# PETROGRAPHY OF THE QUEEN MAUD BATHOLITH, CENTRAL TRANSANTARCTIC MOUNTAINS, ROSS DEPENDENCY, ANTARCTICA

By

J.D. Burgener IV

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

(Geology)

at the

UNIVERSITY OF WISCONSIN

1975

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

## LIST OF TABLES



## LIST OF FIGURES



## LIST OF PLATES

# Abstract

The composite Queen Maud Batholith between the Shackleton and Scott Glaciers consists of early-tectonic (pre-tectonic and syntectonic) granites and post-tectonic gabbros and granites. The batholith was emplaced by stoping and forceful injection during the Ross Orogeny (450-520 m.y.b.p.) under epizonal conditions.

The early-tectonic granites are extremely variable in composition and texture.

The post-tectonic gabbros can be divided into two mappable units: coarse-grained hornblende gabbros and hornblendites, and dolerites. The hornblende gabbros and hornblendites predate the dolerites. The post-tectonic gabbros predate the post-tectonic granites.

The post-tectonic granites can be divided into at least five mappable units: a granophyre, a tonalite, a granodiorite, an equigranular adamellite, and a porphyritic adamellite. The porphyritic adamellite makes up the bulk of the batholith. No age relationships have been determined among the post-tectonic granites.

## INTRODUCTION

During the austral summer of 1970-71 the area between the Shackleton and Robert Scott Glaciers, 84°30' to 86°30'S., 150° to 180°W., a 379,000 square kilometer area, was mapped at a reconnaissance scale (1:250,000) by a party from the Ohio State University/Institute of Polar Studies led by Drs. D. H. Eliot and D. Coates. The group was supplied and transported by U. S. Naval Air Squadron VXE-6. I was in charge of mapping the igneous rocks of the crystalline basement.

The area was first visited by Scott, Shackleton and Amundsen on their way to and upon returning from the South Pole. L. M. Gould was the first geologist to visit the area; specimens he collected were described by Stewart (1934a and 1934b). Since then Grindley et.al. (1964), Barret (1965), McGregor (1965), Wade et.al. (1965), McLelland (1967), Eastin (1970) and Gunner and Faure (1970), among others, have worked in or studied rocks from the area.

## GEOLOGIC SETTING

The central Transantarctic Mountains have undergone at least four orogenic episodes: the Nimrod (1.98 b. y.), the Beardmore (600 m. y.), the Ross (450-520 m. y.), and the Victoria (70 m. y.). Outcrops of rocks deformed during the Nimrod Orogeny are either absent or only locally present in the Shackleton-Scott Glaciers area. Rocks isoclinally folded during the Beardmore and Ross Orogenies and igneous rocks intruded during these orogenies were eroded to a peneplane (the Kukri Peneplane), upon which middle and upper Paleozoic clastic rocks were deposited. These clastic rocks are overlain by the Jurassic Kirkpatrick Basalts and intruded by the associated Ferrar Dolerites.

Gould (1935) suggested that the present Transantarctic Mountains are a giant horst; however, a homoclinal model is now favored because there is no evidence of a fault to the southwest (Robinson, 1964).

The non-plutonic rocks of the crystalline basement (collectively termed the Ross Supergroup) consist of eugeosynclinal meta-argillites and metagreywackes (Beardmore Group) and overlying metaclastic rocks and marble with acidic metavolcanic rocks locally present (Byrd Group). These rocks have been regionally metamorphosed to greenchist facies and overprinted by thermal metamorphism of albite-epidote and hornblende-hornfels facies. Isolated outcrops of higher grade metamorphic rocks (almandine-amphibolite facies) may represent exposures of the oldest paragneisses of the Transantarctic Mountains (the Nimrod Group) or localities where rocks of the Ross Supergroup have been thermally metamorphosed to a higher grade. Isoclinal folding accompanied the regional metamorphism. The Ross Supergroup will not be discussed further, having been described in detail elsewhere (McGregor, 1965).

The plutonic rocks which intruded the Ross Supergroup late in and after the folding episode and produced the thermal metamorphic event are the Granite Harbor Intrusives (formerly called the Granite Harbor Intrusive Complex)[1]. These rocks are compositionally and texturally variable: in the Terra Nova Bay-McMurdo Sound area seven distinct

---

[1]Grindley and Warren (1964) suggested the term "Granite Harbor Intrusives" be limited to syntectonic and post-tectonic intrusive rocks, pretectonic intrusive rocks being interpreted to be correlative with the Campbell Plutonics (Gair, 1964 and 1967). The intent of this suggestion was to separate the intrusive rocks associated with Beardmore Orogen, the Campbell Plutonics, from those associated with the Ross Orogen, the Granite Harbor Intrusives. While such a separation is important, it is presently premature as radiometric dating is the only method of differentiating between the rocks of the two periods

lithologic types have been recognized (Warren, 1970); in the Shackleton-Scott Glaciers area at least nine distinct lithologic types have been recognized.

The early-tectonic[2] Granite Harbor Intrusives of the Shackleton-Scott Glaciers area can be divided into tonalitic and granitic (granodioritic and adamellitic, sensu-strictu) categories. The post-tectonic Granite Harbor Intrusives are compositionally divisible into four categories: gabbro, tonalite, granodiorite and adamellite.

The dominant rock type of the Granite Harbor Intrusives is a coarse-grained, unfoliated to weakly-foliated, porphyritic rock consisting of pink or white poikilitic alkali feldspar phenocrysts in a matrix of oscillatorally zoned andesine, quartz, and biotite with minor hornblende.

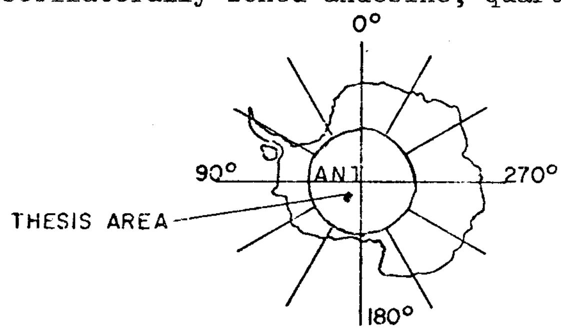



FIG. I LOCATION MAP OF THESIS RESEARCH AREA

---

of intrusion and a lithologic type may be pre-tectonic in one area and post-tectonic in another, e.g., the Irizar Granite, a post-tectonic granite, is reported by Grindley and Lair (1970) to closely resemble the Mt. Rich Granite, a pre-tectonic intrusive rock in the Darwin Glacier area (Haskell et.al., 1964). In this paper, all intrusive rocks which intrude the Ross Supergroup, predate the Kukri Peneplane and have not been shown to be associated with the Beardmore Orogen by radiometric dating, will be considered to be part of the Granite Harbor Intrusives.

[2]In the Shackleton-Scott Glaciers the pre-tectonic and syntectonic Granite Harbor Intrusives have been grouped together in the term early-tectonic since there is insufficient field evidence to differentiate between rocks of the two periods.

Fourteen specimens from the Shackleton-Scott Glaciers area have been dated by isotopic methods (see Craddock, 1970). These data indicate that the major pulse of intrusion of the Queen Maud Batholith accompanied the Ross Orogeny, 450-520 m.y. ago.

## TERMINOLOGY

The terms used in this thesis are from Williams, Turner and Gilbert's *Petrography, An Introduction to the Study of Rocks in Thin Sections* (1954) with two exceptions:

adamellite is used for quartz monzonite, and

dolorite is used for diabase.

Both of these exceptions are made to be consistent with previous literature on the area.

## PRE-INTRUSIVE METAMORPHIC ROCKS OF THE SHACKLETON-SCOTT GLACIERS AREA

In addition to the Ross Supergroup, amphibolite, biotite migmatite, amphibole migmatite and augen gneiss crop out in the Shackleton-Scott Glaciers area. The higher rank metamorphic rocks occur as isolated outcrops with no apparent systematic spatial relationships, surrounded by early-tectonic and post-tectonic intrusive rocks.

It has been proposed that these metamorphic rocks either represent portions of a Precambrian basement older than the Ross Supergroup (the Nimrod Group), or that they are correlative with the Ross Supergroup and have been locally thermally metamorphosed to a higher rank. The grade of metamorphism and the inferred original lithologies of the higher rank metamorphic rocks of the Shackleton-Scott Glaciers area are consistent with those of the Nimrod Group. However, McGregor (1965) has suggested that these rocks are contact migmatites formed by the intrusion of the Granite Harbor Intrusives into the Ross Supergroup. Gradational contacts between the high rank metamorphic rocks and the Ross Supergroup are reported by McGregor (1965) at Mt. Betty (85°11'S., 163°45'W.), and a gradational contact between amphibole migmatite and the Ross Supergroup metasediments was observed at the base on the west side of Mt. Greenlee (84°50'S., 177°00'W.). The gradational contacts suggest that at least some of the exposures represent contact migmatization and thermal metamorphism of the Ross Supergroup.

Amphibole Migmatite[1]

The amphibole migmatite exposed at Mt. Olds (84°40'S., 174°38'W.) has extensive gradational contacts with both an early-tectonic intrusive at Mt. Olds and with a post-tectonic tonalite (the Longhorn Spurs Tonalite) at the south end of Longhorn Spurs. Lenses and dykes of the tonalite and the adamellite cut the gradational contact zone. Lit-par-lit structures are present. The contacts between the amphibole migmatite and the Ross Supergroup rocks are snow covered.

The high-rank metamorphic rock exposed at the base of Mt. Greenlee is, megascopically, very similar to the amphibole migmatite. At Mt. Greenlee there is a gradational contact between the amphibole migmatite and the Ross Supergroup metavolcanics (Taylor Formation, Byrd Group).

> Amphibole Migmatite: The amphibole migmatite is a medium-grained, granoblastic unit composed of normally zoned sodic plagioclase, quartz, subhedral hornblende and accessory opaques and allanite. The plagioclase grains are of variable composition and contain hornblende inclusions. Quartz occurs both as aggregate megacrysts and interstitial grains. Alteration of amphibole to pumpellyite, epidote and chlorite occurs.

The amphibole migmatite is believed to be of injection origin,

---

[1]The metamorphic units are described in an arbitrary order.

the early-tectonic adamellite being injected into the country rock at the southern portion of the exposure at Mt. Olds and the post-tectonic tonalite being injected into the country rock at the northern portion of the Mt. Olds exposure. The rock type and age of the country rock are unknown, although the Ross Supergroup rocks do occur on two sides of the exposure of amphibole migmatite at Mt. Olds.

Amphibolite

Small isolated outcrops of amphibolite occur to the west of the mouth of Shackleton Glacier. The amphibolite on the ridge five kilometers west-southwest of Mt. Wasko has been intruded by an early-tectonic tonalite.

Amphibolite: The amphibolite, a nematoblastic, equigranular rock with an average grain size of 0.33mm., is composed of hornblende, biotite, quartz, oligoclase and accessory sphene, opaques and apatite. The cores of the oligoclase ($An_{28}$) are preferentially altered to sericite. The biotite has orange to mahogany-red pleochroism; the hornblende green to blue-green pleochroism. The quartz is anhedral and strain free.

Augen Gneiss and Schist

At Wilson Portal (84°28'S., 178°25'W.) an augen gneiss and a schist crop out. Schistose layers, 2-3 meters thick, are interlayered with the dominant augen gneiss; contacts are sharp and parallel to the foliation. Abundant slickensides are present in the schistose layers.

At the extreme southern end of the ridge at Wilson Portal there is a skree covered outcrop of fine-grained biotite-microcline-quartz schist. The contact between this schist and the interlayered augen gneiss and schist is snow covered.

At McGinnis Peak (84°32'S., 177°52'W.) a schist similar to the schist interlayered with the augen gneiss crops out.

Augen Gneiss: The augen gneiss is coarse-grained, with anhedral oligoclase and microcline-microperthite augen up to 20 mm. in length, oligoclase augen being more numerous than microcline augen. A mortar texture is developed and some of the oligoclase augen are bent. The matrix consists of anhedral strained quartz, plagioclase, interstitial biotite with accessory opaques, microcline-microperthite and a trace of muscovite. The oligoclase augen are oscillatorally zoned ($An_{15-18}$).

Schist: Fine-grained schist consists of oscillatorally zoned oligoclase and microcline-microperthite megacrysts up to 5 mm. in length set in a matrix of quartz, oligoclase, microcline-microperthite and biotite. Oligoclase megacrysts are more abundant than microcline megacrysts. Hornblende and opaques occur in trace amounts in the matrix.

Biotite-Microcline-Quartz Schist: A mortar texture and ribbon quartz are developed in the fine-grained schist. Megacrysts of microcline occur in a matrix of strained quartz, biotite and accessory opaques, sphene and dravite.

Biotite Migmatite

Biotite migmatite crops out on the northwest face of Olson Crags (86°12'S., 160°48'W.). The rock is fine-grained with thin mafic and felsic banding and extensive ptygmatic folding. There is a contact zone topographically above the migmatite with a post-tectonic granodiorite. Veinlets of the granodiorite become more abundant toward the contact; xenoliths of biotite migmatite are abundant in the granodiorite at the contact.

Biotite migmatite, compositionally and texturally similar to that exposed at Olson Crags, crops out at Robinson Bluff (85°36'S., 159°47'W.). A gradational contact, three meters wide, exists between the biotite migmatite and on early-tectonic tonalitic intrusive at Robinson Bluff.

Biotite Migmatite: The fine-grained melanocratic portion has a mortar texture. Mineralogy consists of anhedral to subhedral plagioclase of variable composition (albite to andesine), strained quartz with sutured grain boundaries, biotite and muscovite with accessory opaques and sphene. Biotite occurs as clots and is altered to chlorite.

The granoblastic leucocratic portion consists of strained quartz, albite and accessory muscovite. The grain size varies from 1 to 2 mm.

## CAMPBELL PLUTONICS

### Lonely Ridge Granodiorite[1]

A foliated granodiorite, the Lonely Ridge Granodiorite, crops out in the Nilsen Plateau (86°20'S., 158°00'W.) area. A rubidium-strontium whole rock isochron gives an age of 611±17 m.y. (Eastin, 1970) indicating that the granodiorite was intruded during the Beardmore Orogeny, and for this reason it has not been included in the Queen Maud Batholith.

The foliation of the Lonely Ridge Granodiorite is thought to have originated during the Ross Orogeny. McLelland (1967) has suggested that the granodiorite is pre-tectonic since "the attitude of the foliation within the Lonely Ridge Granodiorite is consistent over long distances, is not folded and extends into the younger units emplaced into this granodiorite."

Lonely Ridge Granodiorite: The granodiorite is an equigranular cataclasite with a mortar texture developed. The mineralogy consists of andesine ($An_{35-45}$) displaying normal euhedral oscillatory zoning, microcline-microperthite, quartz, brown-pleochroic biotite and accessory hornblende, muscovite, sphene, apatite, zircon and opaques. There are mafic xenoliths present. The modal composition of the Lonely Ridge Granodiorite is given in Table 1 and Figure 2 ($p\epsilon\epsilon lgd$).

---

[1]The rock description of the Lonely Ridge Granodiorite is from McLelland (1967).

## QUEEN MAUD BATHOLITH[1]

The Queen Maud Batholith consists of the Granite Harbor Intrusives between the Shackleton and Scott Glaciers. The members of the Queen Maud Batholith can be grossly differentiated by the presence or absence of foliation. The foliated tonalitic intrusives locally have gradational contacts, approximately 3 meters wide, with the surrounding country rock. The foliated granitic intrusives generally have sharp contacts with the country rock; the extensive gradational contact between the foliated adamellite and the amphibole migmatite at Mt. Olds is the exception. Non-foliated intrusive rocks have sharp contacts with the country rock (again the contact between the Longhorn Spurs Tonalite and the amphibole migmatite at Mt. Olds is the exception), chilled margins and contact metamorphic aureoles of albite-epidote and hornblende-hornfels rank. The early-tectonic intrusions are thought to have been emplaced under transitional mesozonal-epizonal conditions based on the sharp contacts (Buddington, 1959). The field relations and the presence of a granophyre indicate epizonal emplacement conditions for the post-tectonic Granite Harbor Intrusives.

### EARLY-TECTONIC GRANITE HARBOR INTRUSIVES

#### Tonalitic Early-Tectonic Granite Harbor Intrusives

The foliated tonalite has a medium to coarse-grained porphyritic texture; anhedral plagioclase and quartz phenocrysts occur in a well-

---

[1]McGregor (1965) suggests that the term "Queen Maud Batholith" be restricted to the post-tectonic Granite Harbor Intrusives of the area. Murtaugh (1969), discussing what is probably the same batholithic complex in the Wisconsin Range, includes pre-tectonic, syntectonic and post-tectonic intrusive rocks as units of the Wisconsin Batholith. All intrusive rocks which have not been shown to be associated with the Beardmore Orogeny will be included in the Queen Maud Batholith in this paper.

foliated, biotite-rich groundmass. Ellipsoidal amphibolitic pods (10-15 cms. long) occur throughout the tonalite, their long axes lying in the plane of foliation. The mafic bodies have both sharp and gradational boundaries. Tabular amphibolite bodies, varying in thickness from centimeters to meters, occur locally concordant to the foliation. Tourmaline pegmatite and aplite dykes, unfoliated and discordant to the foliation, are locally abundant.

Contacts of the tonalite with the country rock are gradational: at Robinson Bluff (85°36'S., 176°59'W.) apophyses of tonalite intrude amphibolite.

Tonalite: Anhedral andesine and quartz phenocrysts, up to 12 mm. long occur in a matrix of quartz, biotite, plagioclase and accessory sphene, hematite, hornblende, apatite and microperthite. A mortar texture is not uncommon.

At Robinson Bluff and Mt. Benjamin (85°48'S., 160°06'W.) the foliated tonalite is porphyritic with anhedral unzoned andesine ($An_{35-40}$) and anhedral quartz phenocrysts in a matrix of strained biotite, anhedral andesine and accessory microcline-microperthite, hematite, green to blue-green hornblende and apatite. Alteration of biotite to chlorite and andesine to sericite is locally pronounced.

The gneissic tonalite at Mt. Wasko is typified by blue plagioclase phenocrysts and biotite clots. It is a medium-grained porphyritic rock with a hypidiomorphic-granular matrix. Antiperthitic oligoclase phenocrysts ($An_{25-30}$) are oscillatorally zoned, becoming more sodic toward the rim. The matrix consists of quartz, plagioclase and biotite with accessory anhedral sphene, opaques and microcline. Biotite displays yellow to dark-green pleochroism. A weak mortar texture is developed. The plagioclase-microcline boundaries are commonly myrmekitic. The grain size of the phenocrysts is 7.5 mm., the matrix 2.5 mm. Biotite is altered to chlorite and epidote.

A porphyritic gneissic tonalite is the dominant lithology at Mts. Franke (84°37'S., 176°58'W.) and Koob (84°53'S., 169°02'W.). Oligoclase antiperthite phenocrysts have euhedral oscillatory zoning of a reversed nature; the cores are albitic ($An_{10}$) with oligoclase rims ($An_{21}$). Rectangular patches of microcline, all in optical continuity within each grain, occur in the oligoclase. These patches are surrounded by soda rich plagioclase. The matrix is composed of quartz, hornblende and biotite with minor amounts of microcline, sphene and opaques. Biotite and hornblende have yellow to green pleochroism.

The amphibolitic pods have the same mineralogy, differing in the amount of the phases present; most notably there is considerably more hornblende in the mafic pods. Epidote and chlorite occur as alteration products of biotite and hornblende. The modal composition of the foliated tonalite, excluding the mafic pods, is given in Table 1 and Figure 2 (FRNK-4).

A sequence of four tabular units occurs within the foliated tonalite at an elevation of approximately 800 meters on the northeast face of Mt. Franke. The total thickness of these units is about 20 meters; they are visually traceable on the mountainside for at least one kilometer. The four lithologies are in sharp contact with each other and with the dominant foliated tonalite. Foliation is variable within the tonalite but at the contact the foliation and the contact are parallel. Topographically the lowermost of these units is a fine-grained, leucocratic, feldspathic gneiss, 2-3 meters thick; foliation in the unit is visible due to the non-continuous wisps of mafic material. There are two mafic units above the gneiss, each approximately 7-8 meters thick. The lower of these mafic units is a fine-grained, equigranular amphibolite; the upper is brecciated mafic rock with angular blocks 25-40 cms. across composed mainly of pyroxene, set in a quartzo-feldspathic matrix. The uppermost unit is a fine-grained, thinly-layered, pink gneiss, approximately 2-3 meters thick.

Leucocratic Fedlspathic Gneiss: A fine-grained, granoblastic gneiss composed almost entirely of quartz and untwinned plagioclase with accessory sphene, hornblende and microcline. The grain size of the rock is 0.25 mm. A modal analysis of the rock is given in Table 1 and Figure 2 (FPG-1).

Amphibolite: A fine-grained (0.25 mm.) granoblastic rock consisting of plagioclase, clinopyroxene, hornblende and opaques with a trace of apatite.

Pink Gneiss: A fine-grained (0.3 mm.) gneissic tonalite composed of sub- to anhedral oligoclase ($An_{20}$), quartz, interstitial amphibole and accessory sphene, opaques and clinopyroxene. The modal composition of the rock is given in Table 1 and Figure 2 (FPG-4).

Granitic Early-Tectonic Granite Harbor Intrusives

The early-tectonic granites of the Shackleton-Scott Glaciers area have a variety of textures and compositions and it is difficult to make an integrative statement about them; for this reason each exposure will be discussed in turn.

Mt. Franke

A strongly-foliated, fine- to medium-grained leuco-granite, exposed at the base of Mt. Franke, is in sharp contact with and contains xenoliths of amphibolite. No relationship to other granitic rocks is determinable.

Leucogranite: A hypidiomorphic-granular granite consisting of microcline, plagioclase, quartz, biotite and amphibole, with traces of muscovite.

Mt. Olds

A porphyritic, weakly-foliated, medium-grained adamellite occurs at Mt. Olds (84°40'S., 174°38'W.). Contacts with an amphibole migmatite are gradational and the unit is cut by aplite dykes.

Adamellite: Unzoned, anhedral, antiperthitic andesine phenocrysts occur in a matrix of interstitial, strained, fine-grained quartz, mircocline (with quartz inclusions), and sub- to anhedral, yellow to green pleochroic hornblende, and interstitial, green pleochroic biotite with accessory sphene, hematite and epidote. A mortar texture is developed. The modal composition of the rock is given in Table 1 and Figure 2 (OLDS-1).

Mt. Baker

Mt. Baker consists of early-tectonic and post-tectonic intrusive rocks. Early-tectonic granite crops out on the eastern end of the mountain. The central and southern portions of the mountain consist of post-tectonic basic intrusives; the western and northern edges of the mountain are composed of two types of post-tectonic granite. The early-tectonic granite was visited at the northeast corner of Mt. Baker (84°44'S., 172°18'W.). Schistose mafic dykes cut the granite exposure.

Granite: The granite has a fine-grained, cataclastic texture with abundant anhedral megacrysts of strained quartz (up to 5 mm.) with a matrix of anhedral microcline, anhedral quartz, subhedral sodic oligoclase and accessory biotite and garnet.

Nilsen Plateau Adamellite

McLelland (1967) has described four mappable units in the Nilsen Plateau area: the Lonely Ridge Granodiorite, the South Leuco-Quartz Monzonite, the Cougar Canyon Quartz Monzonite and the North Quartz Monzonite. The Lonely Ridge Granodiorite is part of the Campbell Plutonics; the quartz monzonite (adamellite) units are sufficiently similar to permit their being grouped together on the scale of this report and are referred to collectively as the Nilsen Plateau Adamellite.

McLelland (1967) suggests that the porphyritic (locally equigranular) Nilsen Plateau Adamellite is syntectonic based on: 1) apophyses of the adamellite in the Lonely Ridge Granodiorite are foliated parallel to the foliation of the Granodiorite, 2) adamellite bodies with discordant contacts with the country rock are foliated concordantly with country rock, and 3) the presence of mortar texture in portions of the adamellite indicates that the rock had at least partially crystallized previous to any deformation.

Post-tectonic aplite and pegmatite dykes cut the adamellite.

Nilsen Plateau Adamellite: Cataclastic micro-structures of the originally porphyritic rock are abundant. "Quartz crystals have pronounced undulatory extinction and fine-grained xenoblastic mosaics of quartz are ubiquitous. Albite twin lanellae in the plagioclase grains are noticeably bent, and in some samples the larger microcline grains contain fractures filled with quartz. Biotite is bent and ruptured."

Microcline-microperthite phenocrysts, up to 60 mm. in length, are set in a coarse-grained matrix of quartz, andesine and red-brown pleochroic biotite with accessory apatite, sphene, zircon, and opaques. The plagioclase displays normal or oscillatory zoning; in some localities the plagioclase is extensively albitized. The microcline-microperthite phenocrysts are poikilitic. Modal compositions of the Nilsen Plateau Adamellite are given in Table 1 and Figure 2 ($GO_{na}$).

## POST-TECTONIC GRANITE HARBOR INTRUSIVES

The post-tectonic Granite Harbor Intrusives have been divided into gabbroic and granitic units by McGregor (1965). These major categories can be further subdivided:

- gabbroic
  - hornblende gabbros and hornblendites
  - dolerites
- granitic
  - adamellites
    - Speed Adamellite (coarse-grained, porphyritic)
    - Watt Ridge Adamellite (equigranular)
    - Greenlee Granophyre
  - granodiorite
    - Organ Pipe Peaks Granodiorite
  - tonalite
    - Longhorn Spurs Tonalite

## AGE RELATIONSHIPS

The mafic post-tectonic units generally pre-date the post-tectonic granites. McGregor (1965) reports that the more mafic rock is typically older than the more felsic rock. Locally, however, there is some field evidence (xenoliths) that some of the granites pre-date the mafic rocks. There is presently no field evidence on the relative ages of the post-tectonic granites.

## POST-TECTONIC MAFIC GRANITE HARBOR INTRUSIVES

Post-tectonic mafic rocks crop out in both small isolated exposures and large composite exposures. Three extensive exposures of post-tectonic mafic rocks were visited at Amphibole Peak (84°43'S., 155°50'W.), Mt. Baker, and Mt. Feeney (85°37'S., 155°50'W.). All of these composite outcrops are surrounded by post-tectonic granites (contacts snow covered) and are characterized by rock types irregularly varying on a scale of meters.

### Hornblende Gabbros and Hornblendites[1]

The coarse-grained gabbroic rocks are texturally and compositionally variable due to differing degrees of alteration. Megascopically the coarse-grained hornblende gabbros and hornblendites typically have a blocky texture due to large hornblende grains. Exposed contacts with the country rock are sparse, but where observed they are sharp. Due to the variability of the rocks each locality will be described individually.

Hornblende Gabbros and Hornblendites:

Amphibole Peak: A hornblendite crops out in the southwestern portion of the peak. The hornblendite consists of ragged, anhedral hornblende grains with interstitial chlorite and accessory plagioclase. Small grains of tremolite occur on the edges of the hornblende grains. The grain size of the hornblende grains is 4-6 mm. No pyroxene cores were observed.

Mt. Baker: A coarse-grained hornblende gabbro crops out at Mt. Baker. Hornblende occurs as large poikilitic grains with inclusions of plagioclase and clinopyroxene. Clinopyroxene grains contain inclusions of opaques and olivine. Subhedral plagioclase grains are also present.

Bravo Hills: An eight meter thick dyke intrudes a sheared post-tectonic granite (Speed Adamellite). The dyke consists of coarse-grained hornblende, biotite and opaques.

Longhorn Spurs: Euhedral phenocrysts of hornblende (up to 12 mm. long) occur in a black and white speckled matrix. The

---

[1]The order of description is arbitrary; no age relationships are known within the mafic Granite Harbor Intrusives.

groundmass and cores of the phenocrysts are altered to chlorite. Accessory minerals consist of apatite (needles), anhedral, small, interstitial grains of quartz and, rarely, opaques.

Mt. Speed: At the northwest corner of Mt. Speed a gabbro intrudes between a marble and foliated tonalite-amphibolite unit (similar to that exposed at Mt. Franke). A skarn zone is developed in the marble, the contact between the gabbro and the gneissic tonalite-amphibolite unit is sharp. A biotite gabbro occurs next to the foliated tonalite-amphibolite sequence. The biotite-gabbro has a sharp contact with the clinopyroxene gabbro.

The equigranular gabbro next to the skarn is composed of clinopyroxene, plagioclase and opaques with accessory apatite, sphene, biotite and a trace of zeolite. Chlorite and prehnite occur as alteration products of clinopyroxene; the plagioclase is altered to sericite.

The biotite-bearing gabbro is composed of clinopyroxene, biotite and plagioclase with accessory hornblende, opaques, microcline, sphene, and apatite. The biotite rims the clinopyroxene. Epidote occurs as an alteration product of clinopyroxene and hornblende.

## Dolerites

Dolerites, which occur both alone and in association with the hornblende gabbros and hornblendites, are mineralogically similar but texturally variable, with fine-, medium- and coarse-grained equigranular and porphyritic varieties displaying cross-cutting relationships and sharp contacts with each other. Pods of one textural variety, 4-5 meters in length, occur within another textural type.

The dolerites pre-date the post-tectonic granites from field evidence: at Mt. Baker contacts with a post-tectonic granite are baked and silicified, and at Amphibole Peak a tonalite cuts the dolerite.

Dolerite: The texture is typically intergranular although porphyritic (andesine or sodic labradorite subhedral phenocrysts) varieties are present. The equigranular types are composed of subhedral andesine and anhedral hornblende with accessory opaques, sphene, quartz and brown-pleochroic biotite. Trace amounts of a light-green, high-refractive, isotropic mineral are present. The matrix of porphyritic varieties has a similar composition.

The plagioclase ($An_{45-53}$) occurs as both unzoned and zoned (normal and oscillatory) grains. At Mt. Baker some of the anhedral, normally zoned plagioclase phenocrysts have been recrystallized into aggregates of plagioclase and quartz.

The hornblende grains are locally twinned (Amphibole Peak) and are typically poikilitic with plagioclase and opaque inclusions. The pleochroism is green to blue-green.

The plagioclase crystallized first, followed by the opaques and other accessories and finally the hornblende.

The modal compositions of dolerites at two localities, Amphibole Peak (AMBL-4) and Mt. Feeney (FNY-1, FNY-6), appear in Table 2 and Figure 3.

## POST-TECTONIC GRANITIC GRANITE HARBOR INTRUSIVES

The post-tectonic granites of the Queen Maud Batholith consist of at least five lithologic units: the Longhorn Spurs Tonalite, the Greenlee Granophyre, the Watt Ridge Adamellite, the Organ Pipe Peaks Granodiorite and the Speed Adamellite.

### Longhorn Spurs Tonalite

The Longhorn Spurs Tonalite is a medium-grained, equigranular biotite-hornblende-andesine tonalite; porphyritic and coarse-grained varieties occur locally.

The unit has a gradational contact with the migmatite exposed at the south end of Longhorn Spurs. The migmatite is in fault contact with a marble where it is in contact with the tonalite. The tonalite is in sharp contact with a porphyritic hornblende gabbro at the northern end of Longhorn Spurs; xenoliths of the gabbro are present in the Longhorn Spurs Tonalite.

Fine-grained dykes of the tonalite cut the dominant tonalite phase; these dykes are in turn cut by aplite dykes. Mafic dykes, containing tonalite xenoliths, also cut the medium-grained tonalite.

Rocks resembling the Longhorn Spurs Tonalite crop out in the vicinity of Oliver Peak ($84^{o}34'$S., $173^{o}33'$W.), at Mt. Roth ($84^{o}34'$S., $172^{o}22'$W.), and at Mt. Baker. The Mt. Baker exposure contains amphibolite xenoliths and is cut by mafic and aplite dykes.

Longhorn Spurs Tonalite: A hypidiomorphic-granular tonalite (porphyritic varieties have a hypidiomorphic-granular matrix) consisting of quartz, hornblende, biotite and andesine with accessory microcline, sphene, apatite, and zircon. Quartz grains are anhedral, occurring interstitially and as aggregates. Biotite and hornblende grains occur interstitially and are anhedral. Subhedral andesine grains are normally zoned. Anhedral aggregates of plagioclase and of quartz and plagioclase occur in the porphyritic types in addition to the plagioclase phenocrysts. Microcline-microperthite, rare, occurs as anhedral interstitial grains.

The crystallization order was andesine, sphene and opaques, biotite, hornblende, microcline and quartz.

The composition of the andesine ranges from $An_{30}$ to $An_{45}$. Oligoclase ($An_{28}$) occurs in the coarse-grained, equigranular varieties, the late stage, fine-grained dykes and apophyses in the gradational contact zone ($An_{23}$). The porphyritic variety has andesine phenocrysts ($An_{35}$), aggregate clots of andesine ($An_{41}$) and andesine ($An_{44}$) in the matrix.

There is chloritization of the biotite and hornblende, sericitization of the andesine and alteration of the biotite, andesine and hornblende to epidote. The chlorite has green pleochroism and anomolous interference colors. The sericization of the andesine occurs in the cores and in zones in the andesine grains. Clinozoisite occurs in the andesine cores. Epidote occurs as discrete veinlets, 6-10 mm. wide, in the unit.

The modal composition of the Longhorn Spurs Tonalite is given in Table 3, and is plotted in Figure 4.

Greenlee Granophyre

The Greenlee Granophyre is leucocratic and occurs as both a red and a more abundant grey phase. Both phases are porphyritic; anhedral phenocrysts of quartz and subhedral phenocrysts of alkali feldspar (up to 13mm. long), are set in a saccharoidal matrix. Plagioclase phenocrysts, slightly smaller, are locally present. Clots of amphibole are present at the Lubbock Ridge ($84^{o}45'$S., $175^{o}50'$W.) and Cathedral Peaks ($84^{o}45'$S., 175°50'W.).

The contacts with the country rock are sharp. Stump (personal communication, 1970) reports a ten meter gradational contact between the Taylor Formation metavolcanics (Byrd Group, Ross Supergroup) and a granitic intrusive rock at Cathedral Peaks; I did not observe this contact. All contacts which I saw were sharp. There are apophyses of the granophyre in the country rock and xenoliths of the country rock in the granophyre.

The contact between the red and grey phases of the Greenlee Granophyre is gradational over 15-30 cms. at Mt. Greenlee. The red phase occurs as a vertical dyke with sharp contacts in the grey phase at Lubbock Ridge. The exposure of the red phase at the southern end of Cathedral Peaks was not visited.

Greenlee Granophyre: The grey phase at Mt. Greenlee has a porphyritic texture with a granophyric matrix. Anhedral phenocrysts of quartz, euhedral phenocrysts of plagioclase (2.5 mm. long) and euhedral phenocrysts of alkali feldspar (5 mm. long) occur in a matrix of intergrown alkali feldspar and quartz. Accessory minerals include biotite, opaque oxides, hornblende, fluorite and sphene. The composition of the plagioclase was impossible to determine due to the dustiness and sericitization of the grains. Alteration of the hornblende to chlorite is almost complete.

At Lubbock Ridge, the grey phase consists of anhedral quartz and subhedral oligoclase phenocrysts set in a matrix of anhedral quartz, and subhedral oligoclase phenocrysts set in a matrix of anhedral quartz, subhedral oligoclase, anhedral micrographic alkali feldspar and quartz and ragged hornblende with accessory opaque oxides. The oligoclase is both unzoned ($An_{25}$) and zoned (cores $An_{28}$, rims $An_{16}$). The oligoclase is sericitized.

Three textural types of the grey phase are present at Cathedral Peaks: a medium-grained, porphyritic variety with a granophyric matrix; a coarse-grained porphyry with an allotriomorphic-granular matrix; and a medium-grained, equigranular granophyre. Quartz occurs as anhedral phenocrysts in both porphyries (8 mm. long); the phenocrysts are slightly strained with embayed boundaries. There are anhedral plagioclase inclusions and "S"-shaped inclusion trains in the phenocrysts. Alkali feldspar occurs in the porphyritic granophyre as anhedral, micrographic grains in the matrix (3-4 mm. in diameter). Subhedral plagioclase grains (2-3 mm. long) are both unzoned ($An_{29}$) and normally zoned (cores $An_{28-33}$, rims $An_{11-24}$). The plagioclase is highly sericitized. Hornblende grains (2-3 mm. long) occur in all three textural types; they are commonly twinned and have yellow to green pleochroism. Apatite and opaque inclusions occur in the hornblende grains. The hornblende is altered to chlorite and prehnite. The chlorite has clear to green pleochroism and anomalous interference colors. Sphene and opaque oxides occur as accessories.

The red phase at Mt. Greenlee consists of anhedral phenocrysts of alkali feldspar (8 mm. long) and quartz (3 mm. long) in a medium-grained matrix of micrographic alkali feldspar and quartz with accessory sphene, hematite and magnetite. There is a fine-grained chilled margin of similar composition with an equigranular granophyric texture. Muscovite and epidote occur as alteration products.

At Lubbock Ridge the red phase has a porphyritic texture. Subhedral albite ($An_{0-10}$) phenocrysts (3 mm. long) are set in a fine-grained matrix of quartz, plagioclase micrographic alkali feldspar and quartz with accessory hornblende, sphene, allanite and opaques. Epidote and prehnite occur as alteration products of hornblende; some carbonate is also present.

The modal composition of the Greenlee Granophyre is given in Table 3 and Figure 4.

## Watt Ridge Adamellite

The Watt Ridge Adamellite is medium- to coarse-grained, pink, and equigranular. Alignment of plagioclase laths imparts a foliation to the rock at Watt Ridge (84°45'S., 173°47'W.), but the exposures at Amphibole Peak, Cathedral Peaks and Mt. Dodge (84°52'S., 172°22'W.) are not foliated. The Watt Ridge Adamellite is intrusive into the dolerites exposed at Amphibole Peak. No other field relationships were observed.

A textural similarity between the Watt Ridge Adamellite and the Greenlee Granophyre at Cathedral Peaks is apparent microscopically.

Watt Ridge Adamellite: The rock typically has an allotriomorphic-granular texture but is locally hypidiomorphic-granular. Grain boundaries are generally sutured and a mortar texture is locally developed. Essential minerals are quartz, microcline, oligoclase-andesine and biotite.

The quartz is slightly strained, occurring as aggregates and single grains (up to 5 mm. long). At Cathedral Peaks quartz grains contain "s"-shaped inclusion trains. Anhedral microcline grains are typically micro-perthitic and poikilitic with inclusions of subhedral plagioclase and anhedral quartz. Plagioclase is anhedral to subhedral, antiperthitic and normally zoned (cores $An_{30-35}$, rims $An_{20-25}$). Biotite, the predominant mafic, has yellow to brown-green pleochroism and is poikilitic with inclusions of monazite, opaques and apatite. Accessories consist of green pleochroic hornblende, opaques, monazite, apatite and fluorite.

The modal composition of the Watt Ridge Adamellite is given in Table 3 and Figure 4.

Organ Pipe Peaks Granodiorite

The Organ Pipe Peaks Granodiorite is a biotite granodiorite (locally tonalite to adamellite). The texture is predominatly medium-grained, equigranular but is locally fine-and coarse-grained equigranular and porphyritic. The granodiorite crops out at the mouth of and to the east of the Scott Glacier.

At Karo Hills (85°34'S., 154°10'W.) and at Cox Peaks (86°03'S., 153°50'W.), the contacts of the Organ Pipe Peaks Granodiorite with the country rock (Ross Supergroup) are sharp. At Cox Peaks a quartz-muscovite-tourmaline vein occurs at the contact of the Ross Supergroup and the granodiorite; the metamorphic rocks are silicified and contain megacrysts of quartz and alkali feldspar near the contact. Mafic xenoliths are locally abundant in the granodiorite. Pegmatite stringers cut the granodiorite.

Organ Pipe Peaks Granodiorite: The predominant texture is coarse-grained, equigranular, hypidiomorphic-granular but is locally porphyritic.

Quartz, strained and unstrained, occurs as anhedral, interstitial poikilitic grains with biotite, plagioclase and muscovite inclusions. Locally the quartz occurs as aggregate grains. At Cox Peaks there is one specimen in which quartz occurs as rounded phenocrysts.

Microcline-microperthite is dominantly interstitial and anhedral. The grains are poikilitic with anhedral inclusions of plagioclase, quartz, biotite and apatite. Microcline-microperthite-plagioclase contacts are myrmekitic. There is some evidence of deformation in the microcline-microperthite: kink bands are present at Bobo Ridge (85°51'S., 150°48'W.) and microbreccia zones cut the microcline grains at Mt. Seebeck (85°44'S., 150°46'W.).

Plagioclase occurs as both unzoned and zoned (normally and oscillatorally) grains. The compositions of the plagioclase grains are:

COMPOSITION OF PLAGIOCLASE IN THE
ORGAN PIPE PEAKS GRANODIORITE

| Type of Plagioclase grain. | Rock Composition | | |
|---|---|---|---|
| | Adamellitic | Granodioritic | Tonalitic |
| Unzoned | $An_{11-17}$ | $An_{28-34}$ | $An_{33-41}$ |
| Zoned | | | |
| rim | $An_{33}$ | $An_{41}$ | $An_{45}$ |
| core | $An_{21}$ | $An_{26}$ | $An_{35}$ |

Plagioclase is subhedral and poikilitic with anhedral inclusions of plagioclase, biotite, quartz and apatite. There is selective sericitization of some of the cores and zones.

Biotite is the predominant mafic mineral. It typically had yellow to green pleochroism. The grains are poikilitic with inclusions of apatite, opaques and sphene. Alteration to chlorite has occurred along zones parallel to the (0001) cleavage.

Accessories consist of anhedral, green-pleochroic hornblende, sericite in the plagioclase and chlorite in the biotite. There are two types of chlorite present: a green-pleochroic, anomalous brown birefringent variety has formed from biotite; and a none-pleochroic variety with a radiating habit is present (the original material from which this chlorite formed is unknown). Some carbonate is present.

The modal composition of the Organ Pipe Peaks Granodiorite is given in Table 3 and Figure 4.

## Speed Adamellite

The Speed Adamellite is the dominant plutonic lithology of the Queen Maud Batholith. Large, 40 to 125+ mm. long, euhedral to oval, pink phenocrysts of alkali feldspar typify the rock (the larger phenocrysts typically being more ovoid). Inclusions of biotite, quartz and plagioclase are invariably present in the alkali feldspar phenocrysts. Weathering causes the alkali feldspar grains to protrude from the rock. Plagioclase occurs as white subhedral grains, locally as large as or larger than the alkali feldspar grains. Plagioclase is commonly altered to sausserite and sericite. Quartz occurs as anhedral grains which may be smokey, blue, milky or clear. Biotite typically is the dominant mafic mineral although hornblende may locally be more abundant. Garnet is present locally.

The Speed Adamellite invariably contains elliptical, mafic xenoliths. Composition of these xenoliths is variable but the texture is typically fine-grained equigranular.

The Speed Adamellite-Ross Supergroup contacts are sharp. At Beck Peak (86°05'S., 158°58'W.) apophyses of the adamellite invade the Ross Supergroup metamorphic rocks, and xenoliths, up to hundreds of meters long, are present in the adamellite. At Black Rock Glacier (86°15'S., 160°00'W.) the adamellite becomes more foliated and more mafic near the contact with the Ross Supergroup metamorphic rocks; a chilled margin, 20 to 40 cms. wide, is present.

There is no simple relationship between the Speed Adamellite and the other post-tectonic Granite Harbor Intrusives. In the Christy Glacier area (86°05'S., 161°03'W) the Speed Adamellite is intrusive into an unfoliated mafic unit and a granodiorite and contains xenoliths of these units. In the Lillie Range (84°50'S., 170°25'W.) the Speed Adamellite has gradational contacts with both a tonalite (similar to the Longhorn Spurs Tonalite) and a fine-grained, equigranular granodiorite.

On the ridge between Mt. Wade and Mt. Llano (84°50'S., 173°48'W.) both a red phase and the more typical gray-pink phase of the Speed Adamellite are exposed; the contact between the two phases is sharp.

At Mt. Baker and Bravo Hills a secondary foliation is developed in the Speed Adamellite. A mylonite zone is present in the adamellite at Bravo Hills. Mortar texture and ribbon quartz are both developed in the foliated adamellite. A primary foliation is developed in the Speed Adamellite at Mt. Munson (84°49'S., 174°22'W.).

Speed Adamellite: The texture is porphyritic with a medium- to coarse-grained matrix.

Quartz occurs as phenocrysts and in the matrix. The phenocrysts of quartz are rounded and embayed (5 mm. long). Locally the quartz phenocrysts occur as recrystallized aggregates, have sutured grain boundaries and are strained and surrounded by mortar. Matrix quartz is anhedral and interstitial; it is usually clear but locally can be smokey, blue, or milky. At those localities with strained quartz phenocrysts, the matrix quartz is generally unstrained. Inclusions of plagioclase, microcline and apatite needles are locally present.

Microcline occurs as ovoid to subhedral phenocrysts and is rarely found in the matrix. The phenocrysts are typically poikilitic with anhedral to subhedral inclusions of plagioclase, biotite and apatite needles. The microcline is typically microperthitic, both vein and patch types. A rapikivi texture is developed in the Amundsen Glacier area; rims of plagioclase (up to 6 mm. wide) occur on alkali feldspar phenocrysts (up to 50 mm. long). The plagioclase rim is frequently rimmed by alkali feldspar (up to 3 mm. wide).

Plagioclase occurs both in the matrix and as phenocrysts. The grains are subhedral to euhedral, and typically have oscillatory zoning of a normal character. Compositions range from $An_{25}$ to $An_{35}$. Locally some large aggregates of grains are present. The plagioclase is typically poikilitic with inclusions of quartz, microcline, biotite and magnetite. Microcline-plagioclase contacts and quartz-microcline contacts are locally myrmekitic. Bent plagioclase grains occur locally. There is selective sericitization of the cores and zones of the plagioclase grains.

Biotite is the predominant mafic mineral. It occurs as anhedral to subhedral grains in the matrix (2 mm. long).

Opaque inclusions are common, being oriented along cleavage planes. Inclusions of sphene, quartz, and apatite needles are also present.

Accessories include green-pleochroic hornblende, sphene, zoned and unzoned allanite, monazite, apatite and zircon. There is textural evidence for the simultaneous crystallization or exsolution of sphene and opaque oxides.

Biotite and hornblende are altered to chlorite, and epidote, and plagioclase is altered to sericite.

The modal composition of the Speed Adamellite is given in Table 3 and Figure 4.

## Minor Late-Stage Intrusive Rocks

Four types of late-stage intrusives crop out in the Shackleton-Scott Glaciers area: fine-grained mafic dykes, aplite dykes, pegmatite dykes, and a dioritic orbiculite. There are few cross cutting relationships among the dykes, so a sequence of intrusion is impossible to determine.

### Mafic Dykes

Most of the mafic dykes have a schistose or recrystallized hornfels texture, suggesting they were emplaced before the youngest plutons or while the country rock was still hot. At Longhorn Spurs a mafic dyke, which cuts the main phase of the Longhorn Spurs Tonalite, is cut by a late-stage, fine-grained dyke of the Longhorn Spurs Tonalite. McGregor (1965) reports a dyke swarm intruding a leuco-adamellite at Amphibole Peak parallel to the foliation has been "..torn apart into boudins and cut by numerous veins of tonalite." These observations indicate that the mafic dykes were emplaced during the intrusion of the Post-tectonic Granite Harbor Intrusives in the area.

The mafic dykes are both equigranular and porphyritic hornblende diorites. McGregor (1965) reports phenocrysts of calcic plagioclase and quartz in an equigranular matrix of plagioclase and pale-green amphibole.

Aplite Dykes

Aplite dykes, 30 to 50 cms. wide, occur in and have sharp contacts with unfoliated granitic Granite Harbor Intrusives.

Aplite Dykes: The fine- to medium-grained aplites are composed of sodic plagioclase, quartz and microcline-microperthite with accessory biotite, sphene, and, rarely, opaques. The quartz is typically strained and possibly recrystallized. The plagioclase is commonly myrmekitic. The perthitic exsolution is vein type.

Sericitization of the plagioclase and chloritization of the biotite is almost complete. Epidote has formed in the plagioclase and biotite.

Pegmatite Dykes

Pegmatite dykes of variable dimensions are common in the Shackleton-Scott Glaciers area. The pegmatites consist of quartz, alkali feldspar and black tourmaline, with muscovite, garnet and plagioclase present in minor amounts. Pegmatitic graphic granite is locally abundant.

Orbiculite

A dioritic orbiculite occurs as small, circular bodies (5 mm. in diameter) with sharp contacts in post-tectonic granite in the central portion of the Lillie Range. Orbicules (75 mm. in diameter) occur in a matrix of large, euhedral hornblende grains and felsic aphanitic material. The orbicules have a discontinuous pink outer rim.

Orbiculite: The orbicules consist of anhedral, green-pleochoric hornblende and andesine ($An_{46}$) in the core surrounded by a zone of fine- to coarse-grained andesine of the same composition. There is no quartz present. Opaques are rare, mostly occurring as inclusions in the hornblende.

The andesine is almost entirely sericitized. A small amount of epidote is present in the hornblende. Some carbonate is present.

The material between the orbicules consists of euhedral green-pleochroic hornblende grains (up to 35 mm. long) in an aphanitic felsic matrix.

CONCLUSIONS

The composite Queen Maud Batholith was emplaced under epizonal conditions. Sharp contacts, chilled margins, lack of extensive areas of contact migmatization, albite-epidote and hornblende-hornfels grade of contact metamorphism, and the presence of aplite, pegmatite and granophyre are all criteria for epizonal emplacement.

The large xenoliths at Beck Peak and the ubiquity of small mafic xenoliths suggest that the batholith was at least partially emplaced by stopping. The apophyses of the Nilsen Plateau Adamellite, foliated parallel to the foliation of the country rock, could indicate that some forceful injection occurred. This conclusion is dubious however, as many of the contacts between the adamellite and the granodiorite are discordant to the foliation.

Table 1: Modal Compositions of Pre-Intrusive and Early-Tectonic Intrusive Rocks

| Sample | Qtz. | Kspar. | Plag. | Hb. | Bt. | Sp. | Op. | Pts. |
|---|---|---|---|---|---|---|---|---|
| FRNK-4 | 22 % | tr. | 65 % | 7 % | 4 % | tr. | tr. | 300 |
| FPG-1 | 36 | tr. | 64 | tr. | tr. | tr. | tr. | 400 |
| FPG-4 | 40 | tr. | 50 | 7 | 4 | - | tr. | 300 |
| OLDS-1 | 38 | 14 | 39 | 3 | 5 | 1 % | 1 % | 900 |
| WSKO-2 | 36 | 1 | 56 | - | 4 | 1 | 2 | 300+ |
| WSKO-3 | 14 | - | 56 | 23 | 6 | 1 | tr. | 400 |
| $\epsilon O_{na}$* | 33 | 31 | 29 | tr. | 5 | tr. | tr. | 4800+ |
| $pCC_{1gd}$* | 34 | 6 | 42 | 1 | 16 | 1 | 1 | 1200+ |

Table 2: Modal Compositions of Post-Tectonic Dolerites and a Tonalitic Dyke (Granite Harbor Intrusives)

| Sample | Qtz. | Hb. | And. | Bt. | Op. | Sp. | Apa. | Pts. |
|---|---|---|---|---|---|---|---|---|
| AMBL4-1 | 2 % | 48 % | 45 % | 1 % | 8 % | - | tr. | 1000 |
| FNY-1 | 2 | 52 | 36 | 6 | 1 | 2 | tr. | 400 |
| FNY-6 | 3 | 61 | 33 | 1 | 2 | tr. | tr. | 500 |
| LNO-6 | 3 (sericite = 6 %) | 15 | 48 | 17 | tr. | 2 | - | 300 |

Table 3 Modal Compositions of Post-Tectonic Granitic Intrusive Rocks (Granite Harbor Intrusives) at Various Localities

| Sample | Qtz. | Plag. | Kspar | Mafics | Acc. | Points |
|---|---|---|---|---|---|---|
| Longhorn Spurs Tonalite | | | | | | |
| LS-4 | 15 % | 70 % | 2 % | 12 % | 1 % op | 625 |
| LS-10 | 25 | 53 | 10 | 12 | – | 400 |
| Greenlee Granophyre | | | | | | |
| GRNLE-3 | 32 | 14 | 52 | 2 | – | 400 |
| GRNLE-4 | 30 | 9 | 59 | 2 | tr. ms. | 400 |
| CDRL-1 | 30 | 24 | 46 | tr. | tr. sp. | 400 |
| CDRL-3 | 25 | 41 | 23 | 11 | – | 400 |
| CDRL-4 | 23 | 42 | 21 | 14 | – | 400 |
| LBK-1 | 20 | 31 | 45 | 2 | – | 400 |
| Watt Ridge Adamellite | | | | | | |
| WT | 37 | 24 | 34 | 5 | – | 400 |
| DDG-4 | 32 | 24 | 38 | 5 | – | 400 |
| CDRL-2 | 31 | 30 | 29 | 10 | – | 420 |
| Organ Pipe Peaks Granodiorite | | | | | | |
| OP | 25 | 47 | 18 | 10 | – | 400 |
| BB | 31 | 27 | 38 | 4 | – | 400 |
| Cox-1 | 24 | 42 | 26 | 8 | – | 400 |
| CZ | 28 | 46 | 18 | tr. bt. | 6 ms.<br>1 cb.<br>1 ep. | 425 |
| McK | 24 | 53 | 16 | 8 | 1 sp. | 400 |
| NEL | 14 | 53 | 8 | 11 bt.<br>14 hb. | tr. sp.<br>tr. ep. | 179 |
| RUS | 16 | 47 | 15 | 22 | – | 400 |
| Speed Adamellite | | | | | | |
| FS | 32 | 33 | 28 | 7 | – | 400 |
| BKR-1 | 27 | 58 | 10 | 12 | – | 400 |
| LNO-7 | 30 | 41 | 25 | 4 | – | 400 |
| WAP-4 | 27 | 41 | 21 | 11 | – | 400 |

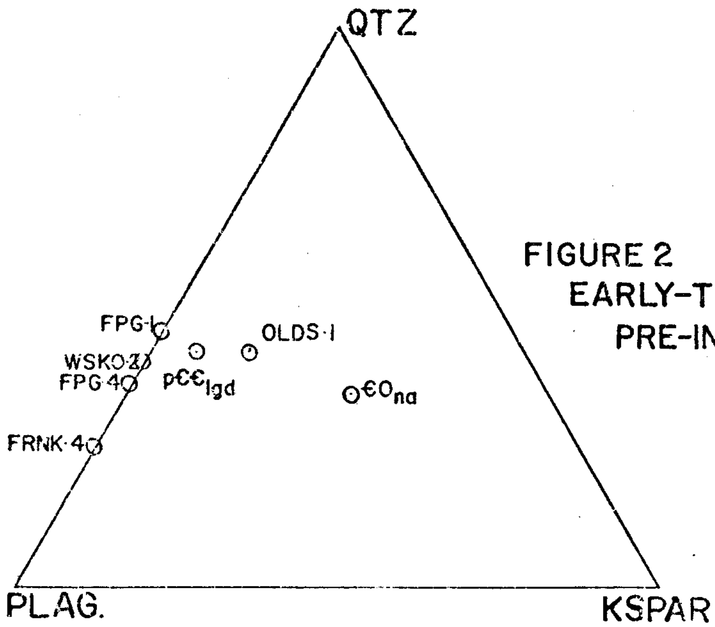



FIGURE 2 MODAL COMPOSITIONS OF EARLY-TECTONIC INTRUSIVES AND PRE-INTRUSIVE ROCKS

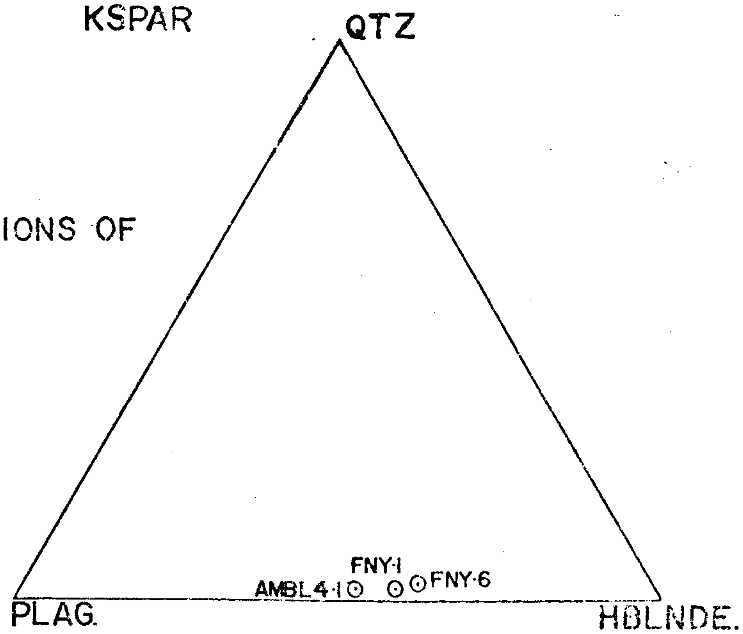



FIGURE 3 MODAL COMPOSITIONS OF DOLERITES

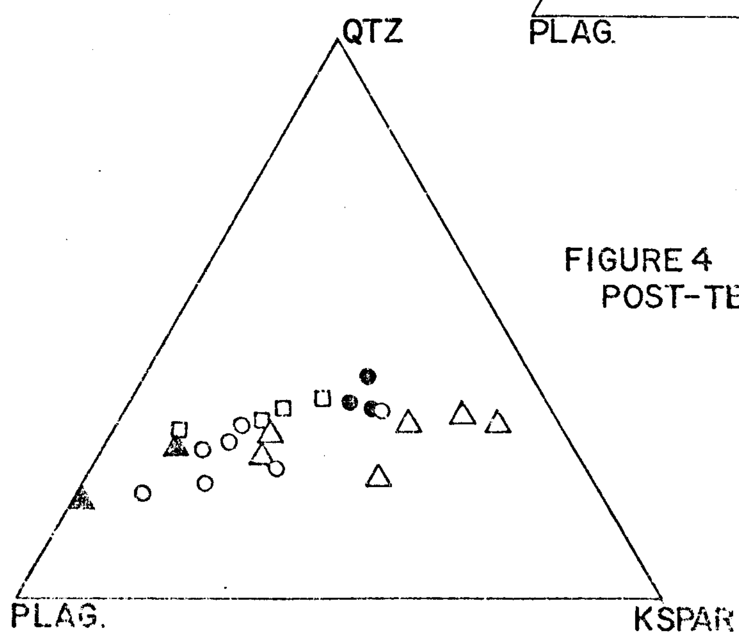



FIGURE 4 MODAL COMPOSITIONS OF POST-TECTONIC GRANITIC INTRUSIVES

- ⊙ ORGAN PIPE PEAKS GRANODIORITE
- ● WATT RIDGE ADAMELLITE
- △ GREENLEE GRANOPHYRE
- ▲ LONGHORN SPURS TONALITE
- □ SPEED ADAMELLITE

## REFERENCES CITED

Barrett, P. J. (1965), "Geology of the Area Between the Axel Heiberg and Shackleton Glaciers, Queen Maud Range, Antarctica, Part 2 -- Beacon Group" New Zealand J. Geol. Geophys., Vol. 8, pp. 344-363

Buddington, A. F. (1959), "Granite Emplacement with Special Reference to North America", Bull. GSA, Vol. 70, pp. 671-747

Craddock, C., Gast, P., Hanson, G. N. and Linder, H. (1964), "Rubidium-Strontium Ages from Antarctica", Bull. Geol. Soc. Am., Vol. 75 pp. 237-240

Eastin, R. (1970), Geochronology of the Basement Rocks of the Central Transantarctic Mountains, Unpublished Ph.D. thesis, Ohio State University

Gair, H. S. (1964), "Geology of Upper Rennick, Campbell and Aviator Glaciers, Northern Victoria Land" in Antarctic Geology

____, (1967), "The Geology from the Upper Rennick Glacier to the Coast, Northern Victoria Land", N.Z.Jl. Geol. Geoph., Vol. 10, pp. 309-344

Gould, L. M. (1935), "Structure of the Queen Maud Mountains", Bull. GSA, Vol. 46, pp. 973-984

Grindley, G. W., McGregor, V. R., Walcott, R. I. and Laird, M. G. (1970), "Geology of the Shackleton Coast" in Geol. Maps of Antarctica

Grindley, G. W., McGregor, V. R. and Walcott, R. I. (1964), "Outline of the Geology of the Nimrod-Beardmore-Axel Heiberg Glaciers Region, Ross Dependency" in Ant. Geology

Grindley, G. W. and Warren, G. (1964), "Stratigraphic Nomenclatures and Correlation in the Western Ross Sea Region" in Antarctic Geology, Proceedings of the First International Symposium on Antarctic Geology, Capetown, edited by R. J. Adie, pp. 314-333, North-Holland, Amsterdam

Gunner, J. and Faure, G. (1970), Rubidium-Strontium Geochronology of the Nimrod Group, Central Transantarctic Mountains, Laboratory for Isotope Geology and Geochemistry Contribution No. 16, Ohio State University

Haskell, T. R., Kennett, J. P., and Prebble, W. M. (1964), "Basement and Sedimentary Geology of the Darwin Glacier Region Area" in Antarctic Geology, Proceedings of the First International Symposium on Antarctic Geology, Capetown, edited by R. J. Adie, pp. 348-351

McDougall, I. and Grindley, G. W. (1965), "Potassium-Argon Dates on Micas from the Nimrod-Beardmore-Axel Heiberg Reg., Ross Dep., Ant." N.Z.Jl. Geol. Geoph., Vol. 8, pp. 314-343

McGregor, V. R. (1965), "Geology of the Area Between the Axel Heiberg and Shackleton Glaciers, Queen Maud Range, Ant., Pt. I", N.Z.Jl. Geol. Geoph., Vol. 8, pp. 314-343

McLelland, D. (1967), Geology of the Basement Complex, Nilsen Plateau, Antarctica (unpublished)

Murtaugh, J. G. (1969), "Geology of the Wisconsin Range Batholith, Transantarctic Mountains", N.Z.Jl. Geol. Geoph., Vol. 12, pp. 526-550

Robinson, E. S., (1964), "Regional Geology and Crustal Thickness in the Transantarctic Mountains and Adjacent Ice Covered Area in Antarctica", (abstract), GSA Spec. Pap. 76, p. 316

Stewart, D. (1934a), "The Petrography of Some Ant. Rocks" Amer. Min., Vol. 19, pp. 150-160

____, (1934b), "A Contribution to Ant. Pet.", Jl. Geol. Vol. 42, p. 550

Wade, F. A., Yeats, V. L., Everett, J. R., Greenlee, D. W., LaPrade, K., and Shenk, J. C. (1965), "Geology of the Central Queen Maud Range, Trans. Mts. Ant." Texas Tech. Col. Res. Rep. Ser., 65-1, 54 pp.

Warren, G. (1970), "Geology of the Terra-Nova Bay-McMurdo Sound Area, Victoria Land", in Geol. Maps of Antarctica

Williams, H., Turner, F. J. and Gilbert, C. M. (1954), Petrography An Introduction to the Study of Rocks in Thin Sections, 406 p. W. H. Freeman and Company, San Francisco, 1954

APPROVED

L. Gordon Medaris, Jr.

Professor L. Gordon Medaris, Jr.

6-2-75

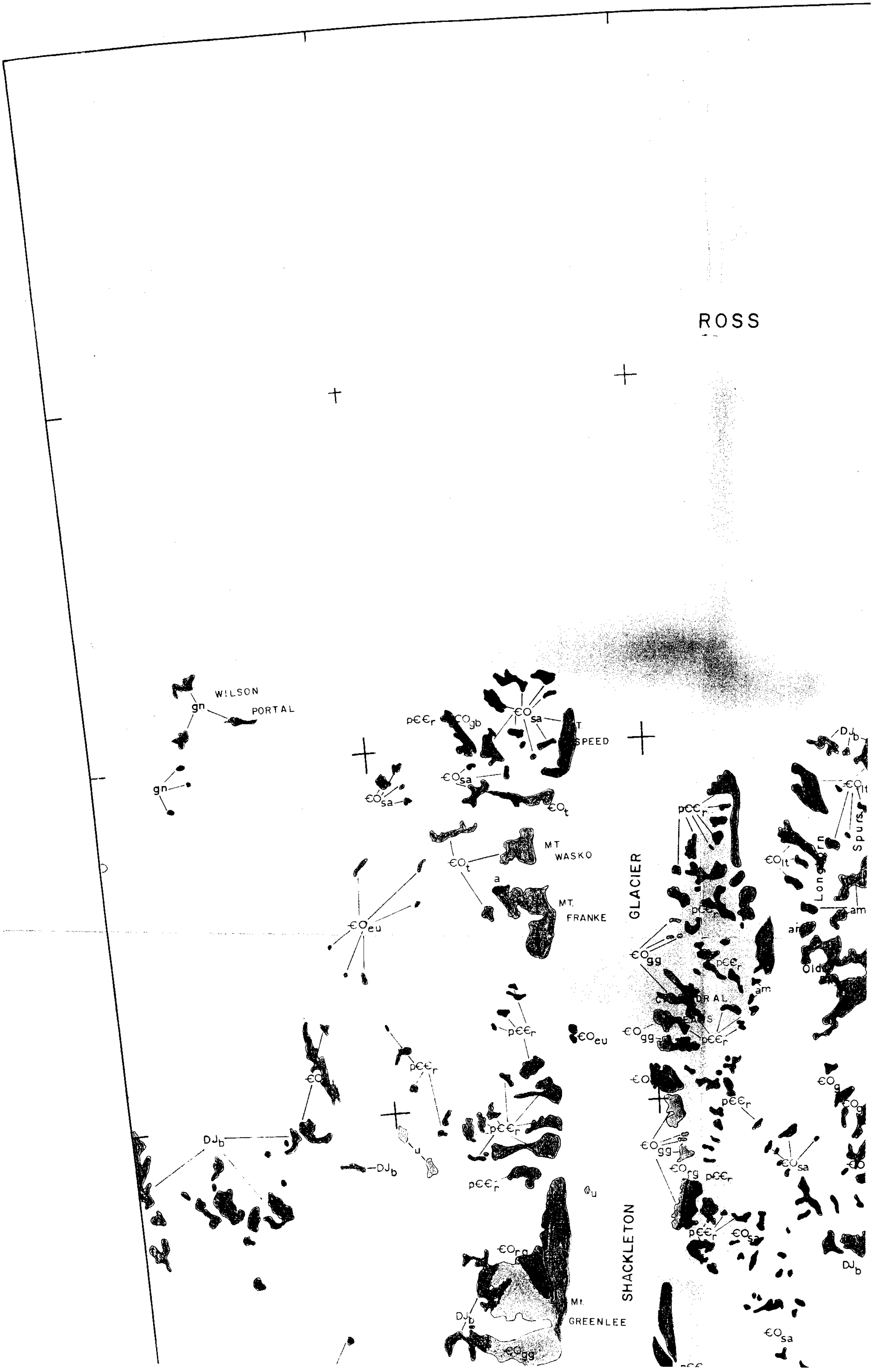
Date

Please Note:

There are 2 Extra large plates with this Thesis. We have copied them in several overlapping sections.

Plate 1

sections


ROSS
WILSON
PORTAL
gn
SPEED
MT
WASKO
MT.
FRANKE
GLACIER
SHACKLETON
Mt.
GREENLEE
DJb
u
Spurs

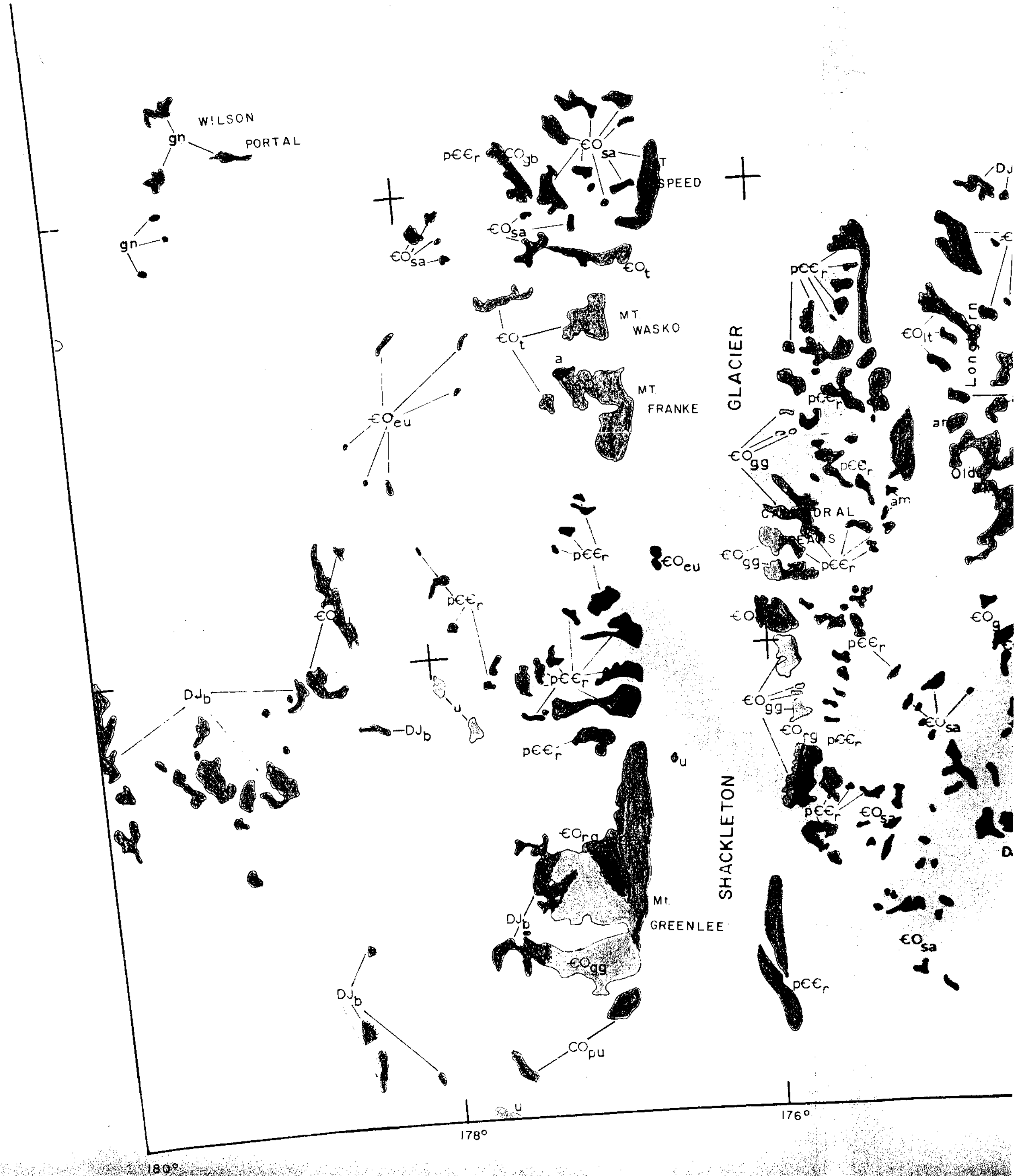
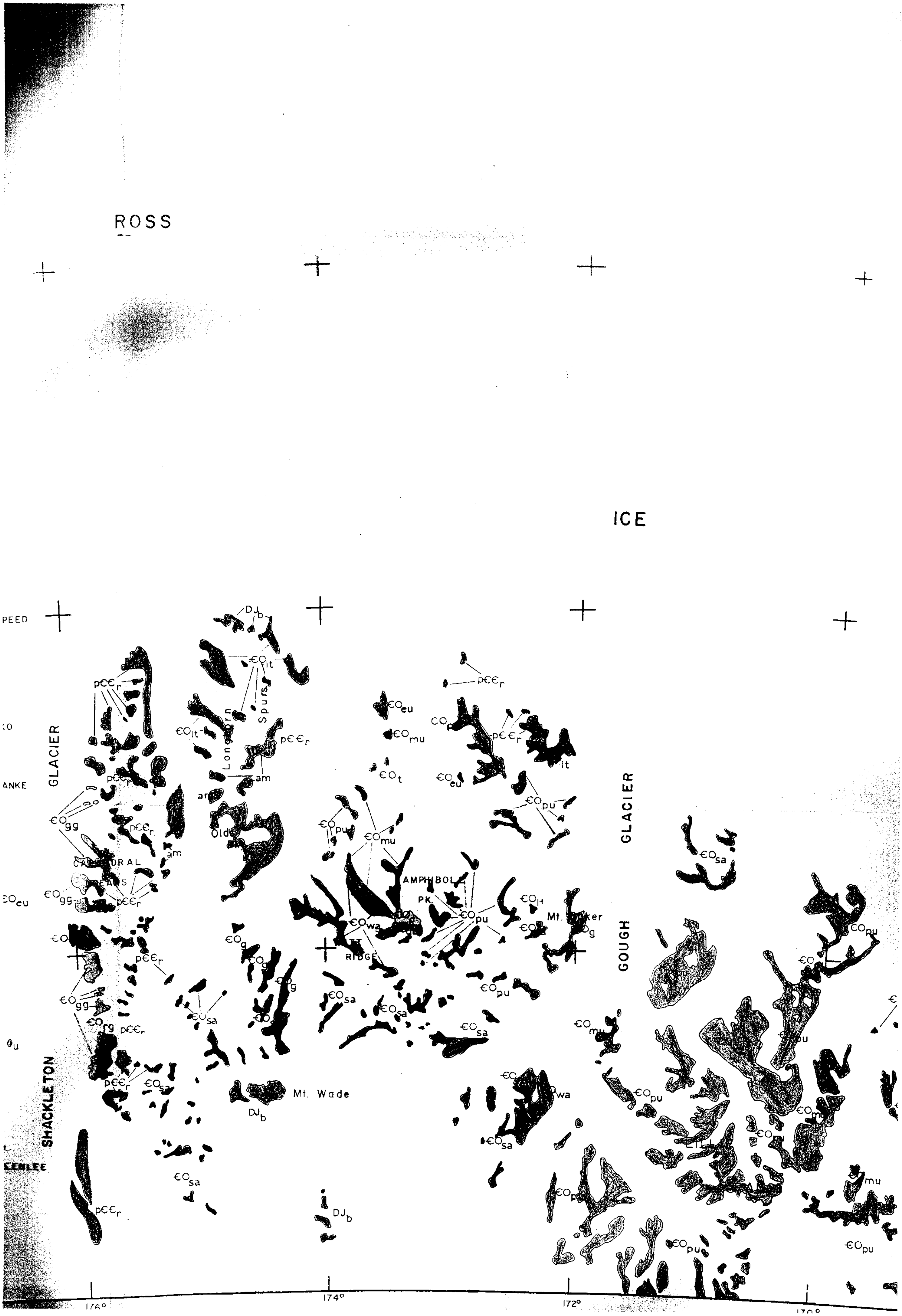
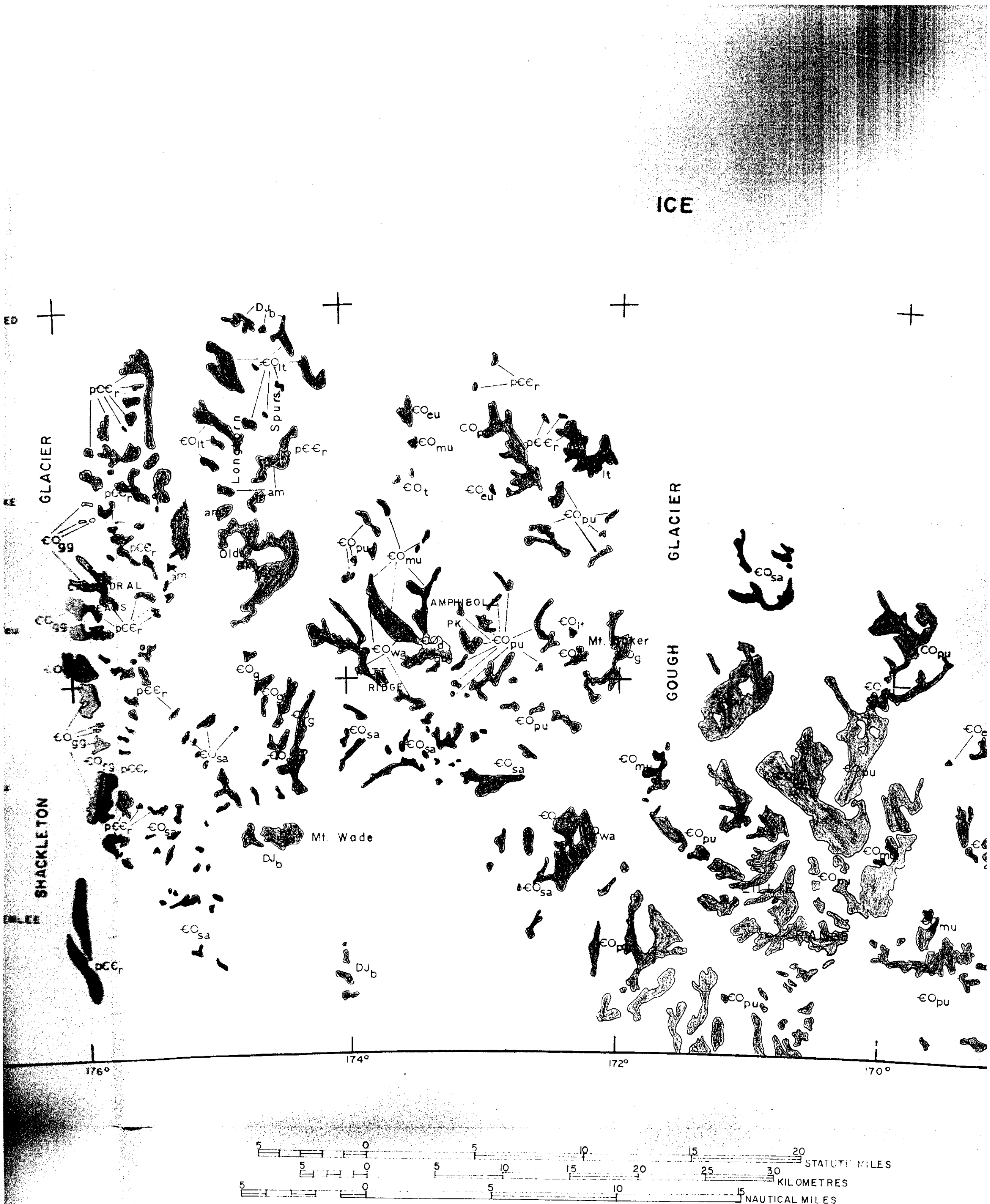



**PLATE I: GEOLOGIC MAP OF THE SHACKLETON**

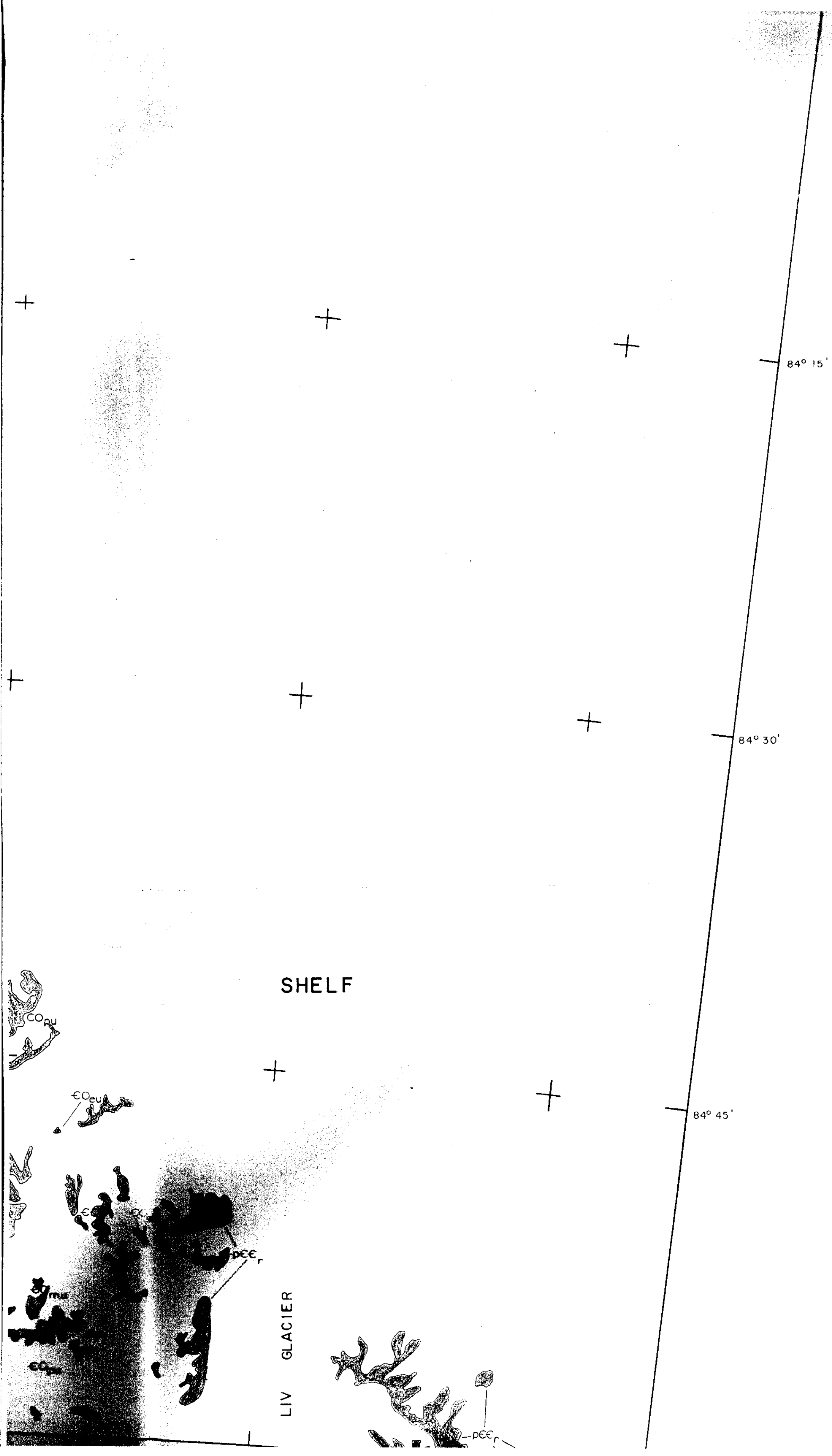
FOR LEGEND SEE PLATE II

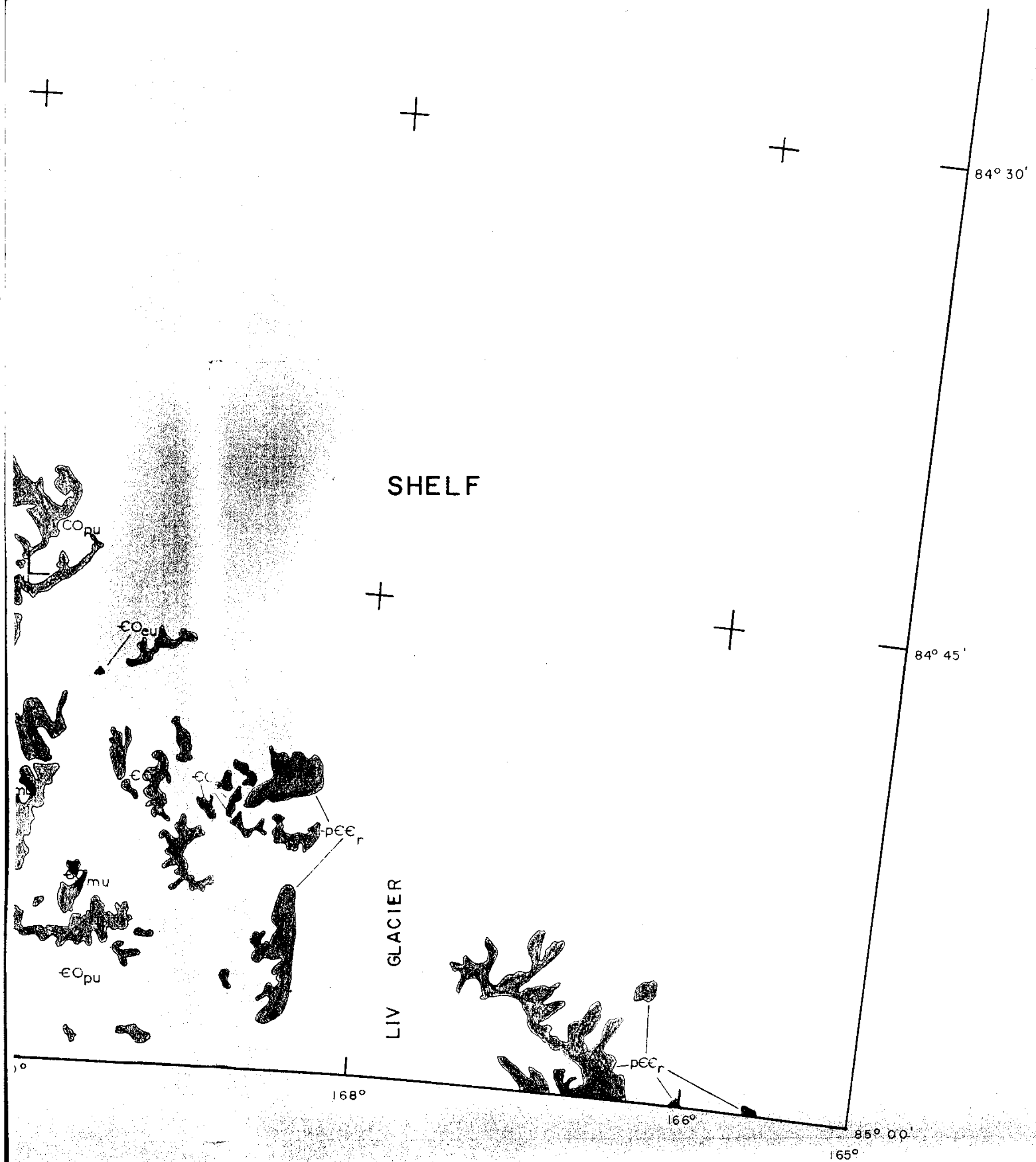

ROSS
ICE
PEED
GLACIER
ANKE
SHACKLETON
GLACIER
GOUGH
Longhorn
Spurs
AMPHIBOLE
PK.
RIDGE
Mt. Wade
DJb
p€€r
€Ogg
€Org
€Oeu
€Olt
€Omu
€Ot
€Opu
€Owa
€Og
€Osa
am
Old
176°
174°
172°




SCALE 1:250,000

F THE SHACKLETON GLACIER QUADRANGLE


84° 15'
84° 30'
84° 45'
SHELF
LIV GLACIER
p€€r
p€€r


SHELF
LIV GLACIER
84° 30'
84° 45'
ЄOpu
ЄOeu
pЄЄr
mu
168°
166°
165°
85° 0'0'

ES

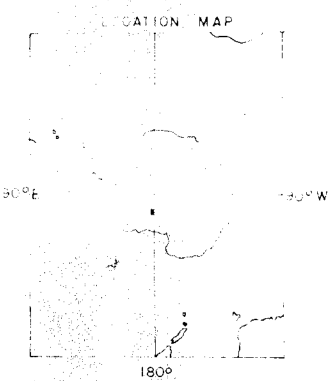
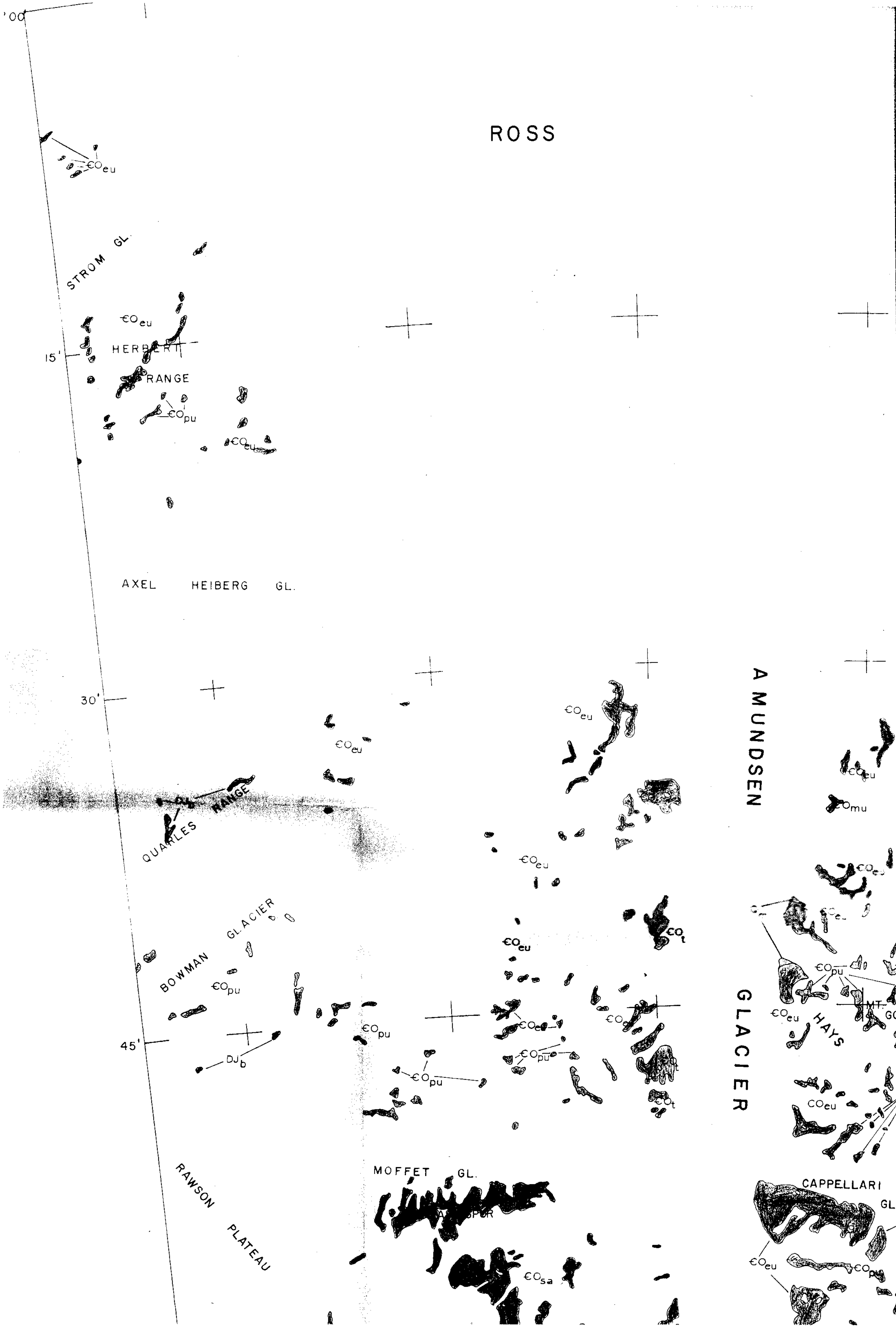
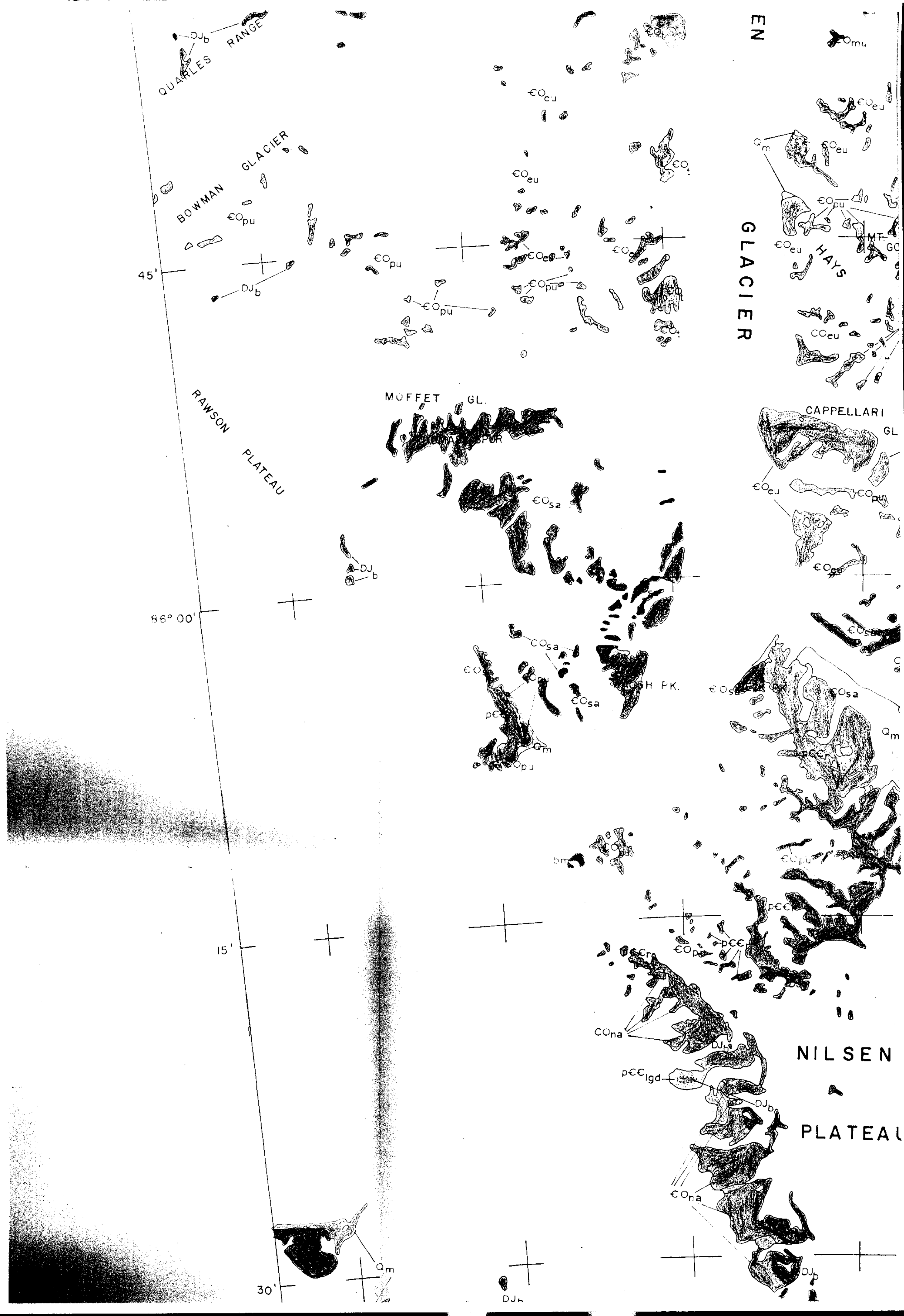

LOCATION MAP
180°

Plate 2

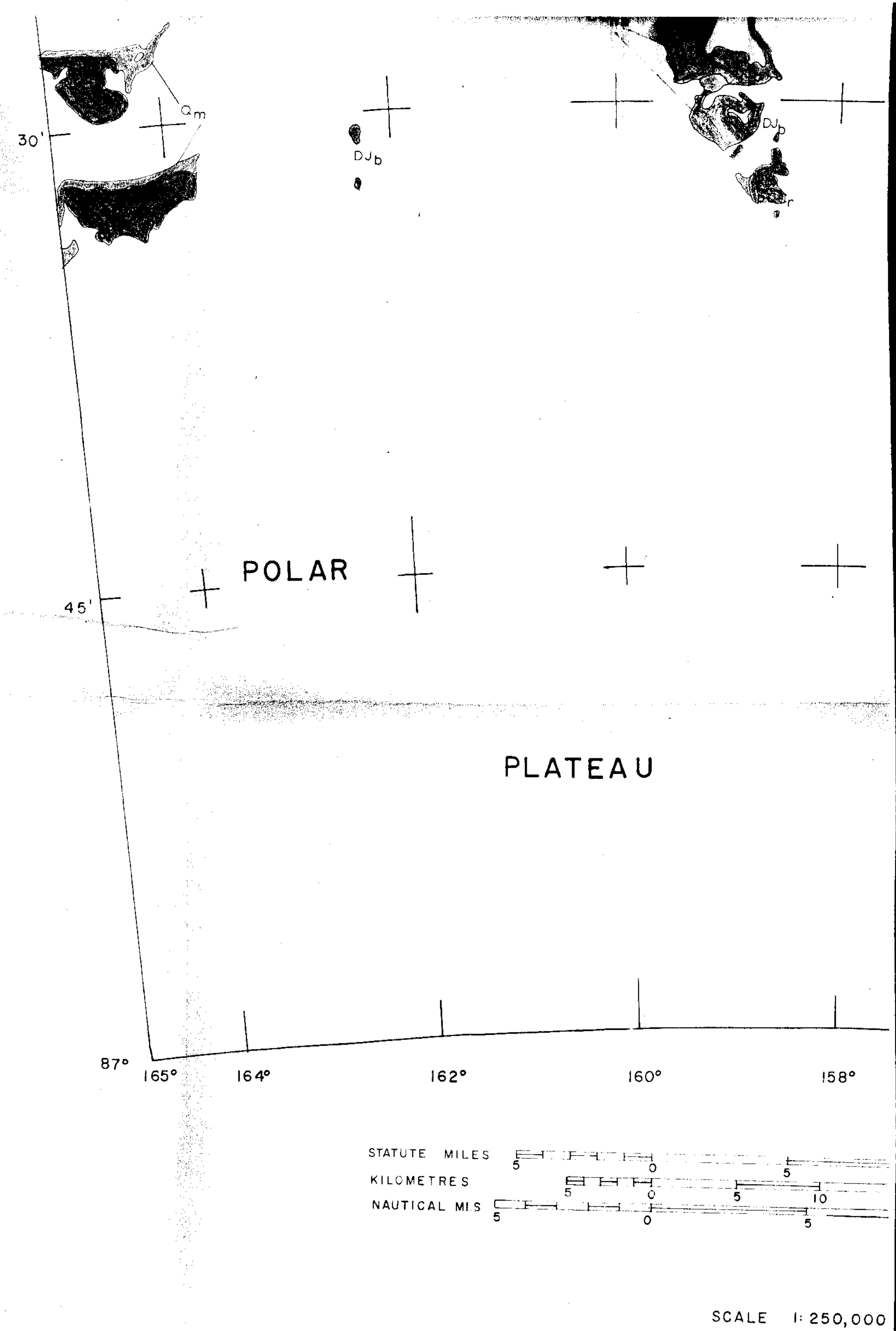
Sections

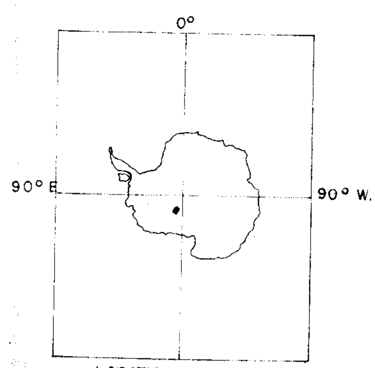


ROSS
STROM GL.
HERBERT RANGE
15'
€Oeu
€Opu
AXEL HEIBERG GL.
30'
QUARLES RANGE
BOWMAN GLACIER
45'
DJb
RAWSON PLATEAU
MOFFET GL.
€Osa
€Ot
€Omu
AMUNDSEN GLACIER
HAYS
MT.
CAPPELLARI GL.



DJb
QUARLES RANGE
BOWMAN GLACIER
€Opu
45'
€Oeu
€Ot
€Omu
GLACIER
HAYS
MT.
€Oeu
Qm
RAWSON PLATEAU
MOFFET GL.
CAPPELLARI GL
€Osa
86° 00'
15'
p€€r
€Ona
p€€lgd
NILSEN PLATEAU
Qm
30'

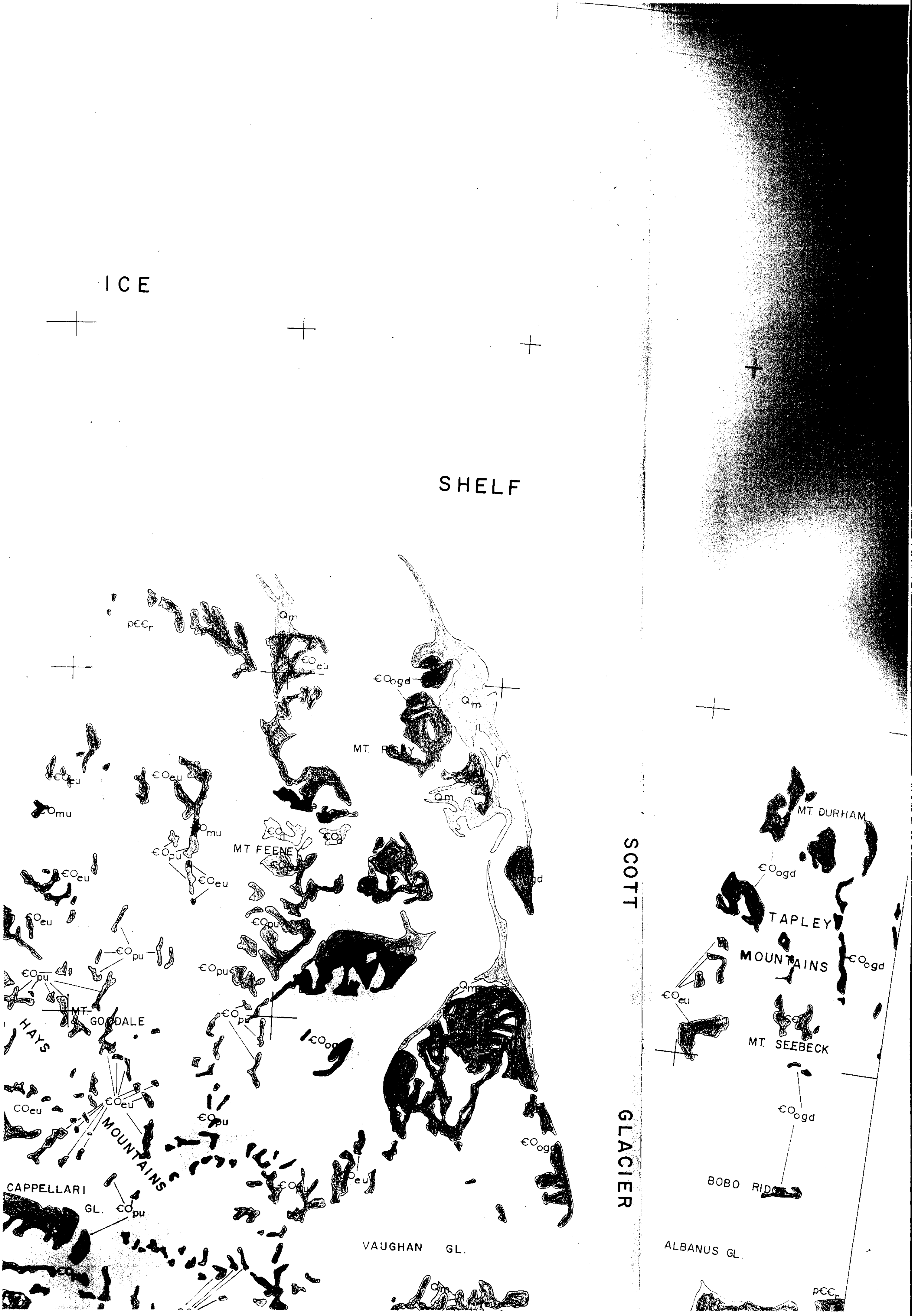


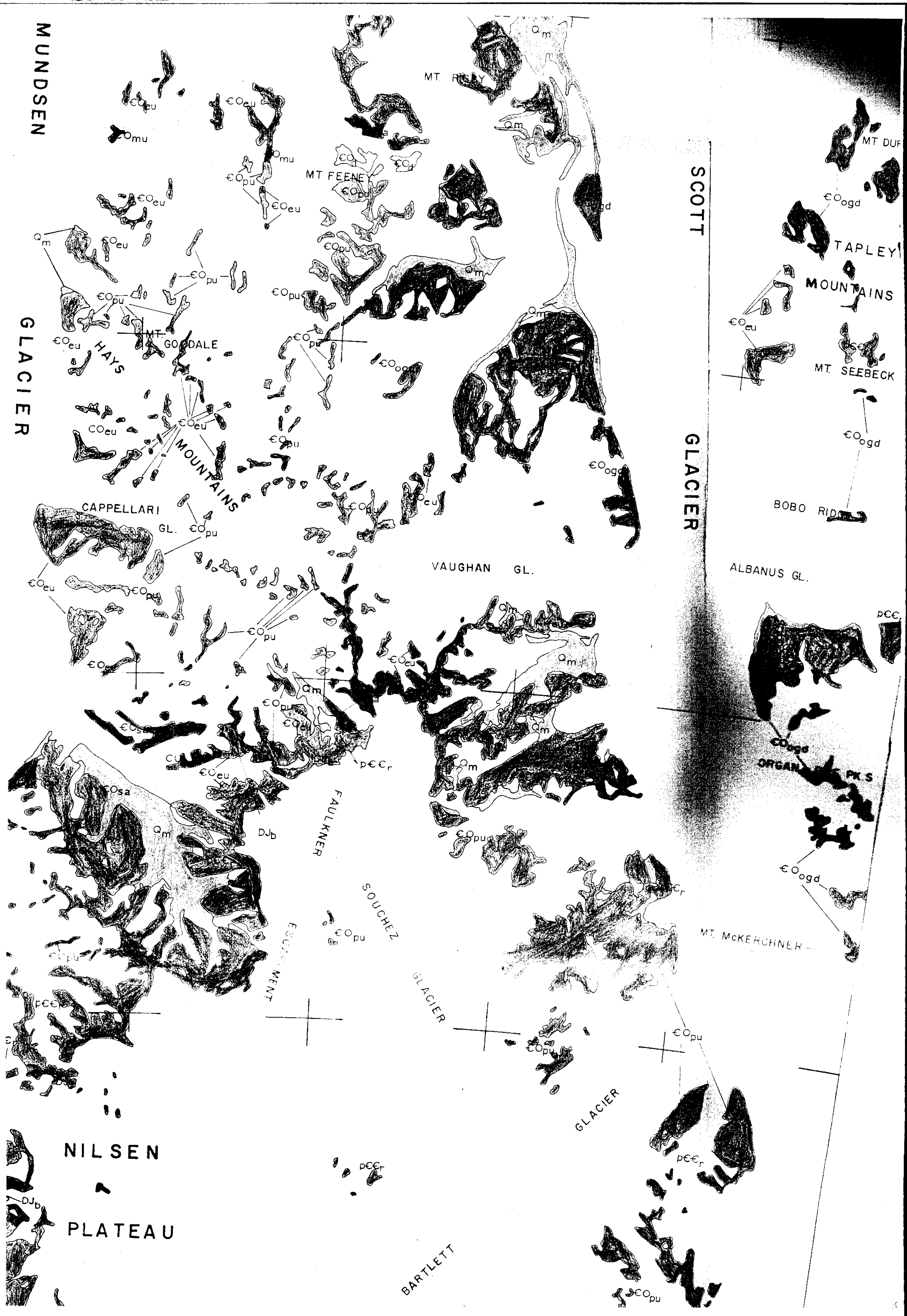



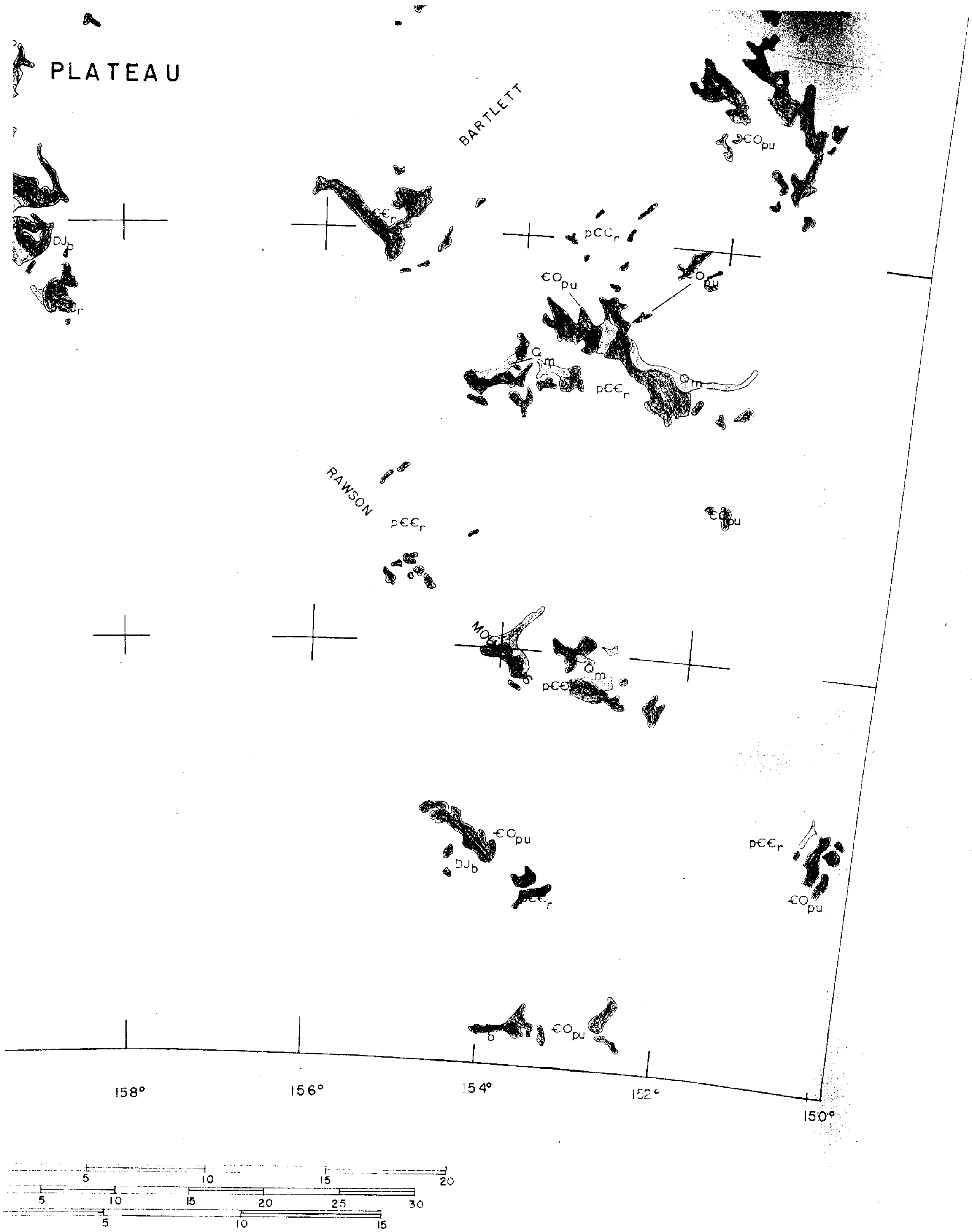

LOCATION MAP

PLATE II: GEOLO

N

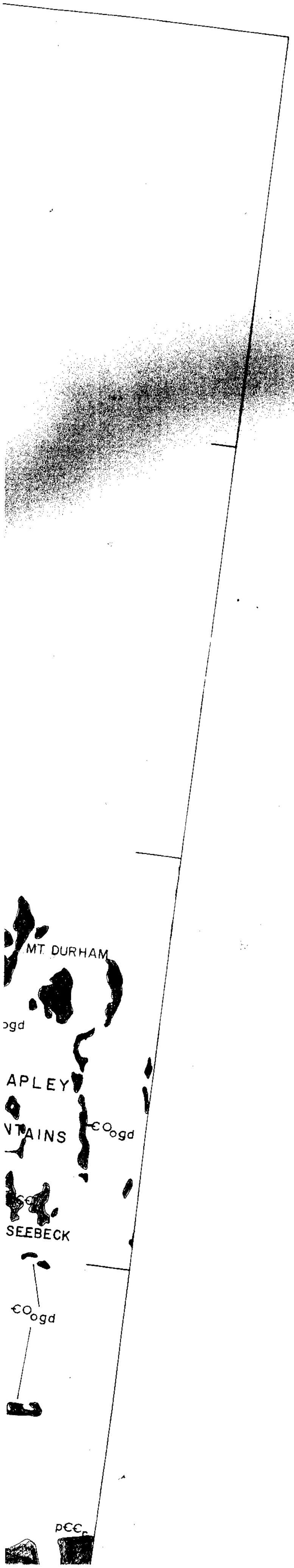

ICE
SHELF
SCOTT
GLACIER
pЄЄr
Qm
ЄOeu
ЄOogd
MT. RIGBY
ЄOmu
ЄOpu
MT FEENEY
ЄOd
MT. GOODALE
HAYS
MOUNTAINS
CAPPELLARI
GL.
VAUGHAN GL.
MT. DURHAM
TAPLEY
MOUNTAINS
MT. SEEBECK
BOBO
ALBANUS GL.

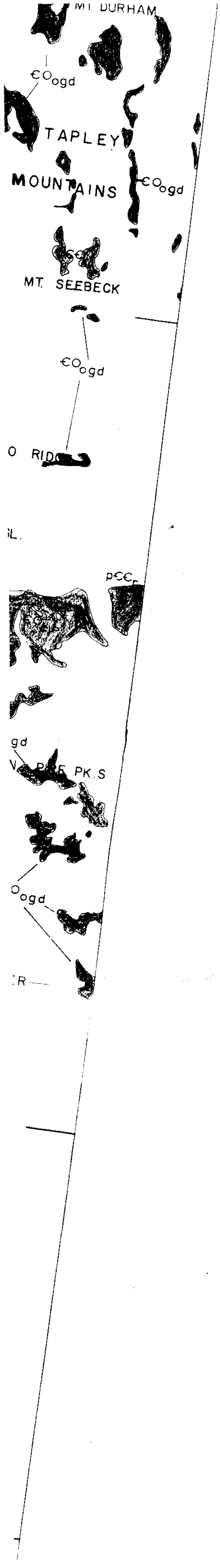

MUNDSEN
GLACIER
MT FEENEY
MT. GOODALE
HAYS
MOUNTAINS
CAPPELLARI
GL.
VAUGHAN GL.
SCOTT
GLACIER
MT DUF
TAPLEY
MOUNTAINS
MT. SEEBECK
BOBO RID
ALBANUS GL.
MT. McKERCHNER
FAULKNER
ESCARPMENT
SOUCHEZ
GLACIER
GLACIER
NILSEN
PLATEAU
BARTLETT
€Oeu
€Opu
€Omu
€Oogd
€Osa
Qm
p€€r
DJb




SCALE 1:250,000

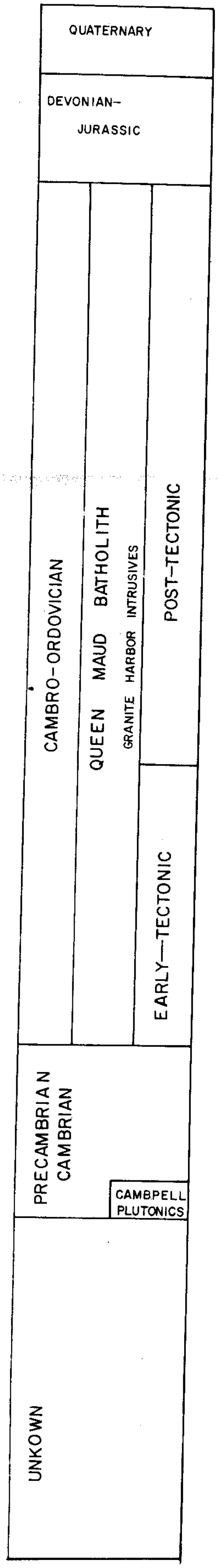
E II: GEOLOGIC MAP OF THE MT. GOODALE AND NILSEN PLATEAU QUADRANGLES


MT. DURHAM
ogd
APLEY
€Oogd
NTAINS
SEEBECK
€Oogd
p€€p


MT. DURHAM
€Oogd
TAPLEY
MOUNTAINS
€Oogd
MT. SEEBECK
€Oogd
pC€r
PK.S

LEGEND

# LEGEND




- Qm — MORAINE
- UNDIVIDED BEACON SUPERGROUP AND FERRAR DOLERITE
- ЄOgg — GREENLEE GRANOPHYRE: grey phase; red phase
- LONGHORN SPURS TONALITE
- ORGAN PIPE PEAKS GRANODIORITE
- SPEED ADAMELLITE
- WATT RIDGE ADAMELLITE
- UNDIVIDED GRANITIC INTRUSIVES
- HORNBLENDE GABBRO AND HORNBLENDITE
- ЄOd — LEUCODOLERITE
- UNDIVIDED MAFIC INTRUSIVES
- GRANITIC INTRUSIVES
- NILSEN PLATEAU ADAMELLITE
- TONALITIC INTRUSIVES
- UNDIVIDED INTRUSIVES
- ROSS SUPERGROUP
- pЄЄlgd — LONELY RIDGE GRANODIORITE
- AMPHIBOLITE
- AMPHIBOLE MIGMATITE
- BIOTITE MIGMATITE
- AUGEN GNEISS AND SCHIST
- u — UNDIVIDED ROCK

CONTACT