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GEOLOGY OF ST. PETER AND GOAT ISLANDS (NUYTS ARCHIPELAGO) AND CAPE BEAUFORT

by

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ABSTRACT

Outcrops of Proterozoic rocks on St Peter Island and Cape Beaufort consist of a complex suite of comagmatic intrusives. The comagmatic suite exhibits a variable degree of deformation and is correlated with the Early Proterozoic Lincoln Complex. In addition on souther St Peter Island, felsic volcanics are intruded by diorite. The volcanics are considered to be equivalent to the 1630Ma rhyolites on St Francis Island.

Outcrops on Goat Island consist of granites to adamellites of the Middle Proterozoic Hiltaba Suite.

A detailed correlation has been made between these basement exposures and those along the mainland coast.

INTRODUCTION

As part of the mapping of the STREAKY BAY 1:250 000 map sheet (Rankin and Flint, in prep.), St Peter and Goat Islands were visited by the authors for 4 days in May 1989. Mapping of previously unmapped basement exposures on the mainland from Matts Point to Cape Beaufort was also conducted. During this period, mapping concentrated on the coastal exposures of Early to Middle Proterozoic basement of the Gawler Craton.

The islands are part of the Nuyts Archipelago Conservation Park, and lie 14-18 km SE of hevenard (Fig. 1). St Peter Island covers an area of approximately 65 km^2, with a maximum elevation of 44m at Mt Younghusband. Goat Island, approximately 1.5km SW of St Peter Island, covers an area of about 8 km^2, with a maximum elevation of approximately 56m.

PREVIOUS WORK

Very little work has been conducted in this region, with only brief visits to the two islands by S.J. Daly, R.B. Major and V. Vitols during the 1974 offshore island helicopter survey. A complexity of granitoid intrusions and volcanics were noted by these officers, and several samples were collected for petrological, geochemical and geochronological analysis. Petrological descriptions were recorded by Steveson (1974). Geochemical analyses for samples from St Peter, Goat, Franklin and Olive Islands from this work are summarised in Appendix A1.

Watkins and Flint (1983) mapped the coastal outcrops of Proterozoic basement on STREAKY BAY, establishing a detailed and complex history of felsic and mafic intrusions. Isotopic dating includes a Rb-Sr age of 1547 ± 566 Ma for megacrystic gneissic granite at Point Westall, 1516 ± 11 Ma for porphyritic granite at Smooth Pool, 1554 and 1589 Ma for diorite at Thevenard and 1542 ± 22 Ma for samples of granite from Point Brown and the Nuyts Archipelago (Webb et al., 1982, 1986). The complex comagmatic intrusive associations noted by Watkins and Flint (1983), plus the isolated nature of individual outcrops resulted in an interpreted intrusive history with several ambiguities.

ACCESS

St Peter Island was reached by utilising the 4.5m aluminium fishing boat launched from Thevenard, taking approximately 40 minutes. The boat was skippered by D.J. Flint (Mineral Resources Branch). A farm house on the island, now owned by the National Parks and Wildlife Service was used as a base, and transport on the island was provided by a resident 4WD Toyota. The assistance of the staff of the Streaky Bay regional office of the National Parks and Wildlife Service during this work was greatly appreciated.

REGIONAL GEOLOGY

The area of investigation is part of the Nuyts Subdomain of the Gawler Craton (Fanning et al., 1988; Parker et al., 1988).

The Gawler Craton contains three megacycles of orogenic development. The following descriptions are adapted from Fanning et al. (1988). The first megacycle comprises a Late Archaean to Early Proterozoic volcano-sedimentary sequence subsequently intruded by the Dutton Suite during the Sleafordian Orogeny at ca 2500-2300 Ma. This sequence is collectively known as the Sleaford Complex in the south and Mulgathing Complex in the northwest of the craton. Sequences of the second megacycle records three phases of basin development and volcanism (Parker and Lemon, 1982) with associated magmatism forming a series of granitoid intrusives (Lincoln Complex) during the Kimban Orogeny. Sedimentation and magmatism during megacycle 2 extending from ca 2000 Ma to ca 1650 Ma. Megacycle 3 is represented by the extensive anorogenic extrusion of the Gawler Range Volcanics at ca 1590 Ma with contemporaneous clastic and volcaniclastic sedimentation, and extensive granitoid plutonism of the Hiltaba Suite.

Within the Nuyts Subdomain, the geology is dominated by plutonic intrusion during both megacycle 2 and megacycle 3 within a pre-existing sialic crust of Archaean Sleaford and Mulgathing Complex rocks. Early Proterozoic metasediments are not known.

Exposure within the coastal zone of STREAKY BAY is dominated by megacycle 2 Lincoln Complex intrusives and megacycle 3 Hiltaba Suite granitoids. Minor volcanics and mafic intrusives also occur, and are interpreted by the authors as part of the Megacycle 2.

Basement exposures are typically unconformably overlain by up to 50m of coastal aeolian calcarenites of the Pleistocene Bridgewater Formation. Locally at Ceduna and St Peter Island, Tertiary ferruginous weathering profiles on the basement are evident, along with minor Eocene sands of the Pidinga Formation and clays of the Garford Formation.

Continuing accumulation of Holocene marine and coastal intertidal sands and muds of the St Kilda Formation within the shallow Denial Bay area has resulted in localised partial burial of coastal basement outcrops. This was particularly noticeable at Matts Point, where partially-buried granite outcrop has been missed in photo-interpretation by earlier workers.

LOCAL PROTEROZOIC GEOLOGY

Exposures of Proterozoic crystalline basement in the Nuyts Archipelago and Denial Bay are limited to discontinuous wave-cut platforms. Outcrop geological maps are included for St Peter and Goat Island (Fig. 2) and Cape Beaufort-Matts Point (Fig. 3).

Geochemical analyses for samples collected are included in Appendix A2, and petrological descriptions are included in Appendix D. Structural data for the outcrops are included in Appendix C and also in Fig. 4.

<u>Southern St Peter Island</u>

The oldest basement lithology in outcrop on St Peter Island is a pink, fine- to medium-grained, even-grained granite (Eγ_2). The granite is leucocratic, with less than 2% mafics and minor clots of muscovite. The granite grades from massive to moderately-well foliated, and locally appears moderately sheared to produce a pink streaky granitic gneiss. The foliation trends approximated 180°-170°/75°-85°W. This granite is in contact with a medium-grained, massive to moderately-well foliated hornblende-rich granodiorite to adamellite (Eγ_3), with up to 10% hornblende + biotite. The foliation is parallel to the foliation in Eγ_2. Contacts between the two units vary. Gradational contacts associated with leucocratic and aplitic veining within both phases, melanocratic layering in the pink granite, plus formation of a mixed hybrid banded granodiorite indicate comagmatic intrusion of the two phases.

Both the pink granite (Eγ_2) and the hornblende adamellite (Eγ_3) contain abundant amphibolite, diorite and dolerite xenoliths, which are elongate subparallel to the foliation (Plate 1). Diorite to dolerite dykes (Eβ_1) comagmatically intrude Eγ_2 and Eγ_3, with backveining and disruption of the dykes by the granitoids. These features are interpreted as extensive mingling of Eβ_1 with Eγ_2 and Eγ_3, and are consistent with products of magma mingling as illustrated by Cook (1988) and Zorpi <u>et al</u>. (1989). The mafic magma was most likely hotter than the felsic magma during intrusion causing enhanced mobilisation and disturbance of the granitoids.

The hornblende adamellite and minor diorite intrusions are exposed extensively along the southwestern coastline of the island. Locally the adamellite is cross-cut by narrow (<10 mm) microshears. Two sets of shearplanes are evident (Plate 2); the first trending 130°/80°SW and the second 020°/80°W. The 130°-striking shears occasionally exhibit dextral strike-slip displacement along the 020° shears of up to 10 cm. The 020° shears commonly form anastomosing networks. Locally, sets of parallel microshear planes form a spaced foliation (Plate 3).

Narrow (<2 m) linear aplite dykes (Ꝑγ_6) crosscut the adamellite and diorite, and trend approximately 100°/80°S.

At Hawks Nest, east of the granitoid outcrops, is a sequence of pink to grey fine-grained porphyritic rhyolites (Ꝑ*v*). The rhyolite contains up to 30% phenocrysts of quartz and feldspar up to 2 mm in width (Plate 4). The rhyolites show some compositional variation, with some samples containing equal proportions of quartz and feldspar phenocrysts, and some with less quartz. Some of the feldspar phenocrysts have mafic cores. No primary layering could be seen in outcrop, although eutaxitic textures, with fiammé and agglomeratic layers are evident in wave-washed cobbles. These features indicate that the fesic volcanics were extrusive and not high-level dykes.

The rhyolite is weakly to moderately-well foliated which is defined by tiny micas. The foliation trends approximately north-south and is vertical. The outcrop exhibits three major joint sets: 320°/90°, 100°/90° and a subhorizontal set.

The base and top of the rhyolite sequence are unknown. The outcrop is bordered to the east and west by highly-weathered medium-grained diorite (Eβ_3) (Plate 5), which intrudes and disrupts the rhyolite. This variably-weathered diorite is interpreted to underlie the recent beach sands immediately west of the outcrop. Sorting of the beach sands by constant wave action has resulted in localised concentrations of heavy mineral sands sourced from the diorite.

Northern St Peter Island

Excellent coastal exposures along the northwestern coastline display a similar complex comagmatic sequence to the southern coastline.

The pink, even-grained granite Eγ_2 is common in this area, grading to a pink-red medium-grained granite and has been comagmatically intruded by abundant Eβ_1 amphibolite and diorite dykes and by a grey, moderately-well foliated, slightly porphyritic granodiorite to adamellite with up to 7% biotite (Eγ_4) (Plate 6). This phase also contains abundant disrupted dykes and xenoliths of Eβ_1. Several diorite dykes exhibit development of a hybrid granodiorite which backveins and disrupts the diorite (Plate 7). This granodiorite hybrid is interpreted as the product of chemical mixing between the granitoids and diorite during comagmatic emplacement. Contact relationships between Eγ_2 and Eγ_4 vary, with gradational contacts and inclusions of both phases within each other. The foliation in the granitoid phases is approximately 010°/80°W, with narrow microshears at approximately 000°/80°W. Within the narrow Eβ_1 dykes, the diorite is moderately well foliated and, in one dyke, folded and lineated. The intensity of the foliation increases with decreasing width of the dyke.

Associated with the granitoids near the massive gabbro are several narrow (<1 m) dykes of fine- to medium-grained granodiorite. These cross-cut the pink-red granite and the porphyritic granodiorite.

A second generation of mafic intrusives crops out on the northwestern coastline of the island, and consists of a large (>500 m wide) plug of massive diorite to gabbro. This massive plug is tentatively correlated with gabbroic plugs ($E\beta_3$) intersected in drillholes at Inkster, Corvisart Bay and Cungena (Whitten, 1963). Close to the margin of the mafic plug, the granitoids contain abundant mafic enclaves and are sheared and well-foliated.

Both at locality 32 and 40, the granitoids and $E\beta_1$ mafics have been sheared to produce fine-grained, leucocratic foliated gneisses, with abundant en-echelon sigmoids of gneiss between small-scale shear planes (Plate 8). The shear planes are oriented approximately 088°/54°N, and the principal foliation is approximately 098°/80°N.

Bird Rock

This is a small wave-washed outcrop 5 km SW of Thevenard sporting a maritime channel marker and abundant cormorants. The outcrop consists of medium, even-grained pink granite $E\gamma_2$ similar to the outcrops on northwestern St Peter Island. The granite has a weak foliation (028°/90°).

Cape Beaufort-Matts Point

Basement exposures along this coastline are very similar to the comagmatic $E\gamma_2/E\gamma_4/E\beta_1$ sequence seen on northwest St Peter Island.

A pink, fine- to medium-, even-grained granite ($Pγ_2$) is comagmatically intruded by a medium-grained, massive grey-pink granodiorite containing up to 10% biotite + hornblende ($Pγ_4$). At Matts Point, inclusions of both phases are found within each other. The granitoids are predominantly massive at this locality, with heterogeneous development of a moderate to intense foliation within narrow zones. The foliation varies greatly in orientation at this locality, varying from 170°/90° to 072°/90°, suggesting some late-stage rotation of an early foliation into narrow shear zones. Within the shear zones, the granitoids have developed into streaky gneisses similar to those on St Peter Island.

Further to the south, at Cape Beaufort, comagmatic disrupted dykes and xenoliths of $Pβ_1$ diorite and dolerite are abundant, typically as rounded, mingled 'blebs' up to 2 m in length (Plate 9). The dykes are parallel to a heterogeneous foliation in the granodiorites, oriented approximately 086°/90°. Several dolerite dykes appear to have medium-grained porphyroblasts of ?metasomatic feldspar. One dyke has a 15 cm wide hornblende ultramafic xenolith near the contact with the granitoids. Some dykes exhibit a mixing hybrid of fine-grained granodiorite within contact zones with the pink, even-grained granite.

A small plug of pink to grey, massive, leucocratic, highly porphyritic granite ($Pγh_3$) intrudes the comagmatic granitoids. This granite has less than 1% mafics and up to 40% feldspar phenocrysts up to 10 mm diameter.

Goat Island

The oldest unit on Goat Island is a medium-grained, moderately-well foliated hornblende adamellite ($Pγ_3$) identical to that seen on southwestern St Peter Island. The adamellite occurs as a large xenolith (12 m^2) within later post-orogenic granite (Plate 10).

The rest of the outcrop on the island consists of 2 main phases of granite undeformed to adamellite.

The first of these (Ꞓγh_1) is a medium- to coarse-grained, moderately to highly porphyritic grey granite to granodiorite (Plate 11). The phenocrysts consist of both quartz and orthoclase, with orthoclase commonly rimmed by albite.

The second phase (Ꞓγh_2) is a pink, medium- even-grained granite to adamellite grading to a medium- to coarse-grained red-pink granite with rare phenocrysts and rare diorite xenoliths. The contacts between Ꞓγh_2 and Ꞓγh_1 vary from gradational to sharp, with diffuse inclusions of Ꞓγh_1 observed within Ꞓγh_2 at several localities. Fine-grained hornblende has concentrated along the contacts between the two phases. 'Sweat-out' pegmatite pods are common within the porphyritic phase near the contacts but less common within the pink phase. The pegmatites contain medium-grained garnet and very-coarse-grained feldspar and quartz. The feldspar commonly exhibits a miarolitic texture, indicating the granites are high-level intrusives.

Pyrite is abundant in both phases, with up to 3% visible in most outcrops. Aplite veins are common throughout both phases. Several quartz veins trending approximately north-south intersect the granitoids on the southeastern coast of the island.

LOCAL CAINOZOIC GEOLOGY

At several localities on St Peter Island, the basement is highly weathered, with a resultant profile of kaolinised and ferruginised basement grading locally into ferricrete. This weathering predates the overlying Pleistocene Bridgewater

Formation and is tentatively dated as Late Eocene to Early Pliocene. A minor local outcrop of ?Pliocene mottled clays, possibly equivalent to the Garford Formation, overlies the ferruginised weathering surface.

Everywhere else, the Proterozoic basement is unconformably overlain by the Middle to Late Pleistocene Bridgewater Formation. This unit, which can be locally subdivided into Upper and Lower Members consists of fine to medium-grained calcareous silts and sands forming coastal aeolianite dunes, with dune foresets up to 10 m thick. The Bridgewater Formation is interpreted to have been deposited in coastal backshore dune environments during fluctuating interglacial sea-level stands (Schwebel, 1978). The Lower Member has been dated at ca.200 00 yrs B.P. (Murray-Wallace et al., 1988), while the Upper Member was deposited at ca.110 000 + 19 000/ - 17 000 yr. B.P., contemporaneous with the marine Glanville Formation (Belperio et al., 1984).

Episodically throughout deposition of the Bridgewater Formation, semi-arid weathering produced multiple coalescing horizons of indurated calcrete, which now form a protective cap on the islands. Localised reworking of the Bridgewater Formation has produced the fine grey silt seen over most of St Peter Island.

The thick, indurated nature of the calcrete on Goat Island suggests that the calcarenites are part of the Lower Member (Qpbl), while the less-indurated calcrete, plus the abundance of calcreted pupal cases of the weevil Leptopius dupontii and occurrence of the land snail Borthriembryon barretti indicate that St Peter Island is capped predominantly by the Upper Member (Qpbu).

Sea levels rose to their present level at ca.6 000 yrs B.P., flooding the shallow Denial Bay area. During this recent period, abundant calcareous and minor quartz sands have accumulated and, with the influence of westerly drift currents, large areas of shallow subtidal to intertidal sand flats (Qhk_1) have accumulated on the northern and eastern sides of St Peter Island. Where the sands have accumulated above the high tide zone and have undergone some degree of aeolian transport, low white coastal dunes and sand spits of the Semaphore Sand (Qhk_4) have formed. On the eastern side of these sand dunes, protected from continual wave action, the calcareous sands have accumulated to form intertidal to supratidal mangrove and samphire sand and mud flats, with progradation of the land as the mangroves migrate seawards.

On the more exposed beaches of southern and northwestern St Peter Island, beach sands of the St Kilda Formation contain a high percentage of medium- to coarse-grained, well-rounded quartz derived from the outcropping granitoids. In addition, heavy minerals sourced from the weathered diorites are locally reworked and sorted into small accumulations. Major heavy minerals present are ilmenite and magnetite (Appendix 4).

REGIONAL CORRELATIONS

Similarities between the intrusive phases and their relationships on St Peter Island, Goat Island and Cape Beaufort, and the intrusive complexes observed by Watkins and Flint (1983) allow correlation with the outcrops observed at Point Westall-Smooth Pool, Point Brown, Wittelbee Point, Cape Vivonne and Ceduna-Thevenard, as well as the other islands of the Nuyts Archipelago. Figure 5 shows the original summary of intrusives from Watkins and Flint (1983), while the ammended and expanded correlation of the Proterozoic igineous units of the area is shown in Figure 6.

The granitoid sequence Ꝑγ_{2-4} plus Ꝑβ_1 is correlated with the Early Proterozoic Lincoln Complex which crops out widely over the Gawler Craton. This sequence was intruded during the Kimban Orogeny. The comagmatic nature of the majority of the Lincoln Complex granitoids is similar in character to the intermixed granitoids and amphibolites/diorites of the Donington Granitoid Suite in the southern Gawler Craton, although the St Peter Island sequence is probably younger than the U-Pb age of 1850 Ma recorded for the Donington Granitoid Suite by Mortimer et al. (1986). Similar mixed intrusive suites are seen locally in exposures at Ifould Lake and other scattered outcrops on the BARTON 1:250 000 sheet (Benbow and Rankin, in prep.). The undeformed diorite plugs (Ꝑβ_3) are correlated with similar diorite-gabbro bodies which occur in the subsurface of western Eyre Peninsula (Whitten, 1963). These mafic plugs are most likely a post-orogenic phase intruded at the end of the Kimban Orogeny.

Weakly-foliated rhyolites (Ꝑv) on St Peter Island appear to be geochemically related to the rhyolites found on St Francis Island (Flint, 1986), which intrude Lincoln Complex granitoids. The rhyolites on St Francis Island were dated at 1490±12 Ma (Rb-Sr; Webb et al., 1986) and 1631±3 Ma (U-Pb; Rosier, 1982; Cooper et al., 1985). The latter age is significantly older than the U-Pb age of 1592 Ma obtained for the Gawler Range Volcanics by Fanning et al. (1988), suggesting that the rhyolites found in the Nuyts Archipelago represent an older, separate extrusive event, possibly related to the last phases of magmatism of the Lincoln Complex.

The porphyritic granodiorite to adamellite on Goat Island (Ꝑγh_1) is very similar to a porphyry cropping out at Calca Bluff (ELLISTON map sheet; Flint, 1989). This unit is correlated with massive biotite adamellites observed on

Franklin and Olive Islands and Goalen Rocks during the 1974 helicopter survey. The pink granite to adamellite phase (Ɛγh$_2$) on Goat Island is locally similar in appearance to the Hiltaba Suite granites which crop out on the eastern portion of STREAKY BAY, and, in particular, in the Toondulya Bluff area where the granites intrude the Gawler Range Volcanics. Seven samples of granite from Goat, Franklin and St Francis Islands produced a Rb-Sr Model 3 isochron age of 1489±15 Ma (Webb et al., 1986). This compares well with a Rb-Sr age of 1478±38 Ma obtained from samples of the Hiltaba Suite from the Hiltaba-Kokatha area (Webb et al., 1986), though the age of intrusion is now believe to be older at 1585±16 Ma (Creaser, 1989) based on U-Pb isotopic analyses of zircons.

The highly porphyritic leucocratic granite plug at Cape Beaufort (Ɛγh$_3$), which intrudes the Lincoln Complex, is identical to the leucocratic, porphyritic Hiltaba Suite granite which crops out at Point Peter, West and St Francis Islands (NUYTS map sheet; Flint, 1986). A Rb-Sr Model 1 age of 1466±79 Ma was obtained from samples from West Island (Webb et al., 1986).

GEOCHEMISTRY

A total of 27 samples of rhyolite, granitoid and mafic rock from St Peter and Goat Islands and Cape Beaufort were analysed for major and minor elements. The analyses are compiled in Appendix 1.2, and major and minor element compositions are reproduced in figures 7-17 Geochemical analyses of volcanics and intrusives from St Francis and Hart Islands, including those of Rosier (1982) and Morrison (1982), have also been included for comparison.

The Lincoln Complex granitoids (Eγ_{2-4}) from St Peter Island have major and minor element compositions commensurate with I-type granitoids, including low CaO and Na_2O, relatively high K_2O and Rb, a wide range of SiO_2 (66-78%) and Fe/Fe+Mg = 0.7. An I-type source for the granitoids is supported by the association of mingled diorite and granite magmas observed at St Peter Island and Point Brown (Berry and Flint, 1988) and the dominance of hornblende in the mafic mineralogy. Similar chondrite-normalised trends for both the granitoids and the Eβ_1 diorite dykes and xenoliths provides further evidence for the comagmatic, single-source nature of the intrusives. The obvious enrichment of Ti and P in the diorites with respect to the granites is due to selective crystallisation within hornblende + pyroxene (and ilmenite for Ti). The Rb - Ba - Sr discrimination diagram of El Bouseily and El Sokkary (1975) shows a trend of differentiation from diorite to strongly differentiated granite.

The Eβ_1 dykes and xenoliths show tholeiitic affinities in both the AFM and Fe_2O_3+TiO_2 - Al_2O_3 - MgO diagrams (using the discrimination fields of Jensen, 1976). Ti/100-Zr-Yx3, Ti/100 - Zr - Sr/z (Pearce and Cann, 1973) and TiO_2 - Fe_2O_3/MgO diagrams show a scatter of compositions, which is most likely due to mobilization of mobile elements during partial retrogression of thin diorite dykes to amphibolite with syn-intrusion fluid movement.

The granitoids plot in the fields of within-plate and volcanic-arc granitoids on the Nb - Y and Rb - Y+Nb discrimination diagrams of Pearce et al. (1984), and are interpreted as within-plate granites. The same tectonic setting was interpreted for the granodiorite dykes at Point Brown (Berry and Flint, 1988).

The rhyolites (Ꞓv) have very similar chondrite-normalised trends plus major and minor element compositions to the rhyolite (Ꞓa) and rhyolite dykes ($Ꞓa_{1-3}$) from St Francis Island (Flint, 1986). Both major and minor element trends display a continuous differentiation series from the Ꞓa rhyolites through the Ꞓv rhyolites to the high-silica (76-78%) $Ꞓa_3$ dykes. Depletion of Sr with increasing SiO_2 suggest a continuous fractional crystallisation of modal minerals plagioclase and clinopyroxene within the parent magma. Zr shows a sharp depletion with decreasing MgO (increasing silica) for the Ꞓv rhyolite and the $Ꞓa_3$ dykes, indicating a late-stage crystallisation of accessory phases within the parent magma. This is similar to the Zr depletion trend reported for the Gawler Range Volcanics by Giles (1988). The $Ꞓa_1$ and $Ꞓa_2$ dykes have discordant trends to the volcanic series, and appear to represent samples of a more fractionated portion of the parent magma. The rhyolites plot in the Nb - Y and Rb-Nb+Y discrimination fields of within-plate and volcanic-arc granites (Pearce et al., 1984), and are interpreted as within-plate felsic extrusives. The Rb - Ba - Sr discrimination plot (El Bouseily and El Sokkary, 1975), also indicates a strong differentiation trend.

The volcanics on St Francis Island were interpreted as having I-type affinities (Cooper et al., 1985). However, with increasing differentiation, the St Peter Island Ꞓv rhyolites display some A-type affinities, including Al_2O_3<13%, Cao<1.5% and high Fe/Fe+Mg.

Associated with the volcanics on St Francis Island, and intruded by $Ꞓa_{1-3}$, is an alkali-rich granite ($Ꞓ\gamma_6$ of Flint, 1986). The high Na_2O+K_2O and Zr, plus low Al_2O_3 (<12%) and very low CaO (<0.5%) and Ba (<100 ppm) indicate the granite has very strong A-type characteristics (Cooper et al., 1985). It is suggested that the granite was produced by partial melt of a depleted lower-crustal source produced by underplating of a hot mantle-sourced magma, and injected at a high crustal level. The rhyolite may have been sourced from either differentiation of the mantle-derived underplate or from a less-depleted section of the heterogeneous lower crust.

The diorite plugs that intrude the Ev rhyolite on St Peter Island show dissimilarities to the earlier - generation Eβ_1 diorite dykes, including enrichment in Zr, Ti, P, Ce and La, and depletion in K and Rb. They are also dissimilar to the normalised trends for mafic dykes intruding Ea and the alkali granite on St Francis Island. The plugs have tholeiitic affinities, with high Ti and Fe enrichment. On the Ti/100 - Zr - Yx3 and Ti/100 - Zr - Sr/z discrimination diagrams of Pearce and Cann (1973) they plot within the fields of ocean-floor and within-plate basalts, and are interpreted as within-plate mafics.

The Hiltaba Suite granitoids from Goat Island and Cape Beaufort have chondrite-normalised plus major and minor element trends distinctly different from the Lincoln Complex granitoids and the A-type alkali granite. The Hiltaba Suite show a depletion in La, Sr and particularly Zr. CaO, Al_2O_3 and Ba range from moderate to low levels, suggesting a trend from I- to A-type granitoids. This suggests that the granites are being produced by partial melt of a partly-depleted portion of the lower crust. The granites plot in the fields of within-plate and syn-collisional granites in the discrimination diagrams of Pearce et al., (1984), and are interpreted as within-plate granites.

The distinctly different geochemical trends of the Hiltaba Suite and the alkali granite indicates that the alkali granite is not part of the Hiltaba Suite magmatic event. This provides additional evidence that the St Peter and St Francis Islands' rhyolites, which are associated with the alkali granite, are distinctly separate, and older, than the Gawler Range Volcanics.

TECTONIC SETTING

The Lincoln Complex comagmatic granitoids and diorites ($Ƚ\gamma_{2-4}$, $Ƚ\beta_1$) have within- plate, I-type affinities. Pitcher (1982) suggested I-type granites could be associated with Cordilleran, Andino-type settings or a Caledonian-type post-orogenic uplift. Combined with the within-plate characteristics, the Lincoln Complex granitoids are likely to be late- to post-orogenic. The presence of shear zones and a variable foliation in the granitoids suggests that they were intruded in the waning stages of the Kimban Orogeny. The variable foliation orientations within the area is most likely due to a combination of refraction of the shear zones through the basement plus rotation of basement blocks between shear zones and faults of syn-Kimban and possible post-Kimban age. The Lincoln Complex magmas were most likely produced by partial melting of a heterogeneous, dominantly I-type Archaean lower crust, due to underplating by a hot mantle-derived basic magma.

The Caledonian-style post-orogenic model of Pitcher (1982) involves tensional relaxation of a previously-compressed crust, with major faulting and rapid uplift. This model allows uplift of the mid-crustal level Lincoln Complex granitoids prior to extrusion of the Ƚv and Ƚa rhyolites and injection of the high-level alkali granite. These highly silicate units are accommodated in Pitcher's (1982) model, with derivation of the melts by "localised remelting of hot but now depleted lower-crustal rocks in response to mantle diapirs rising into the stabilising but deeply-faulted crust". The appearance of diorite plugs after the initial phase of Caledonian plutonism are interpreted by Pitcher (1982) as melt products of adiabatic decompression during uplift, with possible localised-heat introduction fro mantle diapirism. However, this model suggests the diorite plugs will precede the volcanics, and it is therefore possible that the mafic magma pooled in a mid-crustal chamber prior to injection into the slightly-later formed silica magmas.

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APPENDIX A

GEOCHEMICAL ANALYSES

APPENDIX A1

Silicate analyses, computed C.I.P.W. Norm, calculated density and Niggli values.

	ST PETER IS	FRANKLIN IS	OLIVES IS	
	5633 RS 20 RHYOLITE	5633 RS 25 GRANITE	5632 RS 12 GRANITE	* GRANITE
SiO_2	75.53	77.28	76.30	71.30
T_iO_2	.13	.16	.17	.31
Al_2O_3	12.53	12.19	12.31	14.32
Fe_2O_3	.50	.53	.59	1.21
FeO	.65	.40	.75	1.64
MnO	.09	.05	.07	.05
MgO	.27	.16	.28	.71
CaO	.74	.47	1.20	1.84
Na_2O	3.35	3.36	2.90	3.68
K_2O	4.72	4.91	4.50	4.07
P_2O_5	.03	.01	.03	.12
L.O.I.	.84	.51	.49	---
H_2O+	.69	.45	.57	.64
H_2O-	.21	.01	.01	.13
TOTAL	99.44	99.98	99.68	100.02
		C.I.P.W. NORM		
Q	34.00	35.51	37.05	29.06
C	.72	.58	.63	.92
Or	28.64	29.53	27.30	24.50
Ab	30.89	30.71	26.74	31.13
An	3.57	2.31	5.91	8.04
Di	.00	.00	.00	---
Hy	1.40	.56	1.43	3.37
Mt	.54	.56	.63	1.75
Il	.19	.23	.24	.58
Ap	.06	.02	.06	.28
Cc	.00	.00	.00	.12
Calc Density	100.00	100.00	100.00	

Amdel report AN 2956/75
* Le Maitre (1976) Average of 2236 granites.

E00100

	ST PETER IS	FRANKLIN IS	OLIVES IS	
	5633 RS 20 RHYOLITE	5633 RS 25 GRANITE	5632 RS 12 GRANITE	* GRANITE
NIGGLI VALUES				
si				357.17
al				42.27
fm				16.99
c				9.89
alk				30.85
k				.42
mg				.31
qz				133.77

Amdel report AN 2956/75
* Le Maitre (1976) Average of 2236 granites.

Trace element analyses

	Ag	Au	Ba	Be	Bi	Co	Cr	Cu	Li	Mo	Pb	Rb	Sb	Sn	Sr	Th	U	V	W	Zn	Zr
ST PETER IS.																					
5633 RS 20 A			210			<2	<5	6	09		16	240			36	22	8	<10		28	135
GOAT IS.																					
5633 RS 24 B	<1	<.05		3	<10			15		<3	50		X	1		30	16	10	X	32	
FRANKLIN IS.																					
5633 RS 25 A			240			<2	<5	10	74		36	290			75	60	6	<10		46	135
5633 RS 30 b	<1	<.05		3	<10			22		<3	18		x	1		26	8	10	x	25	
OLIVE IS.																					
5632 RS 12 A			170			<2	<5	6	42		50	450	x		46	24	18	<10		39	100

Appendix A2

Geochemical data for samples collected on St Peter and Goat Islands and Cape Beaufort, 1989.

E00100

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NATA CERTIFICATE

30 June 1989

The Director General
SA Department of Mines & Energy
PO Box 151
EASTWOOD SA 5063

REPORT AC 2602/89

YOUR REFERENCE: EX-875, 12/07/0040

REPORT COMPRISING:
Cover sheet
Page K1
Pages I1 - I10
Classic Comlabs cover sheet
Pages 1 - 6

DATE RECEIVED: 22 May 1989

Approved Signatory: Martin R. Hanckel

Manager, Chemistry Services: Dr Brian G. Steveson

for Dr William G. Spencer
General Manager
Applied Sciences Group

The report relates specifically to the sample tested and also the entire batch in so far as the sample is truly representative of the sample source.

hy

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Page K1

Method: Gen 4

Report AC2602/89

Results in Percent.

Sample ID	FeO
RS 146	0.58
147	5.35
149	3.10
150	0.16
151	0.25
152	1.24
156	0.20
157	0.32
158	0.93
159	2.35
161	3.05
165	9.60
166	2.45
167	1.46
168	0.30
169	5.90
171	10.7
172	1.1
173	5.65
174	0.18
175	0.60
176	0.65
177	1.48
178	0.86
179	0.27
182	1.0
183	5.85

NATA Certificate Results in percentages

	5633 RS 146	5633 RS 147	5633 RS 149	5633 RS 150	5633 RS 151
SiO2	77.7	49.9	55.4	73.0	77.7
TiO2	0.18	3.88	4.22	0.33	0.19
Al2O3	12.1	15.3	13.3	13.6	12.0
Fe2O3	1.00	13.5	10.5	1.05	0.32
MnO	0.05	0.19	0.10	0.02	0.03
MgO	0.16	3.86	1.60	0.31	0.08
CaO	0.37	6.50	2.90	0.26	0.15
Na2O	3.44	3.00	3.08	2.50	2.70
K2O	4.60	1.07	0.87	5.55	5.45
P2O5	<0.02	0.70	0.34	0.05	0.03
LOI	0.75	1.57	7.35	1.77	1.12
Totals	100.3	99.5	99.7	98.4	99.8

Total FE as Fe2O3

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Analysis code ORE 2/1 Report AC 2602/89

NATA Certificate Results in percentages

	5633 RS 152	5633 RS 156	5633 RS 157	5633 RS 158	5633 RS 15~~8~~9
SiO_2	74.1	76.3	65.9	69.9	63.7
TiO_2	0.31	0.13	0.69	0.40	0.54
Al_2O_3	13.3	12.6	16.5	14.8	15.4
Fe_2O_3	1.22	0.93	3.78	1.96	4.18
MnO	0.08	0.06	0.09	0.05	0.07
MgO	0.25	0.13	0.56	0.56	2.32
CaO	0.36	0.71	1.44	1.53	4.10
Na_2O	3.04	2.40	3.30	4.20	3.92
K_2O	5.90	5.50	4.08	3.62	3.16
P_2O_5	0.03	<0.02	0.11	0.09	0.19
LOI	1.03	0.86	1.58	1.04	1.64
Totals	99.6	99.6	98.0	98.1	99.2

Total FE as Fe_2O_3

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NATA Certificate Results in percentages

	5633 RS 161	5633 RS 165	5633 RS 166	5633 RS 167	5633 RS 168
SiO2	59.2	47.8	64.7	68.8	78.1
TiO2	0.67	3.04	0.69	0.47	0.14
Al2O3	15.9	15.6	15.7	14.5	11.1
Fe2O3	5.30	14.2	5.45	2.74	0.93
MnO	0.11	0.19	0.14	0.09	0.05
MgO	3.58	4.02	1.59	0.67	0.09
CaO	5.20	7.90	3.80	1.53	0.52
Na2O	4.04	3.00	4.80	4.74	3.22
K2O	2.72	1.12	2.30	3.64	4.76
P2O5	0.32	0.64	0.30	0.10	<0.02
LOI	1.56	1.32	1.07	0.80	0.65
Totals	98.6	98.8	100.5	98.1	99.5

Total FE as Fe2O3

NATA Certificate   Results in percentages

	5633 RS 169	5633 RS 171	5633 RS 172	5633 RS 173	5633 RS 174
SiO2	52.2	47.9	68.7	52.8	75.2
TiO2	0.89	3.12	0.56	0.70	0.22
Al2O3	15.8	15.4	14.0	15.2	12.8
Fe2O3	9.85	15.0	3.30	9.10	1.30
MnO	0.24	0.20	0.11	0.21	0.06
MgO	5.15	4.30	0.55	6.55	0.23
CaO	7.10	8.10	1.75	7.15	0.30
Na2O	4.10	2.90	5.00	4.26	3.66
K2O	1.24	1.03	3.44	1.27	4.98
P2O5	0.33	0.57	0.13	0.22	0.03
LOI	2.16	0.65	0.74	1.87	0.87
Totals	99.1	99.2	98.3	99.3	99.6

Total FE as Fe2O3

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NATA Certificate Results in percentages

	5633 RS 175	5633 RS 176	5633 RS 177	5633 RS 178	5633 RS 179
SiO2	76.3	75.8	72.2	75.0	76.4
TiO2	0.09	0.09	0.26	0.16	0.19
Al2O3	12.9	12.4	13.6	13.0	11.9
Fe2O3	0.97	0.91	2.54	1.50	1.01
MnO	0.12	0.08	0.10	0.13	0.08
MgO	0.17	0.22	0.59	0.34	0.10
CaO	0.54	0.32	1.80	0.76	0.10
Na2O	3.70	3.72	3.18	3.66	4.22
K2O	4.24	4.40	3.98	3.84	4.22
P2O5	<0.02	<0.02	0.11	0.08	0.03
LOI	1.08	1.02	0.93	1.32	0.37
Totals	100.1	98.9	99.3	99.8	98.6

Total FE as Fe2O3

NATA Certificate

Results in percentages

	5633 RS 182	5633 RS 183
SiO2	73.2	47.9
TiO2	0.15	1.71
Al2O3	12.9	14.8
Fe2O3	1.38	16.1
MnO	0.12	0.27
MgO	0.39	6.05
CaO	0.91	6.95
Na2O	3.64	0.68
K2O	4.14	2.34
P2O5	0.05	0.31
LOI	1.16	3.20
Totals	98.0	100.3

Total FE as Fe2O3

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Analysis code ICP 3 Report AC 2602/89

NATA Certificate Order No. 12/07/0040 Results in ppm

Sample	As	Mo	Cr	Zn	Pb	Cd	Co
5633 RS 146	5	5	<5	20	<10	<5	120
5633 RS 147	<5	10	<5	140	<10	5	85
5633 RS 149	<5	5	<5	75	95	5	55
5633 RS 150	5	<5	<5	30	<10	<5	110
5633 RS 151	<5	<5	<5	10	<10	<5	140
5633 RS 152	10	<5	<5	35	<10	<5	110
5633 RS 156	10	<5	<5	25	<10	<5	190
5633 RS 157	<5	<5	<5	75	<10	<5	100
5633 RS 158	10	<5	<5	50	<10	<5	150
5633 RS 159	<5	<5	40	65	<10	<5	75
5633 RS 161	<5	5	85	85	<10	<5	80
5633 RS 165	<5	10	<5	230	<10	5	100
5633 RS 166	<5	<5	<5	90	<10	<5	110
5633 RS 167	<5	<5	<5	100	<10	<5	90
5633 RS 168	<5	<5	5	20	<10	<5	190
5633 RS 169	5	5	70	110	<10	<5	55
5633 RS 171	<5	5	15	140	<10	<5	80
5633 RS 172	10	<5	5	70	10	<5	110
5633 RS 173	<5	5	350	150	<10	5	70
5633 RS 174	<5	<5	10	45	<10	<5	150
Detn limit	(5)	(5)	(5)	(5)	(10)	(5)	(5)

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NATA Certificate Order No. 12/07/0040 Results in ppm

Sample	As	Mo	Cr	Zn	Pb	Cd	Co
5633 RS 175	<5	<5	<5	30	30	<5	130
5633 RS 176	<5	<5	5	80	40	<5	190
5633 RS 177	15	<5	5	40	<10	<5	120
5633 RS 178	<5	<5	5	40	<10	<5	230
5633 RS 179	<5	<5	5	40	<10	<5	140
5633 RS 182	<5	<5	<5	40	15	<5	220
5633 RS 183	<5	5	60	170	<10	5	85
Detn limit	(5)	(5)	(5)	(5)	(10)	(5)	(5)

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Analysis code ICP 3 Report AC 2602/89

NATA Certificate Order No. 12/07/0040 Results in ppm

Sample	Ni	Mn	V	Cu
5633 RS 146	<5	290	<5	5
5633 RS 147	30	1350	290	110
5633 RS 149	20	640	210	5
5633 RS 150	5	110	15	15
5633 RS 151	<5	200	<5	<5
5633 RS 152	<5	540	5	5
5633 RS 156	<5	390	<5	<5
5633 RS 157	<5	560	35	<5
5633 RS 158	<5	390	20	25
5633 RS 159	35	440	70	65
5633 RS 161	75	800	85	110
5633 RS 165	95	1300	260	45
5633 RS 166	<5	940	60	5
5633 RS 167	<5	640	15	5
5633 RS 168	<5	310	5	<5
5633 RS 169	30	1700	180	10
5633 RS 171	45	1550	270	40
5633 RS 172	<5	760	20	<5
5633 RS 173	75	1500	160	40
5633 RS 174	<5	450	10	<5
Detn limit	(5)	(10)	(5)	(5)

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Analysis code ICP 3 Report AC 2602/89

NATA Certificate Order No. 12/07/0040 Results in ppm

Sample	Ni	Mn	V	Cu
5633 RS 175	<5	860	<5	5
5633 RS 176	<5	600	5	<5
5633 RS 177	5	620	20	15
5633 RS 178	<5	980	10	5
5633 RS 179	<5	600	5	<5
5633 RS 182	<5	740	5	5
5633 RS 183	60	2100	320	<5
Detn limit	(5)	(10)	(5)	(5)

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Number of Samples:	28	Date Reported:	29-MAY-1989

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This report relates specifically to the samples tested in so far as that the samples as supplied are truly representative of the sample source. Please address any enquiries to Mr. Trevor Francis.

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for

Dr. John Kikkert
General Manager - Adelaide.
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MM	Miss Anne Reed	Frewville

Report Analyte Codes:
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- L.N.R. - Listed But Not Received.
- I.S. - Insuffiecent Sample for Analysis.

Distribution Codes:
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ANALYTICAL REPORT

SAMPLE	Cs	Rb	Ba	La	Y	Th	Nb
5633 RS 146	<10	230	220	30	26	30	15
5633 RS 147	<10	50	670	40	82	6	15
5633 RS 148	L.N.R.	L.N.R.	L.N.R.	L.N.R.	L.N.R.	L.N.R.	L.N.R.
5633 RS 149	<10	90	2750	140	12	8	14
5633 RS 150	<10	320	1040	70	24	18	15
5633 RS 151	10	270	270	40	24	18	17
5633 RS 152	10	250	470	50	36	16	16
5633 RS 156	25	320	280	<20	18	34	17
5633 RS 157	35	270	1600	70	30	12	18
5633 RS 158	<10	145	1500	50	20	10	11
5633 RS 159	<10	125	1460	40	10	8	8
5633 RS 161	<10	130	1140	40	8	<4	9
5633 RS 165	<10	48	660	20	44	6	11
5633 RS 166	<10	150	1140	40	36	14	10
5633 RS 167	<10	195	1320	80	70	14	24
5633 RS 168	<10	220	140	<20	18	10	15
5633 RS 169	<10	110	580	40	14	8	5
5633 RS 171	<10	36	550	30	36	<4	12
5633 RS 172	<10	115	1080	50	36	18	12
5633 RS 173	<10	92	540	30	10	6	5
5633 RS 174	<10	175	860	40	24	12	13
5633 RS 175	75	600	65	<20	88	26	44
5633 RS 176	30	580	85	20	70	24	34
5633 RS 177	45	320	490	30	32	28	20
5633 RS 178	40	470	180	20	68	28	32
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SCHEME	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1

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Job: 9AD0849
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ANALYTICAL REPORT

SAMPLE	Cs	Rb	Ba	La	Y	Th	Nb
5633 RS 179	10	175	65	30	26	6	12
5633 RS 182	45	620	300	<20	60	28	32
5633 RS 183	85	370	390	20	34	<4	7
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SCHEME	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1

Job: 9AD0849
O/N: AC 2602/89

ANALYTICAL REPORT

SAMPLE	Sn	Zr	Ce	Sr	U	Bi	Sb
5633 RS 146	6	135	60	36	8	<4	12
5633 RS 147	<4	290	90	460	<4	<4	8
5633 RS 148	L.N.R.	L.N.R.	L.N.R.	L.N.R.	L.N.R.	L.N.R.	L.N.R.
5633 RS 149	<4	320	180	780	12	<4	<4
5633 RS 150	<4	210	100	145	10	4	6
5633 RS 151	6	130	50	64	8	6	<4
5633 RS 152	4	190	90	150	6	4	<4
5633 RS 156	<4	115	30	105	6	<4	8
5633 RS 157	<4	320	120	410	10	8	8
5633 RS 158	4	260	90	590	4	<4	4
5633 RS 159	<4	140	70	860	<4	<4	6
5633 RS 161	<4	125	70	790	<4	<4	4
5633 RS 165	<4	270	70	400	<4	<4	10
5633 RS 166	<4	180	80	450	<4	<4	8
5633 RS 167	6	330	140	195	6	<4	4
5633 RS 168	<4	115	<20	20	<4	<4	<4
5633 RS 169	<4	92	50	520	<4	4	6
5633 RS 171	14	240	60	360	<4	4	12
5633 RS 172	<4	290	90	175	6	<4	4
5633 RS 173	<4	66	40	380	4	<4	<4
5633 RS 174	6	175	70	50	<4	6	<4
5633 RS 175	8	82	20	26	10	10	6
5633 RS 176	4	80	20	22	22	<4	6
5633 RS 177	8	160	70	105	10	<4	4
5633 RS 178	<4	100	40	58	14	4	6
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SCHEME	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1

Job: 9AD0849
O/N: AC 2602/89

ANALYTICAL REPORT

SAMPLE	Sn	Zr	Ce	Sr	U	Bi	Sb
5633 RS 179	4	185	60	6	<4	<4	4
5633 RS 182	12	100	30	60	8	4	10
5633 RS 183	<4	125	50	250	4	<4	10
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SCHEME	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1

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Job: 9AD0849
O/N: AC 2602/89

ANALYTICAL REPORT

SAMPLE	Ag	Au
5633 RS 146	<1	<0.02
5633 RS 147	<1	<0.02
5633 RS 148	L.N.R.	L.N.R.
5633 RS 149	1	<0.02
5633 RS 150	<1	<0.02
5633 RS 151	<1	<0.02
5633 RS 152	1	<0.02
5633 RS 156	1	<0.02
5633 RS 157	1	<0.02
5633 RS 158	1	<0.02
5633 RS 159	1	<0.02
5633 RS 161	1	<0.02
5633 RS 165	2	<0.02
5633 RS 166	1	<0.02
5633 RS 167	1	<0.02
5633 RS 168	<1	<0.02
5633 RS 169	1	<0.02
5633 RS 171	1	<0.02
5633 RS 172	1	<0.02
5633 RS 173	1	<0.02
5633 RS 174	<1	<0.02
5633 RS 175	<1	<0.02
5633 RS 176	1	<0.02
5633 RS 177	1	<0.02
5633 RS 178	<1	<0.02
UNITS	ppm	ppm
SCHEME	AAS2	AAS8

Job: 9AD0849
O/N: AC 2602/89

ANALYTICAL REPORT

SAMPLE	Ag	Au
5633 RS 179	<1	<0.02
5633 RS 182	<1	<0.02
5633 RS 183	2	<0.02
UNITS	ppm	ppm
SCHEME	AAS2	AAS8

APPENDIX B

PETROLOGICAL DESCRIPTIONS

THIN SECTION: TSC 51797

STRATIGRAPHIC UNIT: $\text{Ɛ}\beta_3$

ROCK NAME: Dolerite

LOCALITY: 2565/009/1

FIELD RELATIONSHIPS:

A medium-grained dolerite intruding porphyritic rhyolite (ƐV).

THIN SECTION DESCRIPTION:

Medium-grained laths of plagioclase with intergranular clinopyroxene, opaques and ?olivine. The plagioclase is typically zoned and subhedral. The intergranular pyroxene and ?olivine has been substantially altered, with development of abundant opaques and ?clays. Opaques are typically skeletal, replacing both mafics and plagioclase.

Several clinopyroxene grains are ophitic within plagioclase. Several clusters of plagioclase appear to have grown in radiating spherulites.

Modal Analysis

Plagioclase	65%
Opaques	30%
Clinopyroxene	2%
?Clays	3%
Olivine	trace

TSC 51798 5633 RS 146

STRATIGRAPHIC UNIT: Ev

ROCK NAME: Porphyritic rhyolite

LOCALITY: 2565/009/2

FIELD RELATIONSHIPS:

Phenocryst-rich rhyolite, with weak foliation S_1 760/90. Phenocrysts approximately 1:1 quartz:feldspar in hand specimen.

THIN SECTION DESCRIPTION:

The specimen consists of abundant fine- to medium-grained phenocrysts of quartz, orthoclase and plagioclase within a microcrystalline groundmass of quartz + feldspar.

The plagioclase and orthoclase phenocrysts are typically euhedral to subhedral, with variable degrees of sericitisation. Several phenocrysts have recrystallised rims of quartz + feldspar. Quartz phenocrysts are typically embayed, and also exhibit undulose extinction and minor subgrain development, suggesting the rhyolite has undergone weak deformation. Minor muscovite is associated with the feldspar phenocrysts. Very fine-grained zircon occurs in trace amounts within the orthoclase phenocrysts. Minor chlorite occurs as a secondary mineral. The phenocrysts compose 20% of the rock.

Minor opaques occur as fine- to medium-grained euhedral phenocrysts. Highly-altered anhedral and fractured olivine phenocrysts are rare.

Minor elongate zones within and slightly coarser-grained then the groundmass may be recrystallised fiammé.

No compositional layering is evident in thin section, although a very weak foliation defined by the alignment of very fine-grained biotite/chlorite ± opaques is evident.

Modal Analysis

Phenocrysts:		Groundmass:	
Quartz	8%	Quartz+Feldspar	98%
Orthoclase	7%	Sericite+Muscovite	1%
Plagioclase	4%	Biotite+Chlorite	1%
Opaques	1%		
Olivine	trace		
Zircon	trace		

THIN SECTION: TSC 51799 5633 RS 147

STRATIGRAPHIC UNIT: $Pβ_3$

ROCK NAME: Dolerite

LOCALITY: 2565/009/3

FIELD RELATIONSHIPS:

Loose beach cobble of dolerite/diorite amongst in situ outcrop of acid volcanics.

THIN SECTION:

The specimen consists of medium- to coarse-grained, zoned plagioclase laths with intergranular clinopyroxene + orthopyroxene + opaques. The pyroxenes have undergone minor alteration, with development of fine-grained opaques + biotite. Elongate skeletal opaque grains have overgrown both plagioclase and pyroxene grains.

Minor subhedral medium-grained olivine has undergone alteration to produce opaques + iddingsite.

Minor sericite occurs as an alteration product within the core of many plagioclase laths. Many of the plagioclase laths exhibit oscillatory zoning.

Modal Analysis

Plagioclase	66%
Clinopyroxene+ Orthopyroxene	15%
Opaques	15%
Olivine	3%
Biotite	1%
Iddingsite	trace
Sericite	trace

THIN SECTION: TSC 51800 5633 RS 149

STRATIGRAPHIC UNIT: Ꝑβ_3

ROCK NAME: Diorite

LOCALITY: 2565/009/5

FIELD RELATIONSHIPS:

Fine-grained diorite/dolerite intruding porphyritic rhyolite (Ꝑv).

THIN SECTION DESCRIPTION:

The specimen is slightly phenocrystic, with minor coarse-grained plagioclase laths surrounded by medium-grained plagioclase laths with intergranular orthopyroxene. The orthopyroxene has undergone substantial alteration, with abundant growth of fine vesicular opaques. Some medium-grained plagioclase laths are subophitic within the pyroxene grains. The plagioclase laths are rimmed by albite, with the cores exhibiting substantial sericitisation.

Opaques also occur as euhedral, equant grains interstitial to the plagioclase. Olivine occurs as uncommon subhedral phenocrysts subophitic to the coarse-grained plagioclase laths. The olivine is typically substantially altered, with rims of iddingsite. Minor embayed grains of sphene are associated with olivine.

The sequence of crystallisation is interpreted as (plagioclase-olivine-plagioclase) - pyroxene-opaques.

Modal Analysis

Plagioclase	70%
Pyroxene	25%
Opaques	4%
Olivine	1%
Iddingsite	trace
Sphene	trace
Sericite	trace

THIN SECTION: TSC 51801 — 5633 RS 150

STRATIGRAPHIC UNIT: Ᵽv

ROCK NAME: Agglomeratic porphyritic rhyolite

LOCALITY: 2565/009/5

FIELD RELATIONSHIPS:

Loose beach cobble of porphyritic rhyolite amongst in situ outcrop. Has agglomeratic texture, and evidence of flattened fiammé.

THIN SECTION DESCRIPTION:

The specimen is a porphyritic rhyolite, with abundant phenocrysts and polycrystalline aggregates within a microcrystalline groundmass of quartz + feldspar + minor opaques.

The phenocrysts, which comprise 25% of the specimen, include medium-grained and weakly embayed quartz, sericitised orthoclase and skeletal opaque pseudomorphs after ?pyroxene. The presence of undulose extinction and subgrain development within the quartz phenocrysts indicates that the specimen has undergone weak deformation.

A compositional layering is defined by the alignment of elongate aggregates of recrystallised fine-grained quartz, which may represent recrystallised fiammé.

Subangular microcrystalline aggregates of quartz + ?sericite may represent recrystallised tuffaceous fragments.

Modal Analysis

Quartz	20%
Feldspar	20%
Microcrystalline groundmass	55%
Opaques	3%
Sericite	2%

THIN SECTION: TSC 51802 5633 RS 151

STRATIGRAPHIC UNIT: Ꝑv

ROCK NAME: rhyolite

LOCALITY: 2565/009/5

FIELD RELATIONSHIPS:

Loose beach cobble of banded, porphyritic rhyolite amongst in situ outcrop.

THIN SECTION DESCRIPTION:

The specimen is a porphyritic rhyolite, with abundant (30%) phenocrysts (up to 4 mm wide) within a microcrystalline groundmass of quartz + feldspar + minor opaques + ?sericite.

The phenocrysts are dominantly quartz (60%), orthoclase (30%) and pseudomorphs after ?pyroxene (10%). Quartz phenocrysts are euhedral to subhedral and commonly embayed. Many of the quartz phenocrysts exhibit evidence of deformation, including undulose extinction, subgrain development and recrystallisation to polycrystalline aggregates with lobate grain boundaries.

Orthoclase phenocrysts are typically euhedral to subhedral and sericitised. Aggregates of opaques + mica are interpreted as pseudomorphs after ?pyroxene.

The microcrystalline groundmass exhibits a compositional banding defined by bands of slightly varying grain size. This banding parallels a fabric defined by very-fine-grained elongate aggregates of quartz. The fabric could be an original layering or a superimposed deformational foliation.

Modal Analysis

Quartz	18%
Orthoclase	9%
Opaques + mica	3%
Groundmass	68%
Sericite	2%

THIN SECTION: TSC 51803 5633 RS 152

STRATIGRAPHIC UNIT: Ev

ROCK NAME: Rhyolite

LOCALITY: 2565/009/5

FIELD RELATIONSHIPS:

Loose beach cobble of banded porphyritic rhyolite amongst in situ outcrop.

THIN SECTION DESCRIPTION:

The specimen is a highly porphyritic rhyolite, with abundant (30%) phenocrysts (up to 6 mm wide) within a microcrystalline groundmass of quartz + feldspar + opaques + sericite.

Quartz phenocrysts are euhedral to subhedral, commonly embayed and typically fractured, with undulose extinction and subgrain development. Feldspar phenocrysts are intensely sericitised, euhedral to subhedral and contain small inclusions of quartz, mica and opaques. Several phenocrysts consist of opaques + ?chlorite + sericite, and are pseudomorphs after ?pyroxene. Muscovite occurs as medium grains associated with aggregates of fine-grained quartz and ?albite.

Several zones of the groundmass appear rimmed by slightly coarser-grained quartz, suggesting that they represent agglomeratic clasts.

The specimen is cut by several narrow microveins infilled by quartz. Uncommon fine-grained euhedral opaques have overgrown both the groundmass and feldspar phenocrysts.

Modal Analysis

Feldspar	20%
Quartz	8%
Opaques+mica	2%
Groundmass	70%

THIN SECTION: TSC 51804 5633 RS 155

STRATIGRAPHIC UNIT: Plγ_2

ROCK NAME: Quartzofeldspathic gneiss

LOCALITY: 2565/009/9

FIELD RELATIONSHIPS:

Fine- to medium-grained pink granite gneiss with very little mica. Moderate foliation S 000/80W. Very homogeneous. Some leucocratic veins (2 cm wide) parallel to S. ?Sheared version of Plγ_2 pink granite.

THIN SECTION DESCRIPTION:

The specimen is a fine- to medium-grained gneiss, with quartz+microcline forming a granoblastic-elongate framework.

Microcline occurs both as fine matrix grains and as medium-grained aggregates with minor quartz and myrmekite, forming elongate megacrystic aggregates with tails of quartz + microcline slightly coarser-grained than the matrix. Quartz occurs principally as fine matrix grains, with ubiquitous undulose extinction. Grain boundaries vary from curved to lobate.

A gneissic foliation is defined by the elongate megacrysts and tails, plus a preferred orientation of slightly elongate matrix grains. Fine-grained opaques are also elongate parallel to the foliation. Muscovite occurs as ragged medium-grained plates. Many of the grains are elongate parallel to the foliation, while the majority post-date the foliation and have random orientations. Medium-grained opaques are associated with many of the muscovite grains.

Medium-grained anhedral green spinel occurs as a trace mineral.

Modal Analysis

Microcline	50%
Quartz	40%
Muscovite	5%
Opaques	5%
Spinel	trace

THIN SECTION: TSC 51805 5633 RS 156

STRATIGRAPHIC UNIT: $P\gamma_2$

ROCK NAME: Fine-grained granite

LOCALITY: 2565/009/10

FIELD RELATIONSHIPS:

Pink medium-grained granite gneiss with minor muscovite. S 172/75W. On E side of outcrop is comagmatically intruded by massive, unfoliated grey granite (5633 RS 157).

THIN SECTION DESCRIPTION:

The specimen consists of fine to medium-grained quartz + microcline + plagioclase with granoblastic to weakly granoblastic-elongate texture. Grain boundaries are typically curved to weakly lobate. Aggregates of medium-grained quartz + muscovite + microcline are common. Medium-grained biotite is uncommon, and is associated with fine-grained opaques, rare medium-grained subhedral garnet and muscovite.

A weak foliation is defined by a weak preferred orientation of the matrix grains and the megacrystic aggregates.

Modal Analysis

Microcline	40%
Quartz	30%
Plagioclase	10%
Muscovite	10%
Biotite	5%
Opaques	3%
Garnet	2%

THIN SECTION: TSC 51806 5633 RS 157

STRATIGRAPHIC UNIT: $P\gamma_3$

ROCK NAME: Medium-grained granite.

LOCALITY: 2565/009/10

HAND SPECIMEN: Unfoliated grey granite, intrudes pink granite gneiss (5633 RS 156)

THIN SECTION DESCRIPTION:

The specimen is a medium-grained granoblastic granite, with quartz + microcline + minor plagioclase exhibiting lobate grain boundaries. Muscovite and biotite occur as medium-grained ragged plates. Biotite is commonly intergrown with fine-grained euhedral to anhedral opaques, and also contains inclusions of very-fine-grained zircon. Anhedral opaques also occur in association with quartz + feldspar. Plagioclase is commonly sericitised.

Quartz and feldspar exhibit undulose extinction and subgrain development, indicating the granite has undergone weak deformation.

Plagioclase grains have undergone partial sericitisation.

Modal Analysis

Microcline	35%
Quartz	35%
Plagioclase	10%
Muscovite	10%
Biotite	5%
Opaques	5%
Zircon	trace

THIN SECTION: TSC 51807 5633 RS 158

STRATIGRAPHIC UNIT: $Рγ_2$

ROCK NAME: Granodiorite

LOCATION: 2565/009/13

FIELD RELATIONSHIPS:

Banded pink granodiorite gneiss - in contact with unfoliated grey hornblendes-rich clotted granodiorite. At the contact the pink gneiss is melanocrative and layered.

THIN SECTION DESCRIPTION:

The specimen is a fine-grained, weakly-foliated granodiorite, with uncommon megacrysts of microcline and plagioclase within a matrix of fine-to medium-grained quartz + microcline + plagioclase + biotite. Anhedral fine- to medium-grained opaques are scattered throughout the matrix. The coarse feldspar megacrysts are partially sericitised, with minor muscovite inclusions. Several microcline grains exhibit zoning, with sericitisation restricted to the cores.

The matrix grains of quartz and feldspar exhibit lobate grain boundaries, undulose extinction, subgrain development and minor new-grain recrystallisation.

A weak foliation is defined by biotite-rich and biotite-poor layers, and a weak preferred orientation of the biotite.

Zircon occurs as a trace mineral, associated with biotite.

Modal Analysis

Plagioclase	30%
Microcline	30%
Quartz	25%
Biotite	10%
Opaques	2%
Muscovite	2%
Sericite	1%
Zircon	trace

THIN SECTION: TSC 51808 5633 RS 159

STRATIGRAPHIC UNIT: $\text{Ɛ}\gamma_3$

ROCK NAME: Hornblende granodiorite.

LOCALITY: 2565/009/13

FIELD RELATIONSHIPS:

"Clotted" hornblende granodiorite intruding pink granite gneiss (5633 RS 158).

THIN SECTION DESCRIPTION:

The specimen is a medium-grained granodiorite, with abundant equigranular microcline + plagioclase and finer-grained quartz. Plagioclase is typically sericitised. Microcline grains commonly contain a recognisable sericitised core of orthoclase.

Medium-grained biotite and green-blue hornblende is common, with associated medium-grained opaques and euhedral to subhedral sphene. Several sphene grains contain inclusions of plagioclase. Hornblende has been partially replaced by biotite. Zircon and epidote occur as trace minerals.

No tectonic fabric is evident.

Model Analysis

Plagioclase	28%
Microcline	25%
Quartz	25%
Hornblende	10%
Biotite	5%
Opaques	5%
Sphene	1%
Sericite	1%
Zircon	trace
Epidote	trace

THIN SECTION: TSC 51809 5633 RS 160

STRATIGRAPHIC UNIT: Ɛβ_1

ROCK NAME: Diorite

LOCALITY: 2565/009/13

FIELD RELATIONSHIP:

Fine- to medium-grained xenolith within the hornblende granodiorite (Ɛγ_3: 5633 RS 159).

THIN SECTION DESCRIPTION:

This specimen is a hornblende-rich xenolith within the hornblende granodiorite (Ɛγ_3). It consists of coarse-grained subhedral megacrysts of plagioclase and microcline intergrown with medium-grained quartz and hornblende. Feldspar grains are partially sericitised.

Hornblende grains are commonly zoned, with inclusion-rich cores. Sphene, epidote and opaques are associated with the hornblende. Biotite has partially replaced hornblende. One hornblende grain has a fine core inclusion of orthopyroxene. No tectonic fabric is evident.

Modal Analysis

Microcline	30%
Plagioclase	25%
Hornblende	25%
Quartz	12%
Opaques	5%
Biotite	3%
Sphene	trace
Epidote	trace
Orthopyroxene	trace

THIN SECTION: TSC 51810 5633 RS 161

STRATIGRAPHIC UNITE: Pβ$_1$

ROCK NAME: Amphibolite

LOCALITY: 2565/009/15

HAND SPECIMEN:

Medium- to coarse-grained amphibolite xenolith within hornblende granodiorite (Pγ$_3$). Xenolith is elongate.

THIN SECTION DESCRIPTION:

This specimen occurs as a xenolith within Pγ$_3$. Medium-to coarse-grained subhedral plagioclase laths are intergrown with fine-to medium-grained hornblende, plus minor quartz. Plagioclase has been partially sericitised. Hornblende has been partially replaced by fine-to medium-grained biotite opaques. Zircon, epidote and splene occur in trace amounts.

A weak tectonic fabric is defined by a partial preferred orientation of hornblende grains.

Modal Analysis

Plagioclase	40%
Hornblende	40%
Quartz	10%
Biotite	5%
Opaques	5%
Sphene	trace
Epidote	trace
Zircon	trace

THIN SECTION: TSC 51811 5633 RS 165

STRATIGRAPHIC UNIT: Ɇβ_1

ROCK NAME: Diorite

LOCALITY: 2565/009/21

HAND SPECIMEN:

Insitu body of diorite. In contact with hornblende granodiorite (Ɇγ_3).

THIN SECTION DESCRIPTION:

This specimen consists of medium- to coarse-grained plagioclase laths with intergranular medium-grained clinopyroxene and orthopyroxene. Intergranular medium-grained opaques contain inclusions of pyroxene and plagioclase. Pyroxene has been partially replaced by poikilitic hornblende, with associated minor fine-grained biotite + opaques.

Plagioclase has been partially sericitised. Several plagioclase laths are subophitic within clinopyroxene grains. The crystallisation sequence is interpreted as: plagioclase - clinopyroxene + orthopyroxene - opaques - hornblende + biotite.

Modal Analysis

Plagioclase	60%
Clinopyroxene	20%
Orthopyroxene	10%
Opaques	5%
Hornblende	5%
Biotite	trace
Sericite	trace

THIN SECTION: TSC 51812 5633 RS 166

STRATIGRAPHIC UNIT: $Ꝑ\beta_1$

ROCK NAME: Diorite

LOCALITY: 2565/009/29

FIELD RELATIONSHIPS:

Narrow (0.5m wide) dyke of diorite intruding $Ꝑ\gamma_2$ and $Ꝑ\gamma_4$. On east side of dyke contact is sharp with the prink granite ($Ꝑ\gamma_2$). On west side the contact is agmatitic, with intermingling of diorite and porphyritic granodiorite ($Ꝑ\gamma_4$). The dyke is foliated, S 020/90.

THIN SECTION DESCRIPTION:

The specimen consists of fine-grained quartz + feldspar + biotite, with minor fine- to medium-grained hornblende. The quartz and feldspar are equigranular, with curved to lobate grain boundaries. Undulose extinction is common within quartz. Feldspar is typically partially sericitised.

Biotite occurs as fine-grained laths replacing hornblende, with the laths defining a moderate-intensity foliation. Fine-grained anhedral to subhedral opaques are common. Fine-grained anhedral epidote occurs in association with hornblende.

Modal Analysis

Feldspar	50%
Quartz	35%
Biotite	10%
Opaques	3%
Hornblende	1%
Epidote	1%

THIN SECTION: TSC 51813 5633 RS 167

STRATIGRAPHIC UNIT: $P\gamma_4$

ROCK NAME: Adamellite

LOCALITY: 2565/009/29

FIELD RELATIONSHIPS:

Grey phenocrystic granodiorite/adamellite intruded by diorite dyke (5633 RS 166). The granodiorite backveins and disrupts the dyke. The granodiorite also intrudes the pink ademellite $P\gamma_2$. The granitoids are foliated: S 010/90 to 020/90.

THIN SECTION DESCRIPTION:

The specimen is a medium-grained adamellite, with medium- to coarse-grained phenocrysts of plagioclase and microcline. The matrix consists of fine-to medium-grained quartz + microcline + plagioclase, with minor opaques, sphene, biotite and trace fluorite.

The feldspar phenocrysts commonly exhibit sericitised cores and fresh rims. Sphene occurs as euhedral prisms associated biotite + opaques. Trace fine-grained zircon occurs as inclusions within biotite. Minor chlorite has replaced biotite.

A weak foliation is defined by minor elongate aggregates of quartz plus a weak preferred orientation of biotite and sphene grains. Quartz exhibits undulose extinction, subgrain development and minor recrystallisation.

Modal Analysis

Microcline	35%
Plagioclase	35%
Quartz	25%
Biotite	2%
Sphene	2%
Opaques	1%
Fluorite	trace
Zircon	trace
Sericite	trace

THIN SECTION: TSC 51814 5633 RS 168

STRATIGRAPHIC UNIT: $E\gamma_2$

ROCK NAME:

LOCALITY: 2565/009/29

FIELD RELATIONSHIPS:

Pink granite/adamellite intruded by porphyritic granodiorite (5633 RS 167) and diorite dyke (5633 RS 166).

THIN SECTION DESCRIPTION:

The specimen is a medium-grained equigranular granodiorite. Quartz + plagioclase + microcline exhibit straight, curved and lobate grain boundaries. Fine-grained opaques and biotite occur in narrow bands, defining a weak foliation.

Quartz grains exhibit undulose extinction and subgrain development. Feldspar grains exhibit minor polygonal subgrain development.

Modal Analysis

Microcline	33%
Plagioclase	33%
Quartz	30%
Biotite	2%
Opaques	2%

THIN SECTION: TSC 51815 5633 RS 169

STRATIGRAPHIC UNIT: Ɇβ_1

ROCK NAME: Amphibolite

LOCALITY: 2565/009/30

FIELD RELATIONSHIPS:

Foliated amphibolite dyke comagmatically intruding porphyritic granodiorite (Ɇγ_4). S 067/69N. The amphibolite is folded and lineated - L 012/66. The amphibolite is backveined by the granodiorite, with hybridisation along contacts.

THIN SECTION DESCRIPTION:

The specimen is a fine-grained, foliated amphibolite, consisting of fine-grained hornblende and sericitised plagioclase. Hornblende grains define a preferred-orientation fabric. Fine-grained opaques and epidote occur throughout the specimen. Garnet occurs in trace amounts. Rare muscovite plates appear to be replacing plagioclase.

Modal Analysis

Plagioclase	47%
Hornblende	45%
Opaques	2%
Epidote	1%
Sericite	5%
Garnet	trace
Muscovite	trace

THIN SECTION: TSC 51816 5633 RS 171

STRATIGRAPHIC UNIT: Ɛβ$_3$

ROCK NAME: Diorite

LOCALITY: 2565/009/37.1

FIELD RELATIONSHIPS:

Massive medium-grained diorite to gabbro intruding granodiorite. Granodiorite is sheared and foliated close to margin.

THIN SECTION DESCRIPTION:

Medium- to coarse-grained plagioclase laths are intergrown with intergranular orthopyroxene and clinopyroxene. Several plagioclase grains are subophitic within pyroxene. Medium-grained subhedral opaques occur both intergranular to plagioclase and with hornblende replacing pyroxene. Orthopyroxene is commonly rimmed by clinopyroxene. Minor biotite occurs with hornblende.

The crystallisation sequence is interpreted as: plagioclase - orthopyroxene - clinopyroxene - opaques - hornblende + biotite.

Modal Analysis

Plagioclase	60%
Clinopyroxene	25%
Orthopyroxene	8%
Opaques	5%
Hornblende	2%
Biotite	trace

THIN SECTION: TSC 51817 5633 RS 172

STRATIGRAPHIC UNIT: ?Ᵽγ_2

ROCK NAME: Foliated granite

LOCALITY: 2565/009/38

FIELD RELATIONSHIPS:

Streaky gneiss with xenoliths of diorite (Ᵽβ_1). The gneiss is most likely sheared version of Ᵽγ_2 and Ᵽγ_3.

THIN SECTION DESCRIPTION:

The specimen is a fine-grained granite with a weak foliation defined by vague compositional layering and a weak preferred orientation of minor pyroxene and biotite grains.

Quartz, plagioclase and orthoclase are equigranular, and exhibit straight, curved and weakly-lobate grain boundaries. Feldspar grains are typically sericitised. Quartz exhibits undulose extinction and minor subgrain development. Fine-grained opaques are associated with the minor pyroxene and biotite grains.

Modal Analysis

Quartz	35%
Plagioclase	35%
Orthoclase	20%
Clinopyroxene	5%
Opaques	3%
Biotite	2%

THIN SECTION: TSC 51818 5633 RS 173

STRATIGRAPHIC UNIT: Ɇβ1

ROCK NAME: Amphibolite

LOCALITY: 2565/009/38

FIELD RELATIONSHIPS:

Xenolith within streaky, sheared gneiss (5633 RS 172).

THIN SECTION DESCRIPTION:

The specimen is a moderately-well foliated amphibolite. Fine- to medium-grained hornblende and sericitised plagioclase form a granoblastic-elongate texture. Fine-grained opaques + biotite are associated with hornblende. Anhedral remnants of clinopyroxene exhibit replacement by hornblende opaques. Several coarse aggregates of hornblende + opaques pseudomorph original clinopyroxene phenocrysts.

Modal Analysis

Plagioclase	45%
Hornblende	45%
Clinopyroxene	8%
Opaques	2%
Biotite	trace

THIN SECTION: TSC 51819 5633 RS 174

STRATIGRAPHIC UNIT: ?$\text{Е}\gamma_2$

ROCK NAME: Granite

LOCALITY: 2565/009/40

THIN SECTION DESCRIPTION:

The specimen is a fine-grained granite gneiss with equigranular quartz + microcline + plagioclase forming a granoblastic texture. Grain boundaries are straight to curved. Minor fine-grained muscovite occurs as randomly-oriented plates. A weak gneissic foliation is defined by elongate quartz-rich aggregates. Minor medium-grained aggregates of microcline occur.

The specimen is interpreted as a gneissic, grain-refined granite (Еγ_2?), with a polygonal, granoblastic texture suggesting thermal annealing post-deformation.

Modal Analysis

Quartz	30%
Plagioclase	35%
Microcline	30%
Muscovite	2%
Sericite	1%
Opaques	2%

THIN SECTION: TSC 51820 5633 RS 175

STRATIGRAPHIC UNIT: $E\gamma h_2$

ROCK NAME: Granite

LOCALITY: 2565/011/1

FIELD RELATIONSHIPS:

Grey to pink homogeneous granite with approx. 1% biotite. Contains several pods of pegmatite.

THIN SECTION DESCRIPTION:

The specimen is a medium-grained, equigranular granite, with quartz + plagioclase + microcline exhibiting curved to lobate grain boundaries. Plagioclase is commonly sericitised. Minor hornblende + opaques + biotite occur as fine- to medium grains scattered throughout the specimen.

Quartz typically displays undulose extinction and subgrain development, indicating minor deformation during or post-intrusion. Minor chlorite has partially replaced biotite.

Modal Analysis

Plagioclase	35%
Quartz	35%
Microcline	27%
Hornblende	1%
Biotite	1%
Opaques	1%
Sericite	trace
Chlorite	trace

THIN SECTION: TSC 51821 5633 RS 176

STRATIGRAPHIC UNIT: $P\gamma h_1$

ROCK NAME: Granodiorite

LOCALITY: 2565/011/5

FIELD RELATIONSHIPS:

Grey granite-adamellite with abundant pyrite.

THIN SECTION DESCRIPTION:

The specimen consists of equigranular, medium-grained quartz + plagioclase + microperthitic orthoclase. Grain boundaries are consertal. Quartz grains exhibit undulose extinction and minor subgrain development. Minor biotite occurs as randomly-oriented plates associated with fine-grained opaques. The biotite has been partially altered to chlorite.

Feldspar grains contain minor fine-grained inclusions of muscovite, and are partially sericitised. Minor medium- to coarse-grained subhedral orthoclase phenocrysts contain fine-grained subhedral laths of plagioclase.

Modal Analysis

Quartz	30%
Plagioclase	30%
Orthoclase	34%
Biotite	2%
Chlorite	2%
Muscovite	1%
Opaques	1%
Sericite	trace
Apatite	trace

THIN SECTION: TSC 51822 5633 RS 177

STRATIGRAPHIC UNIT: Eγh$_1$

ROCK NAME: Porphyritic granodiorite

LOCALITY: 2565/011/7

FIELD RELATIONSHIPS:

Adamellite-granodiorite with phenocrysts. Abundant pyrite.

THIN SECTION DESCRIPTION:

The specimen contains phenocrysts consisting of aggregates of coarse-grained quartz within a fine- to medium-grained granoblastic matrix of quartz + microcline + subhedral plagioclase laths.

Plagioclase is commonly zoned, with sericitised cores and relatively fresh albitic rims. Both quartz and microcline contain fine- to medium-grained subhedral inclusions of plagioclase. Grain boundaries are curved to weakly consortial. Chlorite (after biotite), fine-grained opaques and muscovite occur as intergranular aggregates. Rare anhedral epidote is associated with chlorite.

Modal Analysis.

Microcline	30%
Quartz	35%
Plagioclase	30%
Chlorite	3%
Opaques	2%
Muscovite	trace
Biotite	trace
Epidote	trace

THIN SECTION: TSC 51823 5633 RS 178

STRATIGRAPHIC UNIT: $Ꞓγh_1$

ROCK NAME: Porphyritic adamellite

LOCALITY: 2565/011/11

FIELD RELATIONSHIPS:

Porphyritic granite, near contact with leucocratic even-grained granite ($Ꞓγh_2$).

THIN SECTION DESCRIPTION:

The specimen consists of medium- to coarse-grained phenocrysts of plagioclase, microcline and quartz within a fine- to medium-grained matrix of quartz + plagioclase + microcline + biotite. Plagioclase phenocrysts exhibit both normal and oscillatory zoning, and are partially sericitised. One quartz phenocryst exhibits a radiating graphic intergrowth with microcline. Quartz grains are typically unstrained. Many quartz phenocrysts contain abundant fine-grained feldspar inclusions around their rims.

Biotite occurs both as medium-grained ragged plates and as fine-grained laths both interstitially and within the feldspar grains. Minor opaques occur as inclusions within biotite. Chlorite has partially replaced biotite.

Modal Analysis

Plagioclase	25%
Quartz	35%
Microcline	35%
Biotite	3%
Chlorite	2%
Opaques	trace

THIN SECTION: TSC 51824

STRATIGRAPHIC UNIT: Ᵽγh_2

ROCK NAME: Granite

LOCALITY: 2565/011/13

FIELD RELATIONSHIPS:

Pink-red coarse-grained granite, grading to even-grained granite. Contains minor diorite xenoliths.

THIN SECTION DESCRIPTION:

The specimen is a medium- to coarse-grained granite, with coarse-grained orthoclase + plagioclase + quartz, plus medium-grained biotite/chlorite + opaques + minor epidote. Plagioclase grains are commonly zoned. Feldspar is typically sericitised. Grain boundaries are curved to weakly lobate.

Aggregates of chlorite + opaques replacing biotite occur interstitial to the feldspar and quartz grains.

Modal Analysis

Quartz	26%
Orthoclase	40%
Plagioclase	30%
Chlorite	2%
Opaques	1%
Biotite	1%
Epidote	trace

THIN SECTION: TSC 51825 5633 RS 182

STRATIGRAPHIC UNIT: Ᵽγh_3

ROCK NAME: Porphyritic granite

LOCALITY: 2565/084/4

FIELD RELATIONSHIPS:

Grey to pink porphyritic leucocratic granite with up to 40% feldspar phenocrysts. Very low % of mafics. Intrudes Lincoln Complex granitoids.

THIN SECTION DESCRIPTION:

Coarse-grained microcline phenocrysts within a fine- to medium-grained matrix of quartz + microcline + plagioclase. The phenocrysts are cut by fractures along which fine grains have recrystallised. The matrix tends to be fine-grained along the margin of the phenocrysts. Quartz in the matrix has lobate to weakly serrate grain boundaries, and exhibits ubiquitous subgrain development.

Minor fine- to medium-grained biotite + opaques + sphene occurs as aggregates within the matrix.

Modal Analysis

Microcline	50%
Quartz	36%
Plagioclase	10%
Biotite	2%
Opaques	2%
Sphene	trace

THIN SECTION: TSC 51826 5633 RS 183

STRATIGRAPHIC UNIT: $Ꞓ\beta_1$

ROCK NAME: Amphibolite

LOCALITY: 2565/009/12

FIELD RELATIONSHIPS:

Boudinaged diorite dyke within pink granite gneiss ($Ꞓ\gamma_2$). Strike 004/85W. Have hybrid granodiorite zone on margin of dyke.

THIN SECTION DESCRIPTION:

Fine- to medium-grained hornblende + biotite + chlorite + opaques + sericitised plagioclase forming a granoblastic-elongate amphibolite. Grain boundaries are ragged to serrate, and grains are typically anhedral. A moderate-intensity foliation is defined by the preferred orientation of biotite + chlorite + hornblende. Clinopyroxene occurs as anhedral remnants being replaced by hornblende + opaques. Minor quartz occurs within the matrix.

The specimen is interpreted as a deformed diorite/dolerite.

Model Analysis

Plagioclase (sericitised)	40%
Chlorite	15%
Hornblende	15%
Biotite	15%
Opaques	10%
Clinopyroxene	5%

APPENDIX C

STRUCTURAL DATA

Location	Feature	Stratigraphic Unit	Orientation
	ST PETER ISLAND		
2565/009/1	joint	Ea	320/90
	"	"	082/24 N
	"	"	006/90
	"	"	048/62
	foliation	"	006/80 W
2565/009/2	joint	"	052/40 SE
	foliation	"	170/90
2565/009/5	joint	"	323/80 NE
	"	"	102/90
	"	"	020/30 W
	foliation	"	008/80 E
2565/009/8	foliation	$E\gamma_2$	000/80 W
2568/009/10	"	"	172/75 W
2565/009/12	dyke	$E\beta_1$	004/85 W
2565/009/13	foliation	$E\gamma_2$	176/87 W
2565/009/14	foliation	$E\gamma_3$	002/84 W
	xenolith elongation	$E\beta_1$	002/86 W
2565/009/15	shear zones	$E\gamma_3$	066/74 N
	"	"	090/61 N
2565/009/16	foliation	$E\gamma_3$	148/80 N
	joint	"	080/75 N
	"	"	150/65 SW
2565/009/20	aplite dyke	$E\gamma_6$	140/90
2565/009/23	" "	"	107/78 S
	shear zone	$E\gamma_3$	000/80 W
2565/009/25	aplite dyke	$E\gamma_6$	100/80 S
	shear zone	$E\gamma_3$	018/80 W
		"	130/80 SW
2565/009/28	foliation	$E\gamma_2$	018/90
2565/009/29	dyke	$E\beta_1$	020/90
	foliation	$E\gamma_4$	010/90
	"		020/90
2565/009/30	foliation	$E\beta_1$	067/69 N
	lineation	$E\beta_1$	012/66
	foliation	$E\gamma_4$	130/75 SSW
	foliation	$E\beta_1$	150/60 NE

2565/009/32	foliation (mylonitic?)	$P\gamma_2$?	098/80 N
	shear zone	"	088/54 N
2565/009/34	foliation	$P\gamma_4$	010/80 W
	foliation	$P\gamma_4$	175/85 W
	shear zone	"	000/80 W
2565/009/36	foliation (mylonitic?)	$P\gamma_4$	166/85 W
	" "	"	120/80 N

BIRD ROCK

2565/084/4	foliation	$P\gamma_2$	028/90

GOAT ISLAND

2565/011/1	joint	$P\gamma h_1$	130/90
	"	"	052/90
	"	"	000/90
2565/011/2	quartz vein	$P\gamma h_1$	162/90
2565/011/3	" "	"	004/47 E
2565/001/8	joint	$P\gamma h_1$	000/90

CAPE BEAUFORT

2565/084/1	foliation	$P\gamma_2$	072/90
	foliation (mylonitic?)	"	170/90
2565/084/4	foliation	$P\gamma_2$	130/70 NE
2565/086/7	"	$P\gamma_2$	050/90
2565/086/8	foliation (mylonitic?)	$P\gamma_2$	058/90
2565/086/10	" "	$P\gamma_2$	086/90

APPENDIX D

HEAVY MINERAL SAND ASSAY

amdel

DETERMINATION OF HEAVY MINERAL CONTENT AND MINERALOGY

1. INTRODUCTION

A beach sand sample was received from Ms. A. Reed of Amdel Limited, Frewville with a request for determination of the heavy mineral content and mineralogy. The sample was labelled 5633 RS154.

2. PROCEDURE

A riffled ~125 g portion was separated statically in tetrabromoethane (2.96 sp. gr.). The >2.96 sp. gr. product was washed, dried and weighed and a portion examined microscopically in loose grain mount and polished section (PS48435).

3. RESULT

The >2.96 sp. gr. product is 26.8% of the sample. It consists of the following minerals :

	Vol. %, est.
Ilmenite	50-55
Magnetite	35-40
Others*	8-10

* pyroxene, garnet, monazite, spinel, tourmaline, Mn-andalusite.

NB. The values quoted are ±20-40% relative.

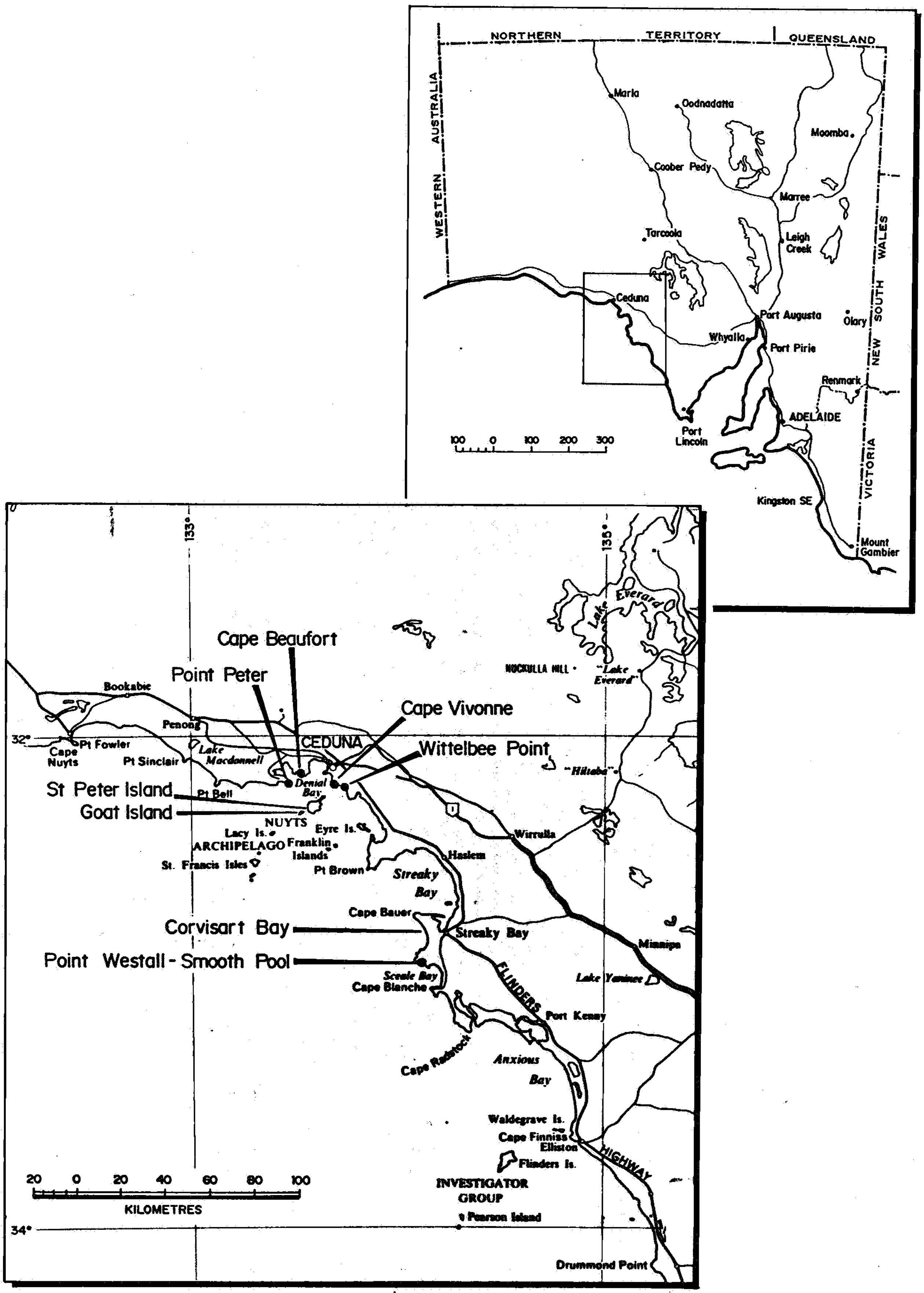


Figure.....1

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. R.	C.D.O.	DATE 29. 11. 89
GEOLOGY OF ST PETER AND GOAT ISLAND	DRAWN R. B.	SCALE As shown	
LOCALITY PLAN	DATE July 1989	PLAN NUMBER S21007	
	CHECKED		

4870

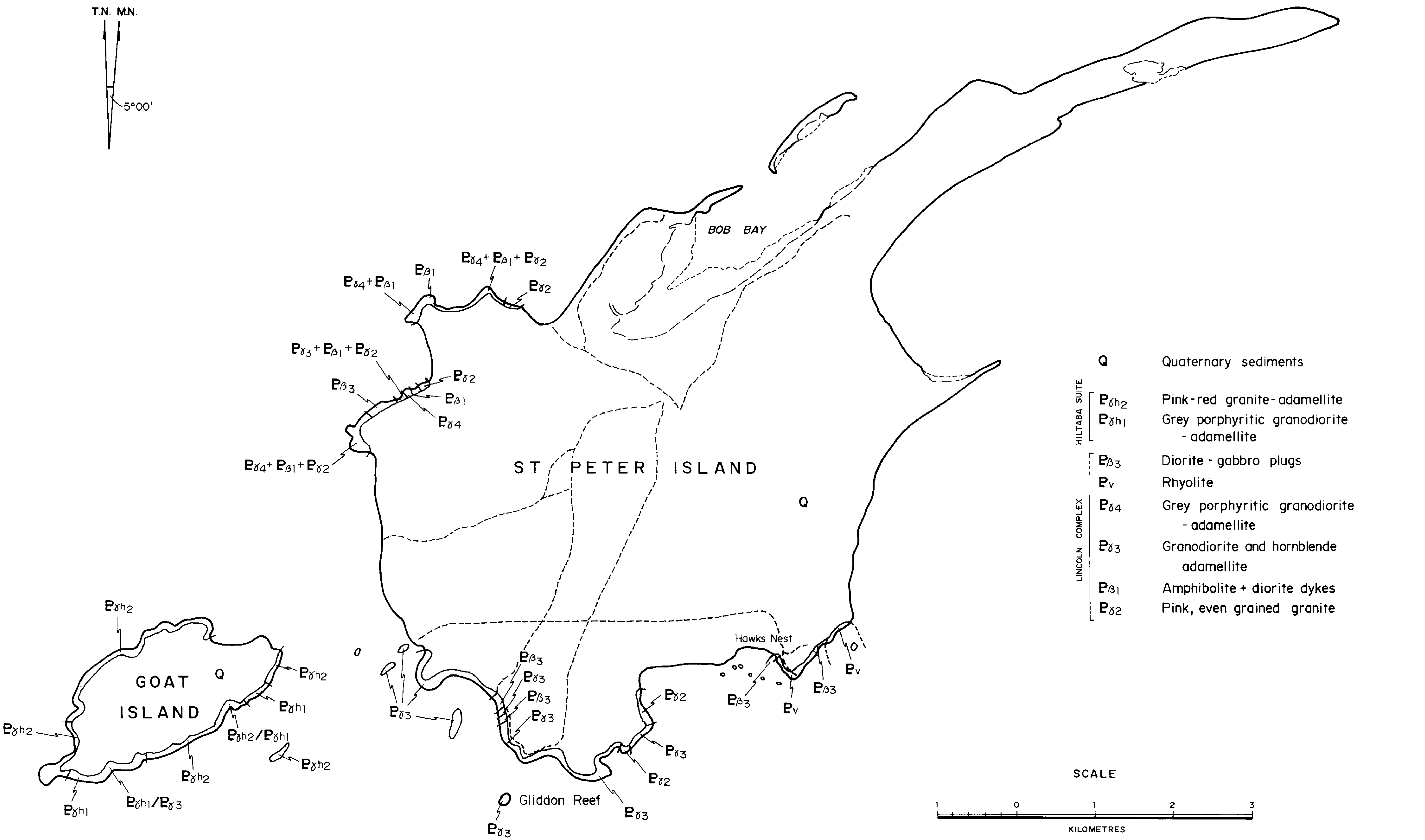


Figure 2

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. R.	CDO 29·11·89 DATE
GEOLOGY OF ST. PETER AND GOAT ISLAND	DRAWN R. B.	SCALE As shown
PROTEROZOIC GEOLOGY	DATE July 1989 / CHECKED	PLAN NUMBER 89-318

4870

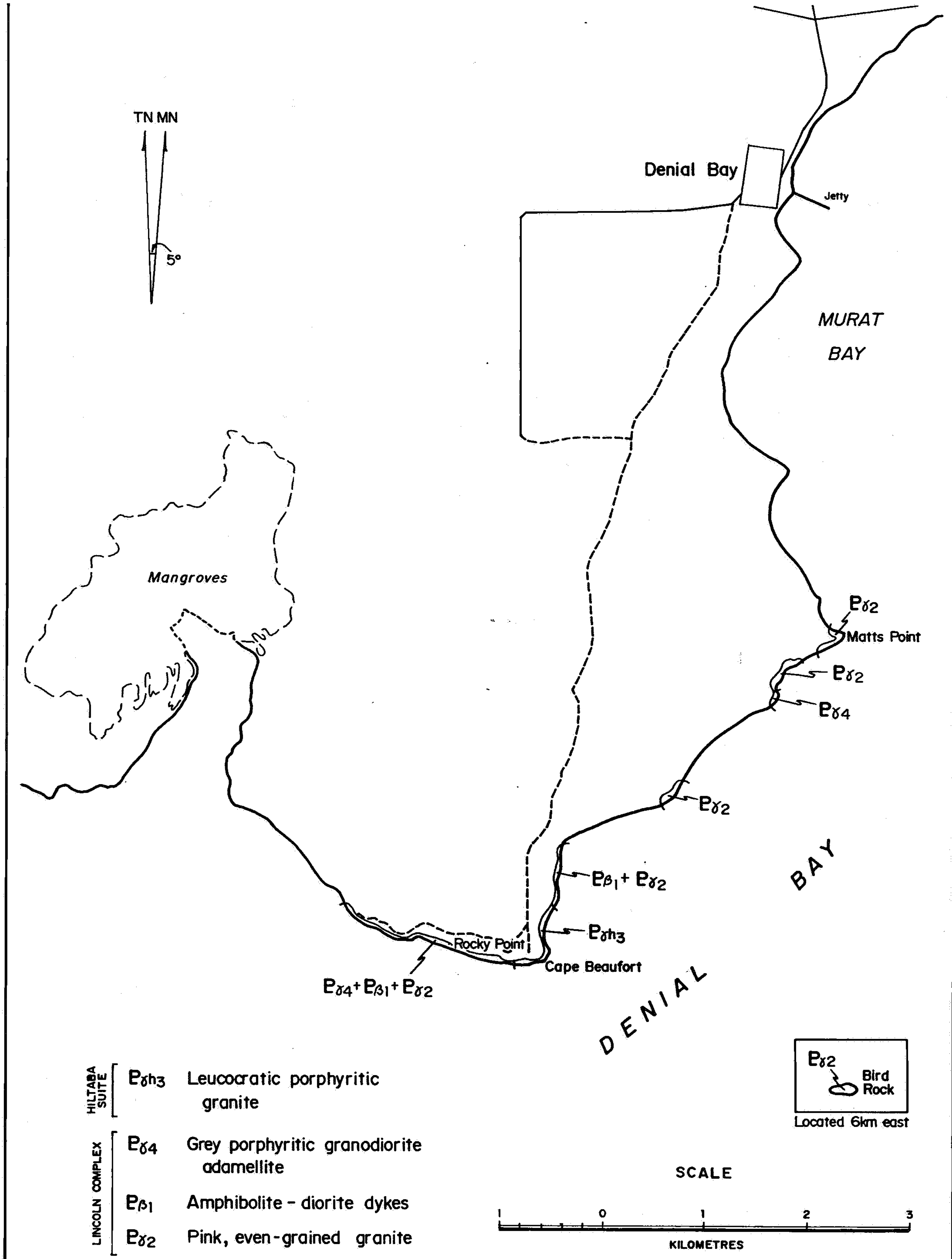


Figure.....3

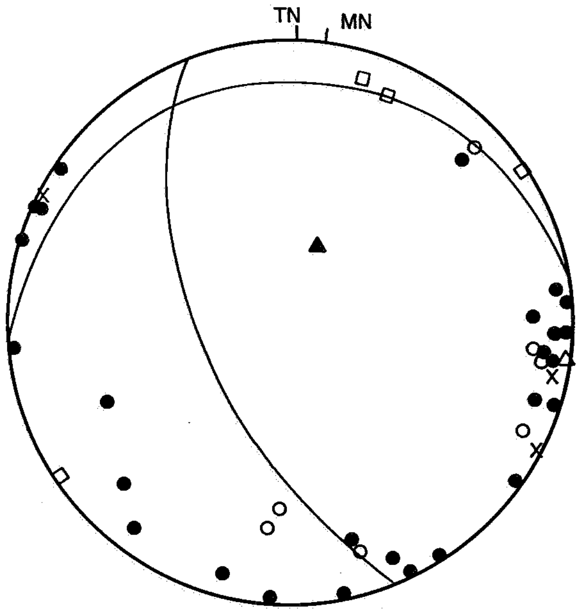
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA.

GEOLOGY OF ST. PETER AND GOAT ISLAND

PROTEROZOIC GEOLOGY OF CAPE BEAUFORT TO MATTS POINT

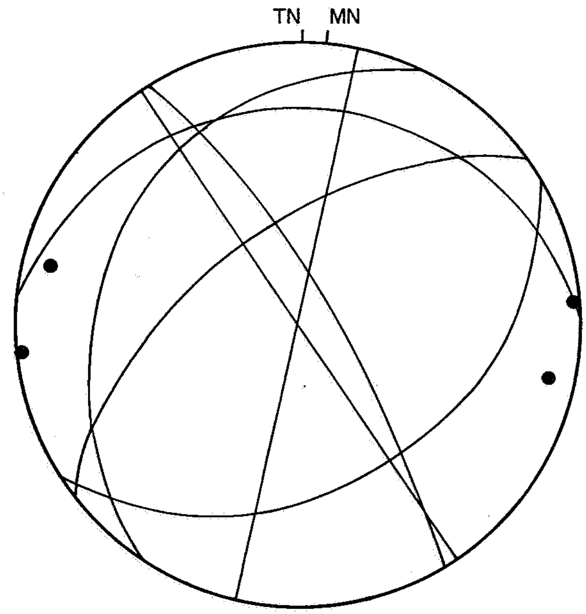
COMPILED L. R.	C.D.O. 29·11·89 DATE
DRAWN R. B.	SCALE As shown
DATE July 1989	PLAN NUMBER
CHECKED	S21008

4870



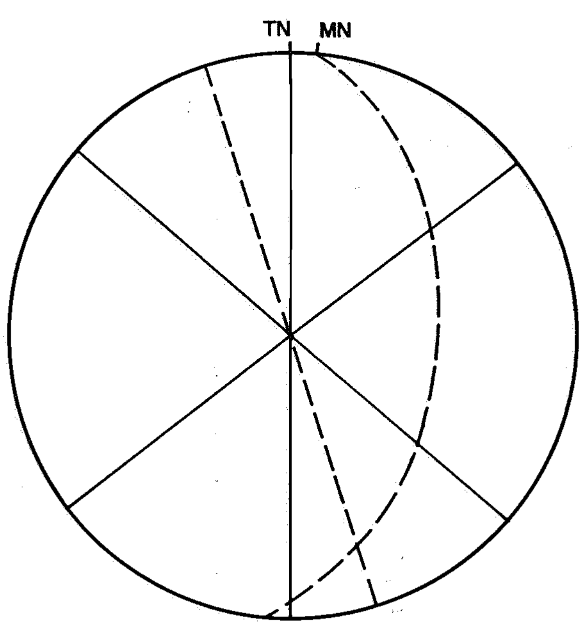
ST PETER ISLAND
LINCOLN COMPLEX

□	S_0	Aplite dyke
×	S_0	$P_{\beta 1}$ diorite dyke
●	S_1	Foliation
○	S_m	Shear zones
△	L_1	Elongation lineation (xenolith)
▲	L_1	Fold axial lineation
/		Joints



ST PETER ISLAND
NUYTS VOLCANICS

●	S_1	Foliation
/		Joints



GOAT ISLAND
HILTABA SUITE

/	Joints
╱ (dashed)	Quartz viens

Figure.....4

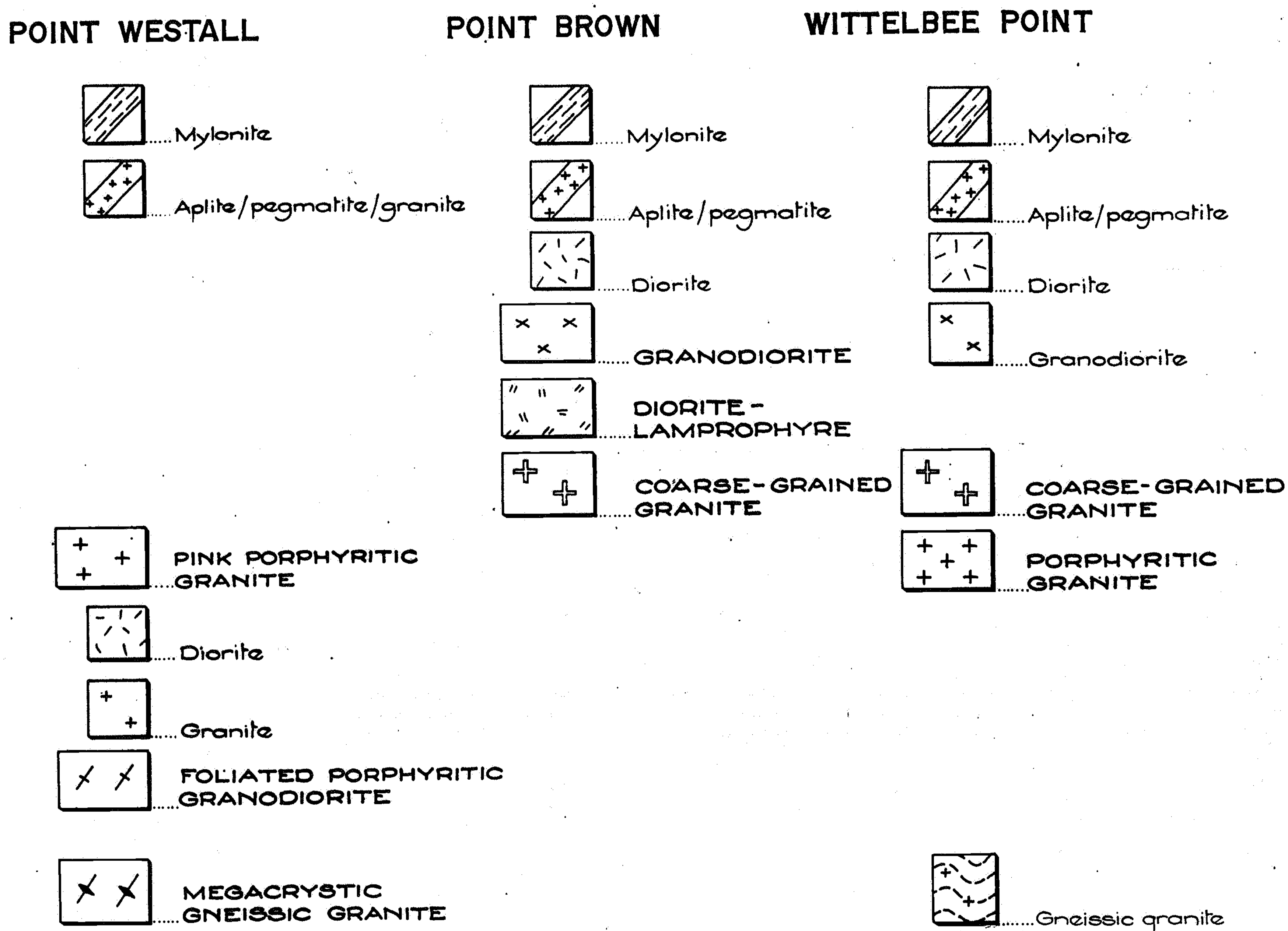
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

GEOLOGY OF ST. PETER AND GOAT ISLAND

EQUAL AREA STEREONET PROJECTIONS OF STRUCTURAL DATA

COMPILED L. R.	C.D.O.	DATE 29·11·89
DRAWN R. B.	SCALE As shown	
DATE July 1989	PLAN NUMBER	S21009
CHECKED		

4870



(From Watkins and Flint (1983))

Figure....5

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

GEOLOGY OF ST. PETER AND GOAT ISLAND

ORIGINAL GEOLOGICAL SUMMARY OF INTRUSIVE SEQUENCES

COMPILED L.R.	C.D.O.	DATE 29.11.89
DRAWN M.R.	SCALE -	
DATE July 1989	PLAN NUMBER	
CHECKED	S21010	

Figure 6

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

GEOLOGY OF ST. PETER AND GOAT ISLAND

REGIONAL CORRELATION CHART

COMPILED L. R.	C.D.O. 29-11-89	DATE
DRAWN R. B.	SCALE -	
DATE August 1989	PLAN NUMBER 89-319	
CHECKED		

GRANITOIDS
ST PETER ISLAND

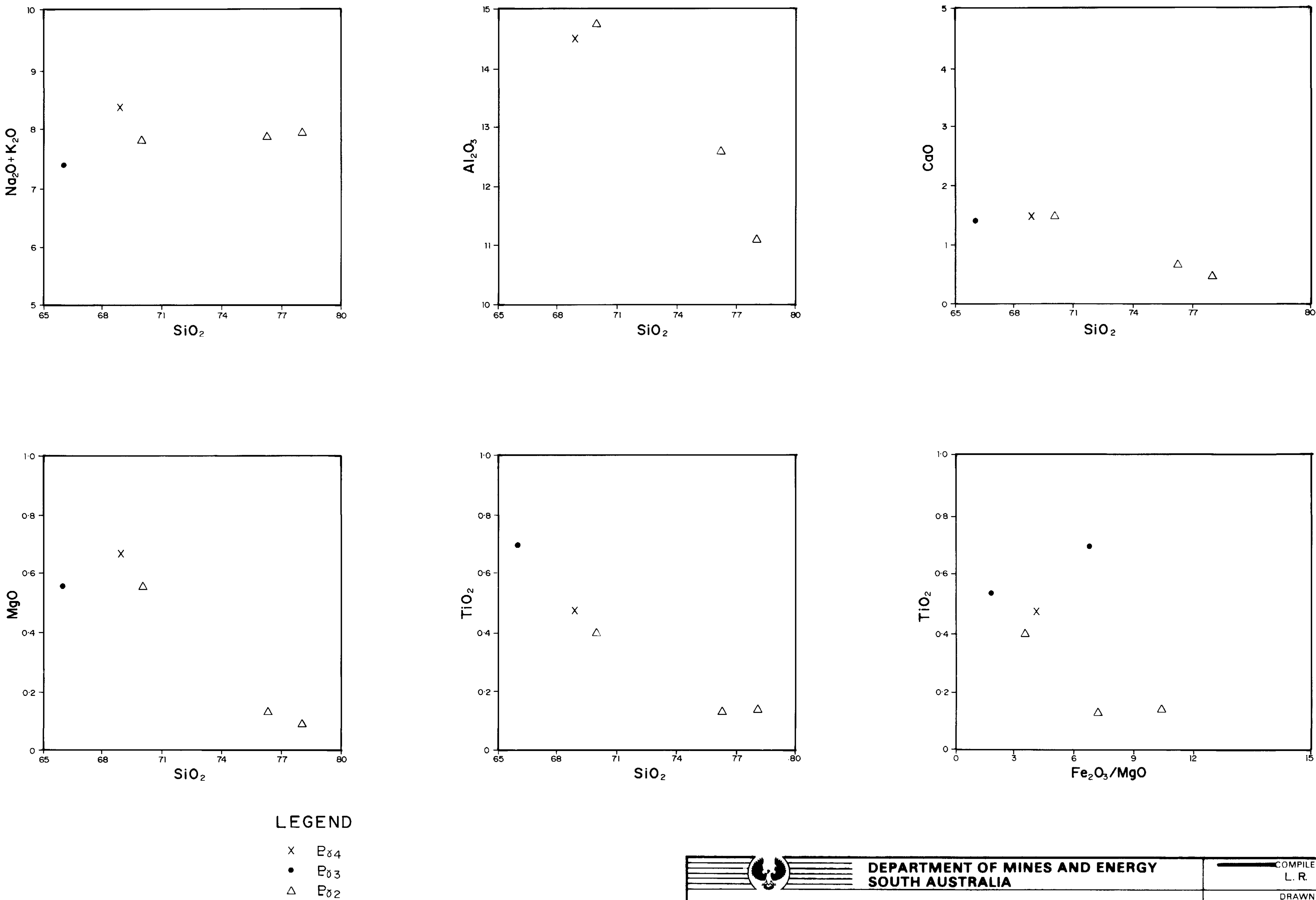


Figure 7

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGY OF ST. PETER AND GOAT ISLAND

LINCOLN COMPLEX GRANITOIDS
MAJOR ELEMENT TRENDS

[redacted] COMPILED L. R.	29.11.89 CDO DATE
DRAWN R. B.	SCALE -
DATE Au[redacted]gust 1989	PLAN NUMBER 89-320
CHECKED	

4870

GRANITOIDS
ST PETER ISLAND

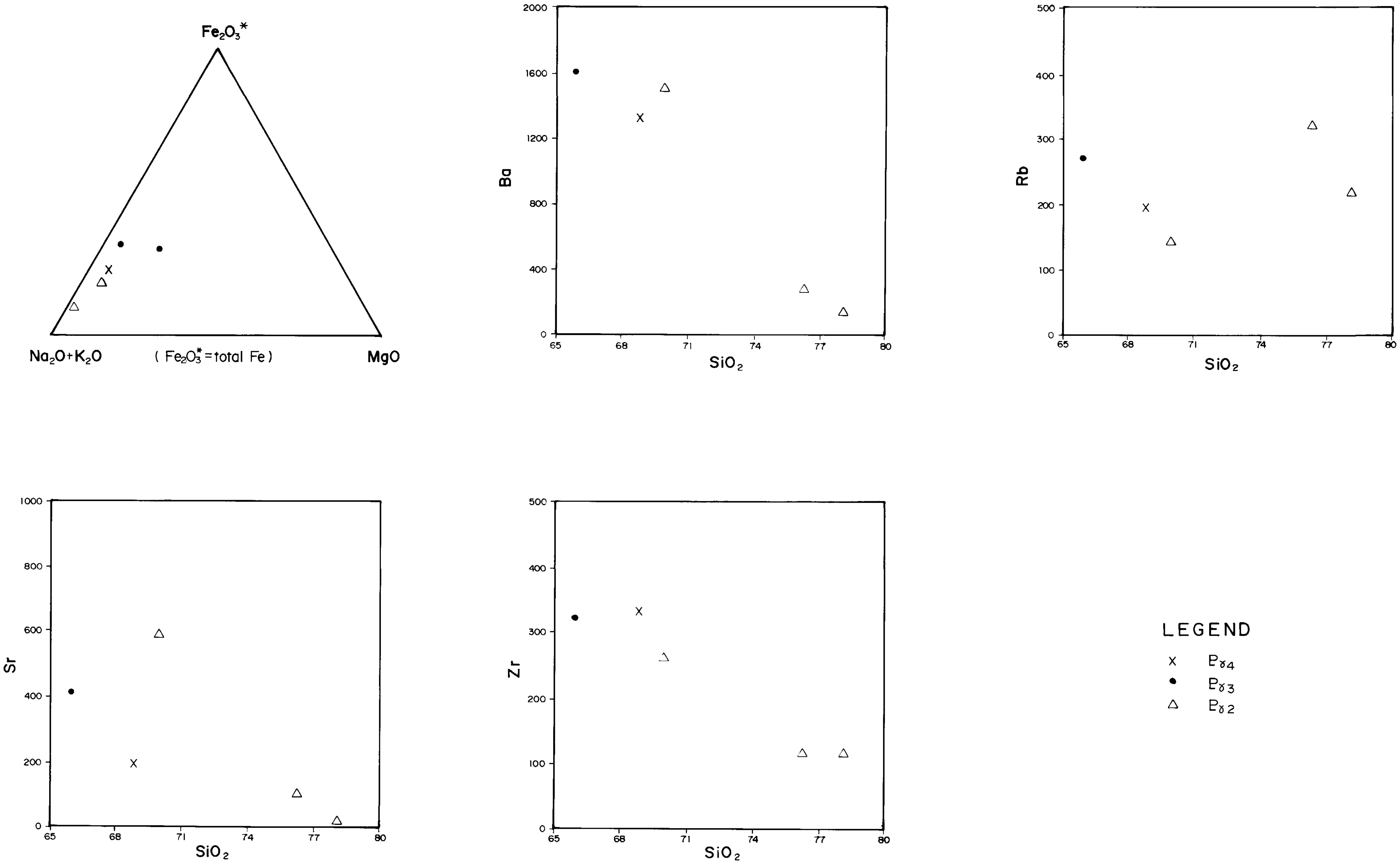
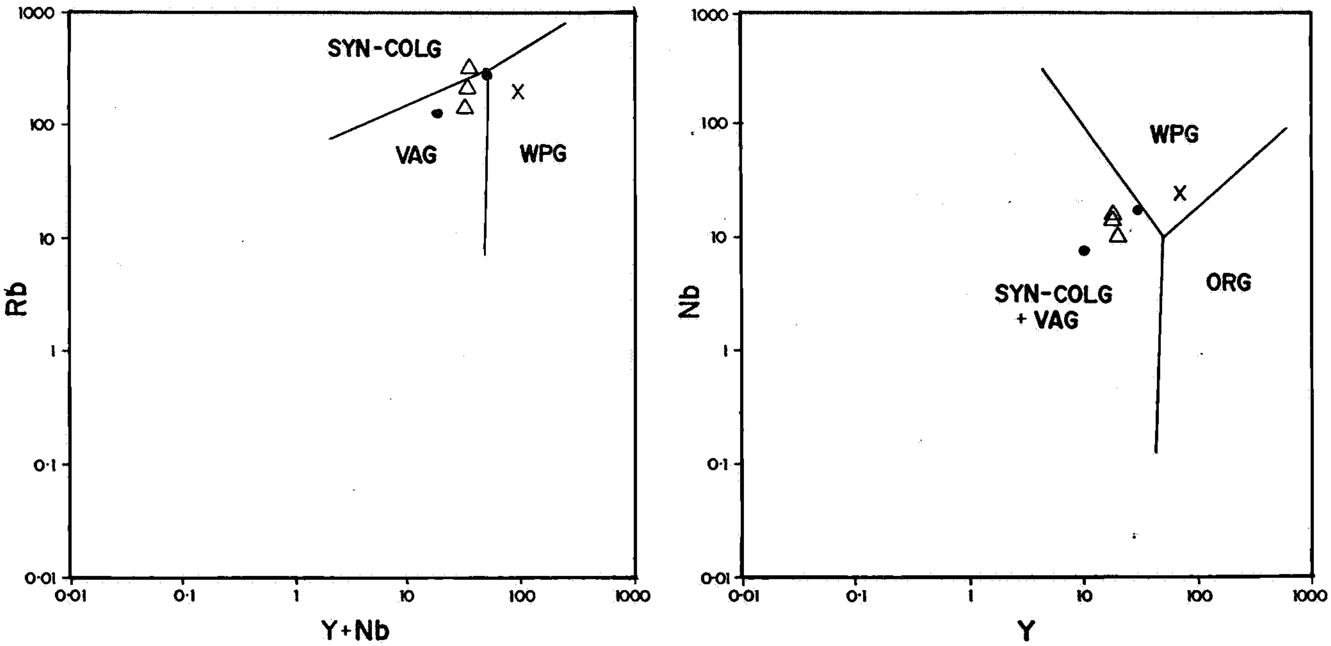


Figure.....8

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. R.	C.D.O. 29·11·89 DATE
GEOLOGY OF ST. PETER AND GOAT ISLAND	DRAWN R. B.	SCALE -
LINCOLN COMPLEX GRANITOIDS AFM AND MINOR ELEMENT TRENDS	DATE August 1989 CHECKED	PLAN NUMBER 89-321

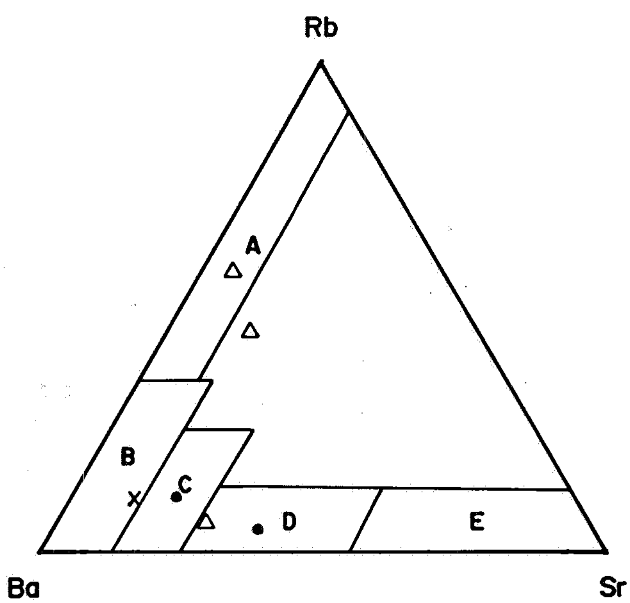
4870

GRANITOIDS
ST PETER ISLAND



Tectonic setting discrimination fields after Pearce *et al* (1984)

Granitoid discrimination fields after El Bouseily and El Sokkary (1975)



LEGEND

× $P\gamma_4$

● $P\gamma_3$

△ $P\gamma_2$

SYN-COLG	syn-collisional granitoids
VAG	volcanic arc granitoids
WPG	within-plate granitoids
ORG	ocean-ridge granitoids

A	strongly differentiated granites
B	normal granites
C	anomalous granites
D	granodiorites and quartz diorites
E	diorites

Figure.....9

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGY OF ST. PETER AND GOAT ISLAND

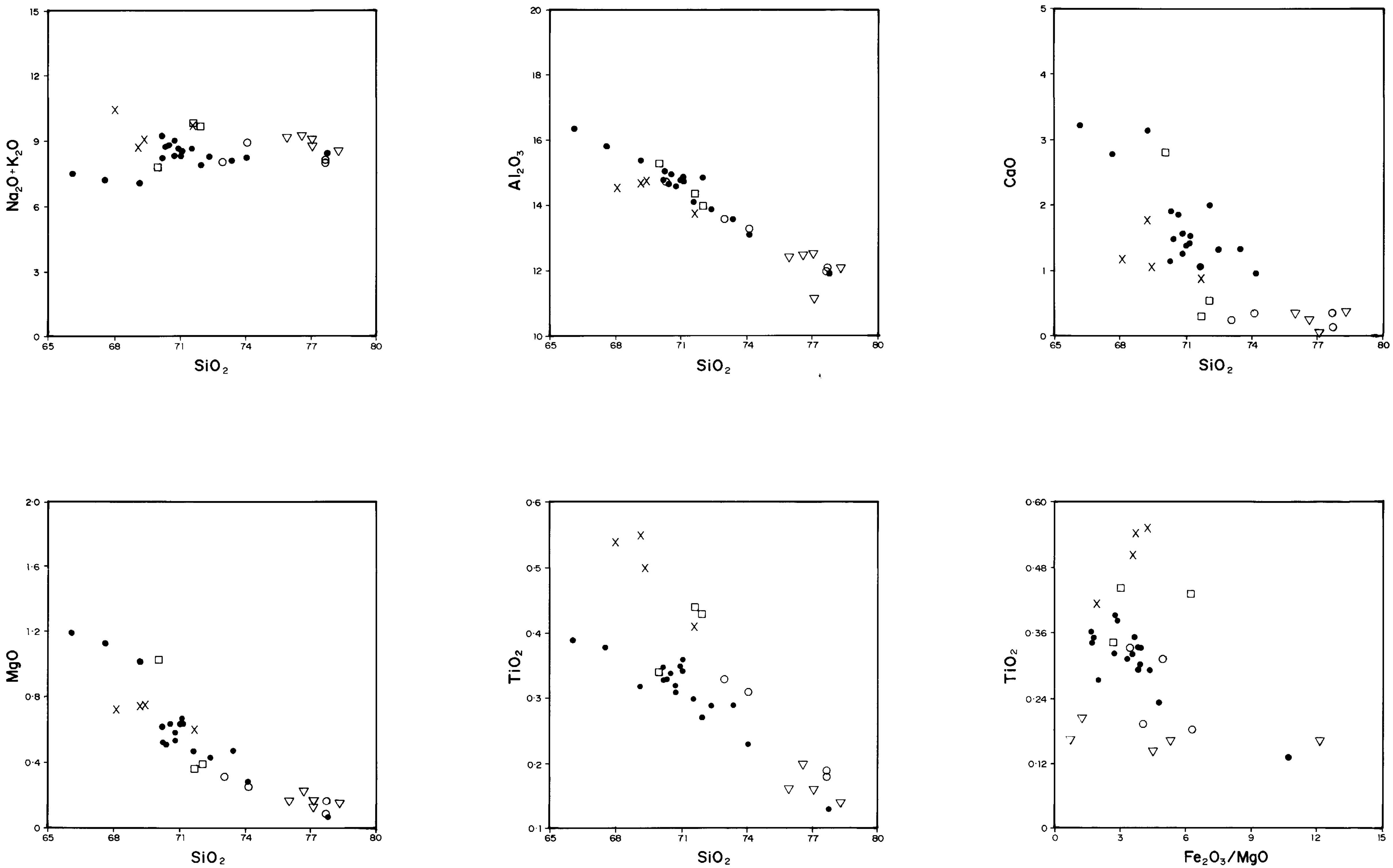
LINCOLN COMPLEX GRANITOIDS

MINOR ELEMENT DISCRIMINATION DIAGRAMS

COMPILED L. R.	C.D.O. DATE 29·11·89
DRAWN R. B.	SCALE -
DATE July 1989	PLAN NUMBER S21011
CHECKED	

4870

ACID VOLCANICS
NUYTS ARCHIPELAGO



LEGEND

▽	Ꞓa3	dykes	rhyolite	St Francis Island
□	Ꞓa2	dykes	rhyodacite	St Francis Island
×	Ꞓa1	dykes	rhyodacite	St Francis Island
●	Ꞓa	volcanics		St Francis Island
○	Ꞓv	rhyolite		St Peter Island

Figure 10

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGY OF ST. PETER AND GOAT ISLAND

ACID VOLCANICS, NUYTS ARCHIPELAGO
MAJOR ELEMENT TRENDS

COMPILED	L. R.		29-11-89
DRAWN	R. B.	SCALE	–
DATE	August 1989	PLAN NUMBER	89-322
CHECKED			

4870

ACID VOLCANICS
NUYTS ARCHIPELAGO

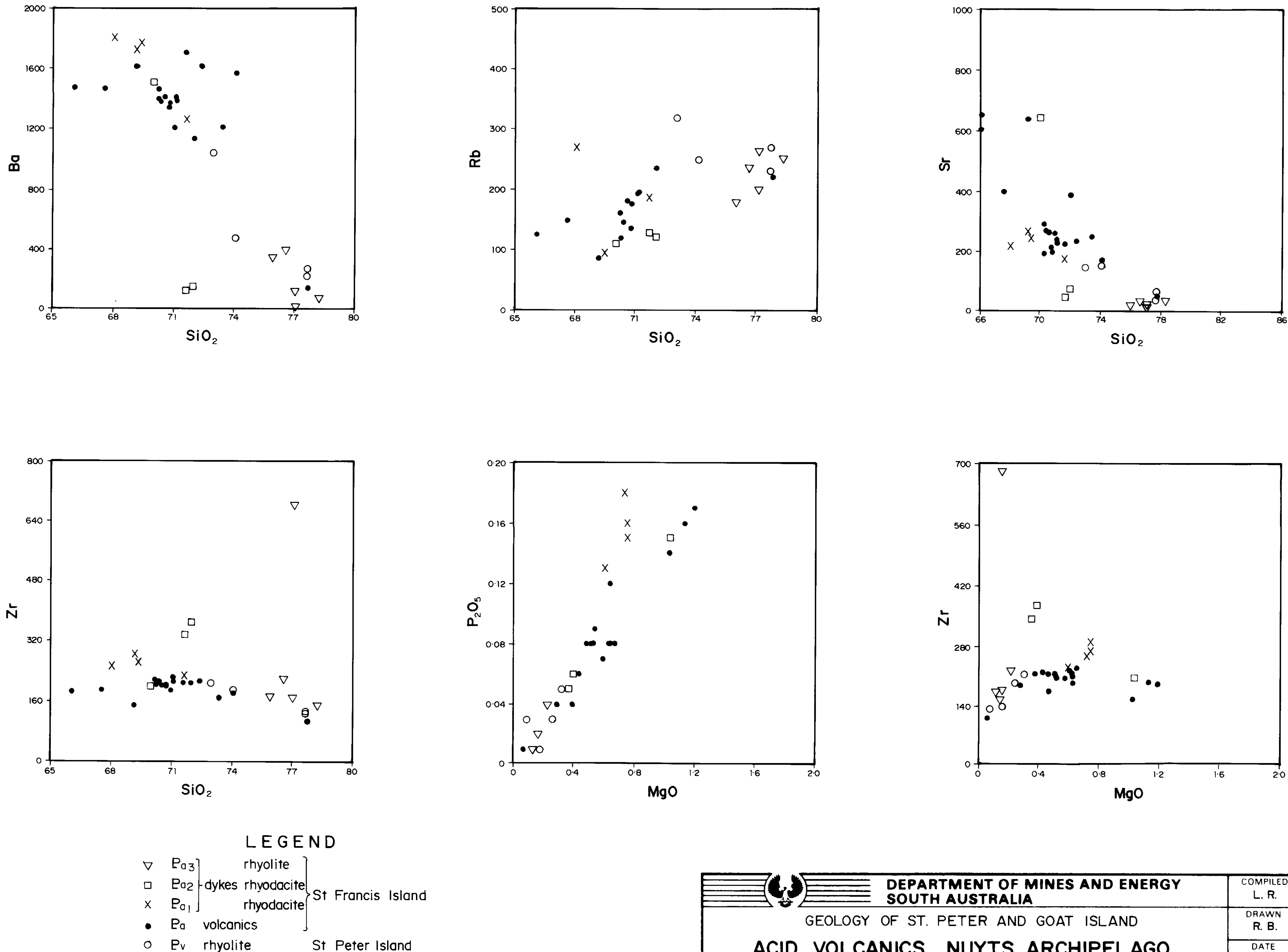
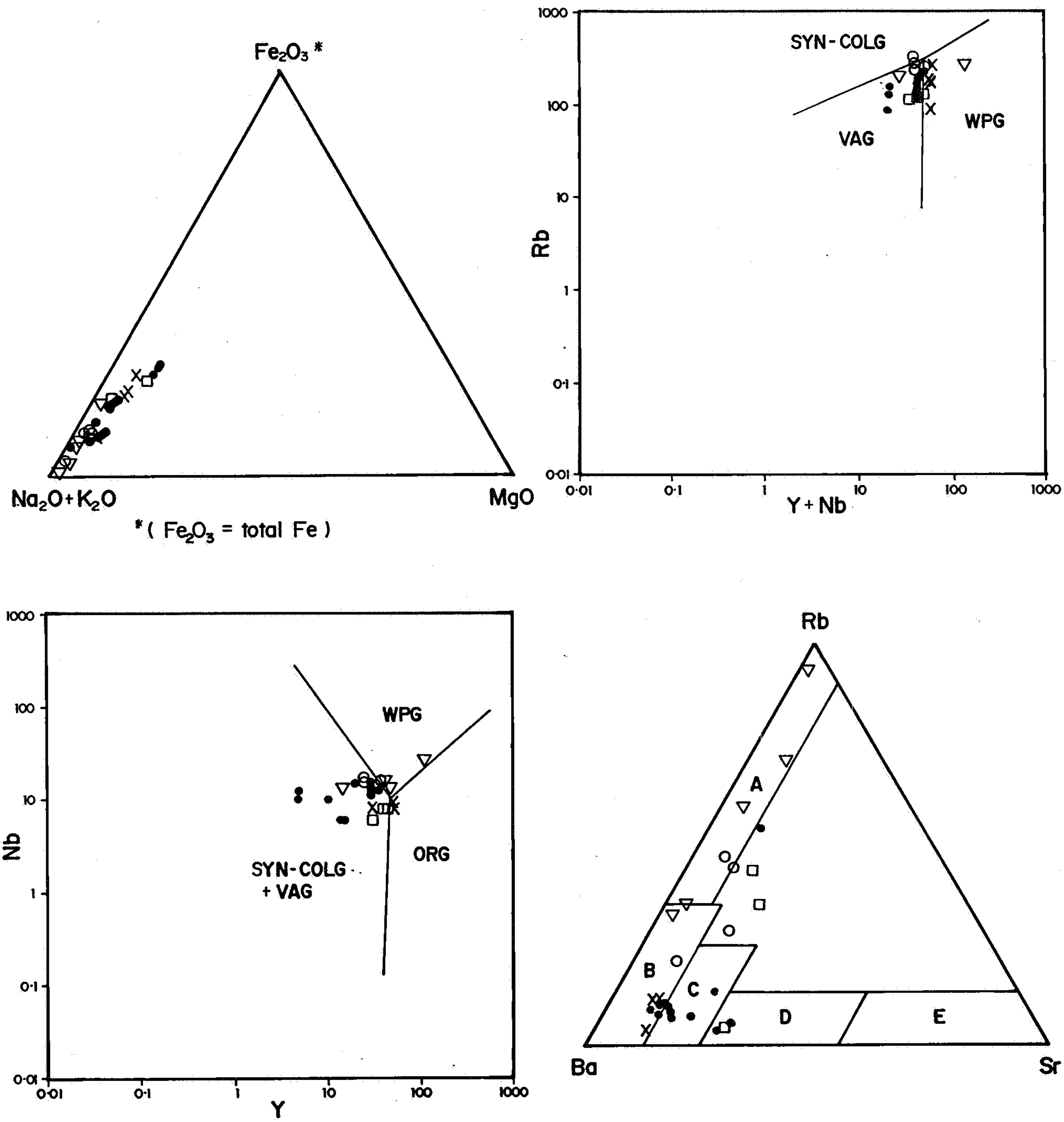


Figure 11

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. R.	CDO	DATE 29·11·89
GEOLOGY OF ST. PETER AND GOAT ISLAND	DRAWN R. B.	SCALE –	
ACID VOLCANICS, NUYTS ARCHIPELAGO MINOR ELEMENT TRENDS	DATE August 1989	PLAN NUMBER 89-323	
	CHECKED		

4870

ACID VOLCANICS
NUYTS ARCHIPELAGO



LEGEND

▽	Ꞓa3	dykes rhyolite	St Francis Island
□	Ꞓa2	dykes rhyodacite	St Francis Island
×	Ꞓa1	dykes rhyodacite	St Francis Island
•	Ꞓa	volcanics	St Francis Island
o	Ꞓv	rhyolite	St Peter Island

SYN-COLG	syn collisional granitoids
VAG	volcanic arc granitoids
WPG	within-plate granitoids
ORG	ocean-ridge granitoids

A	strongly differentiated granites
B	normal granites
C	anomalous granites
D	granodiorites and quartz diorites
E	diorites

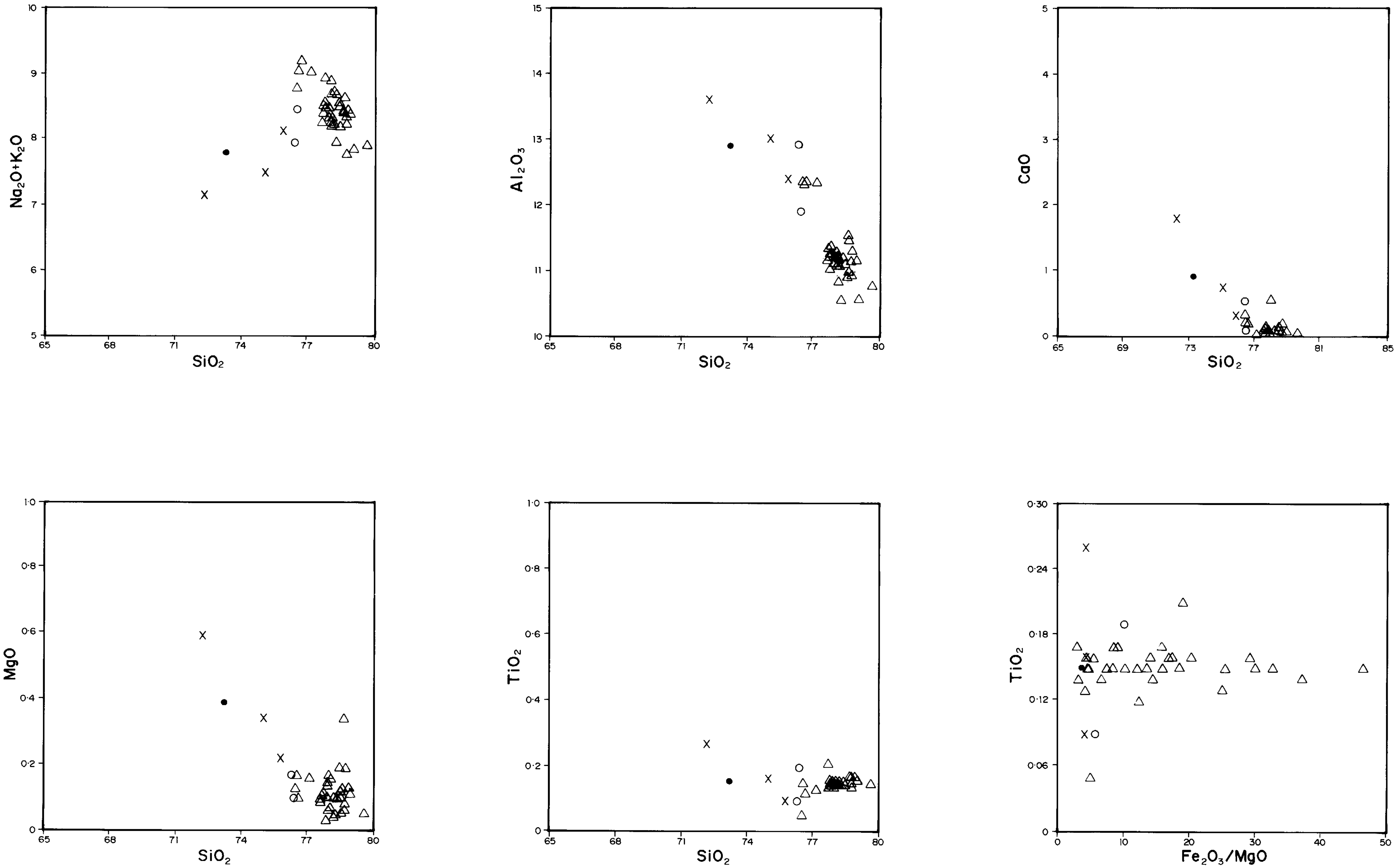
Tectonic setting discrimination fields after Pearce *et al* (1984)
Granitoid discrimination fields after El Bouseily and El Sokkary (1975)

Figure..... 12

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. R.	C.D.O.	DATE 29-11-89
GEOLOGY OF ST. PETER AND GOAT ISLAND	DRAWN R. B.	SCALE -	
ACID VOLCANICS, NUYTS ARCHIPELAGO AFM AND MINOR ELEMENT DISCRIMINATION DIAGRAMS	DATE August 1989	PLAN NUMBER S21012	
	CHECKED		

4870

HILTABA SUITE
NUYTS ARCHIPELAGO



LEGEND

- • Pγh3 - Cape Beaufort
- x Pγh2 } - Goat Island
- o Pγh1 }
- △ alkali granite - St. Francis Island

Figure..... 13

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. R.	LR 29·11·89 CDO DATE
GEOLOGY OF ST. PETER AND GOAT ISLAND	DRAWN R. B.	SCALE –
HILTABA SUITE GRANITOIDS AND ALKALI GRANITE MAJOR ELEMENT TRENDS	DATE August 1989	PLAN NUMBER 89-324
	CHECKED	

4870

HILTABA SUITE
NUYTS ARCHIPELAGO

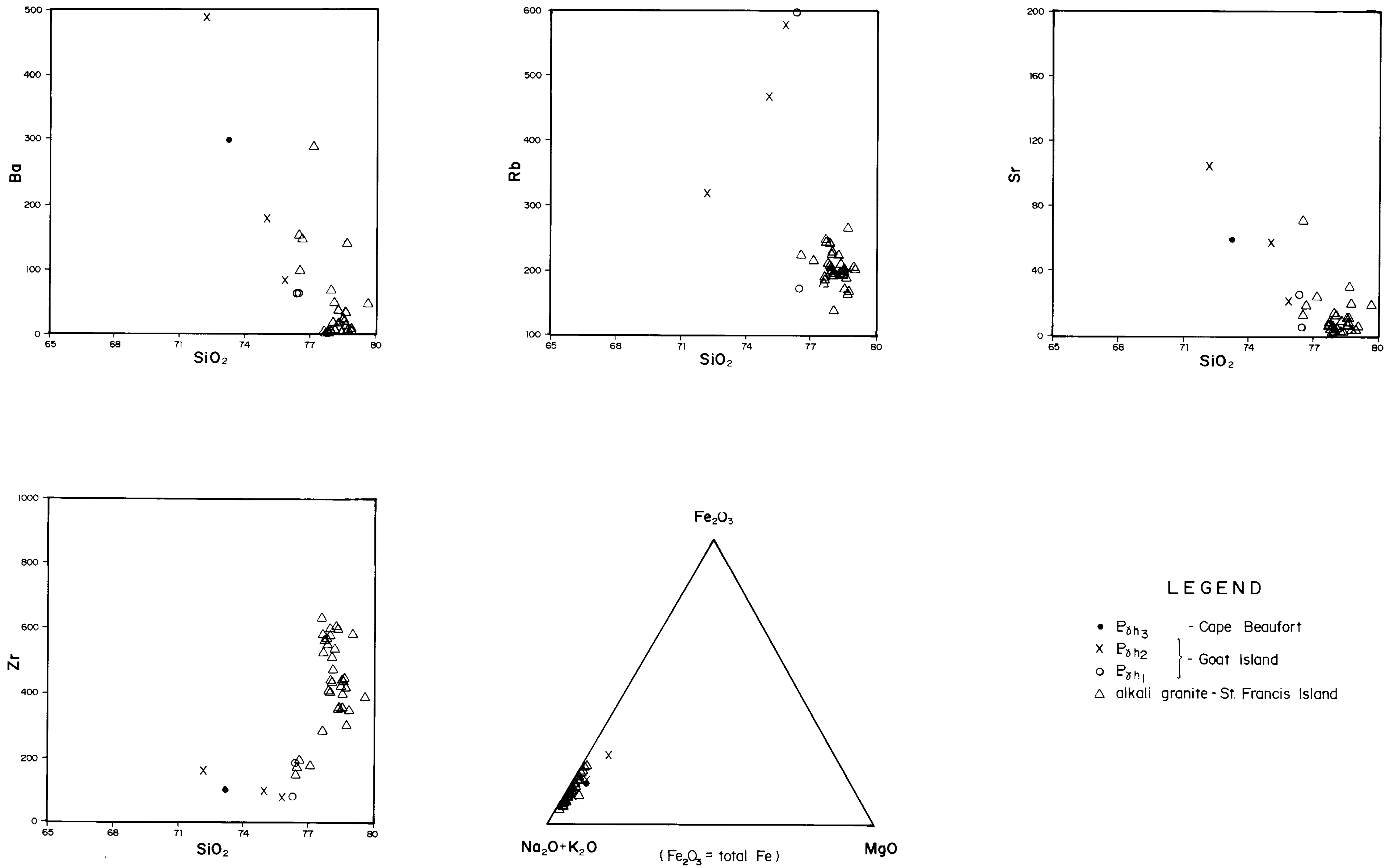


Figure 14

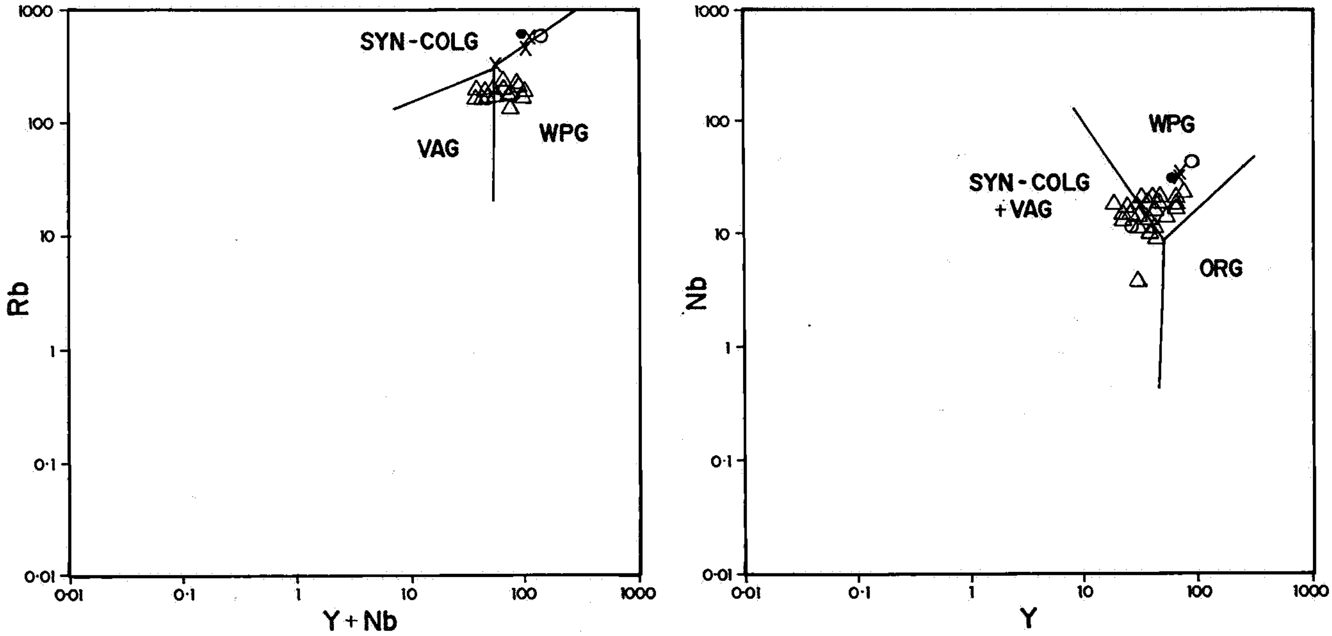
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGY OF ST. PETER AND GOAT ISLAND

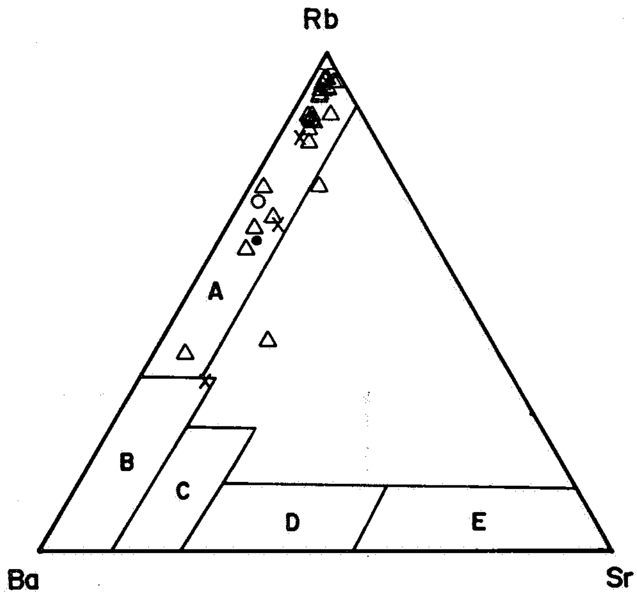
HILTABA SUITE GRANITOIDS AND ALKALI GRANITE AFM AND MINOR ELEMENT TRENDS

COMPILED L. R.	29.11.89 DATE
DRAWN R. B.	SCALE –
DATE August 1989	PLAN NUMBER 89-325
CHECKED	

HILTABA SUITE
NUYTS ARCHIPELAGO



Tectonic setting discrimination fields after Pearce *et al* (1984)
Granitoid discrimination fields after El Bouseily and El Sokkary (1975)



LEGEND

- • $E\gamma h_3$ } – Goat Island
- × $E\gamma h_2$ }
- o $E\gamma h_1$ }
- △ alkali granite - St. Francis Island

SYN-COLG	syn-collisional granitoids
VAG	volcanic-arc granitoids
WPG	within-plate granitoids
ORG	ocean-ridge granitoids

A	strongly differentiated granites
B	normal granites
C	anomalous granites
D	granodiorites and quartz diorites
E	diorites

Figure.....15

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. R.	C.D.O.	DATE 29·11·89
GEOLOGY OF ST. PETER AND GOAT ISLAND	DRAWN R. B.	SCALE -	
HILTABA SUITE GRANITOIDS AND ALKALI GRANITE MINOR ELEMENT DISCRIMINATION DIAGRAMS	DATE August 1989 / CHECKED	PLAN NUMBER S21013	

4870

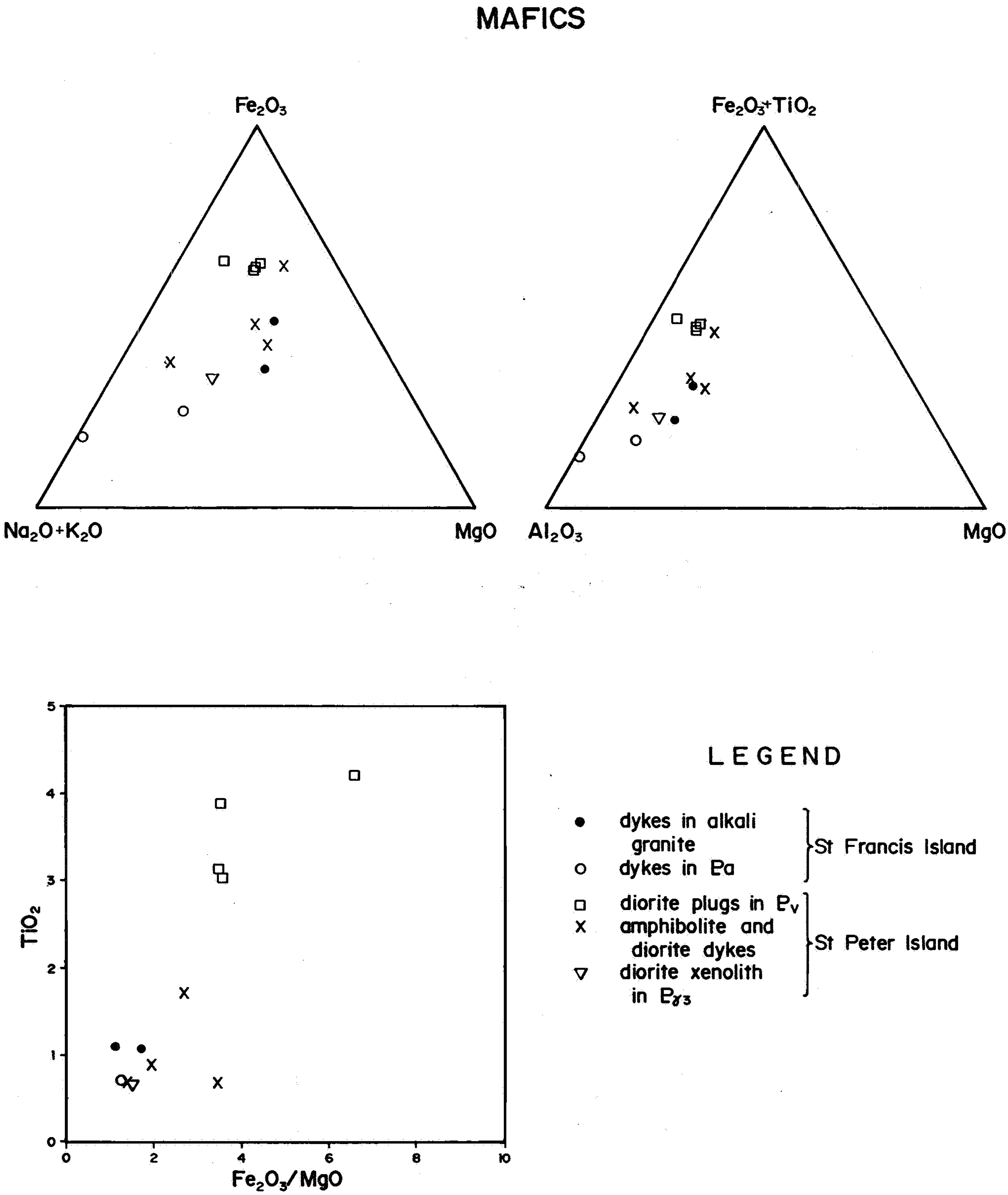


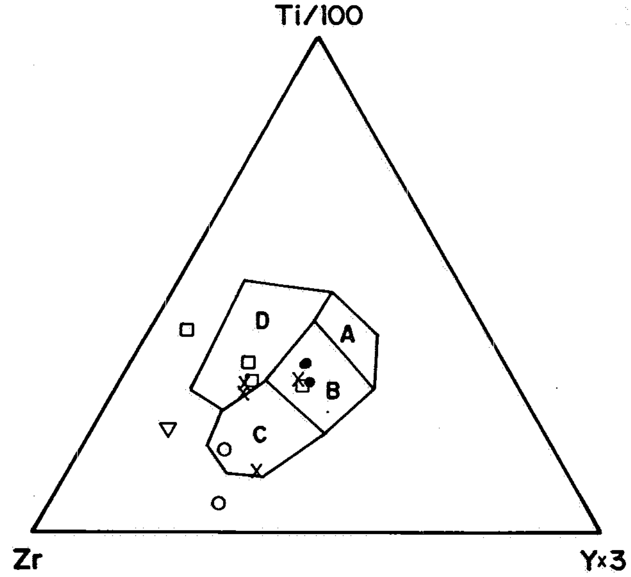
Figure.....16

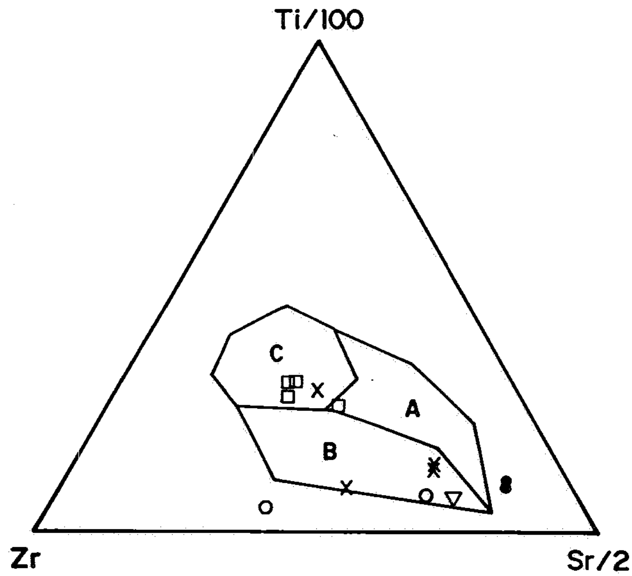
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. R.	C.D.O.	DATE 29·11·89
GEOLOGY OF ST. PETER AND GOAT ISLAND	DRAWN R. B.	SCALE –	
MAFIC INTRUSIVES, NUYTS ARCHIPELAGO AFM AND MAJOR ELEMENT TRENDS	DATE July 1989	PLAN NUMBER	
	CHECKED	S21014	

4870

MAFIC DYKES

NUYTS ARCHIPELAGO





LEGEND

●	dykes in alkali granite	St Francis Island	A	low K tholeiites
○	dykes in Ꝑa		B	low K tholeiites + calc-alkaline basalts
□	diorite plugs in $Ꝑ_v$	St Peter Island	C	calc-alkaline basalts
x	amphibolite and diorite dykes		D	within-plate basalts
▽	diorite xenolith in $Ꝑ_{\gamma 3}$			

Discrimination fields after Pearce and Cann (1973).

Figure.....17

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGY OF ST. PETER AND GOAT ISLAND

MAFIC INTRUSIVES, NUYTS ARCHIPELAGO
MINOR ELEMENT DISCRIMINATION DIAGRAMS

COMPILED L. R.	C.D.O. DATE 29·11·89
DRAWN R. B.	SCALE –
DATE August 1989	PLAN NUMBER S21015
CHECKED	

4870

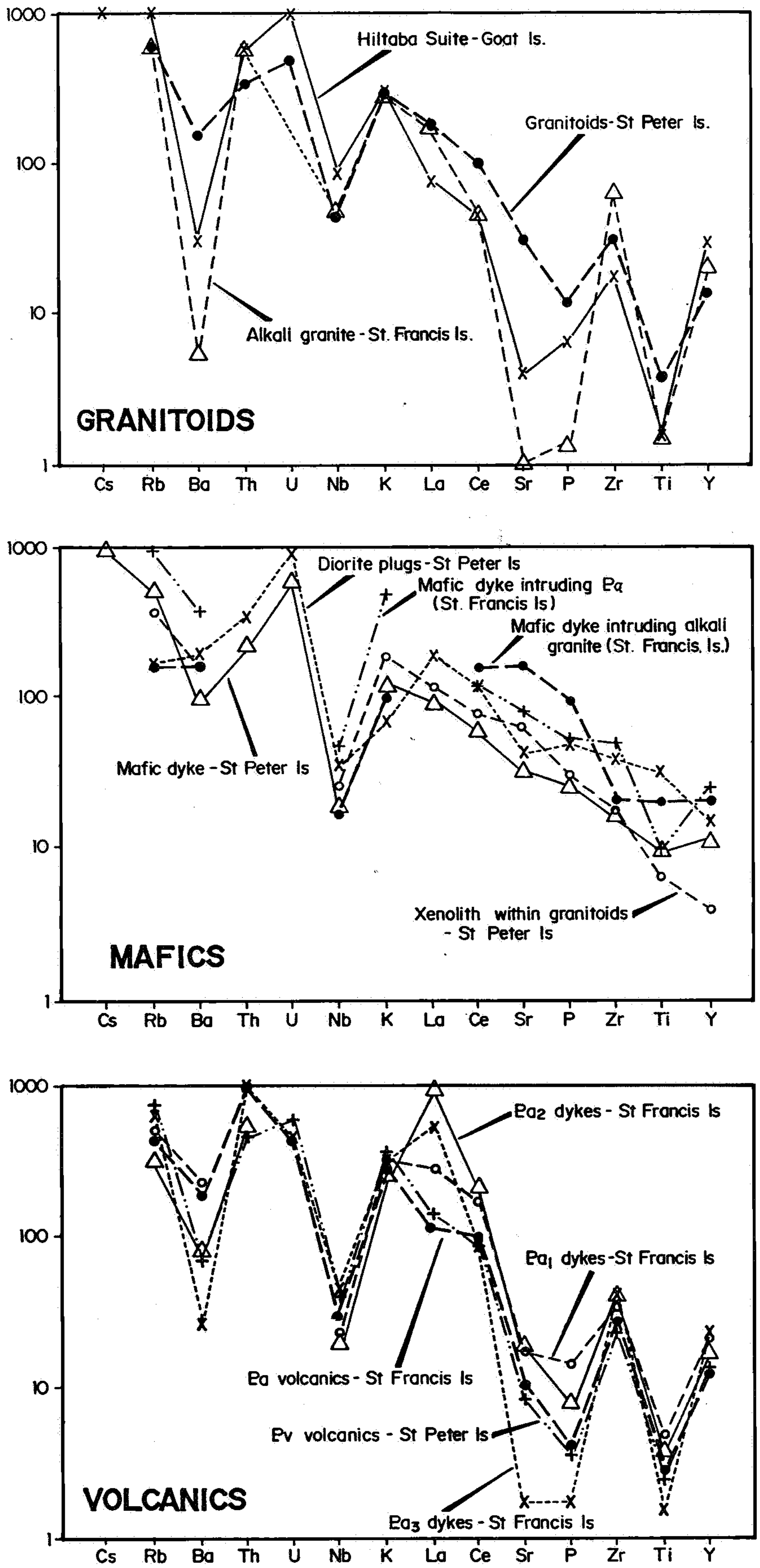


Figure 18

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGY OF ST. PETER AND GOAT ISLAND

CHONDRITE NORMALISED DIAGRAMS FOR INTRUSIVES AND EXTRUSIVES, NUYTS ARCHIPELAGO

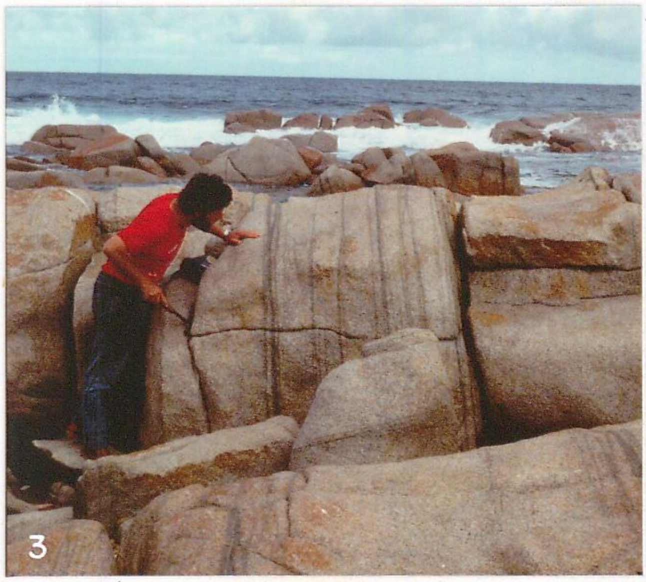
COMPILED L. R.	C.D.O.	DATE 29-11-89
DRAWN R. B.	SCALE As shown	
DATE July 1989	PLAN NUMBER	
CHECKED	S21016	

4870

PLATES

1

2



3

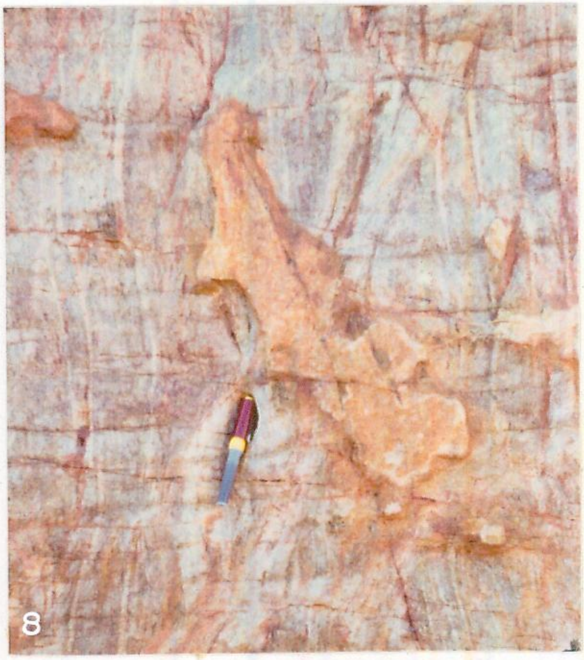
4

5

6

PLATES

7



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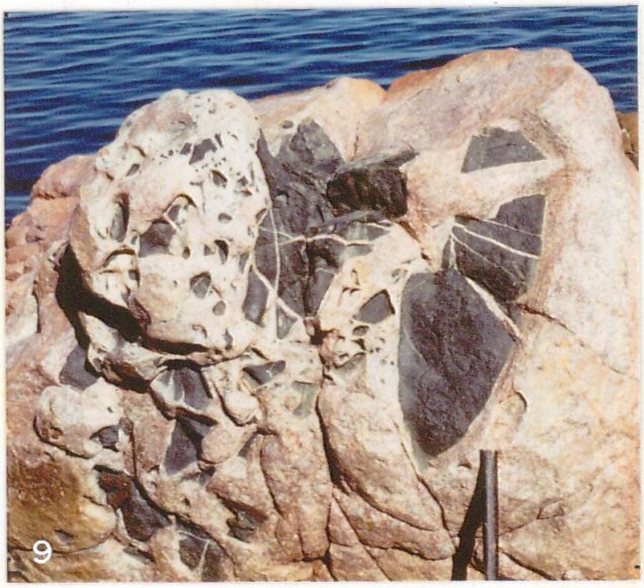

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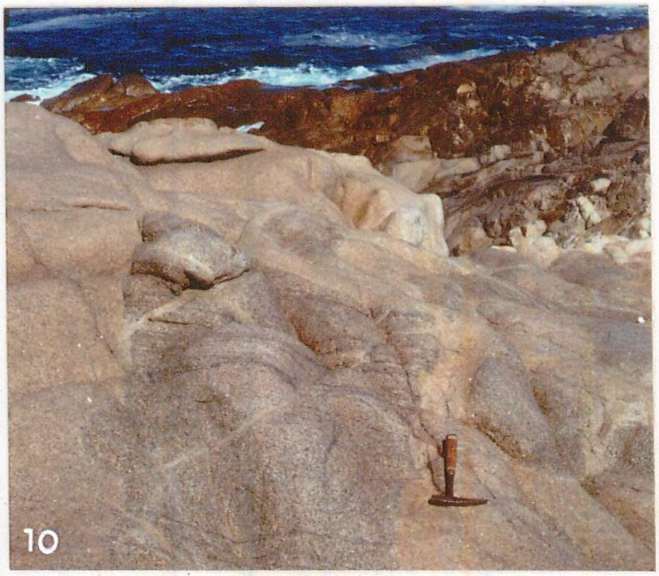

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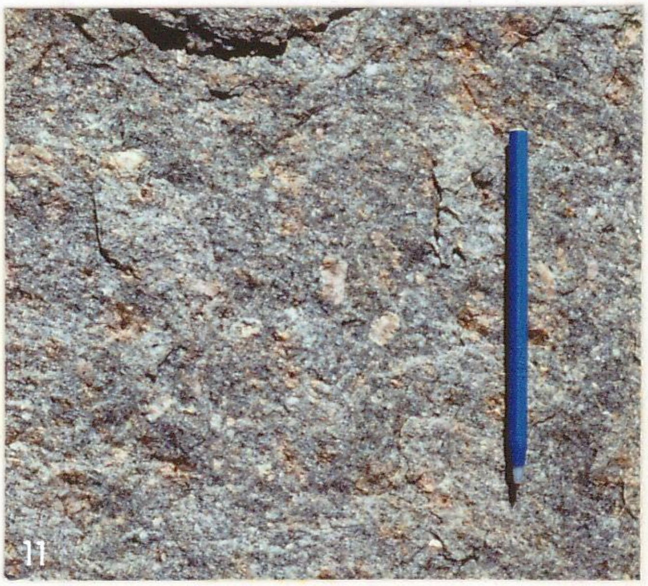

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