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SYENITIC ROCKS OF THE FITZGERALD PEAKS, NEAR NORSEMAN

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by

J.D. Lewis and C.F. Gower*

ABSTRACT

The Fitzgerald Peaks, about 96 km south-southwest of Norseman are formed by an isolated mass of syenite, quartz syenite and alkali granite intruded into a major Archaean batholith. The regional geology and petrology are described, and four complete chemical analyses are given. The syenites contain aegirine-augite for which full chemical, mineralogical and X-ray data are tabulated. The Fitzgerald Peaks Syenite is a high level diapir, probably of anatectic origin, and Proterozoic in age.

INTRODUCTION

The Fitzgerald Peaks are a prominent group of hills located about 96 km south-southwest of Norseman, in the southeastern part of the Lake Johnston 1:250 000 sheet. Peak Charles, 658 m high, is a roughly conical hill of bare rock which rises over 300 m above the Archaean granite plain and is visible for many miles. Peak Eleanora, 503 m high and 10 km to the south, is the other main peak of the group, and between these two prominences there are several lower hills.

During regional mapping of the Lake Johnston area (Gower and Bunting, 1976) it was recognized that the Fitzgerald Peaks were formed by an intrusion of syenitic and alkalic granitic rock which contrasted with the

* Present address: Department of Geology
McMaster University
Hamilton, Ontario, Canada.

porphyritic biotite granodiorites of the surrounding region. More recently, several other alkalic intrusions have been discovered in the Eastern Goldfields Province but the only earlier report of syenites was of a small plug at Yerilla, about 100 km north of Kalgoorlie (Honman, 1917). The Fitzgerald Peaks remains the largest syenitic body known in Western Australia and the present report will deal with its regional setting and petrography, with particular reference to the sodic pyroxene present in the rock.

REGIONAL GEOLOGICAL SETTING

The granitic rocks immediately surrounding the Fitzgerald Peaks area are principally porphyritic biotite granodiorites grading to porphyritic biotite adamellite. These form part of a large Archaean batholith which occupies the eastern third of the Lake Johnston 1:250 000 sheet and extends onto the adjacent Boorabbin, Norseman and Ravensthorpe sheets. The batholith covers an area in excess of 5 000 km^2 and is most commonly a porphyritic biotite adamellite; the only variation is in the proportion of perthitic microcline phenocrysts. The Fitzgerald Peaks are located in the southwest corner of this batholith and comprise the only alkalic rocks found within the granite mass.

The western margin of the batholith is in contact with migmatites about 8 km west of Peak Eleanora, and is clearly delineated by a low, positive aeromagnetic anomaly trending north to northeast. Shearing structures can be seen at the boundary south of Dog Rock, suggesting that the contact is faulted. The migmatites exhibit schlieren and nebulitic structures which trend northeast and are truncated by the porphyritic adamellite.

South of the Fitzgerald Peaks the batholith extends a further 16 km until it is truncated by the northeast-trending Proterozoic migmatites of the Albany-Fraser Province.

In the southern half of the batholith the porphyritic adamellite shows distinct banding or minor variations in mineral concentrations. The strike of the banding is variable and the dip is often less than 30°. Further north the banding is absent and foliations are parallel to the north-northwest Archaean trend. South of the Fitzgerald Peaks the adamellite has a northeasterly foliation, possibly reflecting a Proterozoic influence.

THE FITZGERALD PEAKS

Apart from their topographic expression the rocks of the Fitzgerald Peaks are distinctive in being non-porphyritic and containing a bright-green pyroxene, although locally biotite or amphibole may become dominant. The rock types vary from an almost quartz-free syenite to quartz syenite, granite and adamellite. The rock types, with the possible exception of the biotite adamellite, do not form clear cut mappable units but grade imperceptibly into one another.

Since, apart from one small area, outcrops of the surrounding porphyritic adamellite are absent in the vicinity of the Fitzgerald Peaks the outline of the syenitic rocks can only be inferred from aeromagnetic data (Wells, 1962). The alkalic rocks probably form a roughly crescent shaped mass (Fig.1), although it is possible that an unexposed east-northeast dextral shear passing between Peak Charles and Peak Eleanora has offset what was originally an elliptical body. Numerous foliation measurements were recorded but these fail to give a convincing indication of the three-dimensional form of the body. In general, however, it would seem that the body narrows downward, as foliations on the eastern side dip westwards whereas those on the western side dip eastward. In addition an indistinct banding which dips south at about 25^{o} to 30^{o}, can be seen on Peak Charles, and a similar effect on the north side of Peak Eleanora dips north. It seems likely that the body is a high level diapiric structure which intrudes the porphyritic adamellite and granodiorite of the batholith.

Banding in the syenitic rocks is caused both by variation of the aegirine-augite content and by partially assimilated xenoliths of mafic rocks. Pods, streaks and lenses rich in aegirine-augite are present in all rock types and indicate an inhomogeneity in the original magma. In addition there are pegmatitic veins and pods, some consisting almost entirely of potash feldspar, and others containing large euhedral pyroxene laths. In the larger pegmatites the pyroxene crystals are up to 100 mm long and are elongated perpendicular to the vein walls. Thin stringers of almost pure pyroxene, often only a few millimetres wide, are common and maintain uniformity over several metres.

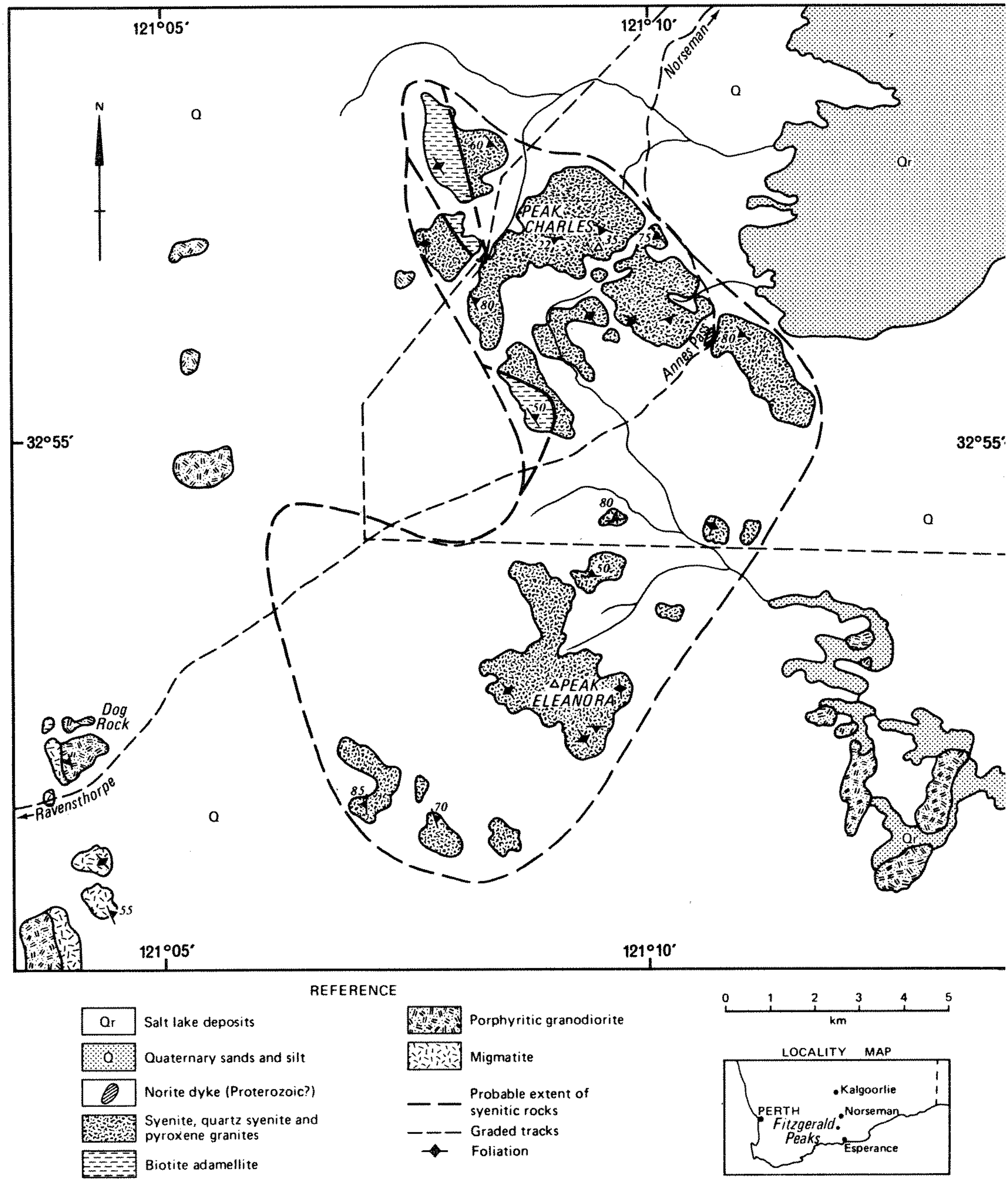

Figure 1. Sketch map of geology of Fitzgerald Peaks area (GSWA 17332)

Xenoliths of mafic rock vary from ghostlike, diffuse patches, through discontinuous pods and lenses, to continuous bands several metres long, which often have sharply defined parallel sides. The lenticular form of some xenoliths is clearly due to minor faulting of an originally continuous band. One such mafic band that has been sectioned (29804) revealed a fine-grained basic granulite containing equal proportions of green hornblende, pale green diopside, and calcic oligoclase (An_{26}). Granitic veins traversing the rock contain bright-green aegirine-augite, and plagioclase bordering the veins has been completely sericitized. The mafic bands could have been early basalt or dolerite dykes which have been remobilized. Later basic dykes also cut the syenites and granites, and appear to occupy pre-existing joint directions. The dominant dyke trends are east-northeast, northeast and northwest, but the dykes are poorly exposed and it is possible that unexposed dykes occupy many of the major fractures in the syenite.

PETROGRAPHY

The Fitzgerald Peaks are composed principally of pyroxene-bearing rocks which range continuously from granite with about 20 per cent modal quartz to syenite with less than 1 per cent quartz. Small areas of medium-grained biotite granodiorite to biotite adamellite are also present. These lack the distinctive pyroxene but have other features which resemble the main syenitic mass. Both rock types are easily distinguished from the porphyritic biotite granodiorite into which they are intruded.

Modal analyses of the main rock types are given in Table 1 and chemical analyses in Tables 4 and 5. Chemical and mineralogical data for the pyroxene of the Fitzgerald Peaks rock are given in Tables 2 and 3.

PORPHYRITIC BIOTITE GRANODIORITE

Specimens collected from scattered outcrops around the Fitzgerald Peaks are of a fairly uniform, coarse-grained, directionless biotite granodiorite (Tables 1 and 5; samples 28861, 28862, 28864).

TABLE 1. Modal analyses of rocks from the Fitzgerald Peaks area

Sample no.	28861	28862	28864	29805	29809	29831	29818	29821	28736
Quartz	32.3	29.3	41.1	21.6	19.7	14.5	6.4	1.0	0.7
Microcline	13.1	50.0	13.2	)		) -	-	-	-
				)15.6	30.7	)			
Perthite	-	-	-	)		)77.5	81.5	85.4	69.0
Plagioclase	48.9	17.6	37.3	47.6	38.3	-	-	-	-
Biotite	5.2	2.6	6.8	9.8	8.2	-	-	-	-
Pyroxene	-	-	-	-	-	5.9	9.8	11.3	24.1
Sphene	-	-	-	1.9	0.9	0.9	0.7	1.0	1.0
Apatite	-	-	0.8	0.7	1.0	0.6	1.3	0.7	2.3

28861-62-64	Biotite granodiorite, major batholith surrounding Fitzgerald Peaks	
29805-09	Biotite adamellite/granodiorite, part of Fitzgerald Peaks	
29831	Pyroxene granite, SW of Peak Charles	)
29818	Quartz syenite, SE of Peak Charles	) Fitzgerald Peaks
29821,28736	Syenite, E of Peak Charles	)

The proportion of microcline, however, is variable; and particularly where phenocrysts are common, the rock grades to an adamellite. The rock is fresh and consists principally of large anhedral crystals of plagioclase and quartz up to 8 mm across, lesser amounts of microcline and a few per cent biotite. Accessory minerals are small prismatic crystals of apatite, zircon and opaque iron oxide. A few small flakes of muscovite are present, either as a late stage mineral or as an alteration product of plagioclase.

The plagioclase is poorly twinned sodic oligoclase with a little untwinned myrmekite. Microcline often encloses small, early formed oligoclase crystals; it is only rarely perthitic, although the plagioclase sometimes contains exsolved patches of antiperthitic microcline.

The biotite present is a dark red-brown variety, strongly pleochroic to pale orange-brown, and is found as small flakes up to 0.5 mm long, lying along crystal boundaries or associated in clots with the accessory minerals.

Texturally the rock is typically granitic and, apart from a little chlorite and sericite, unaltered.

BIOTITE ADAMELLITE

Parts of the small hills to the northwest of Peak Charles are composed of a biotite adamellite which is allied to the main syenitic mass but which has a different mineralogy and texture. The rock is medium grained with a normal granitic texture and consists of anhedral crystals of oligoclase, microcline and quartz with a few per cent biotite, and accessory sphene, apatite, zircon and opaque iron oxide. The plagioclase is usually well twinned, only rarely myrmekitic, and is sodic oligoclase of composition An_{12-15}. In some specimens the oligoclase has a narrow marginal zone of albite. The microcline is usually only slightly perthitic but on occasion the proportion of exsolved albite rises to nearly half the crystal and its appearance approaches that of the syenitic rocks. Flakes of brown biotite up to 1 mm across are scattered randomly throughout the rock, and in some specimens outline a crude foliation.

Modal and chemical analyses of the biotite adamellite are given in Tables 1 and 4 and a photomicrograph in Plate III. Despite the differences in mineralogy and texture, the similarity between this rock and the syenitic mass is shown in the chemical analysis and by various minor mineralogical features. Some specimens contain perthite similar to the main mass, and all contain numerous small lozenges of a distinctive orange-brown sphene which are lacking in other granitic rocks of the area, but which are characteristic of the syenites. The association is further emphasized by pods of biotite adamellite within the main mass, which are similar in texture to sample 29809 but which also contain corroded grains of aegirine-augite (sample 29822) and arfvedsonitic amphibole (sample 29828).

PYROXENE GRANITES AND SYENITES

The major portion of the Fitzgerald Peaks is composed of medium to coarse-grained nonporphyritic granitoid rock containing variable amounts of quartz and green sodic pyroxene. Modal and chemical analyses of a selection of these rocks are presented in Tables 1 and 4. The common characteristics of the mass are the presence of a large proportion of perthitic (or anti-perthitic) feldspar, and lesser amounts of pyroxene and sphene. The proportion of quartz in the rock varies from about 20 per cent to almost nil in a continuous series, and division into granite and syenite is arbitrary. Neither are the varieties distinguishable in the field and, although from thin section evidence certain areas proved to be more syenitic than others (for example, the summit area of Peak Charles), no pattern emerged for the distribution of rock types.

PERTHITE

The principal mineral of rocks from the Fitzgerald Peaks is perthite which in leucocratic varieties can account for almost the whole rock. The mineral is always anhedral, and the crystal margins are usually highly sutured (Plate VII). Most of the perthite is a coarse, streaky variety with about equal proportions of microcline and untwinned sodic plagioclase, but the composition is variable and examples are common of antiperthite containing only small blebs of microcline. Similarly the internal texture of the perthite is variable (Plates V, VI and VII), from varieties with small orientated spindles of plagioclase to those with broad irregular veins of finely twinned plagioclase. In one specimen (Plate V, 26680) there appear to be two potash feldspar phases present in the one crystal. An orientated mesh of fine albite veins has a matrix of well-twinned microcline, and superimposed on this are orientated spindles of poorly twinned microcline. The final degree of exsolution of plagioclase from the perthite occurs when the crystal breaks down to a mosaic of individual albite and microcline crystals. Where optically determinable the composition of the plagioclase is albite (An_{5-10}).

AEGIRINE-AUGITE

A bright-green aegirine-augite is a constant component of the rock and ranges in amount from a few scattered grains up to 25 per cent of the rock. The crystals are usually anhedral to subhedral prisms, 1-4 mm long, often corroded, and sometimes mantled by amphibole. Many pyroxene crystals contain small blebs of quartz so that even the most extreme syenitic varieties are not entirely quartz free. Pleochroism in the aegirine-augite is from X=Z=bright green to Y=yellow green, but the depth of colour is variable. From a moderately saturated colour in most specimens the colour varies to a pale apple-green in others, whereas a few have a deeper colour than usual. It is probable that with a decrease in colour intensity, there is a decrease in the Na content of the pyroxene. The analyzed specimen (Table 2) is of average colour and comes from a pegmatitic lens containing about 70 per cent aegirine-augite as acicular crystals up to 50 mm long, and interstitial quartz and perthite. When compared with analyses of other aegirine-augites presented in Deer and others (1963, vol.2, p.82-84), the Peak Charles material differs only in having a low Al_2O_3 and TiO_2 content, and a slightly higher than average MnO content. The optical properties given in Table 2 were made on single grains mounted on a spindle stage (Bloss and Light, 1973) by the method suggested by Joel (1963). Density was determined by the method of Ellsworth (1928). The results fit reasonably well with the graphs drawn by Deer and others (1963, vol.2, p. 87) for an aegirine-augite containing approximately 24 per cent of the aegirine molecule.

TABLE 2. Chemical and mineralogical data for aegirine-augite

			No. of ions on basis of 6 (O,OH.)	
SiO_2	52.02			
TiO_2	0.15	Si	1.997	2.00
Al_2O_3	0.76	Al'	0.003	
Fe_2O_3	8.15	Al	0.030	1.02
FeO	8.36	Fe^{3+}	0.235	
MgO	8.12	Fe^{2+}	0.268	
CaO	17.67	Mg	0.464	
Na_2O	3.17	Ti	0.004	
K_2O	0.05	Mn	0.023	
H_2O^+	1.33	Ca	0.727	0.97
H_2O^-	0.10	Na	0.236	
P_2O_5	0.04	K	0.002	
MnO	0.72			
Total	100.64			

Specimen 29816: Pegmatite rich in pyroxene from Peak Charles
Analyst: N. Marsh, Government Chemical Laboratories

1. Cell dimensions:
   $a = 9.751 \pm 0.052$ Å, $b = 8.949 \pm 0.044$ Å, $c = 5.258 \pm 0.034$ Å,
   $B = 105.91^\circ \pm 0.24^\circ$, axial ratios: a:b:c = 1.090:1:0.588
   unit cell volume: 441.25 $Å^3$
2. Refractive indices:
   $\alpha = 1.710$, $\beta = 1.722$, $\gamma = 1.735$ (all $\pm$ 0.002)

TABLE 2 - continued

3.	2V = 82°, Extinction angle X∧c = 30°
4.	Pleochroism: X = bright green, Y = yellow green, Z = bright green. dispersion: r>v (moderate).
5.	D = 3.4395 ± 0.0002.

TABLE 3. Aegirine-augite X-ray diffraction data

I	$d_{obs.}$	d_{calc}	hkl	I	$d_{obs.}$	hkl	I	$d_{obs.}$	hkl
27	6.495	6.474	110	5	2.111	$42\bar{1}$	3	1.587	530
7	4.701	4.689	200	3	2.043	$32\bar{2}$	3	1.564	600
14	4.476	4.474	020	3	2.020	240	16	1.551	350
3	3.360	3.355	$12\bar{1}$	2	1.954	141	3	1.528	$62\bar{1}$
95	3.235	3.237	220	2	1.899	$51\bar{1}$	3	1.508	$61\bar{2}$
43	2.996	2.996	$22\bar{1}$	4	1.860	331	6	1.488	123,124
100	2.952	2.951	310	10	1.836	$42\bar{2}$	18	1.424	531,450
13	2.901	2.836	$31\bar{1}$	3	1.776	421	5	1.409	152
13	2.571	2.571	$31\bar{1}$	16	1.754	$50\bar{2}$	5	1.332	252,$61\bar{3}$
14	2.534	2.534	$20\bar{2}$	2	1.675	042	10	1.325	512
12	2.521	2.518	221	10	1.627	$53\bar{1}$	3	1.283	323,522
3	2.349	2.344	400	16	1.617	440	3	1.262	$64\bar{2}$
3	2.306	2.303	311						
2	2.221	2.217	112						
2	2.205	2.205	$22\bar{2}$						
28	2.158	2.158	330						
29	2.136	2.136	$33\bar{1}$						

The powder X-ray data, Table 3, were measured from diffractometer traces. A parameter refinement using the CELFIT program described by Pryce (1970) gave a = 9.751 Å, b = 8.949 Å, c = 5.258 Å and β = 105.91°. The pattern was initially indexed from the data of Frondel and Ito (1966) for an aegirine-augite of similar aegirine content but with a considerable manganese and zinc content. The resulting cell parameters for the Peak Charles material show some variation from the zincian aegirine-augite, particularly in the angle β. When compared with a more 'normal' aegirine-augite from Canada containing 77 per cent aegirine (Nickel and Mark, 1965) the differences in all parameters are considerable. Little information exists on the variation of cell dimensions with composition for the series aegirine - aegirine-augite, but a study of the synthetic series aegirine-diopside by Nolan and Edgar (1963) indicates that the dimensions a and b decrease whereas c and angle β increase with increasing aegirine content. Using the data of this paper and that found by Nickel and Mark there is a suggestion that, although the absolute values differ considerably, the same relationship holds for a, b and c in the natural material whereas the angle β moves in the reverse direction. The reason for this deviation is not known.

AMPHIBOLE

The aegirine-augite is commonly altered to a blue amphibole, pleochroic from a pale straw yellow to varying shades of blue grey. Invariably the amphibole is charged with octahedra of magnetite and blebs of quartz (Plate IV) which indicate that, even in specimens without pyroxene present, the amphibole is an alteration product of aegirine-augite. The patchy colouring probably indicates a variation in composition, but because of the granular nature of the amphibole it is difficult to determine optically. Some of the darker patches of amphibole have a strong dispersion and anomalous birefringence and are possibly arfvedsonitic in composition.

SPHENE

Sphene is a constant and distinctive minor component of all rocks from the Fitzgerald Peaks; it is rarely absent from a thin section and is commonly present at about the 1 per cent level (Table 1). Its form varies from anhedral rounded blebs to well-formed lozenges and tabular shaped crystals up to 2 mm long. The distinctive features which separate it from sphene found in the surrounding granite batholith are its colour and alteration. In hand specimens sphene can sometimes be seen as orange-brown crystals although in thin section the mineral is pale brown and patchily zoned to orange-brown. The crystals are moderately pleochroic in shades of orange-brown, and the birefringence is noticeably lower than normal sphene.

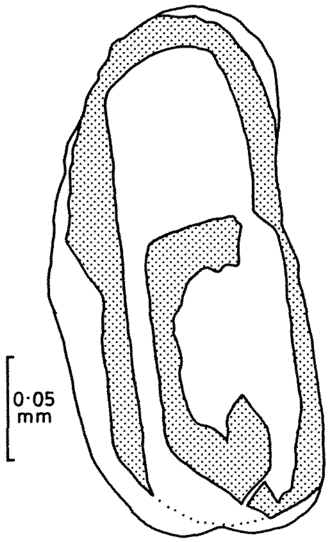

Figure 2. Zoned metamict sphene. Fresh sphene stippled, metamict zones clear. See also Plate VIII (GSWA 17333)

According to Deer and others (1962, vol.1, p.74) the lower birefringence and stronger colour can be correlated with a low Ti and high Fe_2O_3 content for the mineral. The orange hue might be due to the presence of significant amounts of rare earths in the sphene. In most specimens the larger sphene crystals show some degree of alteration, marginally or along cleavages and fractures, to a dark red-brown iron-stained material, but in a few the alteration is to a yellow or orange-brown high relief material which is isotropic or nearly so. In the specimen illustrated (Fig.2 and Plate VIII; sample 29818) there is a narrow outer zone of orange sphene with a zone of pale coloured sphene, and a core of nearly isotropic orange material and sphene. Specimen 29836 shows a large crystal of sphene which has been altered to needles of an opaque oxide, areas of isotropic semitransparent material, and areas of colloform transparent orange material. Sahama (1946, p.116) describes similarly zoned and altered sphene from Finland the analysis of which contained significant amounts of rare earths. X-ray photographs by Sahama also revealed the presence of anatase in the altered material. No mineral identifiable as anatase was seen in the Fitzgerald Peaks rocks but it is probably present in a finely divided state in the altered sphene.

ACCESSORIES

Accessory minerals include magnetite, apatite and zircon. All occur in the small amounts usual for granitic rocks; but in a few specimens apatite, as prisms up to 2 mm long, forms 2-3 per cent of the rock. Apart from the amphibole derived from aegirine-augite and the material derived from the breakdown of sphene, the only secondary minerals present are a little carbonate and rare fluorite.

CHEMISTRY

TABLE 4. Chemical analyses of rocks from Fitzgerald Peaks

Sample no.	29809	29831	29818	29821	A
SiO_2	62.17	69.82	63.18	61.67	61.68
TiO_2	0.85	0.13	0.27	0.57	0.58
Al_2O_3	16.85	14.90	15.93	16.23	16.91
Fe_2O_3	1.79	0.72	0.83	1.15	2.32
FeO	2.71	1.14	2.19	1.85	2.63
MgO	1.35	0.23	1.09	0.58	0.96
CaO	2.72	1.18	2.48	2.61	2.54
Na_2O	4.58	5.27	5.40	5.74	5.46
K_2O	4.18	4.29	6.03	5.56	5.91
H_2O^+	0.73	0.52	0.66	0.58	0.53
H_2O^-	0.60	0.06	0.14	0.08	-
CO_2	0.00	0.00	0.00	0.00	-
P_2O_5	0.32	0.06	0.38	0.31	0.19
MnO	0.02	0.05	0.09	0.12	0.11
Total	98.87	98.37	98.67	97.05	100.00

TABLE 4 - continued

C.I.P.W. norm

Q	11.62	19.67	3.25	2.53	
C	0.61	-	-	-	
Or	24.69	25.35	35.61	32.86	
Ab	38.75	44.59	45.69	48.57	
An	11.41	4.32	1.44	2.11	
Di	-	1.00	6.97	6.35	
Wo	-	0.49	3.50	3.19	
En	-	0.15	1.64	1.44	
Fs	-	0.36	1.83	1.73	
Wol	-	-	-	0.50	
Hy	5.51	1.43	2.30	-	
En	3.37	0.42	1.09	-	
Fs	2.15	1.02	1.22	-	
Mt	2.59	1.05	1.20	1.66	
Il	1.61	0.25	0.52	1.08	
Ap	0.75	0.14	0.89	0.73	

Analyst: N. Marsh, Government Chemical Laboratories. CO_2, H_2O and FeO by chemical methods, remainder by X.R.F.

28909 : Biotite adamellite

28931 : Aegirine-augite granite

29818 : Quartz syenite

29821 : Syenite

A : Average alkali syenite (Nockolds, 1954)

TABLE 5. Partial chemical analyses of rocks from the Fitzgerald Peaks area

Sample no.	28861	28862	28864	29803	29817	29835
MgO	0.53	0.26	0.57	0.19	0.46	0.24
CaO	2.28	0.70	2.06	0.96	1.31	1.66
Na_2O	4.17	3.10	4.25	4.17	5.80	4.05
K_2O	2.75	5.10	2.90	4.44	4.30	3.40

28861-62-64 : Porphyritic biotite granodiorite and adamellites, major batholith surrounding Fitzgerald Peaks

29803-17-35 : Pyroxene granites, Fitzgerald Peaks.

The essentially similar nature of all the rock types from the Fitzgerald Peaks is shown by the chemical analyses of Table 4. Soda and potash values are high in each of the analyzed specimens, and the only significant variations are in the SiO_2 values which decline with falling modal quartz (Table 1), and Al_2O_3 which rises with total modal feldspar. The analysis of sample 29821, a syenite with only 1 per cent modal quartz is similar to Nockolds' (1954) average for an alkali syenite in all except iron content. A strict comparison of the norms of Table 4 and the modes of Table 1 is not possible due to the presence of a soda-bearing pyroxene in the rock, but the most notable omission from the norm is sphene which although present in small amounts is so prominent in the rocks.

The similarity of the biotite adamellite to the main mass of the Fitzgerald Peaks is also shown by the analyses where it is seen that a slightly lower alkali content is the only distinctive chemical feature of the adamellite.

DISCUSSION

The Fitzgerald Peaks Syenite is a diapiric body intruded into an Archaean granite. Foliation and banding in the rock indicate that the intrusion probably narrows downward, and the presence of modal aegirine-augite suggests a high level intrusion. Beyond these generalized and tentative conclusions problems arise because the uniformity of the rock types and the isolation of the intrusion within a 'sea' of granite, allow no more than speculation as to the origin of the magma or its age. No structures within the surrounding granite were observed which could be connected to the intrusion of the syenite, but perhaps the presence of basic dykes within the mass and their absence from the granite give an indication. As noted above the dykes vary from normal, parallel-sided post-syenite intrusions to highly metamorphosed and streaked out rafts. It appears possible that, at the time of intrusion of the Fitzgerald Peaks mass, a local 'hot spot' had developed which allowed both the intrusion of basic dykes and the development of the syenitic magma. Early dykes were metamorphosed and partially absorbed as the magma was emplaced at higher levels, whereas later dykes remain. On this scheme the origin of the syenitic magma was anatectic, although to produce such an alkali-rich and quartz-poor rock a considerable degree of differentiation must have taken place. Assimilation of basic material from early dykes, although locally demonstrable, cannot have a great overall importance as no mixture of normal acidic and basic material would produce the chemistry observed.

From the contrast between the rock types and topography of the Fitzgerald Peaks with those of the surrounding Archaean granites, and the nearness of the Proterozoic Albany-Fraser Province, it is tempting to assume a Proterozoic age for the syenitic rocks. No structures within the syenite or surrounding granites provide evidence for this hypothesis, and there are no similar rock types known within the area of Proterozoic rocks. There is a small outcrop of quartz-poor rocks at Lake Shaster, about 70 km east-southeast of Ravensthorpe, but this is a biotite monzonite having an entirely different texture; the Fitzgerald Peaks Syenite more closely resembles the syenites found further north within the Archaean shield. Radiometric data reported by Turek (1966) support a Proterozoic age, but are open to various interpretations. Based on one whole-rock analysis and a feldspar separate from the same sample, Turek reported an age of 1 670 m.y. with the very high initial $^{87}Sr/^{86}Sr$ ratio of 0.7473. Assuming the data were correct, they not only indicate a Proterozoic age for the Fitzgerald Peaks, similar to ages found in the nearby Albany-Fraser Province (Arriens and Lambert, 1969, p.380), but also show that the magma must be of anatectic origin. Alternative interpretations (W. Compston, written communication) which would allow an Archaean age for the Fitzgerald Peaks rocks involve the assumption either of technical errors in the analysis, or the resetting of the feldspar during the Proterozoic. The only field evidence which suggests an age older than 1 670 m.y. is the presence near Annes Pass of a small exposure of norite (sample 29838). This appears to be part of a dyke which cuts the syenite and which might be related to the major east-west dykes dated by Turek at 2 420 $\pm$ 30 m.y.

Apart from the small intrusion at Yerilla noted by Honman (1917) recent regional mapping of the Eastern Goldfields Province by the Geological Survey has found numerous small, isolated bodies of alkalic rocks. These vary from porphyry dykes at Norseman and Widgiemooltha to larger bodies of syenite and quartz syenite in the Sir Samuel area. All these intrusions are characterized by the presence of aegirine-augite, often altering to an arfvedsonitic amphibole. These bodies are sparsely scattered over an area several hundred kilometres long and do not outline a definite alkalic province within the major greenstone belt of the Eastern Goldfields Province, nor can they be compared with the Fitzgerald Peaks rocks.

However, it is perhaps significant that no syenites are known from the other greenstone belts of the Yilgarn Block, and that within the Wiluna-Norseman belt the alkalic rocks are confined to a relatively narrow central zone.

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P L A T E S

PART IV

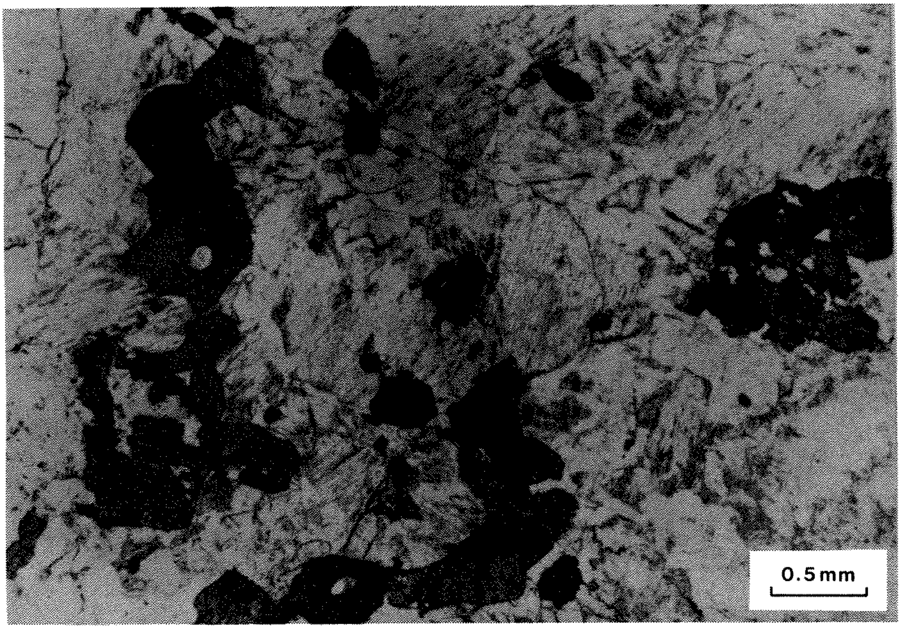

Plate I. 29833: Quartz syenite, Peak Charles. Anhedral aegirine-augite and subhedral sphene in a feldspar matrix (plane polarized light).

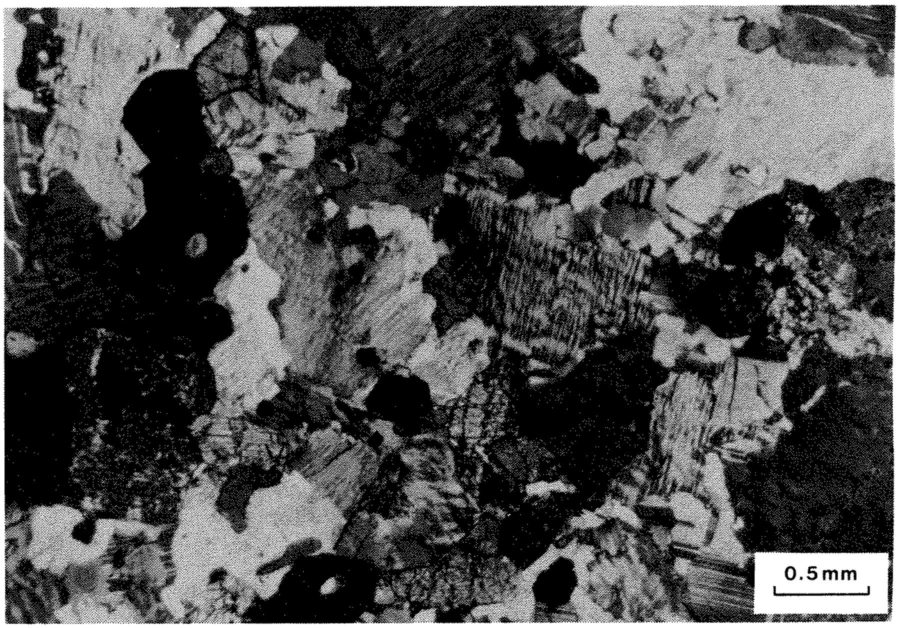

Plate II. 29833: Quartz syenite, Peak Charles. Note the predominance of perthitic microcline, but also the presence of finely twinned and myrmekitic albite (crossed polarizers).

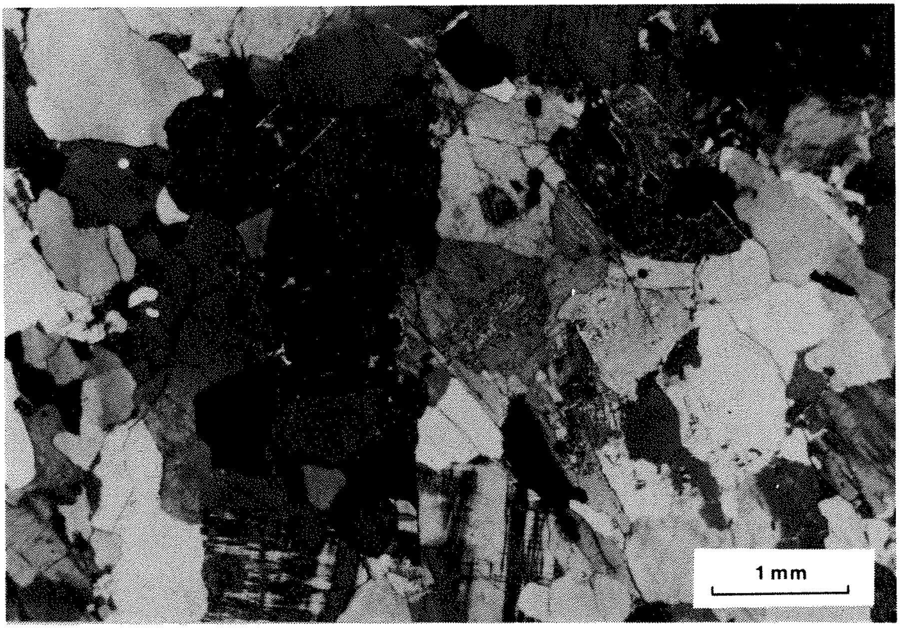

Plate III. 29809: Biotite adamellite, northwest of Peak Charles. Microcline and sodic oligoclase as separate phases and biotite as the principal mafic mineral (crossed polarizers).

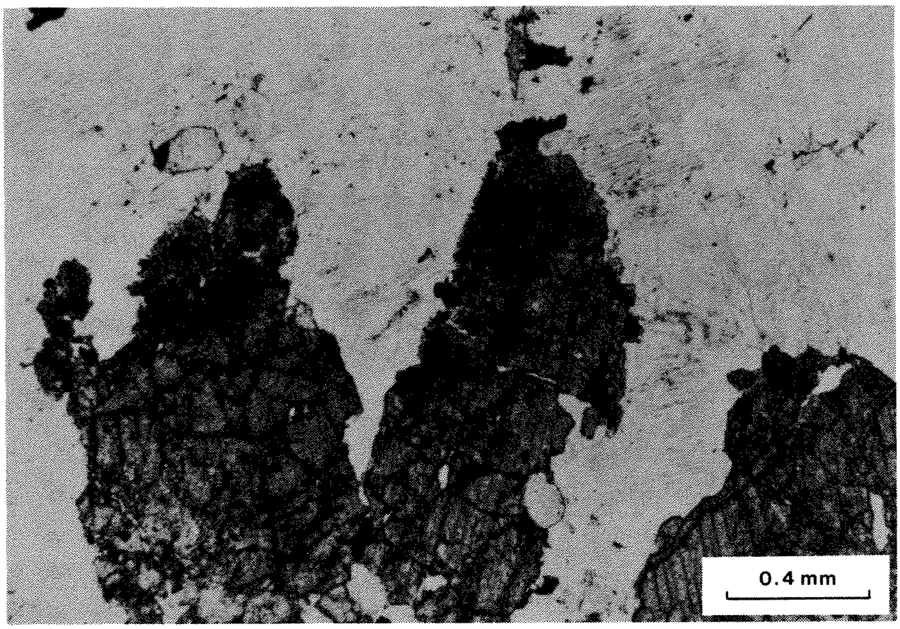

Plate IV. 29821: Aegirine-augite altering marginally to arfvedsonitic amphibole charged with granular magnetite (plane polarized light).

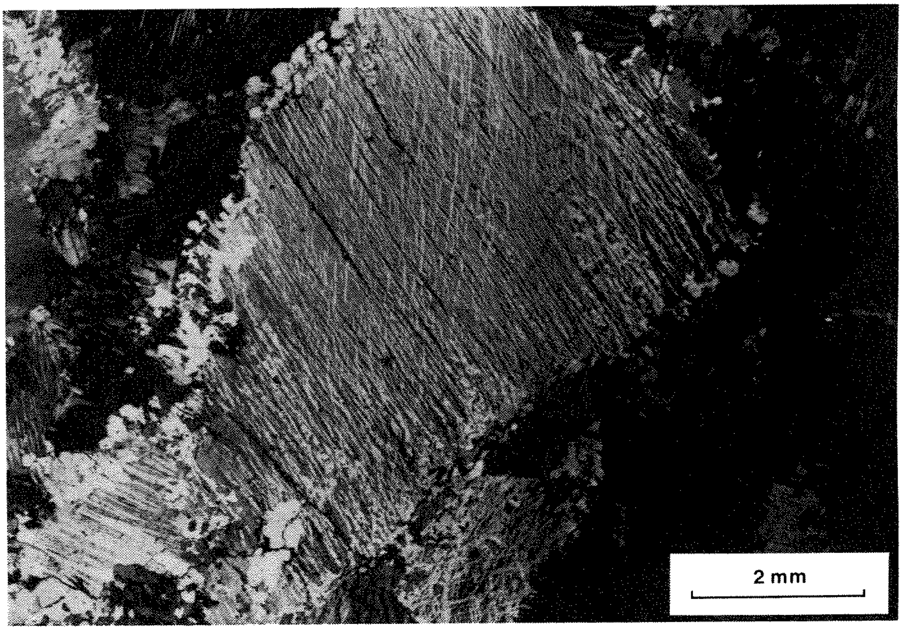

Plate V. 26680: Large perthite crystal with exsolved meshwork of albite and secondary spindles of microcline (crossed polarizers).

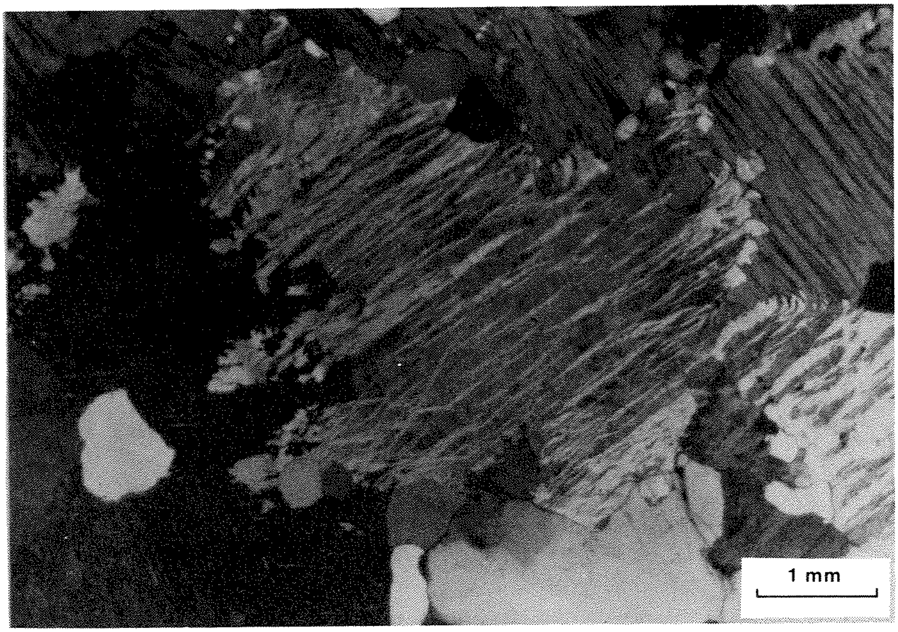

Plate VI. 29812: Perthite with highly sutured lobate margins towards adjacent perthite crystals (crossed polarizers).

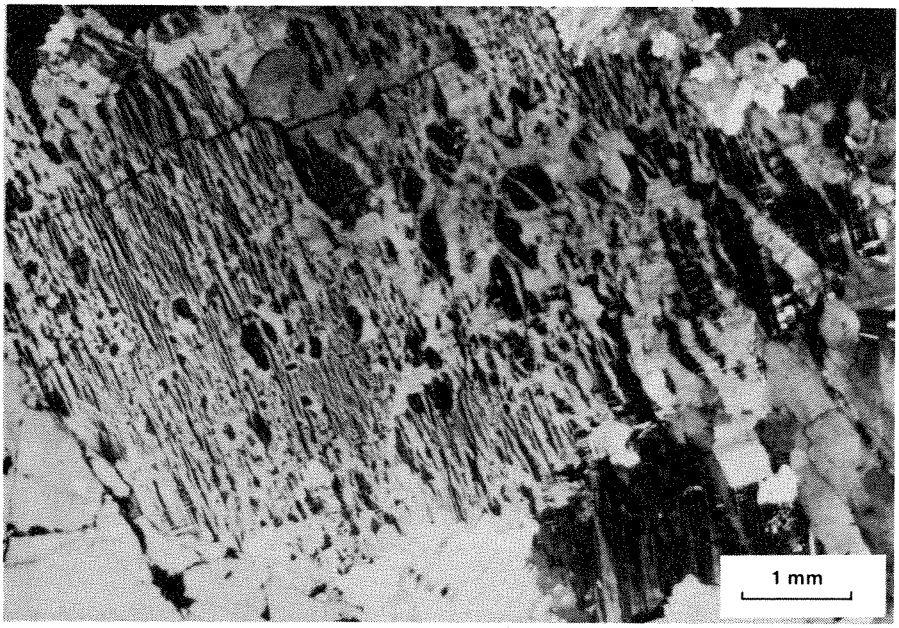

Plate VII. 29815: Perthite showing variations in single crystal from oriented spindles of albite to irregular exsolution veins. The albite is twinned perpendicular to the veins (crossed polarizers).

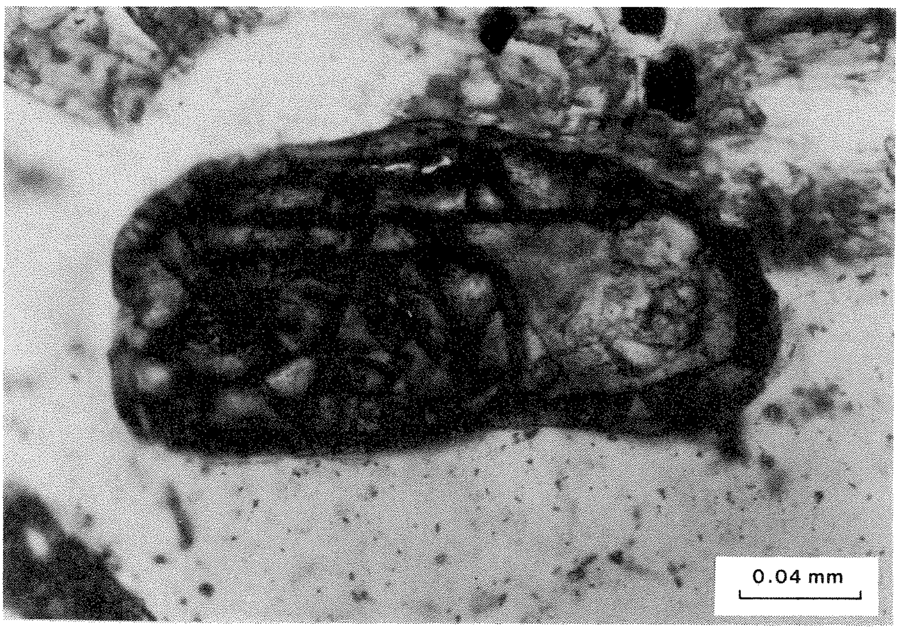

Plate VIII. 29818: Zoned metamict sphene (see also Fig.2).

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