajer 1980e) consists of two formations separated by an unconformity (Fig. 6, 7). The Arctowski Cove Formation (220 m) is represented in the lower part by dark basalt and andesite flows, massive at the bottom (Rakusa Point Member: more than 60 m), alternating with red and purple flow breccias and tuffs in a higher part (Hala Member: 100 m to more than 140 m). Fresh-water sediments (clays, sandstones, conglomerates) with plant remains and brown-coal seams (Petrified Forest Member, maximum 30–50 m thick) occur as fill of an erosional channel cut into undelying andesite lavas (Fig. 8). Lahar-type (debris-flow) coarse to very coarse andesite-basalt agglomerate (Fig. 9) passing to fanglomerate, sometimes with thin lava flows (Skua Cliff Member: 6–24 m), unconformably overlies either the Hala Member or the Petrified Forest Member.

The Point Thomas Formation (more than 300 m to more than 430 m) consists of basaltic-andesitic lava-pyroclastic complex, partly of sheet flow, partly of stratocone characteristics, often with thick explosion breccias.

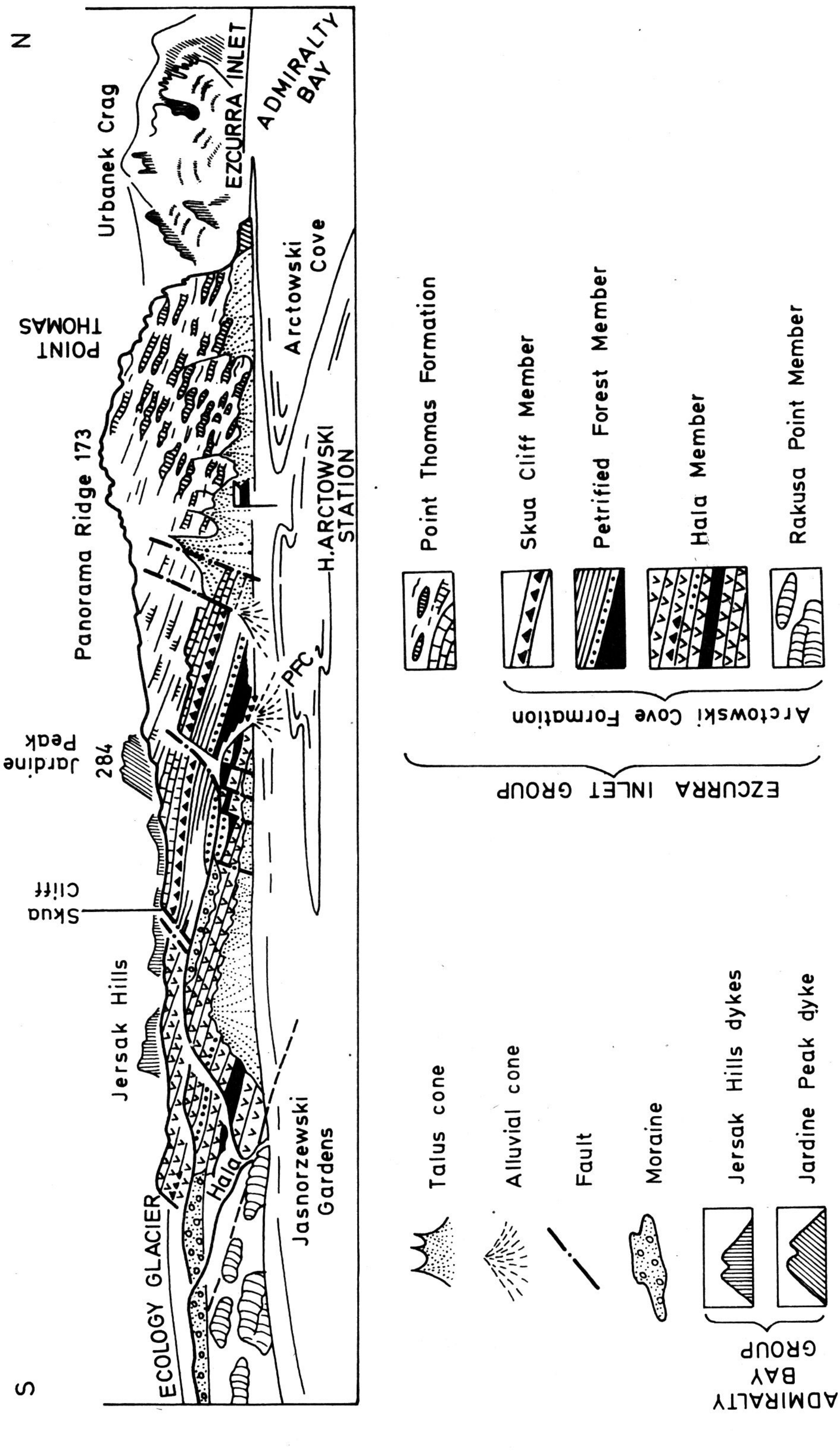


Fig. 6. Geological panorama taken from the vicinity of Latarnia Rock at Arctowski Station, Admiralty Bay

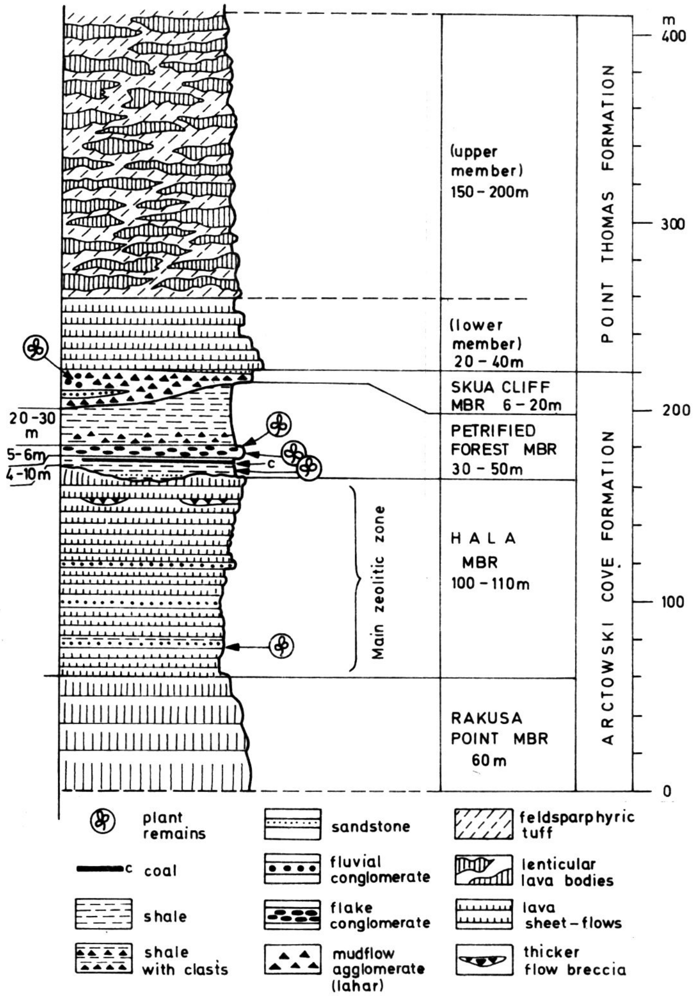


Fig. 7. Lithostratigraphical column of the Ezcurra Inlet Group in the vicinity of Arctowski Station, Admiralty Bay

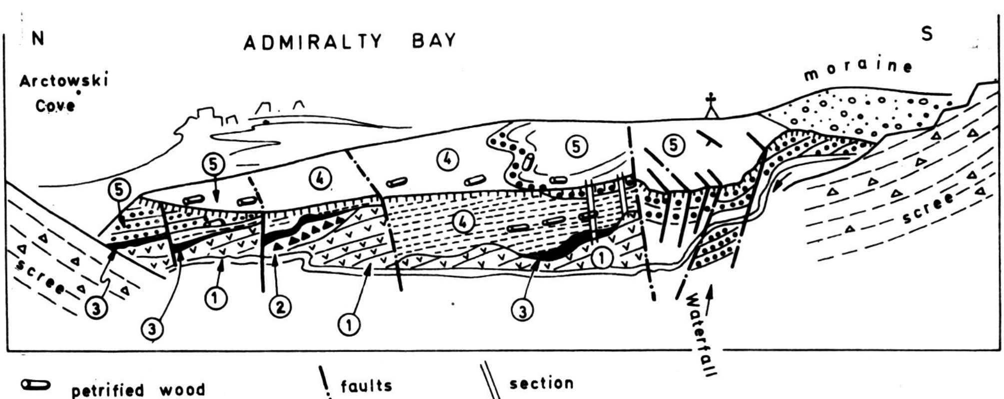


Fig. 8. Perspective view of exposures of the Petrified Forest Member at its type locality (Petrified Forest Creek, Arctowski Station)

1, 2 — Hala Member (1 — andesite, 2 — agglomerate); 3–5 — Petrified Forest Member (3 — regolith, 4 — lower shale, 5 — flake conglomerate)

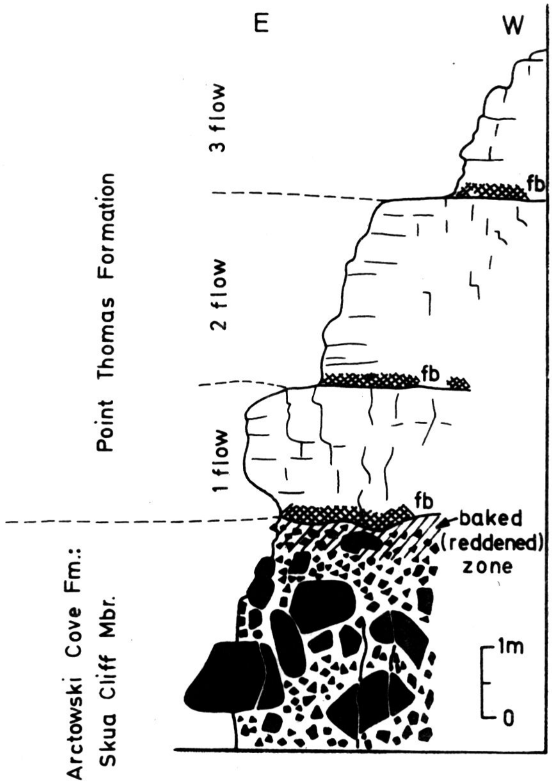


Fig. 9. Contact of the Point Thomas Formation and the Arctowski Cove Formation at the junction of Geographers Creek and Petrified Forest Creek, Arctowski Station
fb — flow breccia

The *Point Hennequin Group* (sensu Barton 1965, not Hawkes 1961) consists of several units of formation and member ranks, formally not yet defined (Fig. 10). It is formed of hypersthene-augite andesite, augite-andesite and trachyandesite lava flows (Tyrrell 1945, Hawkes 1961, Barton 1965) with several agglomerate zones and with two plant-bearing volcanogenic sediment units (see Barton 1964, 1965, Birkenmajer 1980e).

The *Fildes Peninsula Group* (Hawkes 1961, Barton 1965) on Fildes Peninsula, Maxwell Bay, seems to correpond partly to the Ezcurra Inlet Group and partly to the Point Hennequin Group (Fig. 3). A stratiform volcanic-sedimentary complex described by Fourcade (1960) and González-Ferrán and Katsui (1970) from Potter Cove (Maxwell Bay) probably correlates with the Ezcurra Inlet Group of Admiralty Bay. The *Polonia Glacier Group* of King George Bay could represent a missing link between the Ezcurra Inlet Group and the Point Hennequin Group Birkenmajer 1980e).

Admiralty Bay Group. Small hypabyssal intrusions — basalts and andesites, which post-date the King George Island Supergroup, and pre-date the Kraków Icefield Supergroup, have been distinguished as the Admiralty Bay Group (Fig. 6, 10–12, 16). The intrusions cut both through the King

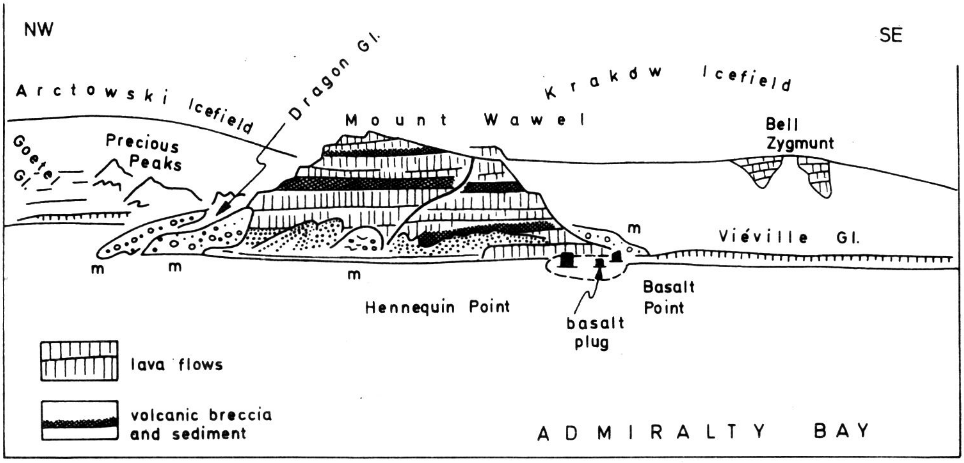


Fig. 10. Schematic geological panorama of the Point Hennequin area, showing lavas and associated rocks of the Point Hennequin Group, and basalt plug of the Admiralty Bay Group m — moraine; talus stippled

George Island Supergroup and through the Mesozoic Martel Inlet and Cardozo Cove groups. They are especially frequent in a zone adjoining the strike-slip Ezcurra Fault. The majority of intrusions pre-date the formation of short faults transversal to the Ezcurra Fault, but some follow these faults. A supposed stratigraphic succession of these intrusions is shown in Fig. 4.

Kraków Icefield Supergroup. This stratiform sedimentary-and-volcanic complex, which occurs between Admiralty Bay and King George Bay, includes rocks previously attributed by Barton (1965) to the Lions Rump Group (now: obsolete — see Birkenmajer 1980g) and the Penguin Island Group (Hawkes 1961; Barton 1961, 1965 — redefined by Birkenmajer

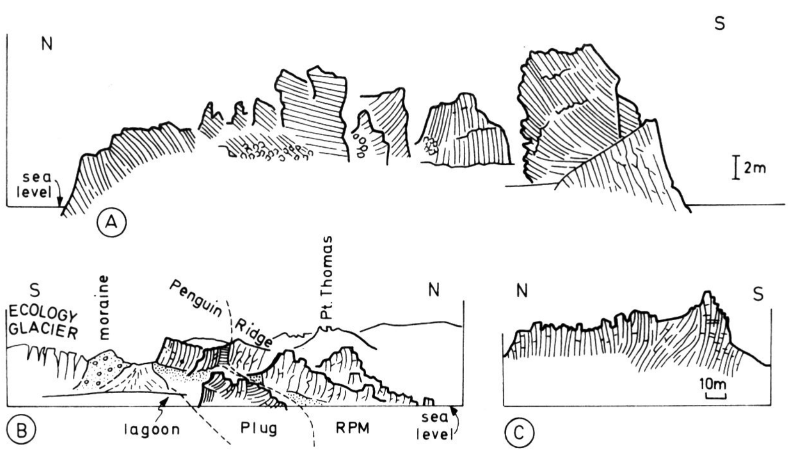


Fig. 11. Admiralty Bay Group: Jersak Hills plugs at Rakusa Point (*A*. *B*) and at Jersak Hills (*C*)

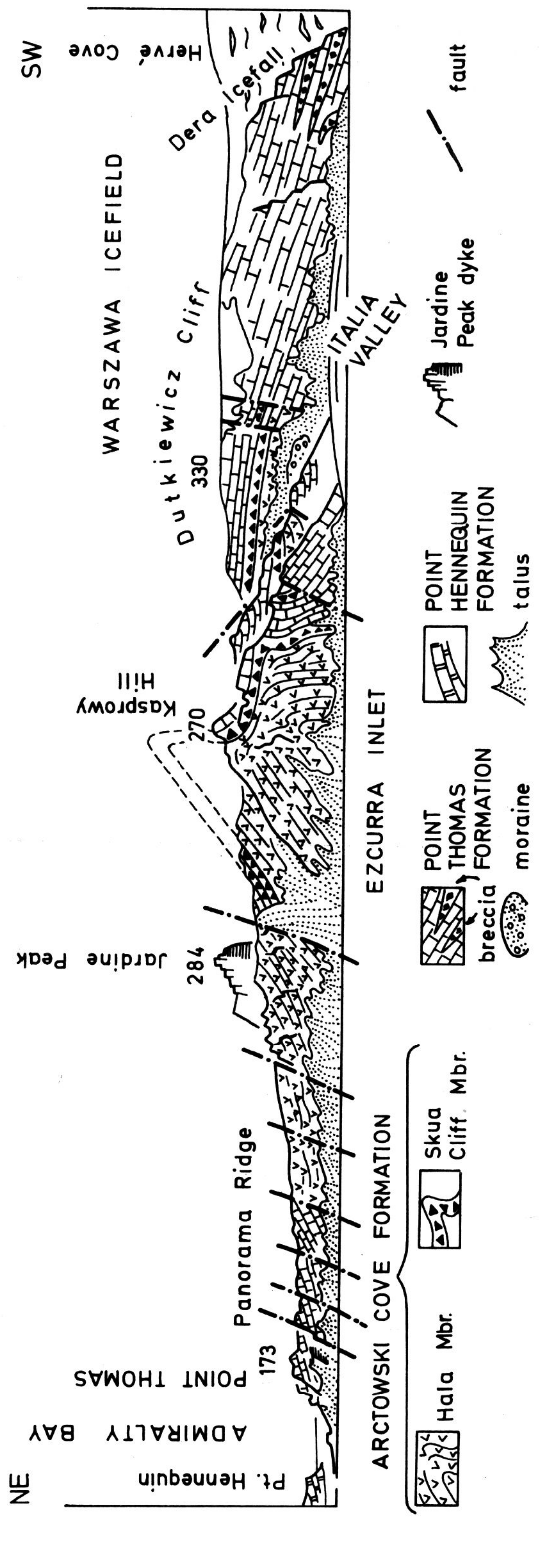


Fig. 12. Geological panorama taken from ship at anchor at Ezcurra Inlet (Dalmor Bank), Admiralty Bay

1980c. g). The supergroup consists of lavas (both basic and acidic), lahar-type agglomerates, fluvial deposits (conglomerates, sandstones etc.), glacial tillites (both continental and marine), and marine fossil-bearing strata (Birkenmajer 1980 a, b, g). Two lithostratigraphic groups have been distinguished: the lower Chopin Ridge Group and the upper Legru Bay Group.

The *Chopin Ridge Group* is best developed east of Legru Bay. Within the area shown in the geological map of Admiralty Bay (Fig. 16), it occurs at Vauréal Peak and its vicinity. The group consists of four formations separated from one another by erosional and, party, angular unconformities (Fig. 13, 14). The basal Mazurek Point Formation is represented by olivine-basalt lava flows. There follow glacigenic sediments of the Polonez Cove Formation, with continental tillites at the bottom and glacio-marine sediments with ice-rafted blocks in a higher part. These remains of an extensive glaciation of Antarctic continent *(Polonez Glaciation)*, probably the largest Cenozoic glaciation of Antarctica, are associated with marine ingression which deposited *Pecten*-bearing conglomerate of Pliocene age.

GROUP	FORMATION	MEMBER
LEGRU BAY	VAURÉAL PEAK	
	MARTINS HEAD	
	HARNASIE HILL	
	DUNIKOWSKI RIDGE	
CHOPIN RIDGE	WESELE COVE	
	BOY POINT	
	POLONEZ COVE	OBEREK CLIFF
		SIKLAWA
		LOW HEAD
		KRAKOWIAK GLACIER
	MAZUREK POINT	

(base unknown)

Fig. 13. Lithostratigraphical standard for the Kraków Icefield Supergroup (Pliocene — ?early Pleistocene)

There follow acidic porphyritic lavas of the Boy Point Formation and fluvial (probably interglacial) large-scale cross-bedded agglomerates, conglomerates and sandstones (mainly reworked Boy Point Formation) distinguished as the Wesele Cove Formation.

The *Legru Bay Group* is separated from the Chopin Ridge Group by an erosional and partly angular unconformity. It consists of four formations (Fig. 13). The lower Dunikowski Ridge Formation (60–70 m) is composed of grey augite-andesite lava flows alternating with thick, coarse, lahar-type agglomerate and conglomerate. It laterally passes into the Har-

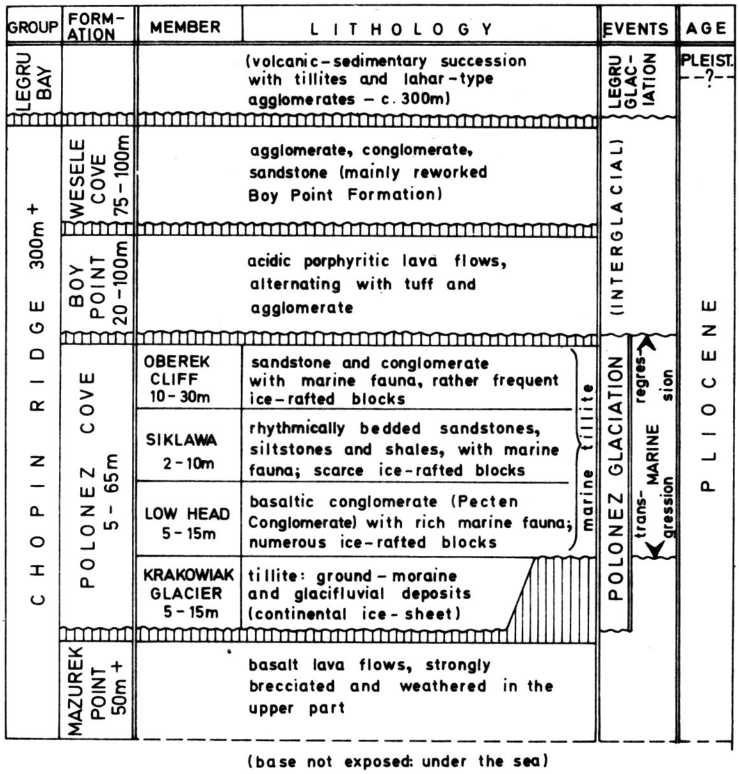


Fig. 14. Lithostratigraphy of the Chopin Ridge Group (Pliocene)

nasie Hill Formation (up to 200 m thick) which is a cinder cone consisting of lapilli-tuff alternating with agglomerate, pelitic tuff and thin lava flows. The succeeding Martins Head Formation (more than 120 m) consists of augite-andesite lava flows regularly alternating with lahar-type agglomerates and reddish tuffs. Finally, the Vauréal Peak Formation (up to 80–100 m thick) is represented by coarse tillite which infills deep buried valleys cutting through older formations of the Legru Bay Group, and even through the Chopin Ridge Group. This tillite is remain of local glaciation of South Shetland Islands (*Legru Glaciation*) probably disconnected from the main continental glaciation of Antarctica.

A Pliocene age is suggested for the Chopin Ridge Group, basing on the *Pecten* conglomerate fauna (compare Adie 1964, Barton 1965) which belongs to the Polonez Cove Formation. New faunal collections assembled in 1979 will probably allow to date the fossiliferous strata with more precision. A Pliocene and early Pleistocene (?) age is suggested for the Legru Bay Group (see Fig. 3). It is hoped that radiometric control of the age based on K-Ar dating of lavas from the Kraków Icefield Supergroup will help define their age as well as the age of glaciations.

6. Quaternary rocks

The Quaternary rocks include a group of intrusives (Cape Syrezol Group) and a plateau-basalt and stratocone succession (Penguin Island Group), as well as late Pleistocene and Holocene moraines, outwash, raised beaches and Recent coastal and mountain slope deposits, etc.

The *Cape Syrezol Group* consists of olivine basalt plugs and dykes and associated explosion breccias which cut through the Chopin Ridge and the Legru Bay groups. These intrusions generally post-date the Kraków Icefield Supergroup, and are probably of Pleistocene age. Some of the intrusions could be partly coeval with the Legru Bay Group (Fig. 3).

The *Penguin Island Group* is represented by volcanic succession (olivine-basalt lavas, tuffs, agglomerates, plugs etc.) of the Penguin Island stratocone which is its type locality (Tyrrell 1921, Hawkes 1961, González-Ferrán and Katsui 1970, Birkenmajer 1980c, g). The age of the group is Holocene.

The *late Pleistocene moraines* are poorly preserved (residual) in the vicinity of Arctowski Station close to the highest Holocene sea water-mark (55–65 m a.s.l.).

There is a series of *raised beaches* and stormridges and other features related to Holocene deglaciation and land uplift (John and Sugden 1971; Curl 1976). The most complete Holocene succession of raised marine features was measured by the author in the vicinity of Arctowski Station west of Rakusa Point (metres a.s.l.): 2–6; 7–12 (15); (12) 14–15; 16–(22); 25–28 (30–32); 32–35 (38–40) and 40–42; 52–54, 65. Further inland and westward, there are remains of older still erosional terraces covered with residual gravel at 105—115, 120–125, 130–135, 180, 205, 225–255 m above the sea. These raised terraces are certainly of pre-Holocene age and could correspond to several interstadials or interglacials of the Pleistocene.

Holocene glaciation. Stages of Holocene glacier advances and retreat were dated in some areas of Admiralty Bay with respect to raised marine beaches, and with the helt of lichenometric method (Birkenmajer 1980d, g. On Keller Peninsula, the following stages of activity of small corrie glaciers (Fig. 15) were recognized: 1) the maximum advance, termed the *Ferguson Glacial Event*, has been dated as 741 years B.P. (before 1979 A.D.), i.e. about 1240 years A.D.; 2) a relative stagnation of ice-front occurred for a period of about 500 years, from the first half of the 13th century through the 18th century; 3) morainic ridges lichenometrically dated as 300–200 years B.P. (from 1720 to 1779 A.D.) may be correlated with the *False Bay Glacial Event* (about 1720 A.D.) of Everett (1971) and Curl (1976); 4) a rapid glacier withdrawal occurred during a period of about 50 years from the end of the 18th century through the first decades of the 19th century; 5) two successive recession moraines dating back to around 1830 A.D. correspond to a relative standstill of glacier front; 6) slowing-down of glacier retreat followed for a period of more than 100 years from mid-19th century to mid-20th century; 7) a rapid increase of glacier-retreat rates is marked for the past two decades.

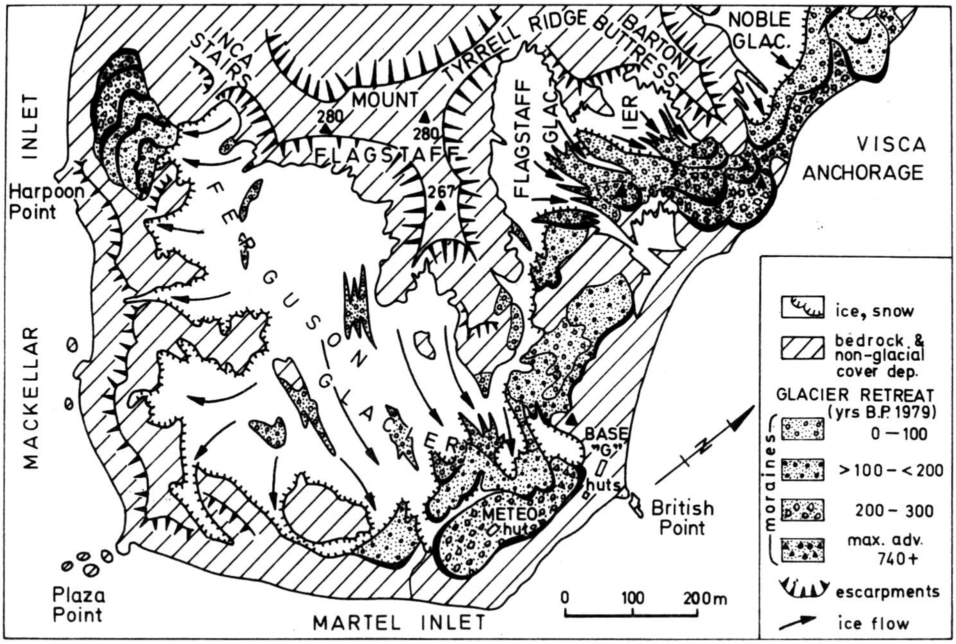


Fig. 15. Age distribution of Neoglacial moraines at Keller Peninsula, southern part, based on lichenometric dating

The last stage of glacier withdrawal is confirmed by the British glaciological work on Keller Peninsula (Stansbury 1961, Noble 1965). During a 12-year observation period (1948–1960) there was an overall negative balance of the Flagstaff Glacier, and the glacier appeared to be in slow recession, losing more water during years with negative budgets than was accumulating by years with positive budgets.

Presently (1977–1979), the majority of glaciers of the Admiralty Bay area are characterized by a recessive regime. However, some glaciers (e.g. Ecology Glacier, Baranowski Glacier, Dera Icefall, Rościszewski Icefall) quite recently surged over modern (20th century) stormridges and lowest beaches, and had formed push-moraines. The material of these push-morained is a mixture of glacier till and beach gravel, frequently with freshly preserved whale bones, fragments of whaling boats, oars etc., the remains of early 20th century whaling activity (thus 50–70 years old). In some push-moraines wooden planks from Heinz-ketchup crates, certainly no more than 20–30 years old, were found.

7. Outline of structural history

Mesozoic. The Mesozoic volcanic-and-sedimentary complex of the Admiralty Bay area represents remains of an andesitic island arc formed as a result of subduction of the Pacific oceanic plate under the margin of the Antarctic continent. A considerable thickness of the complex (more than 1100 m), and its stratiform character, with infrequent intraformational unconformities, indicate a rather quiet, low-rate subduction of the oceanic plate under the Antarctic continental plate during a prolonged period of time: Upper Jurassic and possibly Lower Cretaceous.

Apart from the zone adjoining the Ezcurra fault where the Mesozoic stratiform complex is often strongly folded as a result of late Tertiary diastrophism, the complex is either monoclinal or arranged in gentle domes. However, angular unconformity of about 25 degrees between the Mesozoic lavas (Cardozo Cove Group) and the Tertiary rocks at Dufayel Island is indicative of at least local stronger disturbances.

The Andean intrusions (Wegger Peak Group) which represent the latest stage of Mesozoic subduction and diastrophism in the South Shetland Islands arc, and the mineralization (quartz-pyrite veins) associated with them, are unfolded but often displaced by transversal faults.

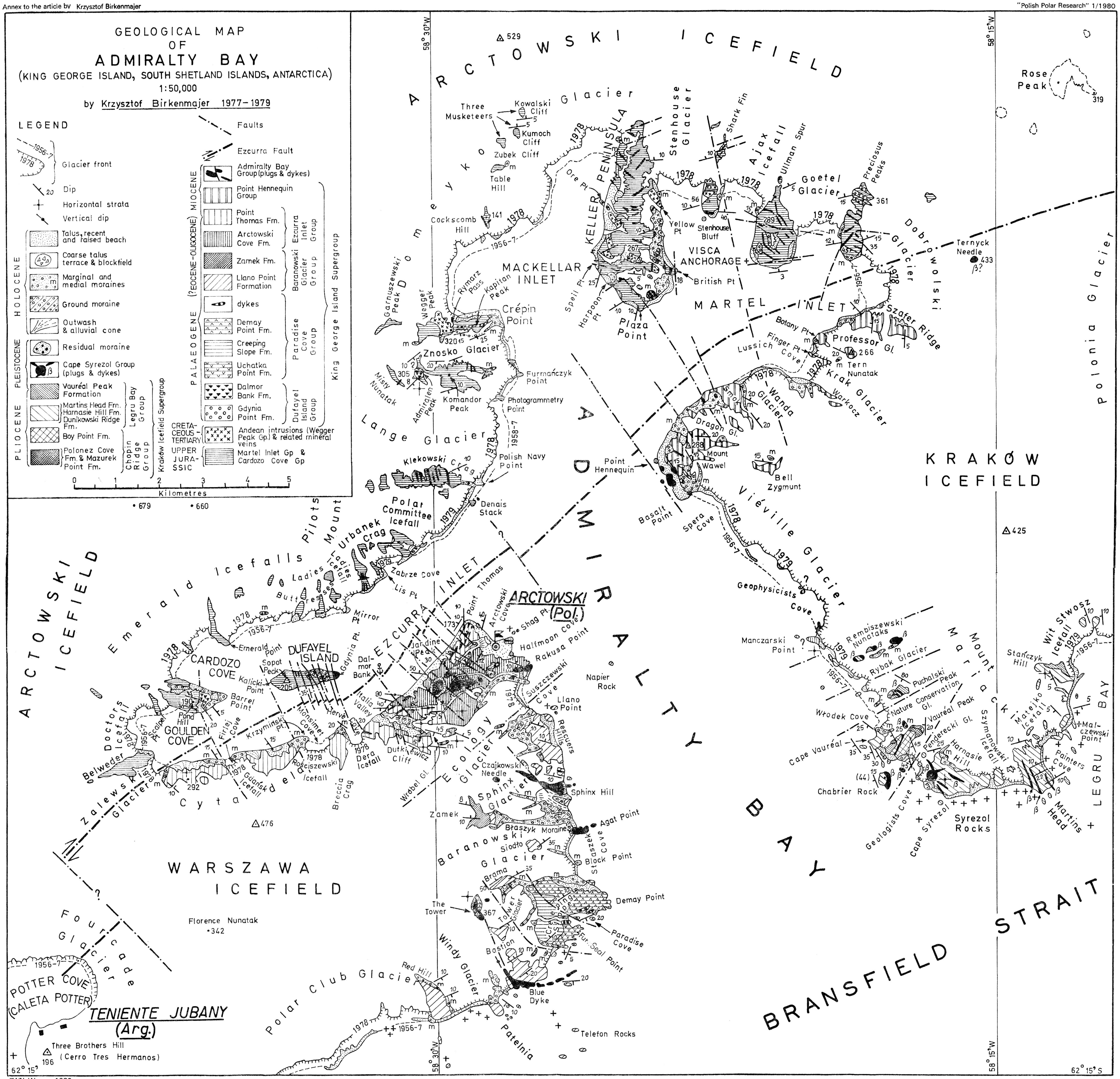
Tertiary. The formation of a thick (more than 2700 m) basaltic (tholeiitic) — andesitic suite of the King George Island Supergroup (?Eocene — Middle Miocene) corresponds to a rather quiet period of initial rifting and renewed subduction at the margin of the Antarctic continent. Thick flood-basalt sheets have spread over vast areas of an intra-arc graben being fed from long fissures parallel with the present Bransfield Strait.

Three volcanic cycles probably corresponding to stages of rifting and subduction may be recognized. They begin with flood basalts (tholeiites) and end with more acidic basaltic andesites and porphyritic andesites. The latter are the only rocks of the supergroup for which stratocone centres have been recognized.

A period of tectonic deformation corresponding with the Miocene-Pliocene boundary post-dates the King George Island Supergroup and pre-dates the Kraków Icefield Supergroup. An *older phase* (late Miocene?) was responsible for gentle folding of the Tertiary complex and for the formation of strike-slip (probably dextral) Ezcurra Fault, which is a major tectonic feature of Admiralty Bay area is unknown, but the active thawed zone during the from Dobrowolski Glacier to Zalewski Glacier respectively. The fault separates the predominantly Mesozoic terrain on the north from the Tertiary domain on the south, and its apparent vertical throw exceeds 2.5 km.

The Ezcurra Fault runs parallel with the axis of King George Island, and probably continues in other islands of the archipelago as a major linear feature of the South Shetland Islands arc. Its origin may be due to rotation of Antarctic continent anticlockwise with respect to the margin of the Pacific plate.

Several generations of basaltic and andesitic dykes and plugs (Admiralty Bay Group) have been recognized on both sides of the Ezcurra Fault, some of them clearly indicating the sense of horizontal displacement, e.g. en-échelon dykes at Ullman Spur (Fig. 16). Locally, strong folding appeared close to the fault, which had produced short steep brachyanticlines widest near the fault and closing farther off the fault. The recumbence of the Kasprowy Hill anticline to SW (Fig. 12) confirms assumed right-lateral movement along the Ezcurra Fault.



PWN, Warsaw 1980

Fig. 16. Geological map of Admiralty Bay, King George Island

A *younger phase* of tectonic deformation (?early Pliocene) produced dense faulting NW-SE, transverse to the Ezcurra Fault. These faults cut through the majority of dykes and plugs of the Admiralty Bay Group, thus clearly post-date them, and only some, youngest dykes of this group have used the faults. Moreover, the transverse faults served as ways of penetration of mineralizing solutions which had produced quartz-, red jasper-, calcite-haematite-, calcite- and mixed veins, sometimes with traces of copper minerals.

The tectonic style of the Kraków Icefield Supergroup (Pliocene and ?early Pleistocene), which occurs along the Bransfield Strait, is different from that of the Ezcurra Fault area. It is supposed that this supergroup post-dates the formation of both the Ezcurra Fault and the faults transversal to it. The apperance of olivine basalt flows at the base of the Chopin Ridge Group indicates deep fracturing of the Bransfield Strait area, and provenance of flood basalts of the Mazurek Point Formation from the mantle.

The subsequent Pliocene glaciation (Polonez Glaciation) of the area, part of an extensive continental ice-sheet, had resulted in isostatic subsidence of the continental plate and caused a short-lived ingression of the sea in the marginal part of the Antarctic continent. The regression, which followed as a result of isostatic recovery during deglaciation, was accompanied with acidic volcanic activity and strong vertical displacements of tectonic blocks adjacent to the Bransfield rift. These blocks have been subjected to deep dissection by subaeral erosion during an interglacial period preceding the Legru Glaciation.

A new cycle of volcanic activity started with hypersthene-augite andesite lava flows and tuffs interstratified with agglomerates (Legru Bay Group), and was succeeded by olivine-basalt intrusions of the Cape Syrezol Group (Pleistocene), then by olivine flood-basalts and finally by stratocones of the Penguin Island Group (Holocene). It is believed that these volcanic stages reflect stages of sea-floor spreading of the Bransfield Rift.

No strong folding was associated with the Pliocene and Quaternary stages. The rock complexes of the Chopin Ridge and Legru Bay groups show, however, a multitude of erosional and angular unconformities, intraformational reworking of lavas and sediments and large-scale cross-bedded units, as well as fragments of stratocones, all pointing out to a very unstable pattern of tectonic blocks and volcanic forms at the margin of the Bransfield Rift. These groups are cut by infrequent faults which often served as ways of penetration of olivine-basalt magma (dykes). The fault-and-dyke pattern in the zone adjacent to the Bransfield Strait is often radial with respect to major volcanic centres of the area.

8. Current geological processes

Extensive ice-cover of King George Island restricts the action of the majority of surficial geological processes to a very narrow coastal zone, to margins of glaciers and to nunataks. The depth of permafrost in the

Admiralty Bay area is unknown, but the active thawed zone during the austral summer months does not exceed 0.5–1.5 m depth on nunataks and rocky coasts, and may be slightly thicker only in the areas of coast covered with beach gravel and sand.

Periglacial processes are developed on a small scale. Patterned grounds have been found on high residual terraces (vicinity of Arctowski Station) and on strongly frost-shattered rocky promontories (e.g. Demay Point). Blockfields and block-terraces have a restricted significance. Talus and alluvial or mixed cones are frequent near steep escarpments and cliffs, but are also developed on a small scale (e.g. near Point Thomas, near Point Hennequin, near Demay Point). Gelifluction and mudflows develop sometimes in areas exposed to gravitational winds and afternoon solar radiation, for example on the western slopes of Keller Peninsula. The action of meltwater from snowfields and glaciers on the morphology of the area is negligible, and practically restricted to three areas: vicinity of Point Thomas-Arctowski Station-Italia Valley, forefield of Sphinx Glacier and Keller Peninsula.

Strong gravitational winds cause deflation in some areas (e.g. between Point Thomas and Jardine Peak) covered with dry fine material, the result of gelifraction.

Lack of carbonate rocks and the predominance of lavas and tuffs of basaltic and andesitic composition over water-laid sediments in the geological structure of Admiralty Bay, indicates the direction of chemical processes of weathering. This weathering acts predominantly in areas inhabited by penguins and other bird colonies and at breeding grounds of sea mammals, mainly elephant seal. There, both massive lavas and porous tuffs and other pyroclastic rocks are strongly decomposed.

Subglacial water action is especially efficient in areas built of soft tuff and shale, for example near Baranowski Glacier, as may be seen from widely expanding red suspension in the sea close to the glacier front.

As a result of isostatic uplift and related regression of the sea from the Admiralty Bay area, caused by deglaciation during the last 10,000 years, the rocky coasts of the bay are rimmed with stormridges and raised and recent gravel-sand beaches. Thus the direct abrasive action of waving and sea-ice on bedrock is restricted to small areas of newly ice-freed rocky promontories. Ice-cored moraines set free from ice as a result of glacier recession, are subject to thermal erosion and denudation by melting of ice-core during summer months, and locally produce a characteristic morainic landscape (e.g. near Ecology Glacier, near Baranowski Glacier, at Keller Peninsula, in inner Martel Inlet). Abrasive cliffs in moraines exposed to sea action are, as usual, ephemeral.

The author's warm thanks are due to Dr S. M. Zalewski and to Dr S. Rakusa-Suszczewski, leaders of the Polish 1977–78 and 1978–79 expeditions to Arctowski Station respectively. The help offered by various members of these expeditions, and by helicopter crews and ships' crews in particular, was invaluable. Dr A. K. Tokarski (geologist) and Eng. K. Rolnicki (technical assistant), members of the 1978--79 Earth sciences group led by the present author, helped to organize the daily routine work with great success. Their assistance is here acknowledged with pleasure.

9. Summary

Admiralty Bay, which is the largest inlet on King George Island (South Shetland Islands, West Antarctica) was geologically mapped by the author during Polish Expeditions to Antarctica between 1977 and 1979. The following rock-complexes have been differentiated:

1) Mesozoic stratiform complex of andesitic and rhyolitic lavas and sediments (Martel Inlet Group and Cardozo Cove Group: probably Upper Jurassic):

2) Andean intrusions represented by gabbroic and dioritic dykes with associated pyrite-mineralization (Wegger Peak Group: approximately Cretaceous-Tertiary boundary);

3) Tertiary stratiform complex of basaltic and andesitic lavas and interstratified sediments, altogether more than 2700 m thick (King George Island Supergroup: probably Eocene — Middle Miocene);

4) Late Tertiary intrusive complex of basaltic and andesitic dykes and plugs (Admiralty Bay Group: probably boundary of Miocene and Pliocene);

5) Late Tertiary effusives: olivine basalts, andesites etc., and sediments, about 600 m thick (Kraków Icefield Supergroup: Pliocene and ? Early Pleistocene) with well-preserved traces of two subsequent glaciations;

6) Quaternary intrusions (Cape Syrezol Group: Pleistocene) and effusives (Penguin Island Group: Holocene), mainly olivine basalts, related to opening of the Bransfield rift.

An outline of structural history of King George Island is also presented.

10. Резюме

Залив Адмиральты, который является величайшим заливом острова Кинг Джорж в Южных Шетландах (Западняя Антарктика) был геологически исследован автором статьи во время польских экспедиции в 1977—79 годах. Выделено следующие скальные комплексы:

1) Мезозойский слоистый комплекс лав андезитовых и риолитовых прокладанных осадками (группы Залива Мартеля и Кардозо Ков: вероятно верхняя юра);

2) Андийские интрузии в виде даек которым сопутствует пиритовая минерализация (группа Веджер Пик): вероятно граница мелового и третичного периода);

3) Третичный прокладной комплекс базальтовых и андезитовых лав с вкладками осадок насчитывающий свыше 2700 м мощности (сверхгруппа Острова Кинг Джорж: вероятно эоцен — средний миоцен):

4) Поздние третичные базальтовые и андезитовые интрузии (дайки и чопы — группа Залива Адмиральты: вероятно граница миоцена и плиоцена);

5) Поздний третичный эффузионный комплекс: оливиновые базальты, андезиты итп а также осадки около 600 м мощности (сверхгруппа ледника Краков: плиоцен и нижный плейстоцен?) с хорошо сохранёнными следами очередных оледенении;

6) Четвертичные интрузии (группа Мыса Сирезол: плейстоцен) и эффузивные породы (группа Острова Пингвина: голоцен (в основном оливиновые базальты, которых появление было связано с открытием шва Брансфильда.

Представлено также очерк структуральной истории Острова Кинг Джорж.

11. Streszczenie

Zatoka Admiralicji, która jest największą zatoką Wyspy Króla Jerzego w Południowych Szetlandach (Antarktyka Zachodnia) była badana geologicznie przez autora w czasie polskich wypraw w latach 1977—1979. Wyróżniono następujące kompleksy skalne:

1) mezozoiczny kompleks warstwowany law andezytowych i riolitowych przekładanych osadami (grupy Zatoki Martela i Zatoki Cardozo: prawdopodobnie jura górna);

2) intruzje andyjskie reprezentowane przez dajki gabrowe i diorytowe, którym towarzyszy mineralizacja pirytowa (grupa szczytu Weggera: przypuszczalnie granica kredy i trzeciorzędu);

3) trzeciorzędowy kompleks warstwowany law bazaltowych i andezytowych z wkładkami osadów, liczących ponad 2700 m miąższości (nadgrupa Wyspy Króla Jerzego: prawdopodobnie eocen — środkowy miocen);

4) późnotrzeciorzędowe intruzje bazaltowe i andezytowe (dajki i czopy — grupa Zatoki Admiralicji: prawdopodobnie granica miocenu i pliocenu);

5) późnotrzeciorzędowy kompleks efuzyjny: bazalty oliwinowe, andezyty itd. oraz osady, około 600 m miąższości (nadgrupa Kopuły Krakowa: pliocen i wczesny plejstocen?), z dobrze zachowanymi śladami dwóch kolejnych zlodowaceń;

6) intruzje czwartorzędowe (grupa Przylądka Syrezol: plejstocen) i efuzywy (grupa Wyspy Pingwin: holocen), głównie bazalty oliwinowe, których pojawienie się było związane z otwieraniem się ryftu Bransfielda.

Przedstawiono również zarys historii strukturalnej Wyspy Króla Jerzego.

12. References

1. Adie R. J. 1958 — Geological investigations in the Falkland Island Dependencies since 1940 — Polar Record, 9 (58): 3–17.
2. Adie R. J. 1964 — Geological history (In: Antarctic Research, Eds. R. Priestley, R. J. Adie, G. de Q. Robin) — London, 117–162.
3. Barton C. M. 1961 — The geology of King George Island, South Shetland Islands — Prel. Rep. Falkd Isl. Dep. Surv., 12: 1—18.
4. Barton C. M. 1964 — Significance of the Tertiary fossil floras of King George Island, South Shetland Islands (In: Antarctic geology, Ed. R. J. Adie) — North-Holland Publ. Co. Amsterdam 603–609.
5. Barton C. M. 1965 — The geology of South Shetland Islands. III. The stratigraphy of King George Island — Sci. Rep. Brit. Antarct. Surv., 44: 1–33.
6. Bibby J. S. 1961 — The geology of Ezcurra Inlet and Point Thomas, Admiralty Bay, King George Island, South Shetland Islands — Prel. Rep. Falkd. Isl. Dep. Surv., 8: 1–10.
7. Birkenmajer K. 1975 — Polskie badania geologiczne w Zachodniej Antarktyce (1977–1978) — Przegl. geol. 1 (309): 1–6.
8. Birkenmajer K. 1980a — A revised lithostratigraphic standard for the Tertiary of King George Island, South Shetland Islands (West Antarctica) — Bull. Acad. Pol. Sci., Sér. Sci. Terre, 27: 49–57.
9. Birkenmajer K. 1980b — Discovery of Pliocene glaciation on King George Island, South Shetland Islands (West Antarctica) — Bull. Acad. Polon. Sci., Sér. Sci. Terre, 27: 59–67.
10. Birkenmajer K. 1980c — Age of Penguin Island volcano, South Shetland Islands (West Antarctica) by lichenometric method — Bull. Acad. Pol. Sci., Sér. Sci Terre, 27: 69–76.
11. Birkenmajer K. 1980d — Lichenometric dating of glacier retreat at Admiralty Bay, King George Island, South Shetland Islands (West Antarctica) — Bull. Acad. Pol. Sci., Sér. Sci. Terre, 27; 77–85.
12. Birkenmajer K. 1980e — Tertiary volcanic-sedimentary sucession at Admiralty Bay, King George Island, South Shetland Islands, Antarctica — Studia Geol. Pol. 64: 7–65.
13. Birkenmajer K. 1980f — New place-names introduced to the area of Admiralty Bay, King George Island, South Shetland Islands (Antarctica) — Studia Geol. Pol. 64: 67–87.
14. Birkenmajer K. 1980g — Report on geological investigations of King George Island, South Shetland Islands (West Antarctica) in 1978–79 — Studia Geol. Pol. 64: 89–105.

15. Birkenmajer K. (in press) — Polskie badania geologiczne w Zachodniej Antarktyce (1978–1979) — Przegl. geol.
16. Covacevich V., Lamperein V. 1972 — Ichnites from Fildes Peninsula, King George Island, South Shetland Islands (In: Antarctic Geology and Geophysics, Ed. R. J. Adie) — Universitetsforlaget, Oslo, 71–74.
17. Curl J. E. 1976 — A glacial history of the South Shetland Islands, Antarctica — Inst. Polar Stud. (Ohio), Rep., 63: 1–74.
18. Diaz H., Teruggi M. E. 1956 — Contribución a la geológia de la Antártida Occidental. II. Descripción geológica y petrográfica de algunas localidades de la Antártida Occidental — Publ. Inst. Antárt. Argent., 2: 77–152.
19. Everett K. R. 1971 — Observations on the glacial history of Livingston Island — Arctic, 24: 41—50.
20. Ferguson D. 1921 — Geological observations in the South Shetlands, the Palmer Archipelago, and Graham Land, Antarctica — Trans. Roy. Soc. Edinb., 53 (1): 29–55.
21. Fourcade N. H. 1960 — Estudio geológico-petrográfico de Caleta Potter, Isla 25 de Mayo, Shetland del Sur — Publ. Inst. Antárt. Argent., 8: 1–119.
22. González-Ferrán O., Katsui O. 1970 — Estudio integral del volcanismo cenozoico superior de las islas Shetland del Sur, Antártica — Ser. Cient. Inst. Antárt. Chil., 1 (2): 123–174.
23. Grikurov G. E., Krylov A. Ja., Poljakov M. M., Covbun Ja. N. 1970 — Vozrast gornych porod v severnoj časti Antarktičeskogo Poluostrova i na Južnych Šetlandskich Ostrovach (po dannym kalij-argonovogo metoda) — Inf. Bjull. Sov. Antarkt. Eksp., 80: 30–33.
24. Grikurov G. E., Poljakov M. M. 1968 — Geologičeskie stroenie p-ova Fildes, jugozapadnaja okonečnost' o. King Džordž (Waterloo) — Biull. Sov. Antarkt. Eksp., 71: 17–24.
25. Hawkes D. D. 1961 — The geology of the South Shetland Islands. I. The petrology of King George Island — Sci. Rep. Falkd. Isl. Dep. Surv., 26: 1–28.
26. John B. S., Sugden D. E. 1971 — Raised marine features and phases of glaciation in the South Shetland Islands — Brit. Antarct. Surv. Bull., 24: 45–111.
27. Noble H. M. 1965 — Glaciological observations at Admiralty Bay, King George Island, in 1957–58 — Brit. Antarct. Surv. Bull. 5: 1–11.
28. Orlando H. A. 1963 — La flora fosíl en las inmediaciones de la Peninsula Ardley, Isla 25 de Mayo, Islas Shetland del Sur — Contr. Inst. Antárt. Argent., 79: 1–17.
29. Orlando H. A. 1964 — The fossil flora of the surroundings of Ardley Peninsula (Ardley Island), 25 de Mayo Island (King George Island), South Shetland Islands (In: Antarctic Geology, Ed. R. J. Adie) — North-Holland Publ. Co. Amsterdam, 629–636.
30. Schauer O. C., Fourcade N. H. 1963 — Estudio geológico-pertográfico del extremo occidental de la isla 25 de Mayo, Islas Shetland del Sur — Contr. Inst. Antárt. Argent., 78: 1–14.
31. Schauer O. C., Fourcade N. H. 1964 — Geological-petrographical study of the western end of 25 de Mayo Island (King George Island), South Shetland Islands (In: Antarctic Geology, Ed. R. J. Adie) — North-Holland Publ. Co Amsterdam, 487–491.
32. Schauer O. C., Fourcade N. H., Dalinger R. E. 1961 — Contribución al conocimiento geológico del extremo occidental de la Isla 25 de Mayo y Peninsula Ardley, Islas Shetland del Sur — Contr. Inst. Antárt. Argent., 60: 1–16.
33. Stansbury M. J. 1961 — Glaciological observations at Admiralty Bay, King George Island, South Shetland Islands, 1959–60 — Falkd. Isl. Dep. Surv., Prel. Glac. Rep., 4: 1–45.
34. Tyrrell G. W. 1921 — A contribution to the petrography of the South Shetland Islands, the Palmer Archipelago, and the Danco Land Coast, Graham Land, Antarctica — Trans. Roy. Soc. Edinb., 53: 57–79.

35. Tyrrell G. W. 1945 — Report on rokcs from West Antarctica and the Scotia Arc — Discovery Rep., 23: 37–102.

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