The petrology of the older granites around Bauchi, Nigeria

Mosobalaje Olaloye Oyawoye

Thesis

Submitted for the Degree of Doctor of Philosophy

In the University of Durham.

The Petrology of The Older Granites Around Bauchi, Nigeria,

by

MOSOBALAJE OLALOYE OYAWOYE, B. Sc., F. G. S.

Hatfield College

and

The Department of Geology

Durham Colleges.

Durham.

June, 1959

VOLUME TWO

ILLUSTRATIONS

LIST OF PLATES

PLATES Figure -

9	A	A photomicrograph of the Arkosic Quartzite, crossed nicols.
	B	A photomicrograph of the Arkosic Quartzite, ordinary light.
10	A	Sieve fabric in the pyroxene of Calcsilicate rocks.
	B	Photomicrograph of a poikiloblastic garnet.
11	A	Photomicrograph showing texture of Biotite Gneiss.
	B	Photomicrograph of contact area of a microcline porphyroblast with the groundmass.
12	A	Hand-specimen of the Agmatite.
	B	Pegmatite.
13	A	Tourmaline Crystal.
	B	Tourmaline in graphic granite.
14	A	Biotite Gneiss (hand-specimen)
	B	Biotite Gneiss (" ")
15	A	A photomicrograph of the Biotite Gneiss in Plate 14, Fig. A.
	B	A photomicrograph of the Biotite Gneiss is Plate 14, Fig. B.

PLATES	Figure.	
23	A	A bent and brecciated plagioclase crystal.
	B	Crystalloblastic plagioclase crystals.
24	A-D	The arrangements of the ferro-magnesian minerals in the Fayalite-Quartz Monzonite.
25	A	Rod-like aggregates of Fayalite.
	B	Charnöckitic Fayalite-Quartz Monzonite (Hand-specimen.)
26	A	Photograph of a section of the shown in Plate 25 Fig. B (between crossed polaroids.)
	B	As in Plate 26 Fig. A but ordinary light.
27	A	Porphyroblast-like areas in the Quartz-Diorite.
	B	The specimen above (Plate 27, Fig. A) stained for potash.
28	A	The micro-texture of the Quartz-Diorite.
	B	Irregular calcic core in a zoned plagioclase crystal of the Quartz-Diorite.
29	A	A bent plagioclase crystal in the Quartz-Diorite.
	B	Needle-like inclusions in the plagioclase of the Quartz-Diorite.

PLATES Figure

30	A-B	Poikiloperthite in the Quartz-Diorite.
31	A-B	Schiller Structure in the Ferro-hypersthene of the Quartz-Diorite.
32	A	Myrmekite.
	B	Matured Myrmekite.
33	A	Old Myrmekite.
	B	Post-Myrmekite.
34	A	Stringlet perthites.
	B	String perthites.
35	A	Film perthites.
	B	Rod perthites.
36	A	Vein perthites.
	B	Vein perthites (streak variety)
37	A	Patch perthites.
	B	Poikiloperthites.
38	A	Antiperthites.
	B	Bleb from the antiperthites in (Plate 38, Fig. A) enlarged.

PLATES	Figure	
39	A	Pseudocataclastic texture.
	B	Pseudo-cataclastic texture with relic cataclastic structure.
40	A	Checkerboard structure.
41	A	A dyke-like body of cataclastic rocks.
	B	Hand-specimen from above (Plate 41 Fig. A)
42	A	Interstitial microcline grains in the Biotite Granite.
	B	Microcline porphyroblast in Biotite Granite.
43	A	A photograph of the Quartz-Diorite to show lineation structure.
	B	Dolerite dyke with inclusions (hand-specimen)
44	A	Micro-texture in trachyte
	B	Micrographic and felsitic textures.
45	A	Cataclastic Rocks.
46	A-B	Cataclastic sctructure (higher degree of deformation than illustrated in Plate 45.)
47	A	A photomicrograph of a perfect augen.
	B	Photomicrograph of epidote rock.

PLATES Figure

48	A	Photomicrograph of Silicified rock.
	B	Zoned plagioclase with perthite rim.

LIST OF FIGURES

Figure

LIST OF MAPS

PLATE 1

Fig. A: The Yuli Hill inselberg, a good example of a turtle-back.
(From a photograph by Bain (1926))

Fig. B: View of the Dumi Hills showing a good example of a whale-back. This group of hills contains several examples of whale-backs. Note the exfoliation scars.
(From a photograph by Bain (1926))

PLATE 1

Fig. A

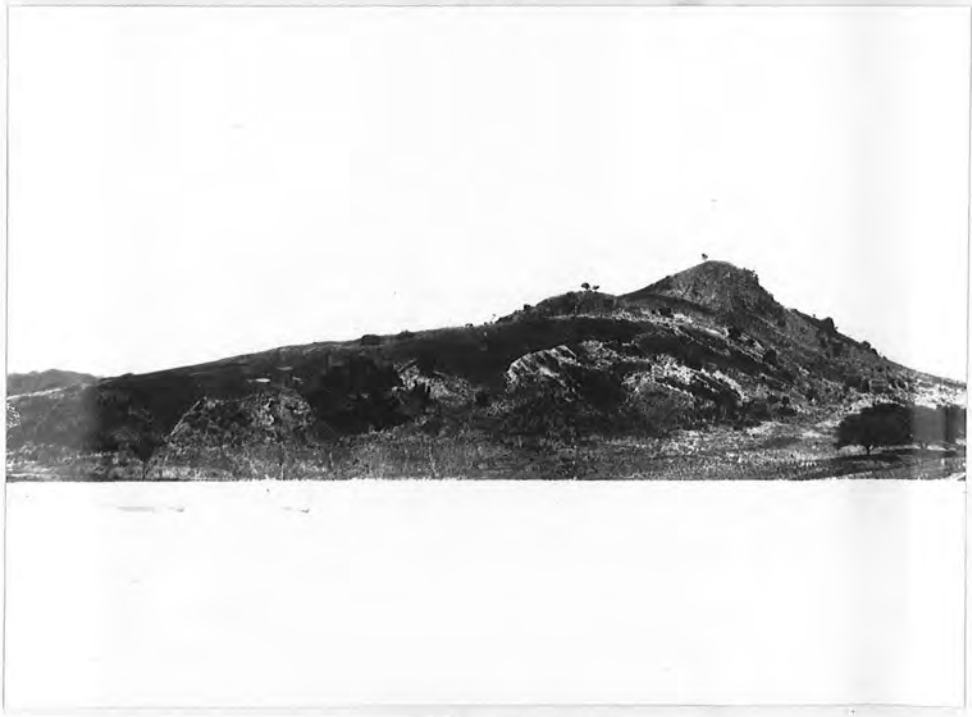


Fig. B

PLATE 2

Fig. A: The Shadawanke Hill viewed from the Jos Road at the Bauchi city limit from a point north of the Administration building. Note the near-perfect conical shape. (The scar on the right side of the photograph is a flaw in the negative which is regretted.)

Fig. B: The Buli hills in contrast to most of the inselbergs of the district, are a jagged chain of hills rising about 2000 ft. above the surrounding plain. They bear a striking resemblance to the Younger Granite hills around Jos. (From a photograph by Bain, 1926.)

PLATE 2

Fig. A

Fig. B

PLATE 3

Fig. A: Agmatitic dissection of the Biotite by pegmatitic and granitic dykes. Photograph taken near the road about 2 miles north of the Ran Gate, Bauchi.

Fig. B: Similar agmatitic structures about ¾ of a mile east of Tiruin hill. In this and the above illustration the foliation is structurally continuous from one block to another (see fig. 3). The dyke running right to left across the photograph is two feet wide towards the extreme.

PLATE 3

Fig. A

Fig. B

PLATE 4

Fig. A: Xenolith-like dense fine grained granitic rocks commonly found within the Fayalite-Quartz Monzonite.

Fig. B: A portion of an aerial photograph (Bauchi Circle, No. 18957) showing parallel gashes (overlay) believed to be fault zones.

PLATE 4

Fig A

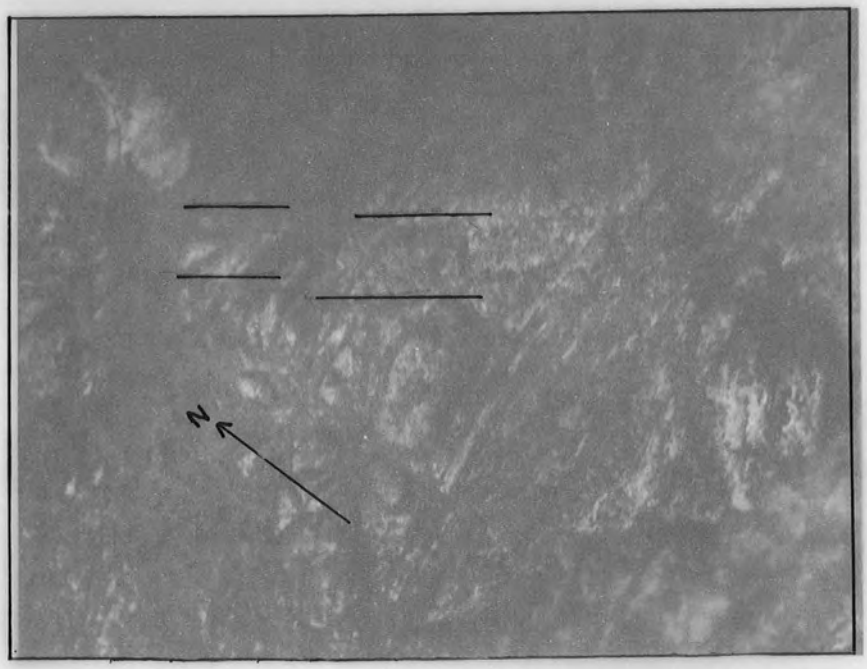


Fig B

PLATE 5

Fig. A: A small hill north of Shadawanke showing jointing in the Biotite Granite.

Fig. B: A triangular projection of the Fayalite-Quartz Monzonite into the Medium-grained Biotite Granite. Note the indefinite character of the contact, especially on the lower side, despite the sharp line of textural contrast.

PLATE 5

Fig. A

Fig. B

PLATE 6

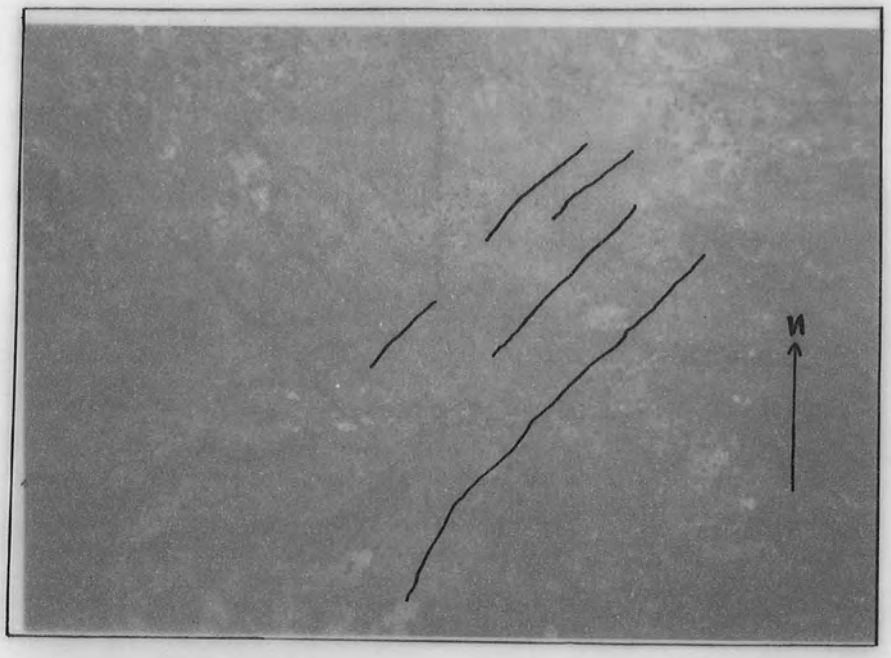


Fig. A

Fig. B

PLATE 6

Fig. A: A portion of an aerial photograph (Bauchi Circle, No. 21399/31) showing a number of trachyte dykes striking north-west.

Fig. B: A portion of an aerial photograph (Bauchi Circle, No. 18957) showing the north-west to south-west trend of the Dumi hills.

PLATE 7

Fig. A: (ME200) Granulite (x 70, Crossed Nicols)

A photomicrograph showing lepidoblastic texture in granulite, Ran Hill, Bauchi.

Fig. B: (ME179) Hornfelsic Granulite (x 70, Crossed Nicols)

A photomicrograph showing part of a coarse lensoid aggregates of plagioclase (dark) in microperthite (grey) and quartz (white).

Airstrip, Bauchi.

PLATE 7

Fig. A

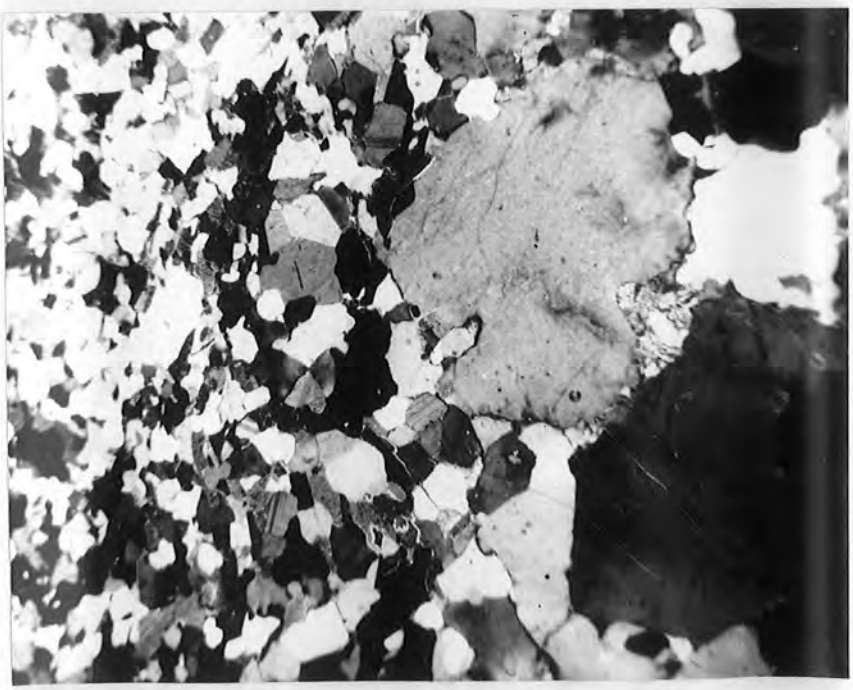


Fig. B

PLATE 8

Fig. A: (ME206) Amphibolite
(x 0.1, Crossed Nicols)

Amphibolite, possibly originally a dyke, is dissected and partly assimilated by granitic mass which becomes coarser where amphibolite had been completely digested. ¼ of a mile North Ran Gate, Bauchi.

Fig. B: (ME206) Amphibolite
(x 70, Crossed Nicols)

A photomicrograph showing granoblastic texture in amphibolite specimen taken from a block seen in Plate 8 Fig. A.

PLATE 8

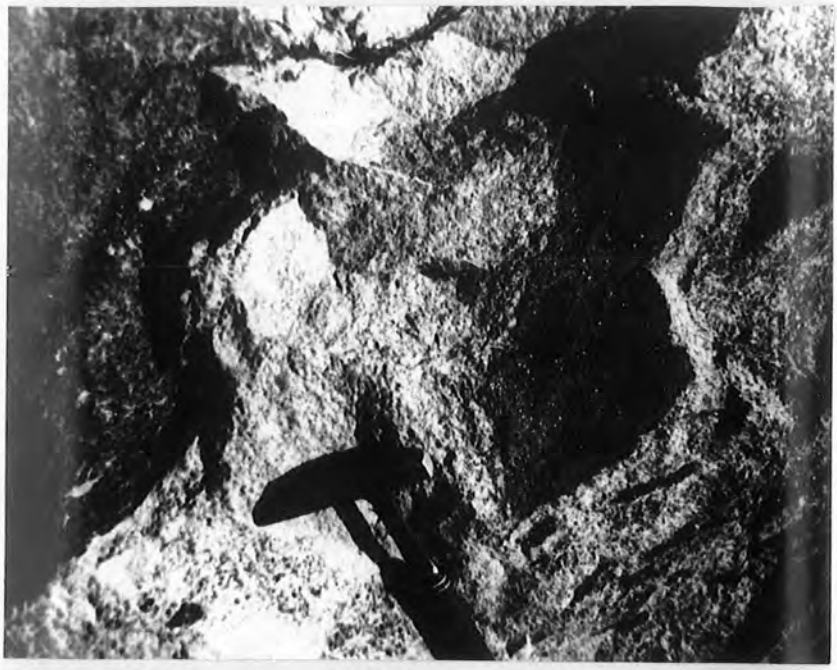


Fig. A

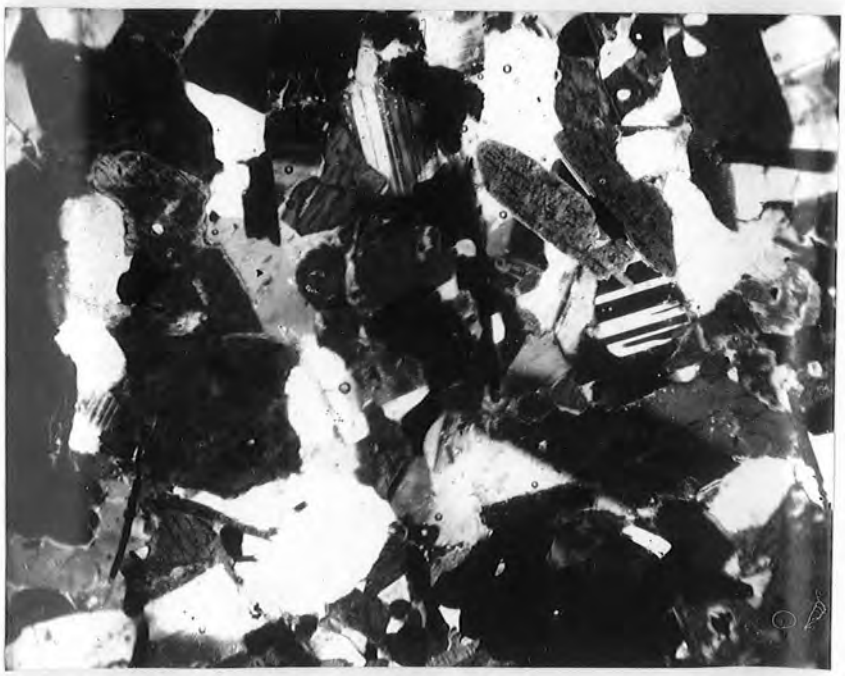


Fig. B

PLATE 9

Fig. A: (ME238) Arkosic Quartzite
(x 70, Crossed Nicols)

The Arkosic Quartzite shown in this photomicrograph is composed of microcline, (showing gridiron twinning), plagioclase and quartz. The texture is granoblastic. Airstrip, Bauchi.

Fig. B: As above but under ordinary light showing a black opaque mineral as patches and intergranular films.

PLATE 9

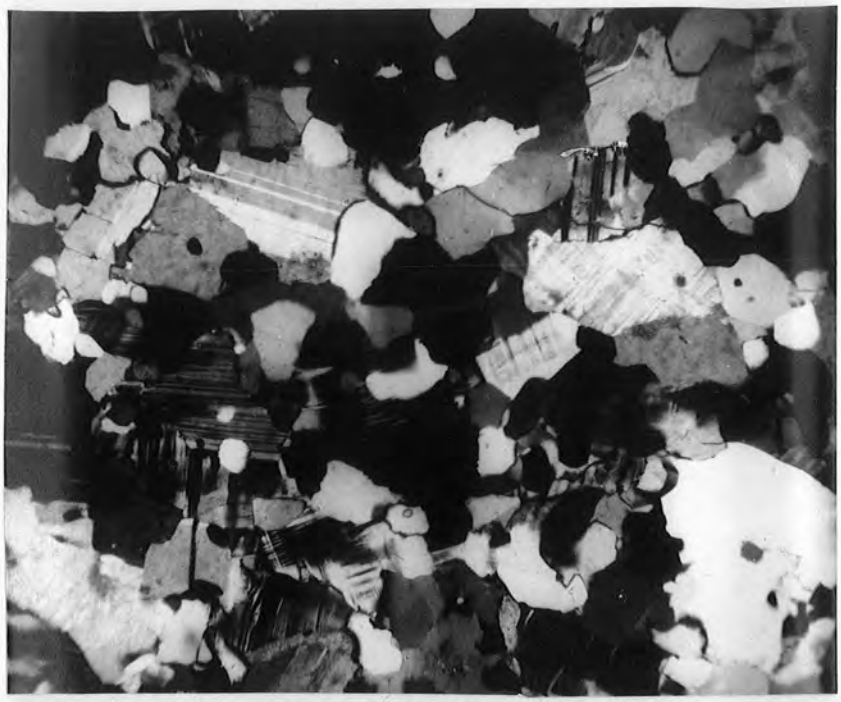


Fig. A

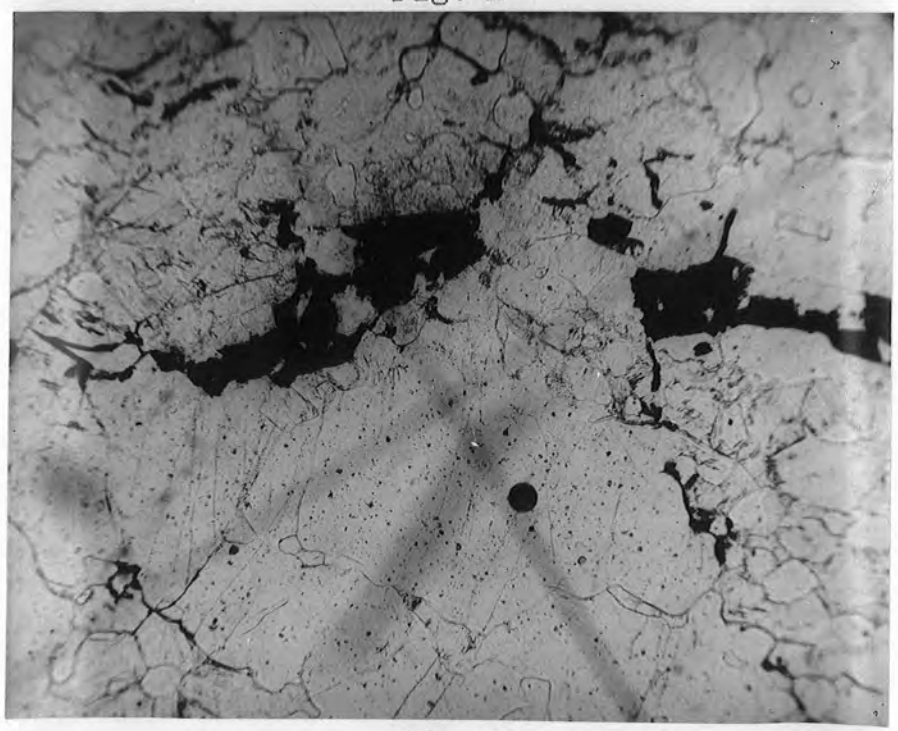


Fig. B

PLATE 10

Fig. A: (ME170) Calcsilicate Rock
(x 70, Crossed Nicols)

A photomicrograph showing a poikiloblastic pyroxene, an example of sieve fabric. Kundun village, Bauchi.

Fig. B: (ME165) Calcsilicate Rock
(x 70, Crossed Nicols)

A photomicrograph of calc-silicate rock showing garnet (black) with inclusions of pyroxene, calcite and quartz. One mile north of Miri, Bauchi.

PLATE 10

Fig. A

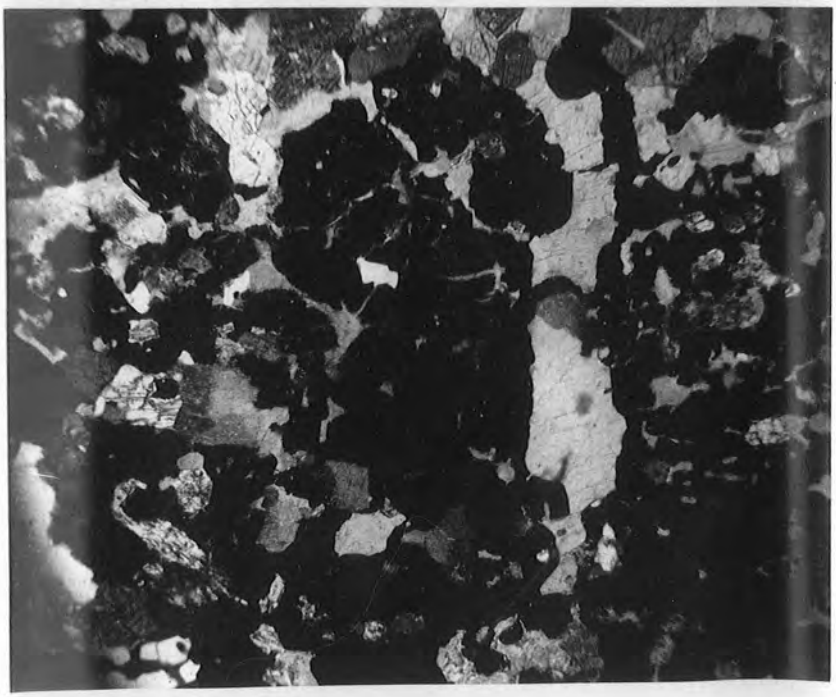


Fig. B

PLATE 11

Fig. A: (ME217) Biotite gneiss
(x 60, Crossed Nicols)

A micro-drawing of Biotite Gneiss from the Agmatites showing the granoblastic texture. Note the inter-granular microcline (cross hatched). Biotite is shown strongly hatched and plagioclase lightly hatched, quartz forms the clear areas south of Magamma hill, Bauchi.

Fig. B: (as above) (x 70, Crossed Nicols)

A photomicrograph showing the margin and central portion of a microcline porphyroblast from the specimen (ME217) described above. Note the Crystalloblastic sutured nature of the border of the porphyroblast against the groundmass.

PLATE 11

Fig. A

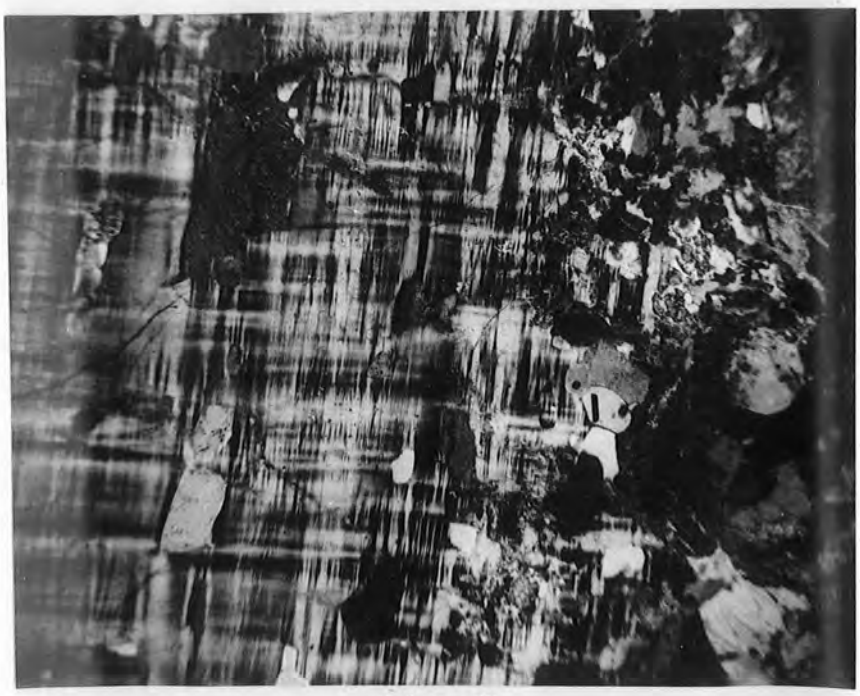


Fig. B

PLATE 12

Fig. A: (MEF126) Agmatitic Gneiss (x 0.6)

A hand-specimen (ME259) with an indefinite contact between the Biotite Gneiss blocks and the Quartzo-feldspathic dykes crossing the specimen from top roght to bottom left. From a distance this gives the impression of a sharp contact due to colour contrast: south of Magamma hill, Bauchi.

Fig. B: (ME181) Pegmatite (x 0.5)

A hand-specimen of microcline from a graphic pegmatite dyke south of Miri village, just North of Jos Road. More usually (especially in the Agmatites, the Mixed Gneiss and the pegmatites) such large feldspar crystals show no gr aphic intergrowth.

PLATE 12

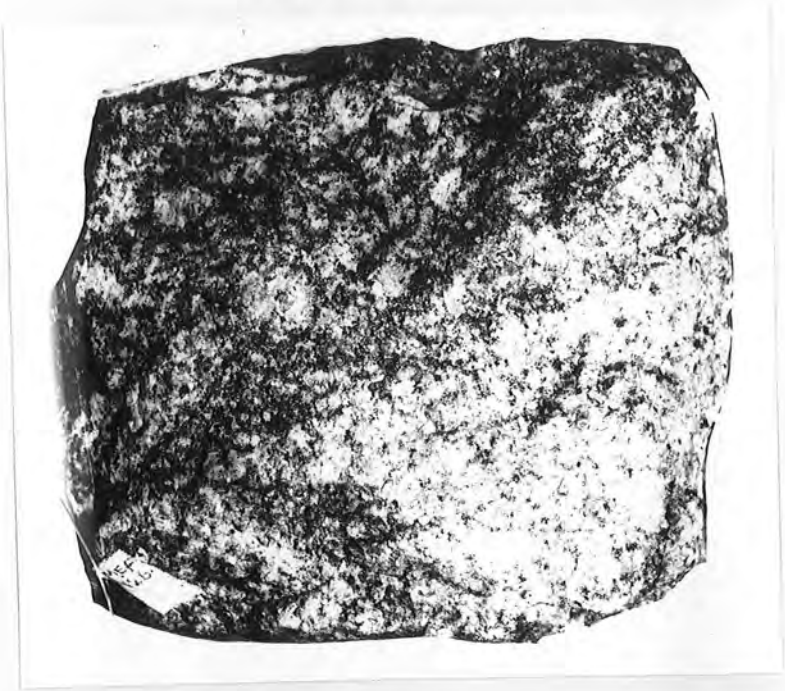


Fig. A

Fig. B

PLATE 13

Fig. A: (ME154) Tourmaline (x I)

A hand-specimen of pegmatite with large tourmaline crystal. Guru village, Bauchi

Fig. B: (ME153) Tourmaline (x $\frac{3}{4}$)

Tourmaline replacing plagioclase in a graphic pegmatite dyke. North Zungar hill, Bauchi.

PLATE 13

Fig. A

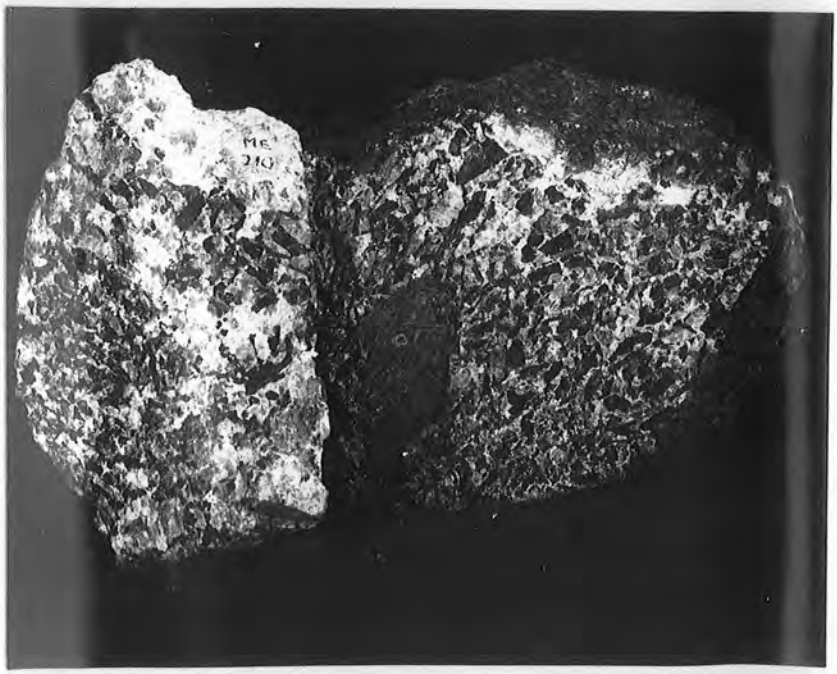


Fig. B

PLATE 14

Fig. A: (ME185) Biotite Gneiss (x 0.8)

A hand-specimen of the Biotite Gneiss showing banded structure. 1 mile south-west of Miri village.

Fig. B: (ME188) Biotite Gneiss (x 1)

Another type of Biotite Gneiss with poorly developed banding. From Shadawanke hill, Bauchi.

PLATE 14

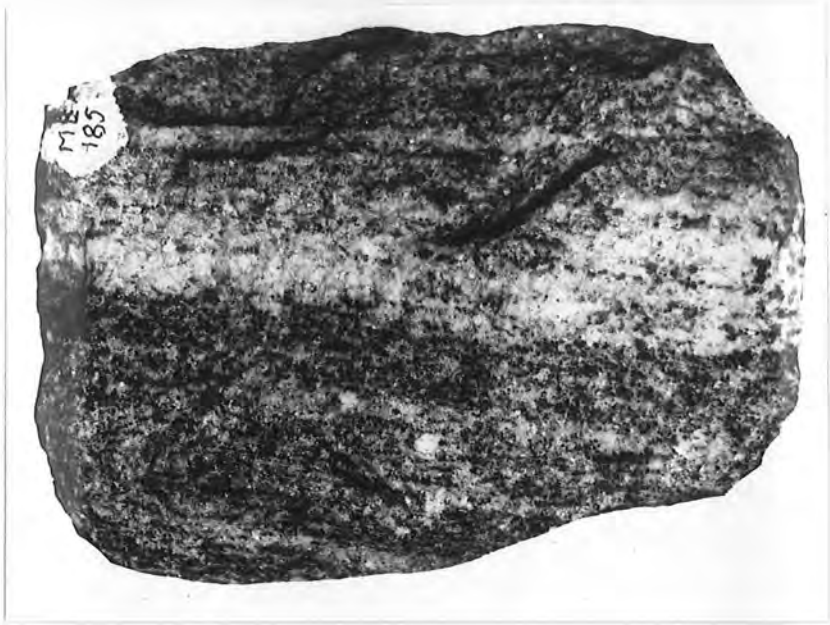


Fig. A

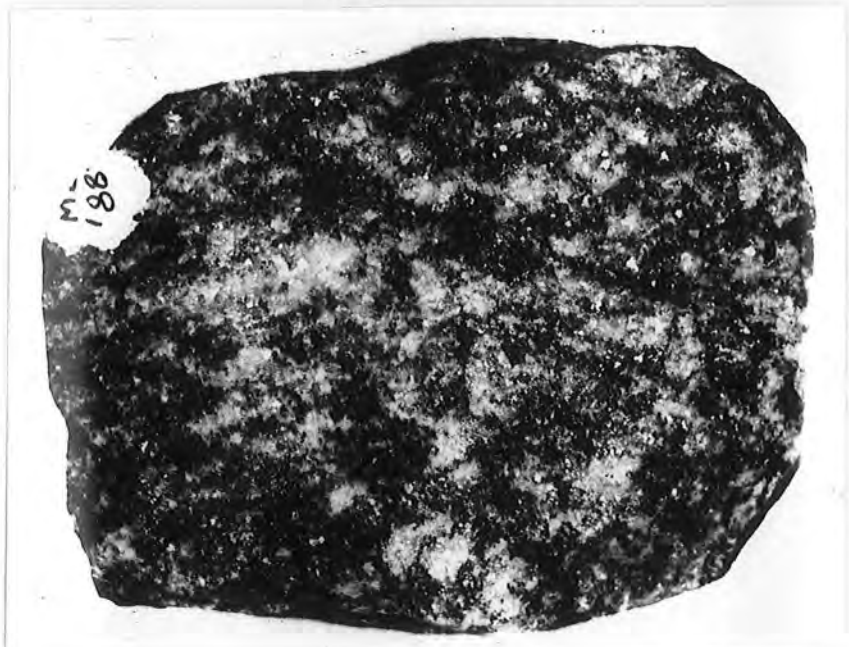


Fig. B

PLATE 15

Fig. A: (ME185) Biotite Gneiss
(x 70, Crossed Nicols)

A photomicrograph of the specimen shown in Plate 14 Fig. A, showing the alternating bands of biotite-rich area and quartz-microcline zones.
(See sketch).

Fig. B: (ME188) Biotite Gneiss (x 70)

A micro-drawing of specimen shown in Plate 14 Fig. B with biotite (strong hatching) rich and biotite free areas, intergranular microcline (crossed-hatched) is present in the biotite-free areas.

PLATE 15

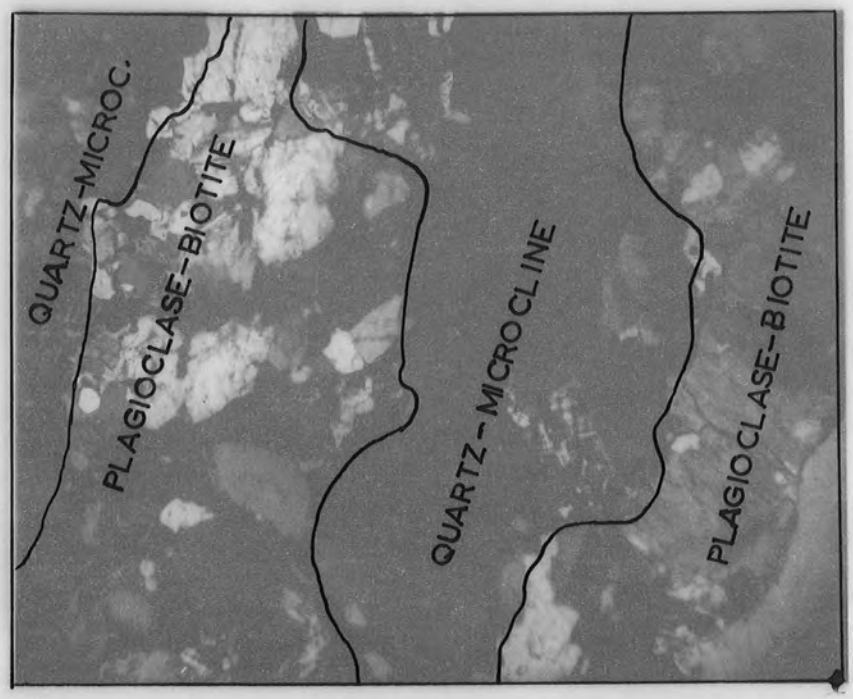


Fig. A

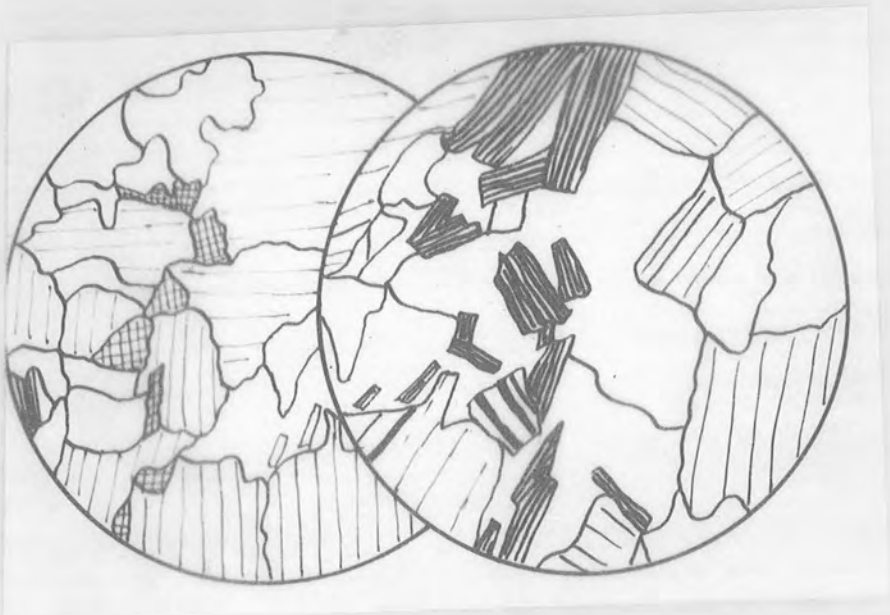


Fig. B

PLATE 16

Fig. A: (ME234) Biotite Granite (x $\frac{3}{4}$)

A hand-specimen showing medium sized microcline porphyroblasts. Guru hill, Bauchi.

Fig. B: (ME126) Biotite Granite (x 8/9)

A hand-specimen of an area of sporadic development of large microcline porphyroblasts characteristic of the Biotite Granite. $\frac{1}{4}$ of a mile East of Shadawanke village, Bauchi.

PLATE 16

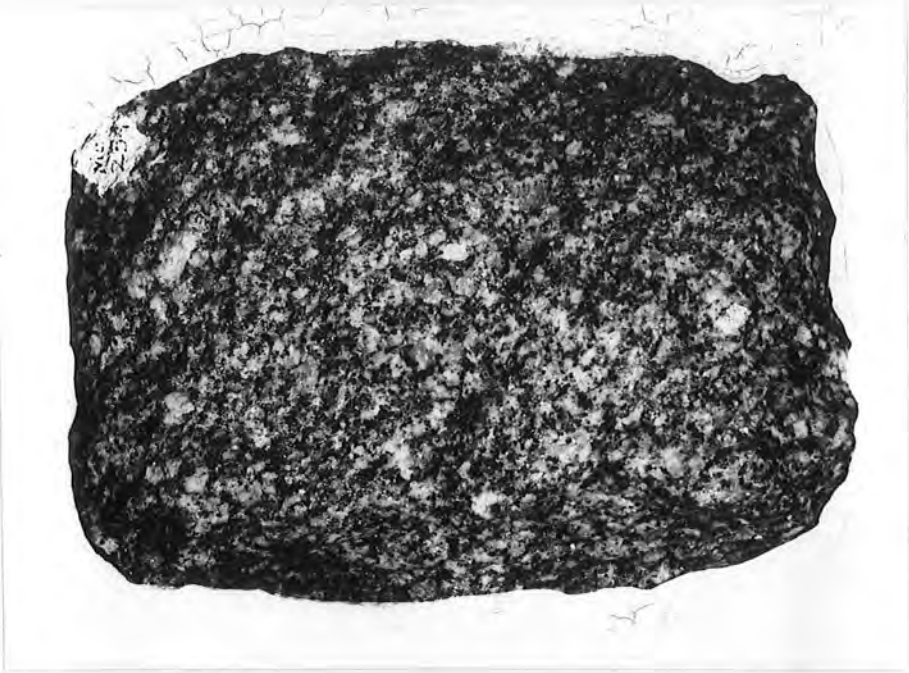


Fig. A

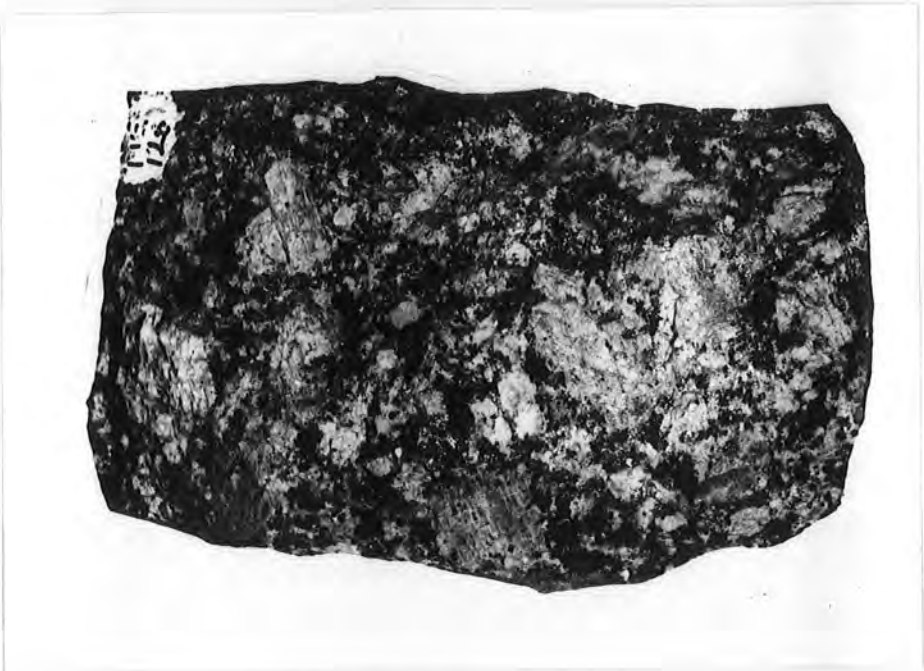


Fig. B

PLATE 17

Fig. A: (ME191) Biotite Granite
(x 70 Crossed Nicols)

A photomicrograph of the Biotite Granite showing the granoblastic aggregates of microcline, plagioclase, quartz and scanty biotite. ¼ of a mile West of Runde hill.

Fig. B: (ME131) Medium-grained Biotite Granite
(x 70)

A photomicrograph of the Medium-grained Biotite Granite. The biotite are clustered along vein-like aggregates of quartz which surround the larger crystals of plagioclase. Note the absence of intergranular microcline. North Kofar Wombai hills, Bauchi.

PLATE 17

Fig. A

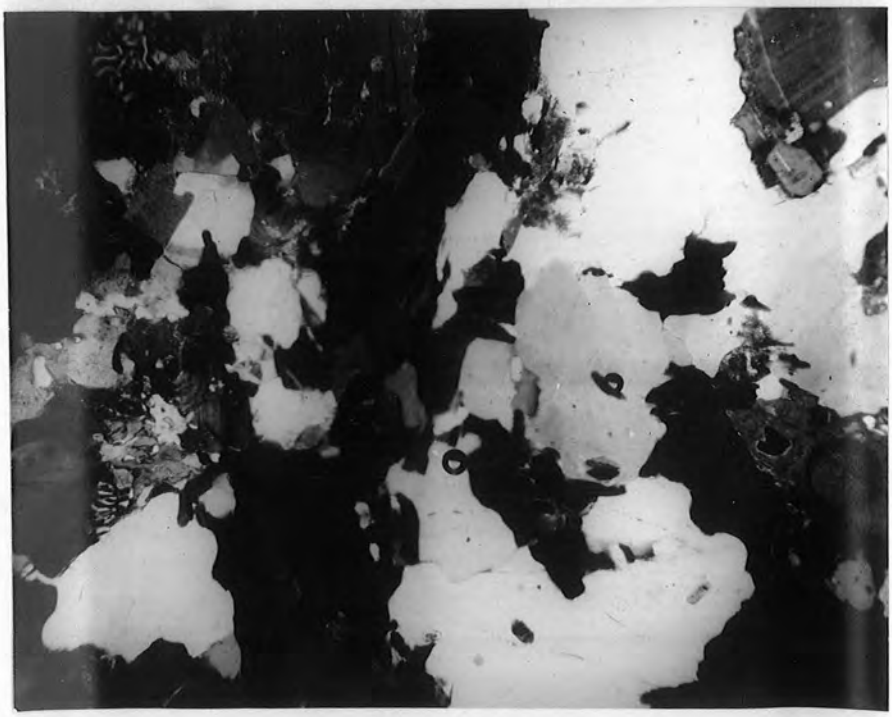


Fig. B

PLATE 18

Fig. A: (ME214) Medium-grained Biotite Hornblende granite
(x 70, Crossed Nicols)

A photomicrograph showing a granoblastic aggregate of microcline, plagioclase, quartz biotite and hornblende, the latter two, appearing as a black area in the centre, can just be distinguished from each other. South of Ran hill, Bauchi.

Fig. B: (As above) (x 70, Crossed Nicols)

A photomicrograph showing another area of the same thin section illustrated above as Plate 18 Fig. A.

PLATE 18

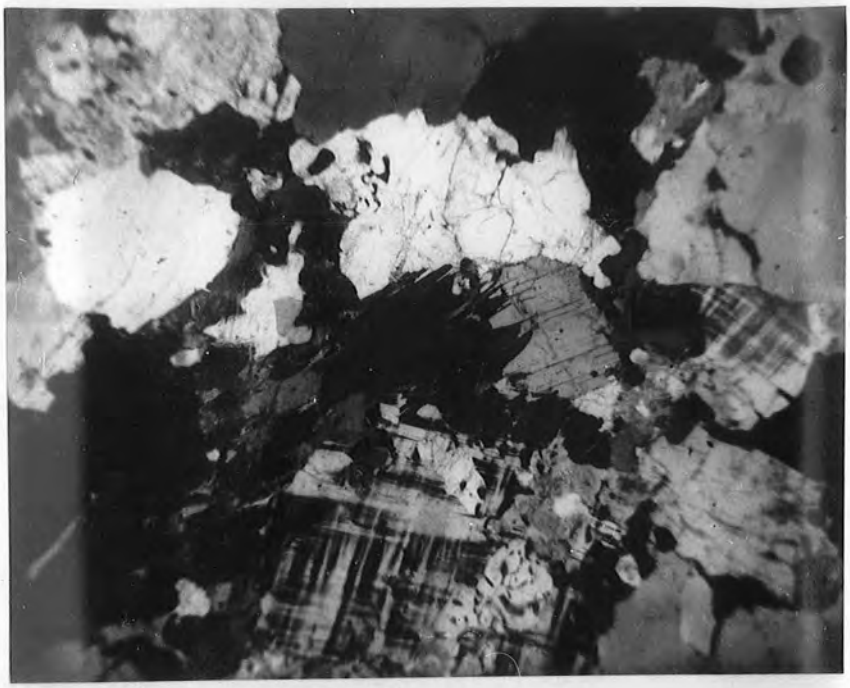


Fig. A

Fig. B

PLATE 19

Fig. A: (ME113) (9/10) Biotite Hornblende Granite

A stained hand-specimen showing the Crystalloblastic structure of the large microcline crystals in the Biotite Hornblende Granite. Dumi village, Bauchi.

Fig. B: (ME150 x 2/3) Biotite Hornblende Granite

Another stained specimen of the Biotite Hornblende Granite. (MEF150 x 2/3), ½ of a mile East of Miri village, by Road-side. Bauchi.

PLATE 19

Fig. A

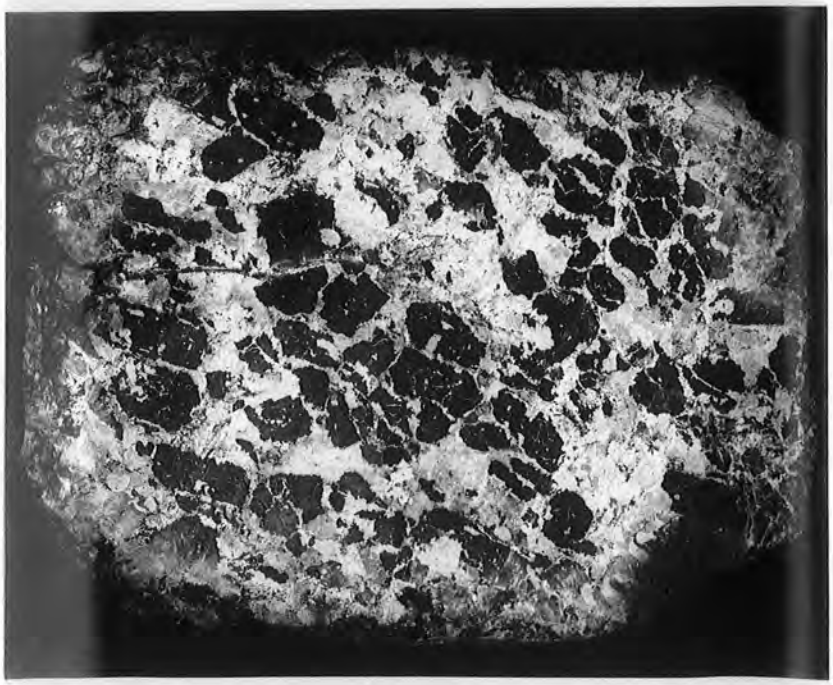


Fig. B

PLATE 20

Fig. A: (MEF150) Biotite Hornblende Granite (x 70, between crossed polaroids)

A photograph of the Biotite Hornblende Granite section showing the granoblastic (xenomorphic) granular texture. Note the seriate porphyritic texture imparted by various sizes of large grains microperthite in a groundmass of mosaic aggregates of quartz, plagioclase, biotite and hornblende. About $\frac{1}{2}$ of a mile East of Miri village, Bauchi.

Fig. B: (ME124) Biotite Hornblende Granite (x 50, Crossed Nicols)

Micro-drawing showing reversed orientation of twinning lamellae at the contact of Microcline and plagioclase from a specimen of Biotite Hornblende granite. $\frac{1}{4}$ of a mile South-East of Baskin hills, Bauchi.

PLATE 20

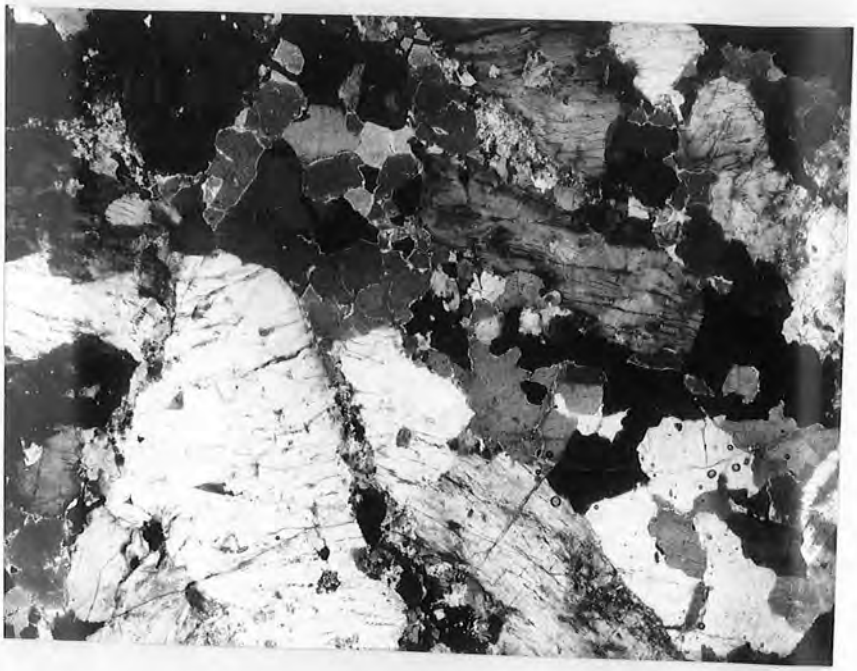


Fig. A

Fig. B

PLATE 21

Fig. A: (ME101) Fayalite-Quartz Monzonite (x $^{2}/_{3}$)

A stained hand-specimen of the Fayalite-Quartz Monzonite showing the crystalloblastic habit of the large microcline crystals (black). Kobi Hill, Bauchi.

Fig. B: (ME222) Fayalite-Quartz Monzonite (x $\frac{1}{2}$)

A stained specimen showing irregular distribution of the crystalloblastic microcline crystals. Kofar Wombai Hill, Bauchi.

PLATE 21

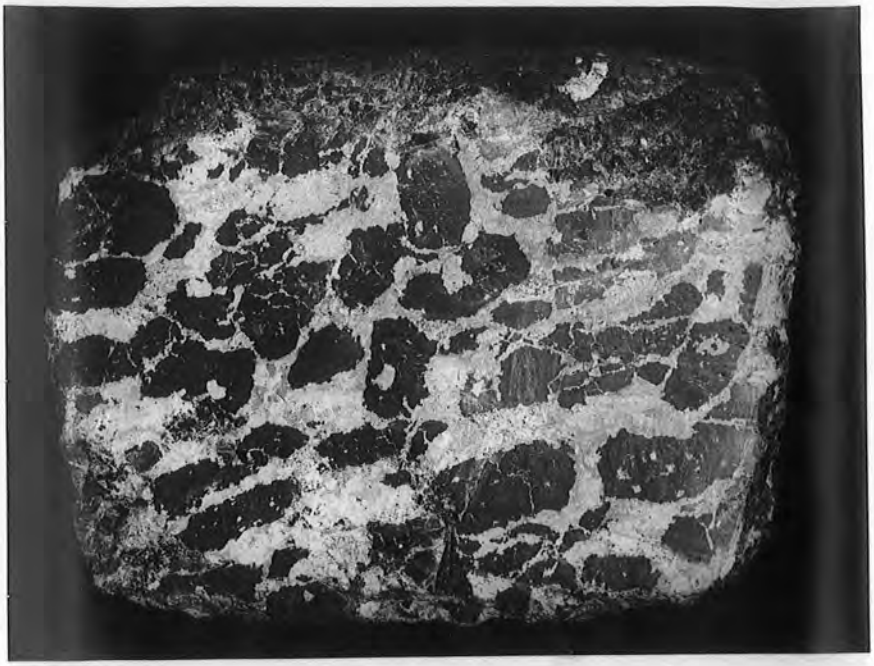


Fig. A

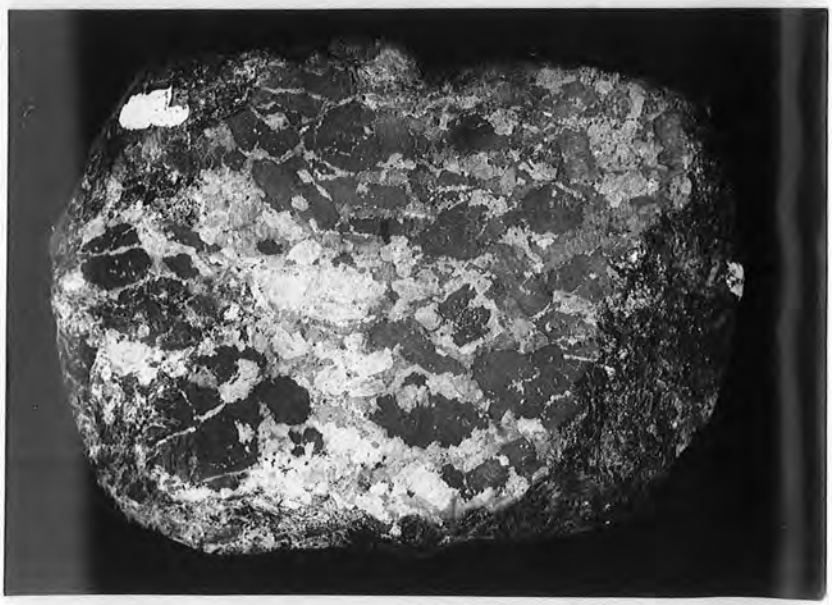


Fig. B

PLATE 22

Fig. A: (ME101) Fayalite-Quartz Monzonite
(x 4 between crossed polaroids)

A photograph of the Fayalite-Quartz Monzonite, showing a large microcline grain in the granoblastic groundmass of plagioclase, quartz, hornblende, fayalite and pyroxenes. Note the crystalloblastic (sutured) outline of microcline.
Locality as for Plate 21 Fig. A.

Fig. B: As above (x 70, Crossed Nicols)

A photomicrograph showing a replacement feature between the plagioclase and the microcline in the Fayalite-Quartz Monzonite.

PLATE 22

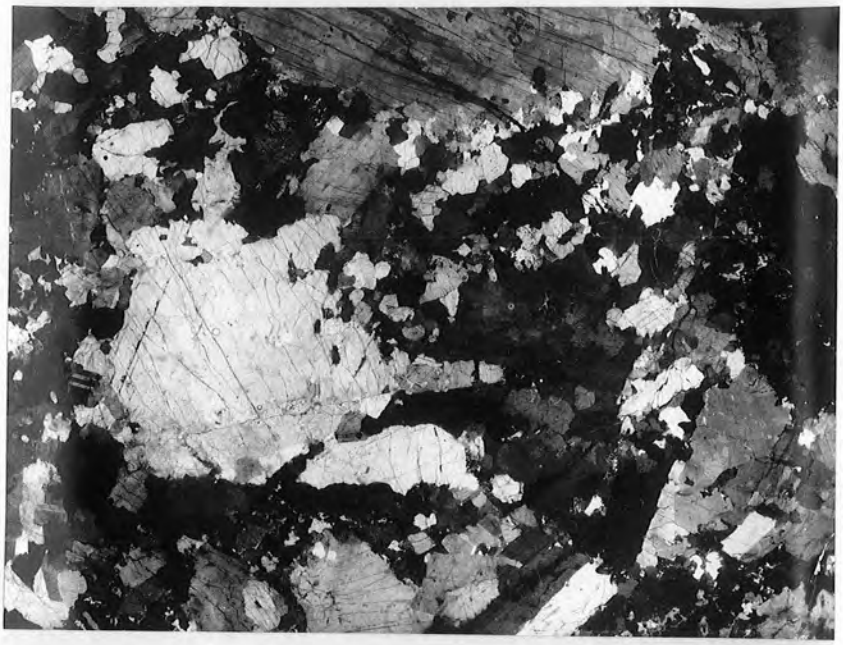


Fig. A

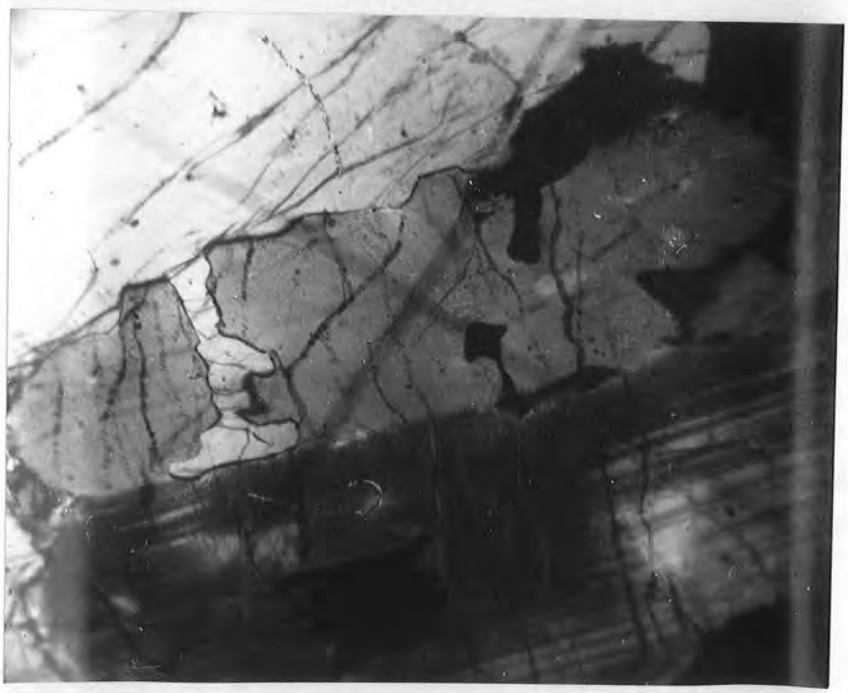


Fig. B

PLATE 23

Fig. A: (NTB1886a) Fayalite-Quartz Monzonite (x 70, Crossed Nicols)

A photomicrograph showing a bent and brecciated plagioclase with strain extinction. Kofar Wombai Hill, Bauchi.

Fig. B: (NTB1886) As above (x 70, Crossed Nicols)

A photomicrograph showing intergrowth crystalloblastic plagioclase in the Fayalite-Quartz Monzonite. Kofar Wombai Hill, Bauchi.

PLATE 23

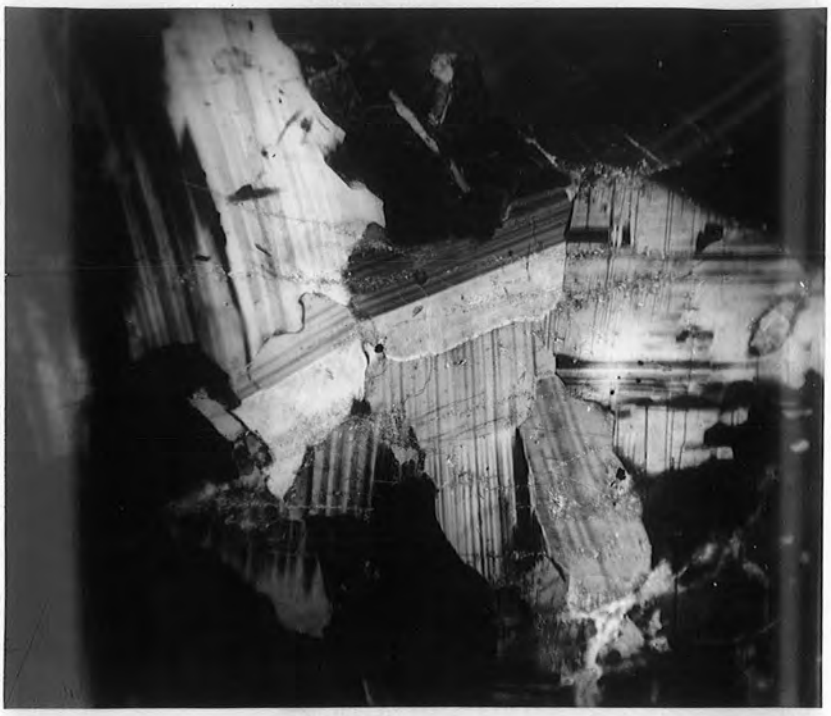


Fig. A

Fig. B

PLATE 24

Photomicrograph of the Fayalite-Quartz Monzonite.

Fig. A: (ME101) (x 70, Crossed Nicols)
Photomicrograph showing the zoned arrangements of the ferromagnesian minerals. Note that the hornblende is not quite a reaction round the fayalite and pyroxene but an envelope round the outer side of the whole structure. (See overlay). Kobi hill, Bauchi.

Fig. B: (ME108) (x 70, Crossed Nicols)
Photomicrograph showing zoned arrangement of quartz, fayalite, hornblende and biotite. Buli hill, Bauchi.

Fig. C: (NTB1886a) (x 70, Crossed Nicols)
Photomicrograph showing almost parallel arrangements of quartz, fayalite, pyroxene, hornblende and plagioclase. Wombai hill, Bauchi.

Fig. D: (ME101c) (x 70, Crossed Nicols)
Photomicrograph showing structures similar to those described in Figs. A to C above developed around plagioclase margins. Note the vein-like attitude.

PLATE 24

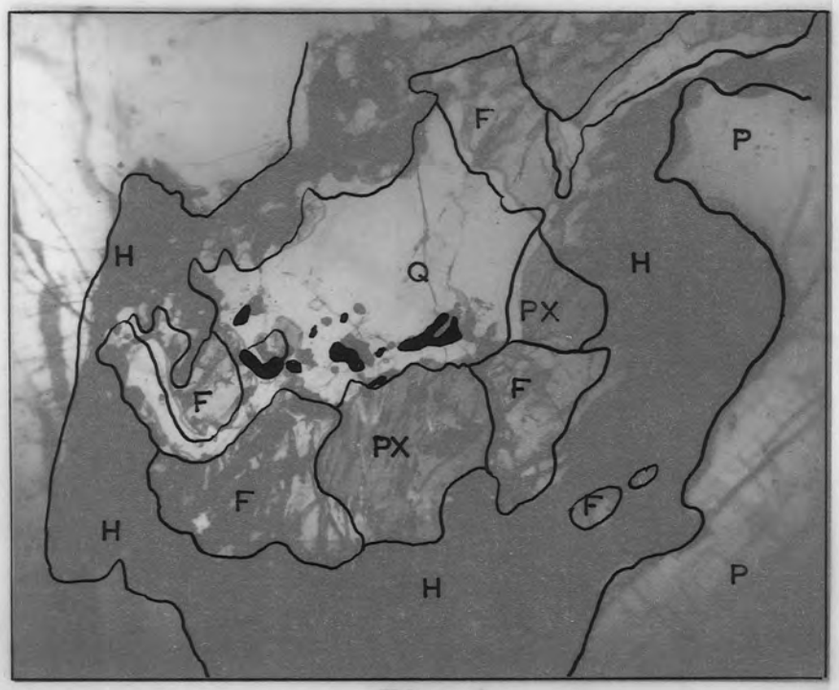
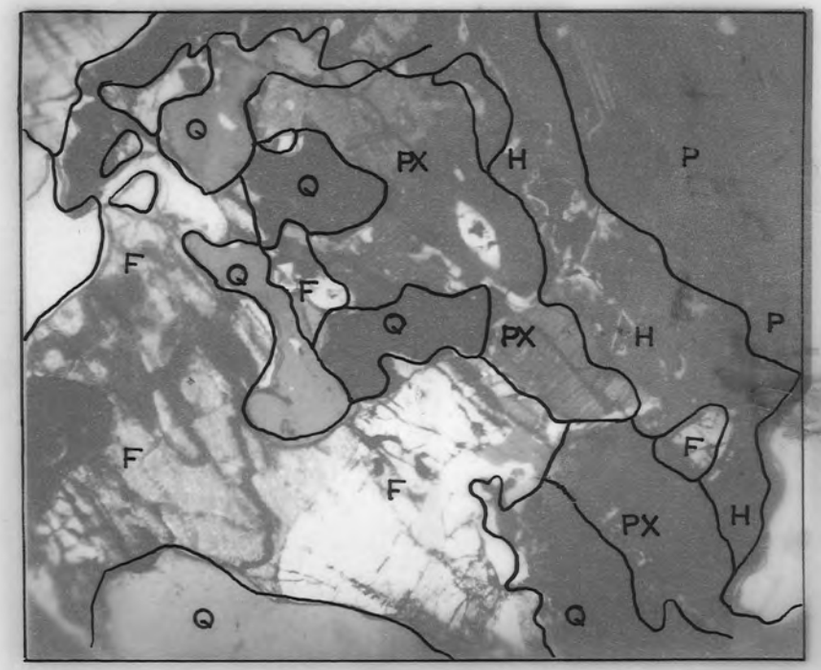
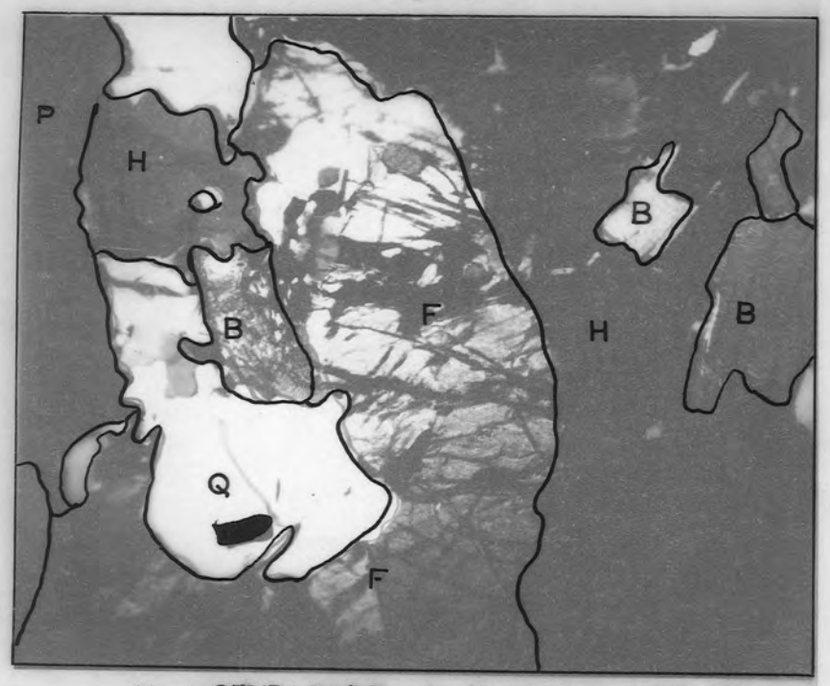
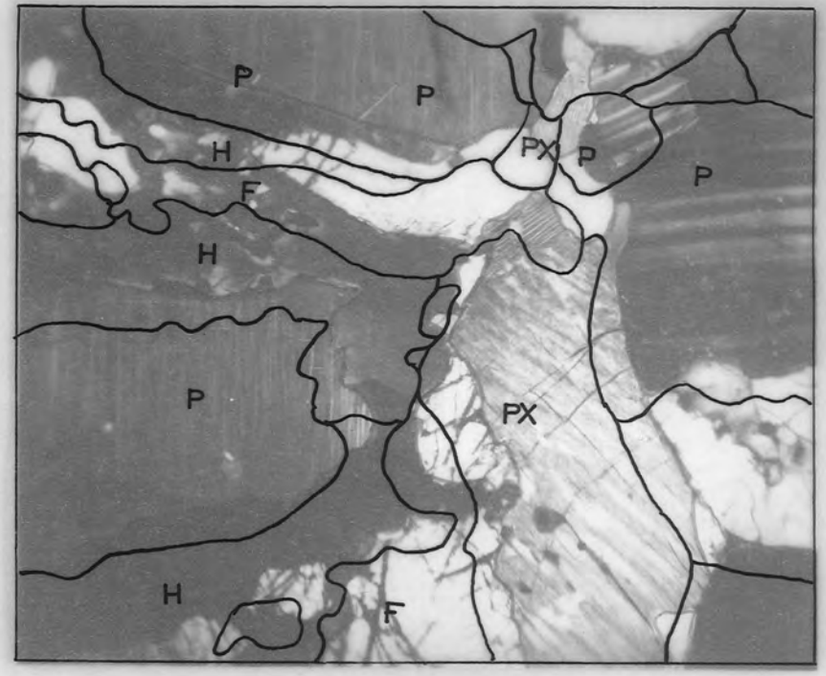


Fig. A







H= HORNBLENDE, P= PLAGIOCLASE, PX= PYROXENE, F= FAYALITE, B= BIOTITE, Q= QUARTZ.

PLATE 25

Fig. A (ME101) Fayalite-Quartz Monzonite
(X70, Crossed Nicols)

Photomicrographs showing fayalite (right) occurring as a rod-like aggregate along the contact of plagioclase and microcline crystals. Kobi hill, Bauchi.

Fig. B (ME102) Charnockitic Fayalite-Quartz Monzonite. (X3/4)

A photograph of the stained hand-specimen of the charnockitic Fayalite-Quartz Monzonite. Note rude alignment of the microcline porphyroblasts (dark areas on photograph). Yelwa Bridge, Bauchi.

PLATE 25

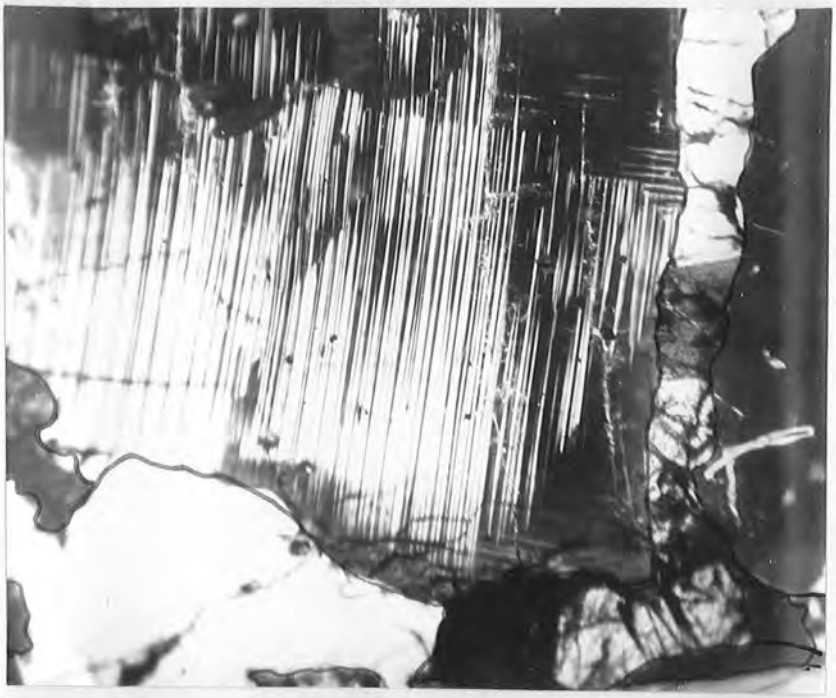


Fig. A

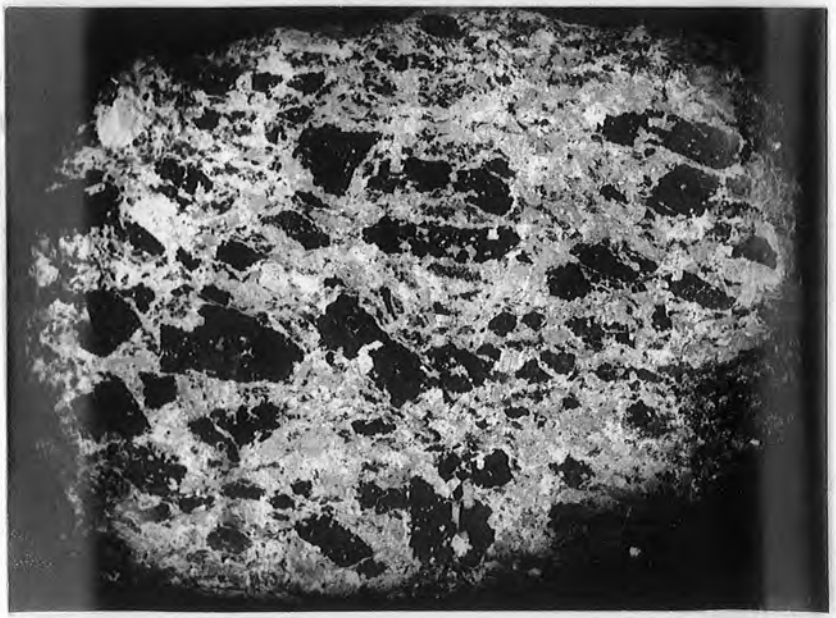


Fig. B

PLATE 26

Fig. A: (ME102) As for Plate 25 Fig. B
(x 4, between Crossed Polaroids)

A photograph of a section placed between crossed "polaroids" plates showing the texture of the charnockitic Fayalite-Quartz Monzonite. Yelwa Bridge, Bauchi.

Fig. B: The same section as in Fig. A above
(ordinary light.)

The photograph shows the localization of the ferromagnesian minerals along the definite zones in the rock.
Yelwa Bridge, Bauchi.

PLATE 26

Fig. A

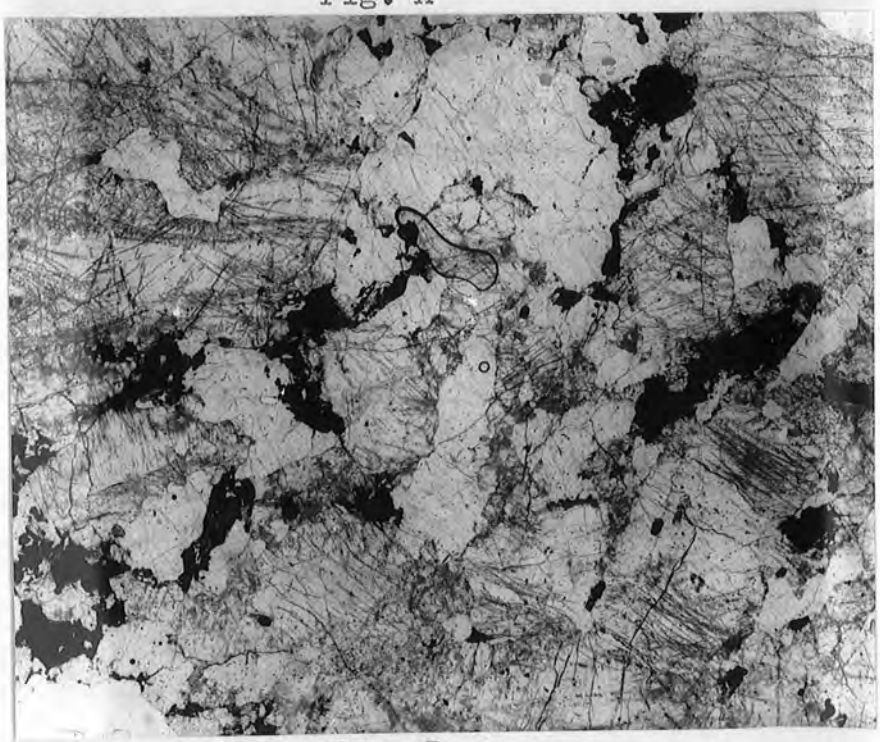


Fig. B

PLATE 27

Fig. A: (ME209) Quartz-Diorite.

A small polished chip showing pseudo-porphyritic texture in Quartz-Diorite. The phenocryst-like light areas resemble the large microcline in the Fayalite-Quartz Monzonite but are actually made up of small interlocked plates of plagioclase and Alkali feldspar (see Fig. B). North of Kofar Wombai hills, Bauchi.

Fig. B: As for Fig. A above.

The same specimen as above after staining, showing only small patches of potash feldspar (coloured black).

PLATE 27

Fig. A

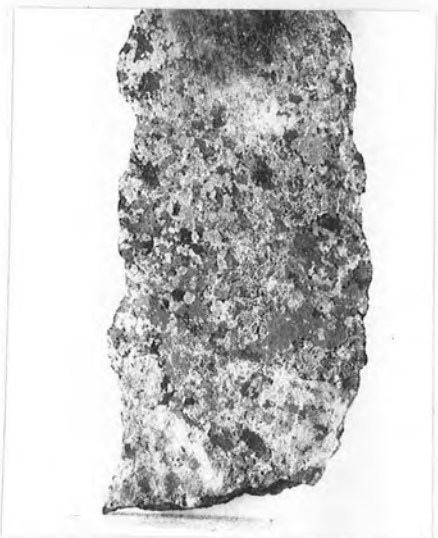


Fig. B

PLATE 28

Fig. A: (ME209) Quartz-Diorite
(x 70, Crossed Nicols)

A photograph showing granoblastic texture in the Quartz-Diorite. Note also the occasional bent plagioclase crystal.
North of Kofar Wombai hill.

Fig. B: (ME266) Quartz-Diorite
(x 70, Crossed Nicols)

A photomicrograph showing the irregular outline of the basic core in a zoned plagioclase from the Quartz-Diorite.
A few yards West of Gudun hill, Bauchi.

PLATE 28

Fig. A

Fig. B

PLATE 29

Fig. A: (ME209) Quartz-Diorite
(x 70, Crossed Nicols)

Photomicrograph showing a bent crystal of plagioclase (right). North of Kofar Wombai hill, Bauchi.

Fig. B: (ME266) Quartz-Diorite
(x 70, Crossed Nicols)

Photomicrograph showing plagioclase (white) with extremely fine inclusions of opaque material like closely spaced parallel dashes. A few yards West of Gudun hill, Bauchi.

PLATE 29

Fig. A

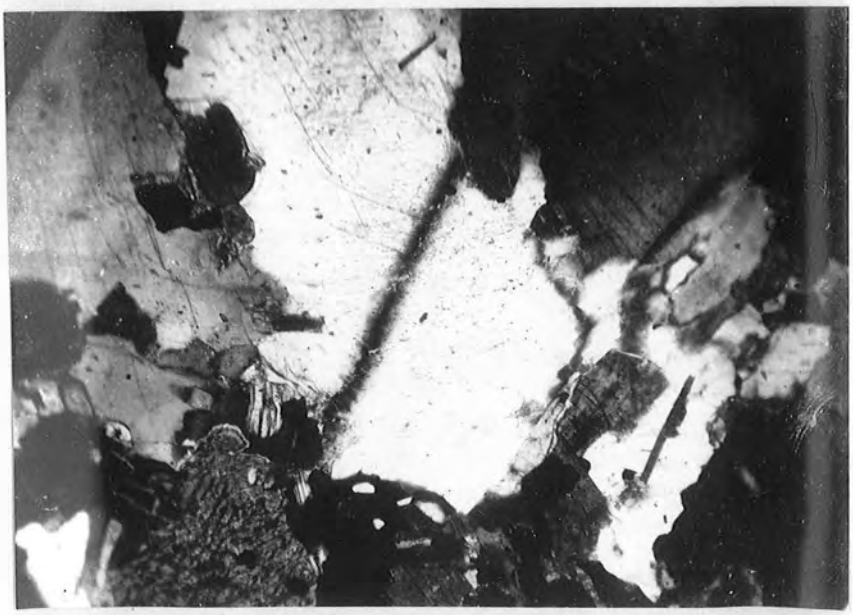


Fig. B

PLATE 30

Fig. A: (ME209) Quartz-Diorite
(x 70, Crossed Nicols)

A photomicrograph showing patches of optically-continuous plagioclase in the alkali feldspar, (left). Note the optical continuity with the larger portion of the plagioclase (right) outside the alkali feldspar. The structure may be termed poikiloperthite. North of Kofar Wombai hill, Bauchi.

Fig. B: (ME208) Quartz-Diorite
(x 70, Crossed Nicols)

Another photomicrograph showing the structure also illustrated by Fig. A above. Note the presence of few optically discontinuous grains. Few yards South-West of Kivini hill.

PLATE 30

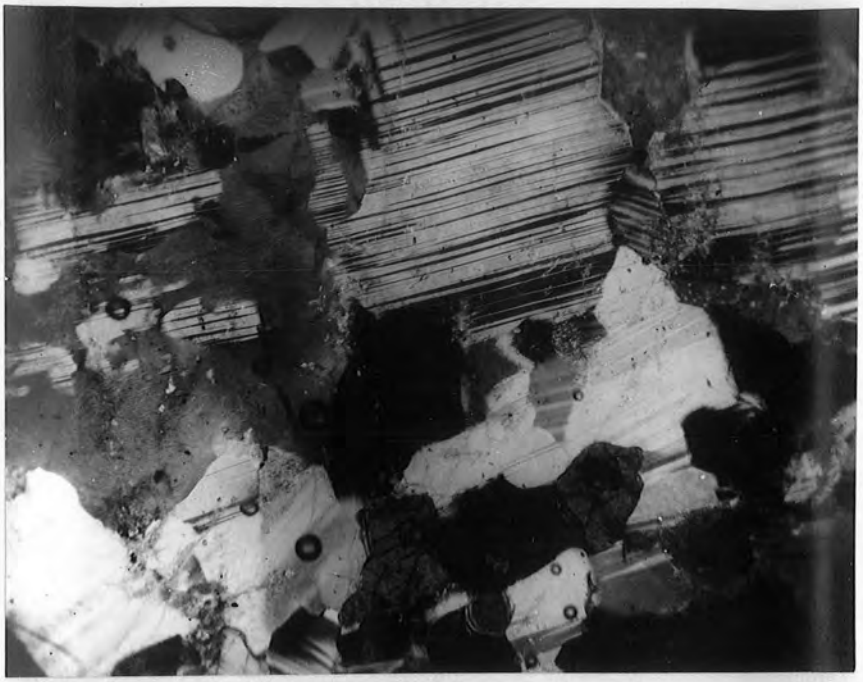


Fig. A

Fig. B

PLATE 31

Fig. A: (ME266) Quartz-Diorite
(x 70, Crossed Nicols)

Photomicrograph showing schiller structure in the ortho-pyroxene of the quartz-diorite. The inclusions are parallel needles of two minerals; one brown and the other opaque. A few yards West of Gudun hills.

Fig. B: As for Fig. A above. (x 70)

Another area in the same section.
(Fig. A above)

PLATE 31

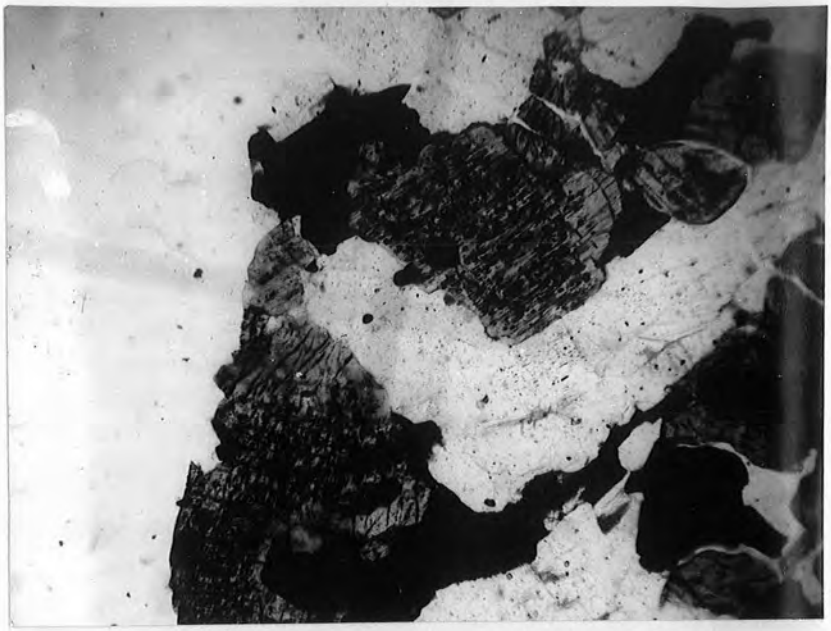


Fig. A

Fig. B

PLATE 32

Fig. A: (ME125) Biotite-Hornblende Granite
(x 70, Crossed Nicols)

A photomicrograph showing coral-like masses of matured myrmekite.
West end of Buli Hill, Bauchi.

Fig. B: (ME101) Fayalite-Quartz Monzonite
(x 70, Crossed Nicols)

A photomicrograph to show an almost ideal myrmekite with early and late stages. Kofar Wombai Hill, Bauchi.

PLATE 32

Fig. A

Fig. B

PLATE 33

Fig. A: (ME101) Fayalite-Quartz Monzonite
(x 70, Crossed Nicols)

A photomicrograph showing an old myrmekite area with late and decline stages. Note excretory quartz enveloping the plagioclase.
Kobi Hill, Bauchi.

Fig. B: (ME109) Fayalite-Quartz Monzonite
(x 70, Crossed Nicols)

A photomicrograph showing a post-myrmekite stage with all the quartz excreted and distributed round the plagioclase.
Buli hills, Bauchi.

PLATE 33

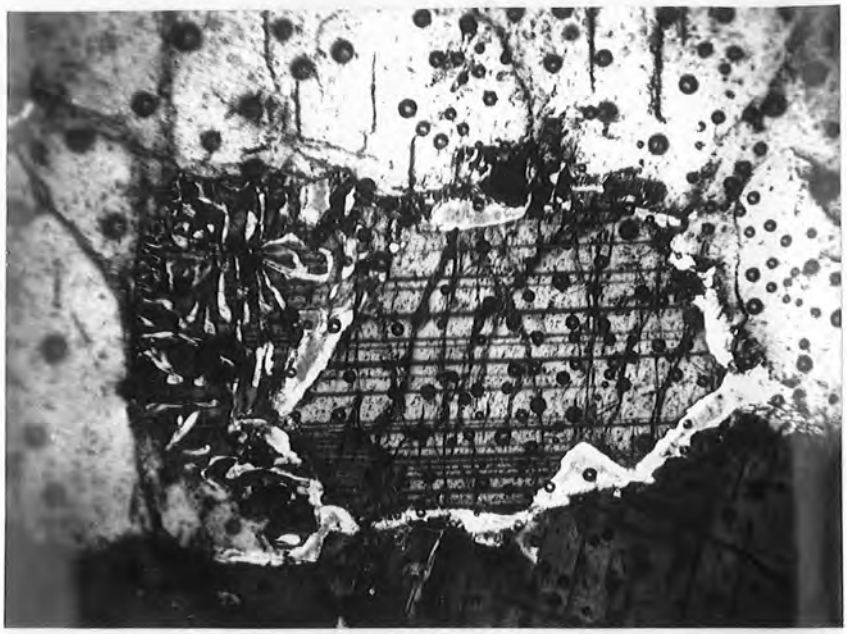


Fig. A

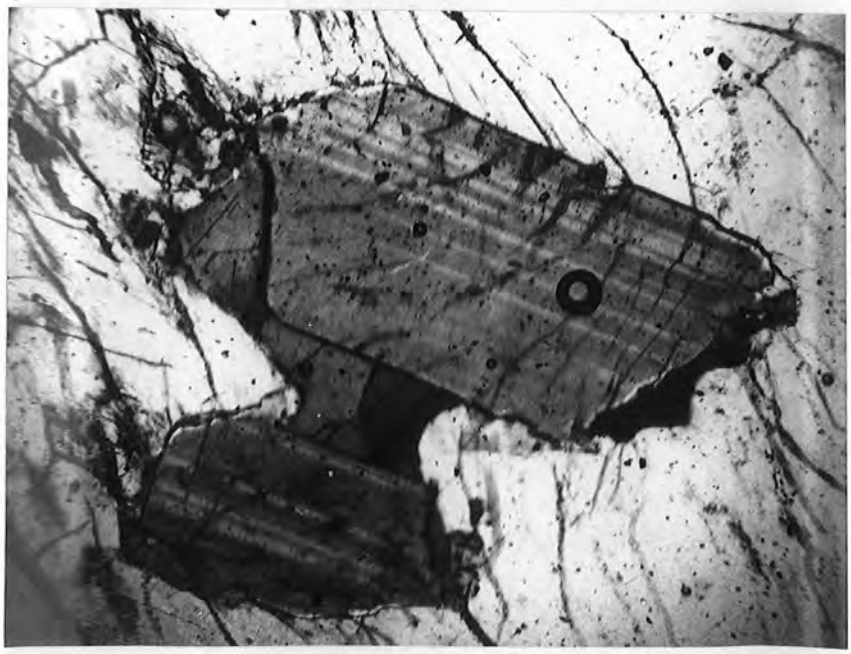


Fig. B

PLATE 34

Fig. A: (NTB1886) Fayalite-Quartz Monzonite (x 60, Crossed Nicols)

A photomicrograph showing the stringlet type of perthite. Kofar Wombai hill, Bauchi.

Fig. B: (ME121) Biotite-Hornblende Granite (x 60, Crossed Nicols)

A photomicrograph showing string perthite formed by the union of two or more stringlet. Note the tendency to develope a plume-like appearance.

PLATE 34

Fig. A

Fig. B

PLATE 35

Fig. A: (ME139) Biotite-Hornblende Granite (x 60, Crossed Nicols)

Photomicrographs showing two types of film perthite.

1 mile South of Gudun hill, Bauchi.

Fig. B: (ME136) Biotite-Hornblende Granite (x 60, Crossed Nicols)

The worm-type perthite shown in this photomicrograph is possibly a special section of the film type.

1 mile North-West of Zungar hills.

PLATE 35

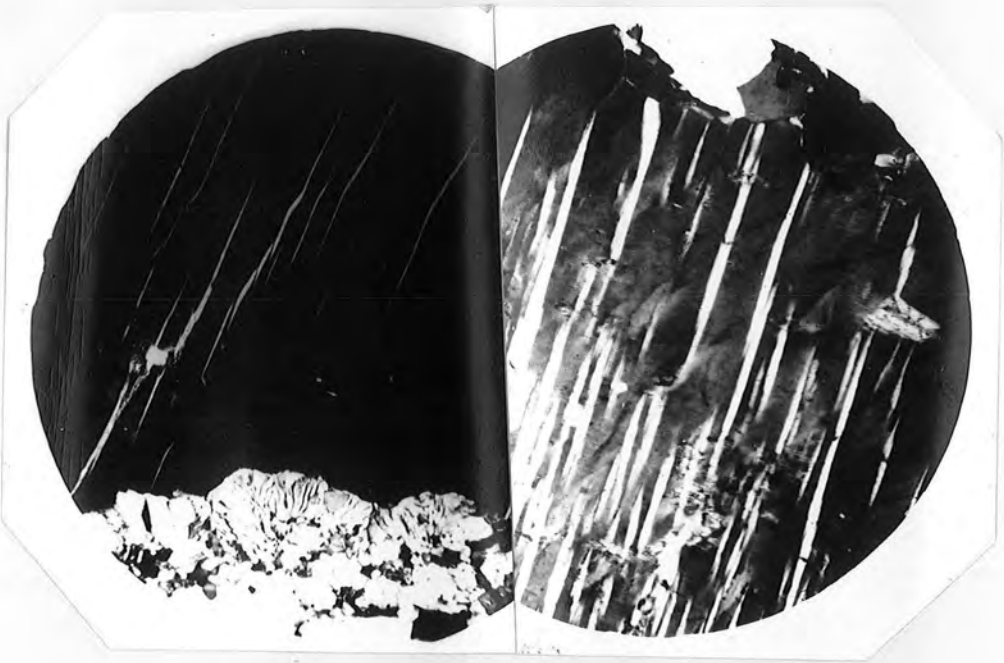


Fig. A

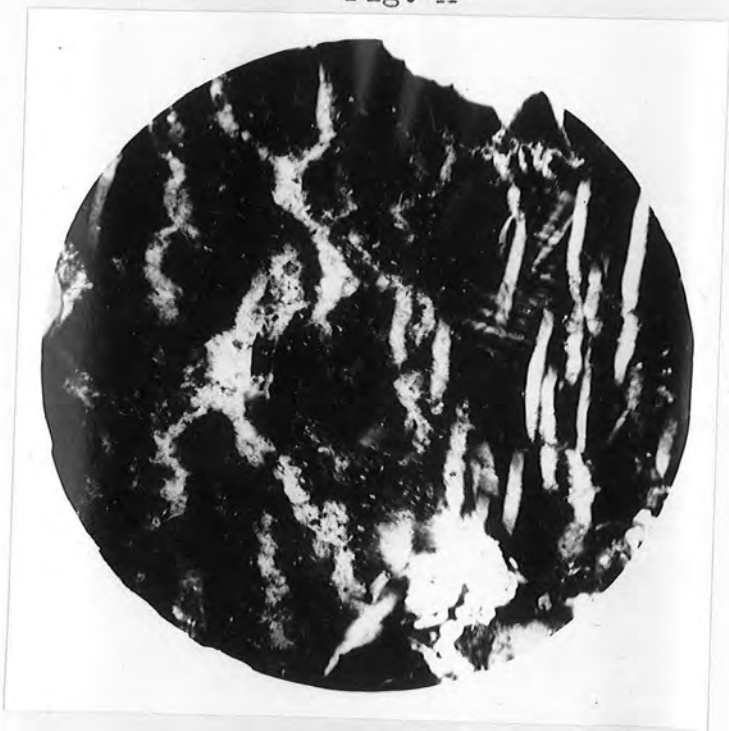


Fig. B

PLATE 36

Fig. A: (ME181) Pegmatite (x 70, Crossed Nicols)

A photomicrograph showing vein-type perthite in a large microcline crystal from a pegmatite. Note the branching habit. 1 mile South-West of Miri village, Bauchi.

Fig. B: (ME116) Biotite-Hornblende Granite (x 70, Crossed Nicols)

A photomicrograph illustrating another type of vein perthite sometimes called streak perthite (Andersen, 1928) Jura hill, Bauchi.

PLATE 36

Fig. A

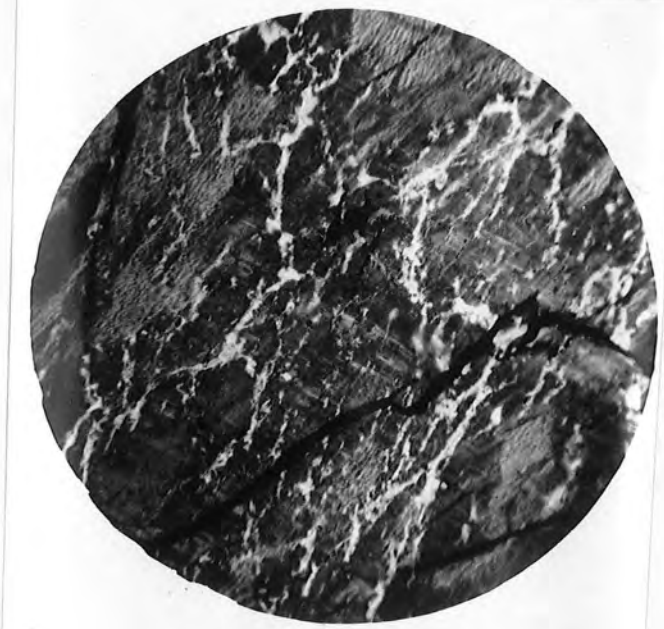


Fig. B

PLATE 37

Fig. A: (ME158) Cataclastic Rock
(x 60, Crossed Nicols)

Photomicrograph showing patch perthite. Note the connection of the blebs by small veinlets. Zungar hill, Bauchi.

Fig. B: (ME209) Quartz-Diorite
(x 70, Crossed Nicols)

A photomicrograph showing poikilo-perthite. Note the optical continuity of the bleb with the larger plate of plagioclase to the left.
North Kofar Wombai hill, Bauchi.

PLATE 37

Fig. A

Fig. B

PLATE 38

Fig. A: (ME133) Quartz-Diorite
(x 70, Crossed Nicols)

Photomicrograph showing anti-perthite.

North Kofar Wombai hill, Bauchi.

Fig. B: As for Fig. A above. (X210)

A micro-drawing of the large Alkali feldspar bleb to the top left in the Fig. A of this plate showing the development of perthitic structure in the bleb, thus forming a compound perthite.

PLATE 38

Fig. A

Fig.B

PLATE 39

Fig. A: (ME150) Biotite-Hornblende Granite
(x 4, Crossed Nicols)

Photograph showing pseudo-cataclastic structure. The best example can be seen between the two large feldspar on the right-hand side of the photograph.
½ of a mile East of Miri Village.

Fig. B: (ME140) Biotite-Hornblende Granite
(x 70, Crossed Nicols)

Photomicrograph showing pseudo-cataclastic texture, a relic of previous cataclastic texture. A few yards North of Miri hills.

PLATE 39

Fig. A

Fig. B

PLATE 40

Fig. A: (ME237) Pyroxene Granulite
(x 70, Crossed Nicols)

Photomicrograph showing checkerboard structure in the plagioclase. The blebs are believed to be of plagioclase feldspar and from their parallel extinction is about oligoclase in composition (near Ab_{75}). Air strip, Bauchi.

PLATE 40.

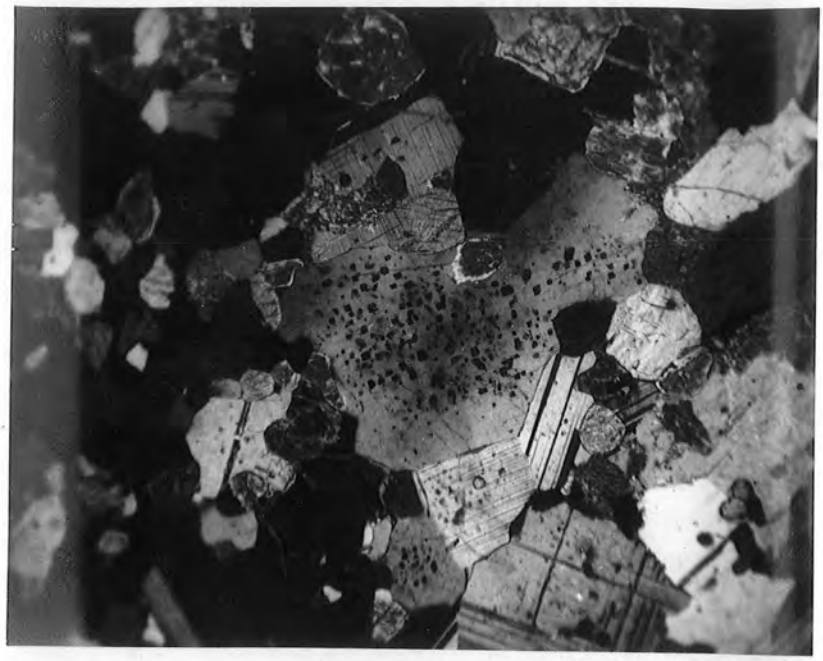


Fig. A.

PLATE 41

Fig. A: A photograph of a dyke-like body of cataclastic rock with large post-deformation microcline porphyroblasts (white spots).
Just North of Tiruin Village, Bauchi.

Fig. B: A photograph of a specimen from the dyke shown in (Plate 41, Fig. A). Note the microcline crystal grown across the deformation S plane (see overlay).
Just North of Tiruin Village, Bauchi.

PLATE 41

Fig. A

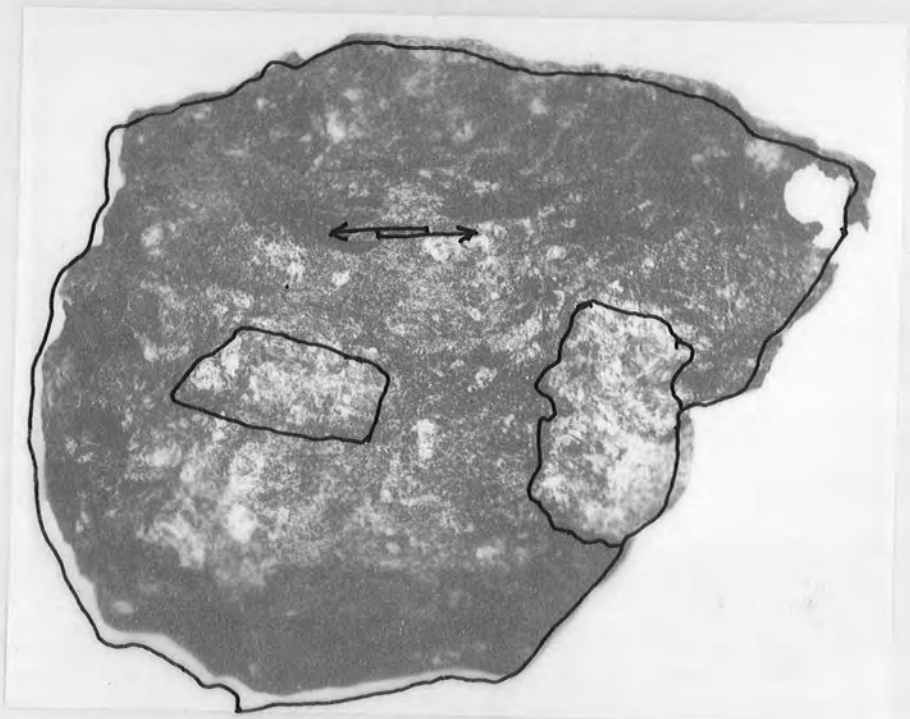


Fig. B

PLATE 42

Fig. A: (ME184) Biotite Granite
(x 70, Crossed Nicols)

A photomicrograph illustrating patchy development of intergranular microcline. Note the optical continuity of some grains. North of Miri Village.

Fig. B: (ME184) Biotite Granite
(x 70, Crossed Nicols)

A photomicrograph showing a porphyroblast developing through the coalescence of intergranular patches. Note the sutured character of the outline of the porphyroblast, North of Miri Village.

PLATE 42

Fig. A

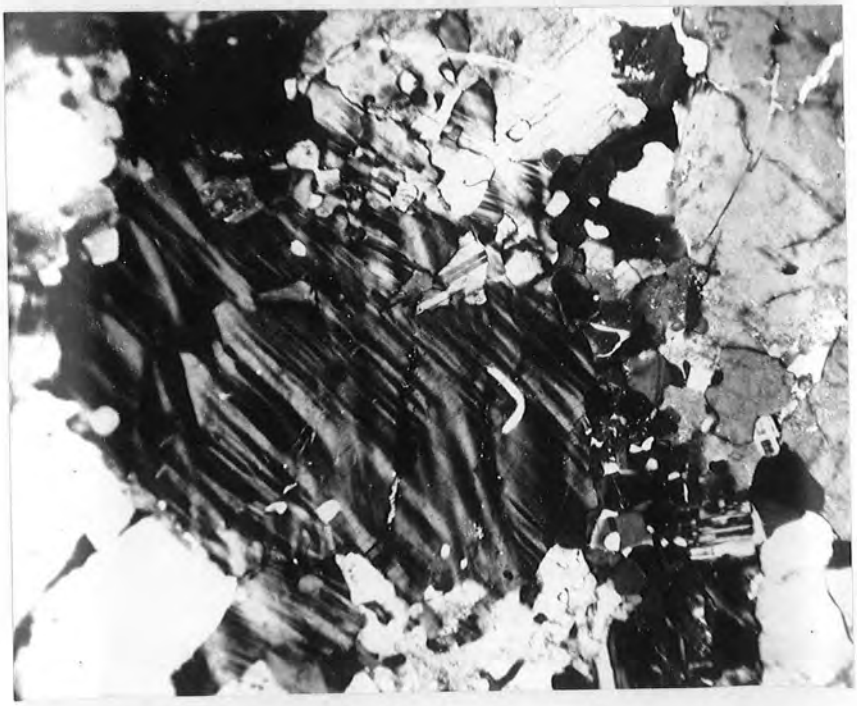


Fig. B

PLATE 43

Fig. A: (ME209) Quartz-Diorite (x $\frac{3}{4}$)

A photograph of a hand-specimen showing lineation structure believed to be inherited from earlier gneiss.
North Kofar Wombai hill, Bauchi.

Fig. B: (ME166) Dolerite (x $\frac{1}{2}$)

A photograph of a specimen from a dolerite dyke with xenoliths of the intruded gneiss.
1 mile North Tiruin village, Bauchi.

PLATE 43

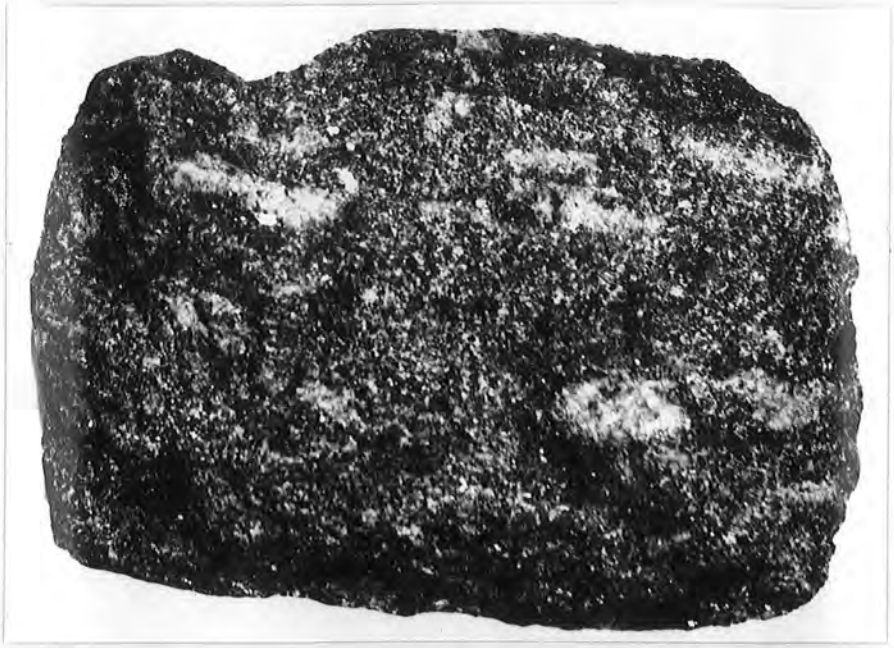


Fig. A

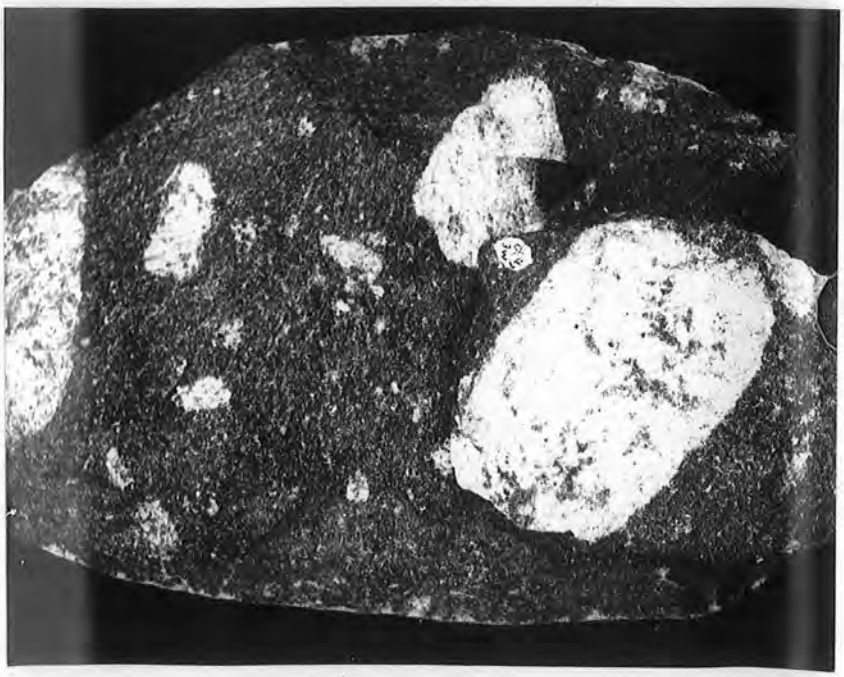


Fig. B

PLATE 44

Fig. A: (ME168) Trachyte (x 70, Crossed Nicols)

A photomicrograph showing trachyte texture from a riebeckite trachyte dyke.
Jos Road, City limit, Bauchi.

Fig. B: (ME209) Altered Rock
(x 70, Crossed Nicols)

A photomicrograph showing micrographic and felsitic textures in the baked Biotite Granite.
About 1 mile North of Zungar hill, Bauchi.

PLATE 44

Fig. A

Fig. B

PLATE 45

Fig. A: (ME158) Cataclastic Rock (x $\frac{3}{4}$)

A specimen of cataclastic rock showing a relatively early stage of deformation. Zungar hill, Bauchi.

Fig. B: (ME158B) Cataclastic Rock (X1)

Specimen showing a slightly greater degree of deformation than that seen in (ME158) above (Plate 45, Fig. A). North Zungar Hill, Bauchi.

PLATE 45

Fig. A

Fig. B

PLATE 46

Fig. A: (ME179) Cataclastic Rock (X8/9)

A photograph showing strong cataclastic deformation of Biotite-Hornblende Granite.
Miri Village, Bauchi.

Fig. B: (ME192) Cataclastic Rock ($X\frac{3}{4}$)

A photograph illustrating a more advanced stage of deformation than that shown above (Plate 46, Fig. A).
South of Jura hill, Bauchi.

PLATE 46

Fig. A

Fig. B

PLATE 47

Fig. A: (ME163) Cataclastic Rock
(x 70, Crossed Nicols)

A photomicrograph showing a perfect augen of microcline in a groundmass of granular quartz and feldspar.
Tiruin Village, Bauchi.

Fig. B: (ME151) Epidote Rock (x 70, Crossed Nicols)

A photomicrograph showing epidote plates on feldspar projecting into quartz.
(Bulambiri village) West Buli hills, Bauchi.

PLATE 47

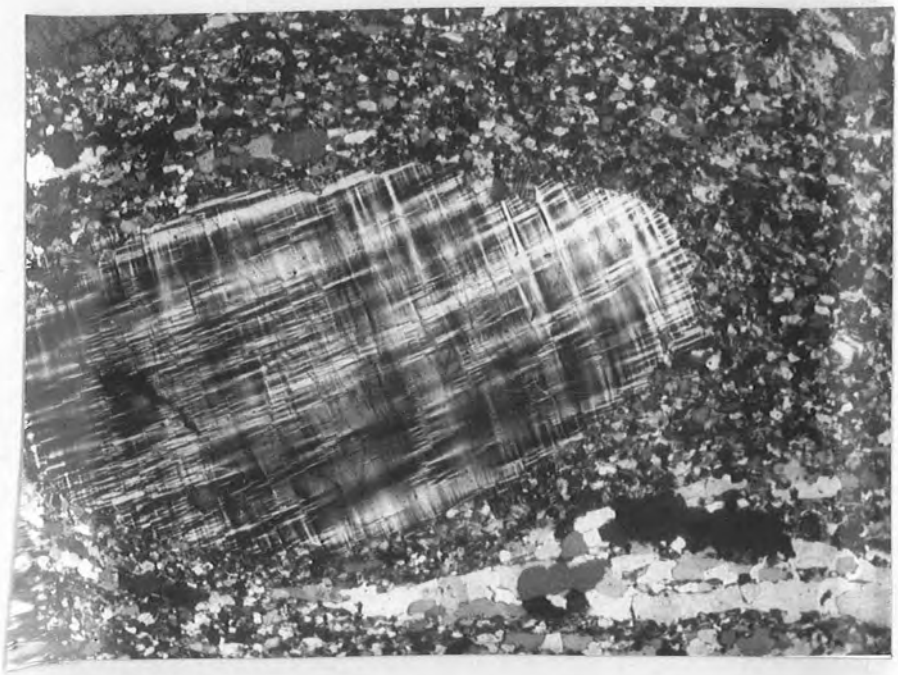


Fig. A

Fig.B

PLATE 48

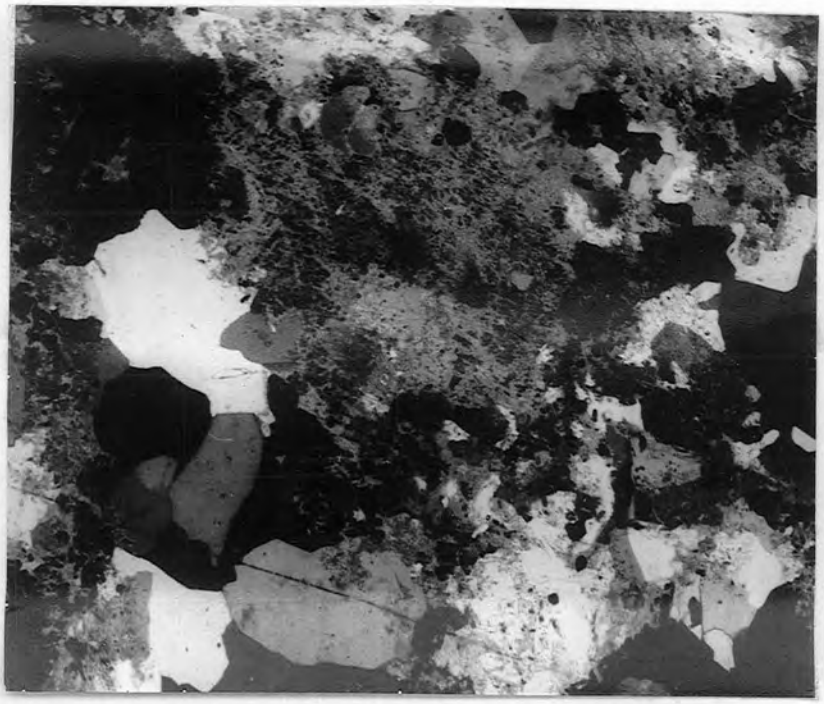


Fig. A

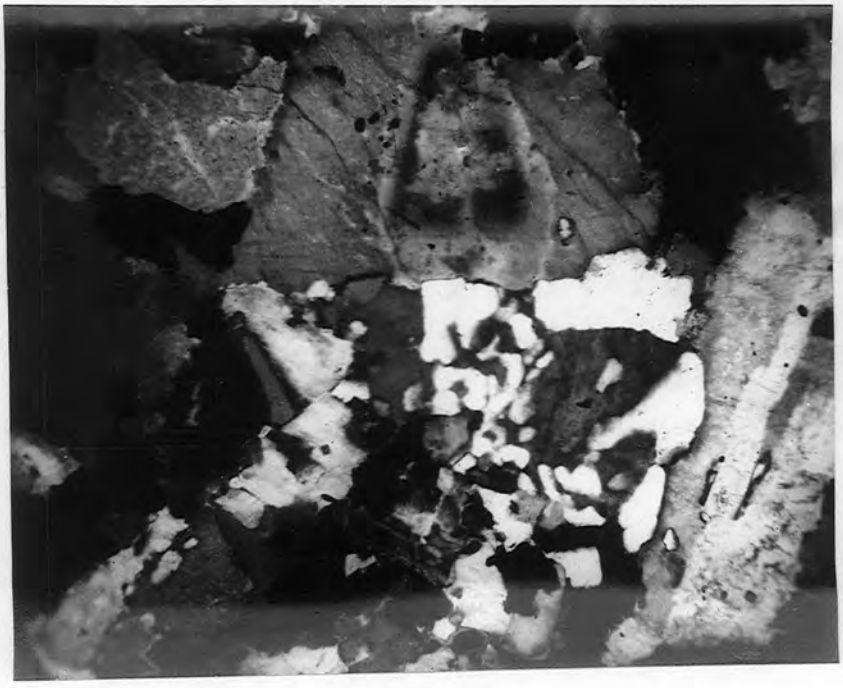


Fig. B

Fig. 1.

The provisional Geological map of Nigeria (1943) showing the position of the Bauchi district (circle) in the Undifferentiated Basement Complex. Note the relative position of the Younger Granites (cross-hatched).

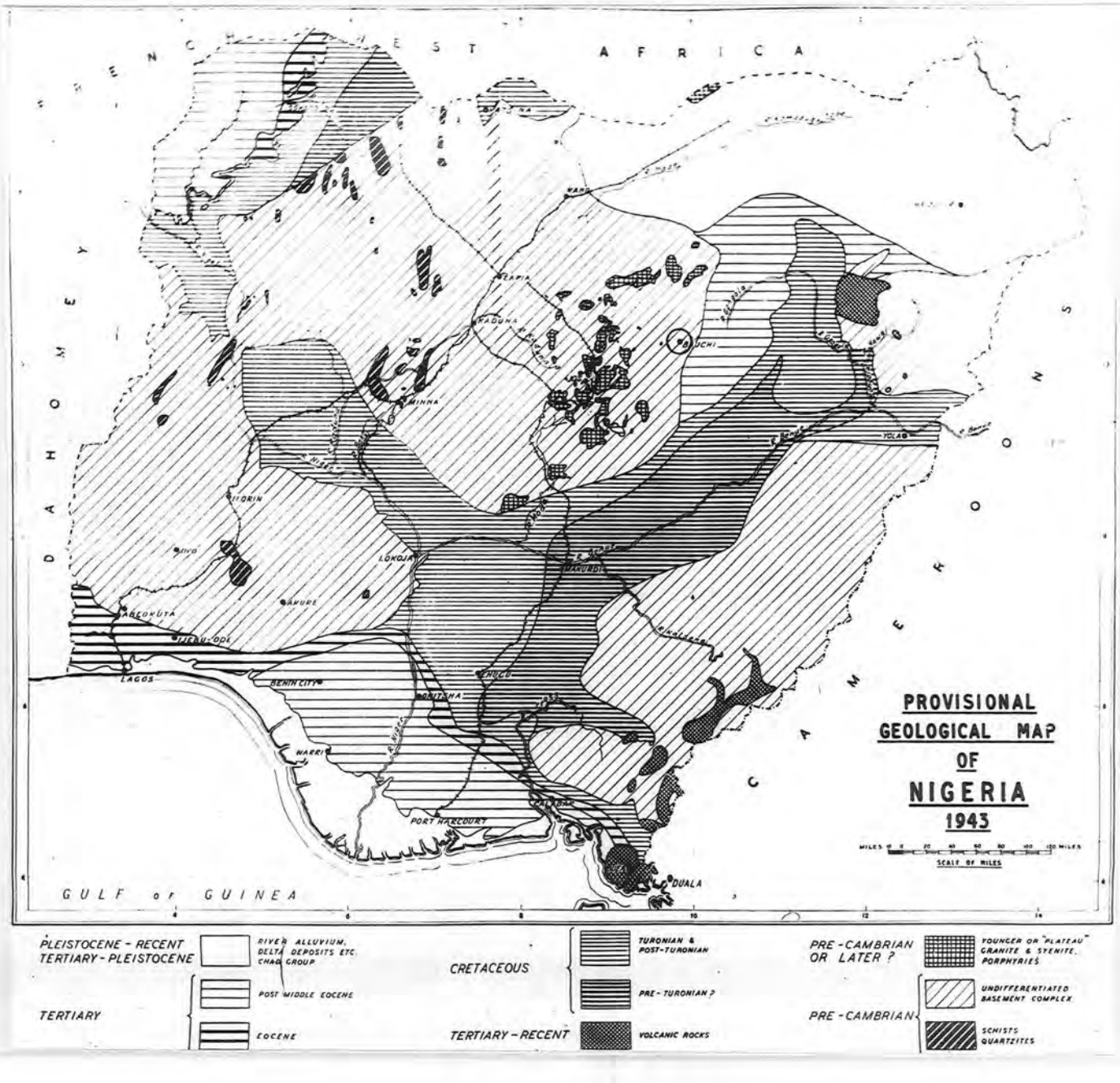

FRENCH WEST AFRICA
DAHOMEY
CAMEROONS
GULF of GUINEA
KANO
KATSINA
ZARIA
KADUNA
BAUCHI
MINNA
YOLA
ILORIN
IVO
LOKOJA
ABEOKUTA
IJEBU-ODE
AKURE
LAGOS
BENIN CITY
WARRI
ONITSHA
PORT HARCOURT
CALABAR
DUALA
PROVISIONAL
GEOLOGICAL MAP
OF
NIGERIA
1943
SCALE OF MILES
PLEISTOCENE - RECENT
TERTIARY - PLEISTOCENE
RIVER ALLUVIUM, DELTA DEPOSITS ETC. CHAD GROUP
TERTIARY
POST MIDDLE EOCENE
EOCENE
CRETACEOUS
TURONIAN & POST-TURONIAN
PRE-TURONIAN ?
TERTIARY - RECENT
VOLCANIC ROCKS
PRE-CAMBRIAN OR LATER ?
YOUNGER OR "PLATEAU" GRANITE & SYENITE, PORPHYRIES
PRE-CAMBRIAN
UNDIFFERENTIATED BASEMENT COMPLEX
SCHISTS QUARTZITES

Fig. 2.

Sketch map showing the preferred NE-SW trending in the hills around Bauchi. This direction also corresponds with the general foliation direction of the rocks - see Map B. (Adapted from the contour map by Bain, 1926). See also plate 6, fig. B.

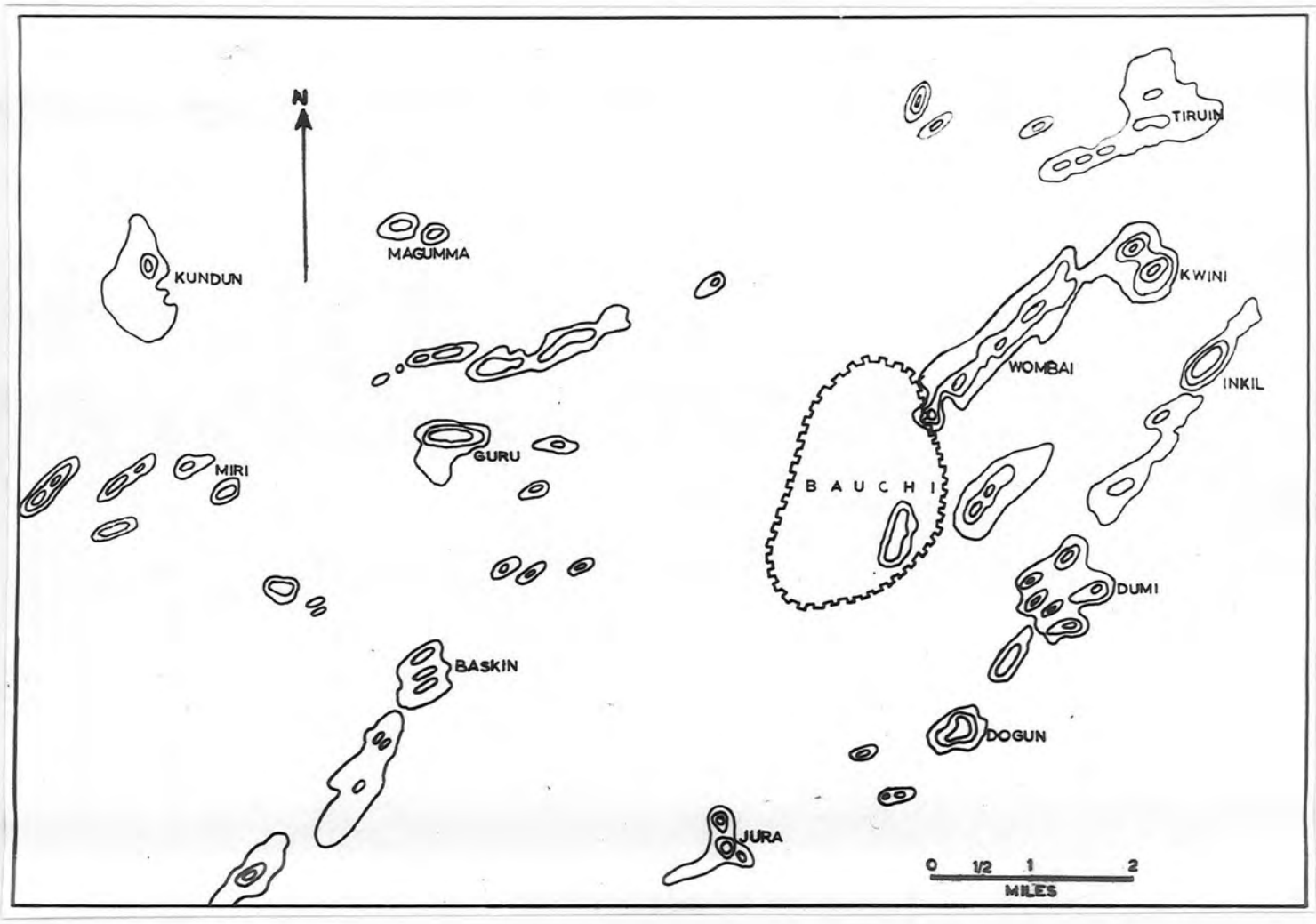
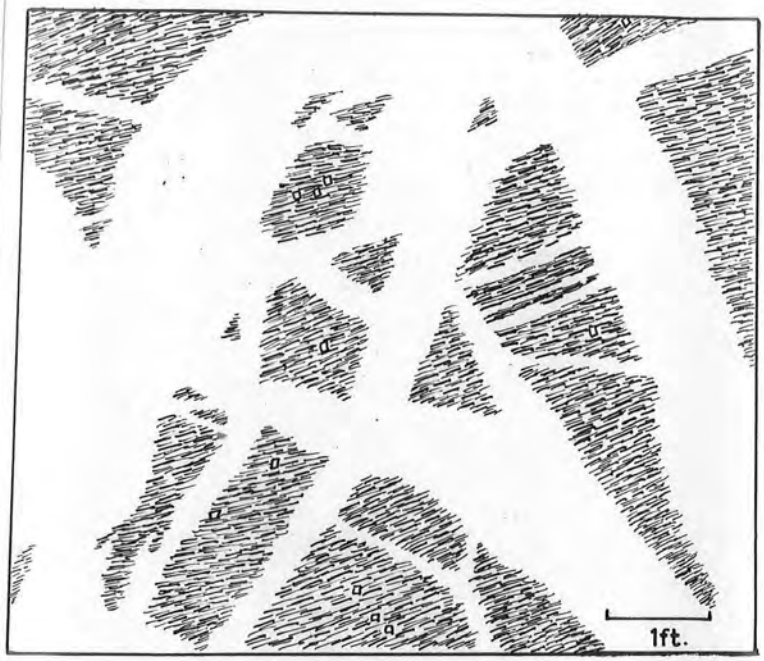

N
KUNDUN
MAGUMMA
TIRUIN
KWINI
WOMBAI
INKIL
GURU
MIRI
BAUCHI
DUMI
BASKIN
DOGUN
JURA
0 1/2 1 2
MILES

Fig. 3



THE AGMATITIC GNEISS

Agmatitically dissected gneiss showing structural continuity of foliation from one block to the other. The blank areas represent pegmatite and granite dykes and veins.

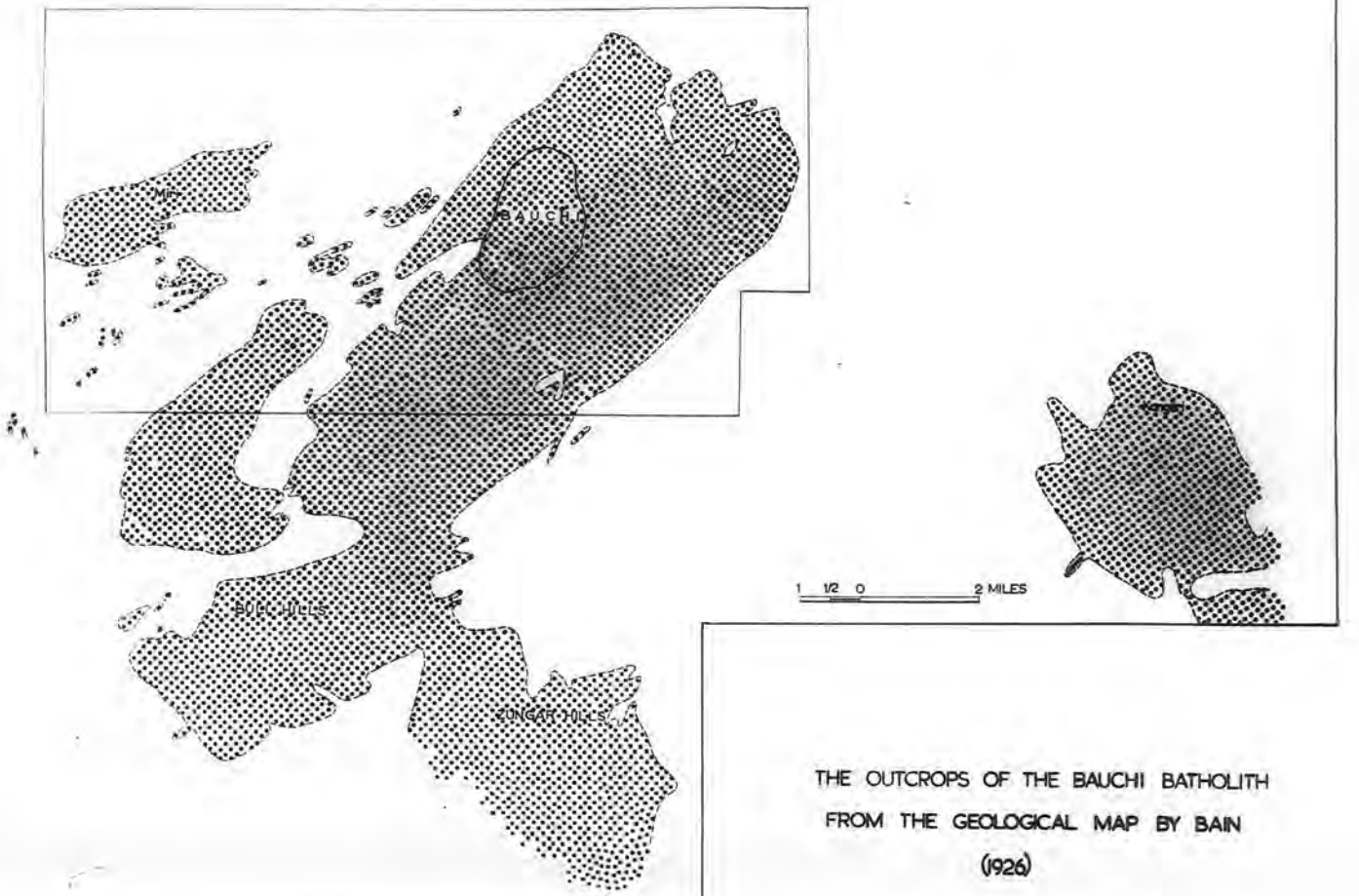
Fig. 4.

Diagram showing the sporadic development of concentrations of large feldspar crystals in the Quartz Diorite, These feldspar-rich areas closely resemble the Fayalite-Quartz Monzonite; they grade on all sides into normal Quartz Diorite.

0
30
60 FEET

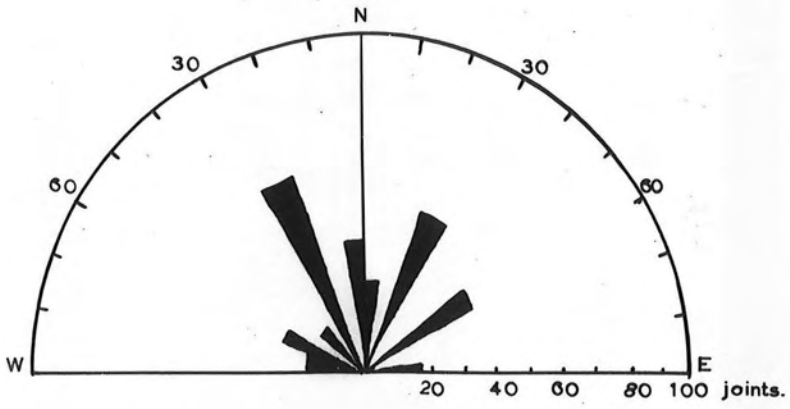
Fig. 5.

Sketch map showing the known extent of the rocks comprising the Bauchi Batholiths. The outcrops are mainly of Biotite Hornblende granites and the Fayalite-Quartz Monzonite, with a smaller amount of Quartz Diorite. It is possible that similar rocks may cover a considerable area of the unmapped country to the south.



THE OUTCROPS OF THE BAUCHI BATHOLITH
FROM THE GEOLOGICAL MAP BY BAIN
(1926)

Fig 6.



JOINT SETS IN THE MIGMATITIC ROCKS

Joint Sets in the Biotite Granite and Biotite Gneiss (Migmatites).

Fig. 7.

Areas of lit-par-lit gneiss like the one shown in the diagram can be seen just north of Shadawanke village. The black bands represent granulite and the dashes are granitic bands, mostly quartzo-feldspathic dykes and veins. The open rectangles of disjointed blocks are calcsilicate porphyroblasts, rock which are not as abundant in the general district as suggested by this diagram; for a mile or more around this area calcsilicate rocks may not be seen again.


0
2
4 FEET

Fig. 8.

This is a sketch map of the area around the inselberg (two circular contour lines) about ½ mile East of Shadawanke hill showing the various characters of the Biotite Granite: evenly distributed Medium sized porphyroblasts of microcline (indicated by small blocks); sporadic development of large Microcline porphyroblasts (large blocks); numerous patches of biotitic Schlieren (fine hatching) and some pegmatite dykes.

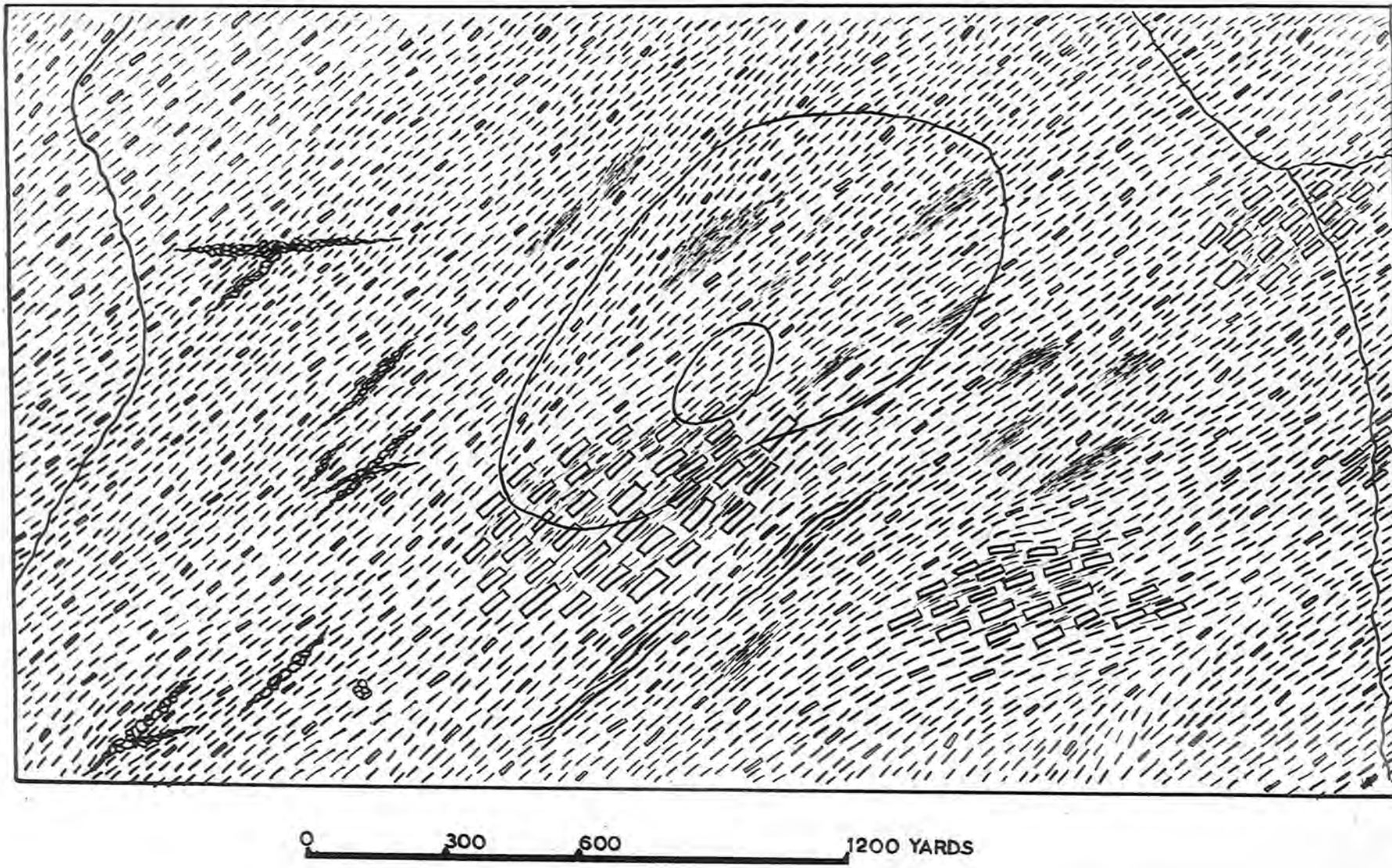
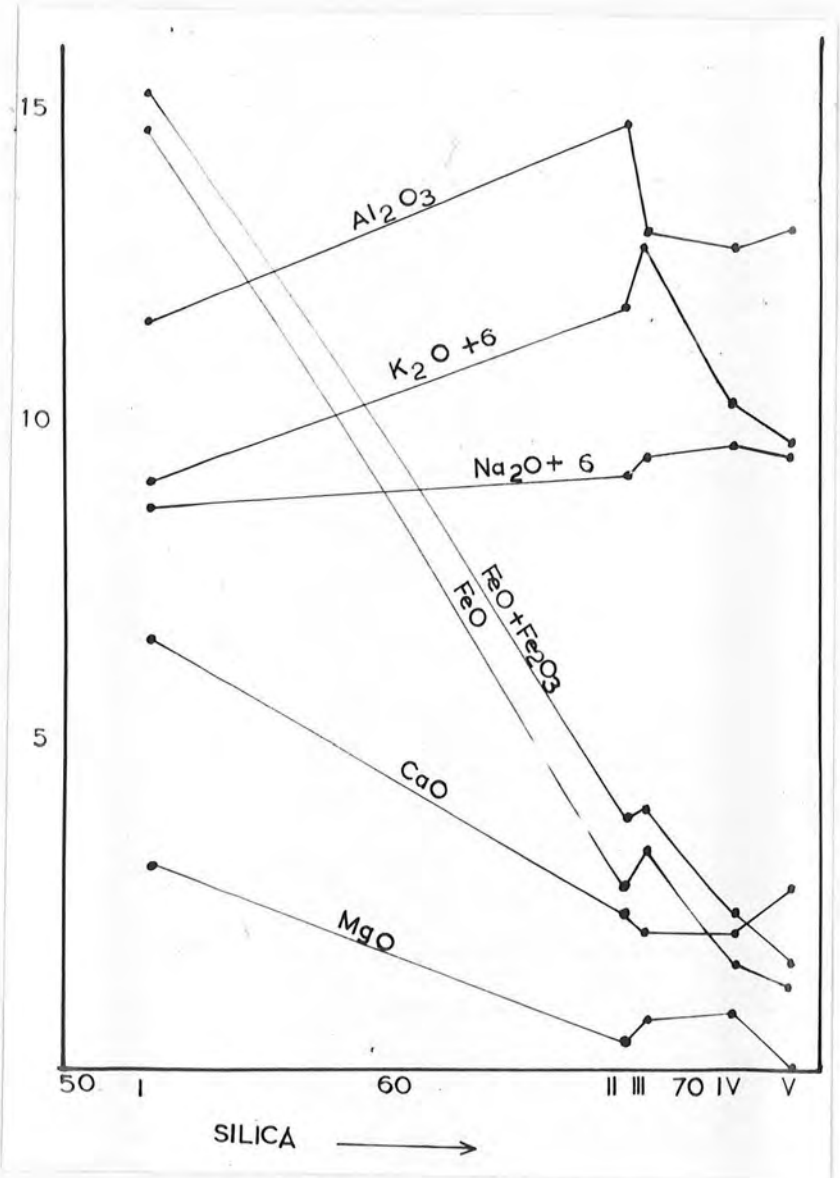

0
300
600
1200 YARDS

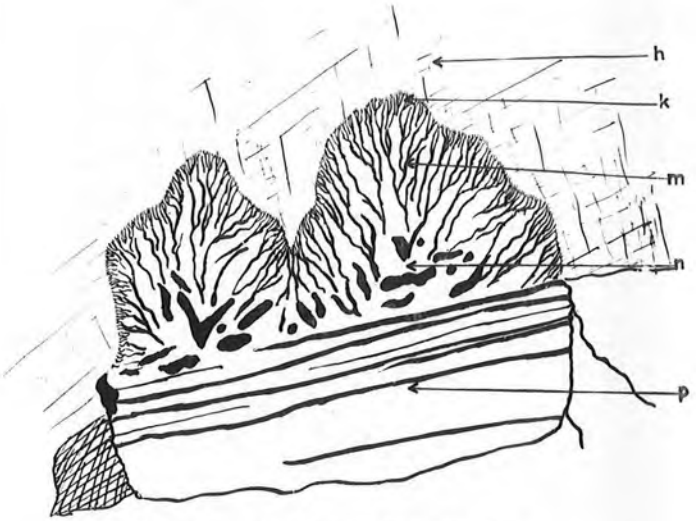
Fig. 9.



(Wt. %)

Diagram showing the chemical variations in the rocks of the Bauchi district. (Calculated from data given in Table 6, p. 47).

Fig. 10



THE STAGES IN THE DEVELOPMENT OF MYRMEKITE.

A diagramatic representation of an ideal myrmekite area;

h = Alkali feldspar

k = Early stage

m = Late stage

n = Decline stage

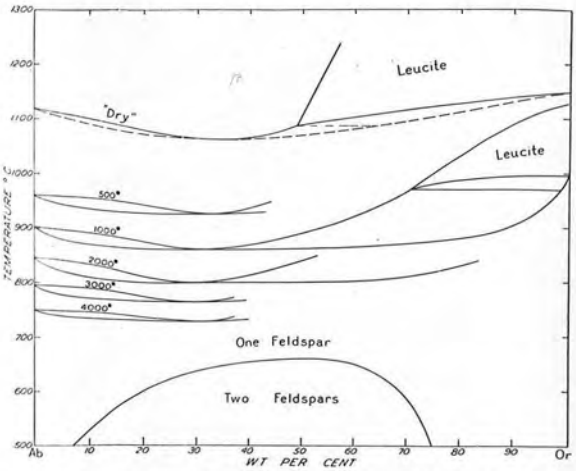
p = "Pedestal" Plagioclase.

Fig. 11

Equilibrium diagram showing the phase relation in the alkali feldspar.

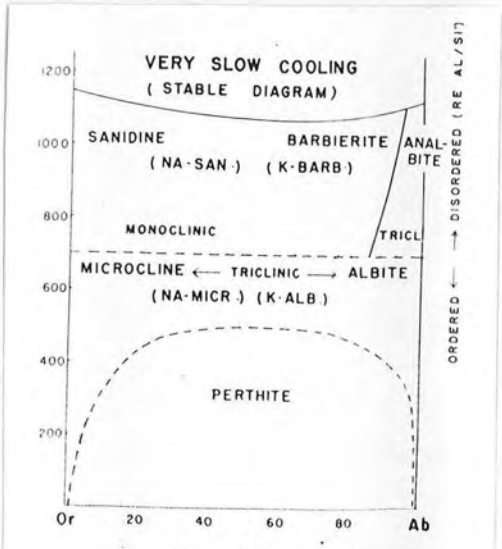
(a) after Bowen and Tuttle (1958)

(b) after Laves (1952)



–Isobaric equilibrium relations in the system $NaAlSi_3O_8$–$KAlSi_3O_8$–H_2O projected onto the Ab–Or face of the temperature–composition prism

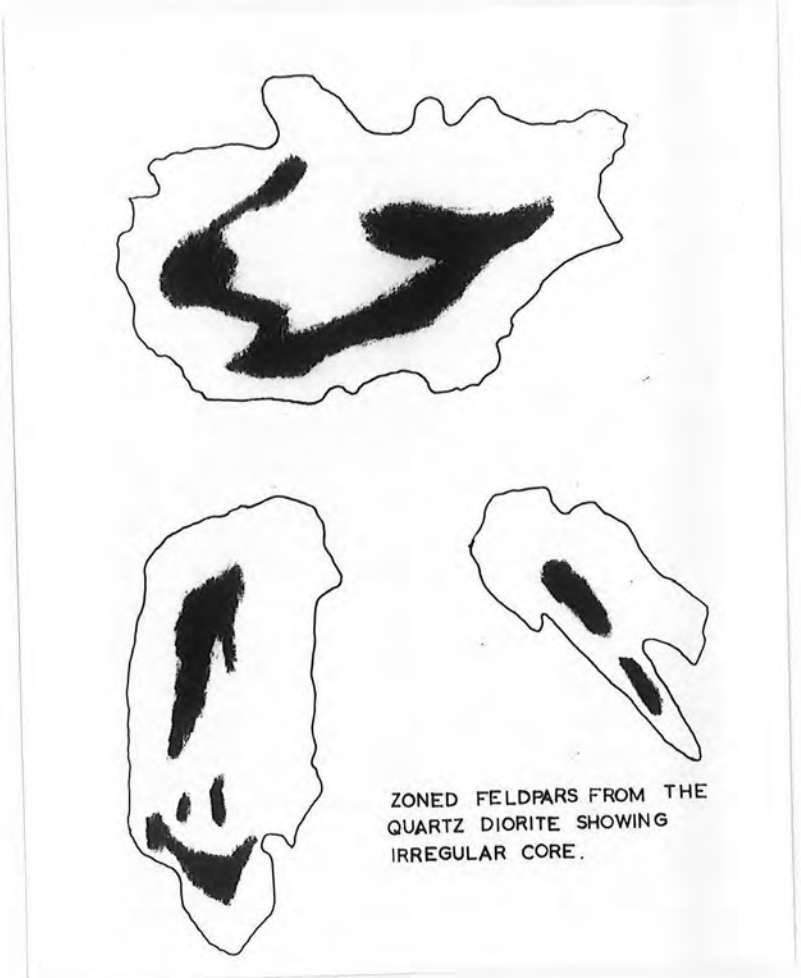
(a)



The probable phase diagram

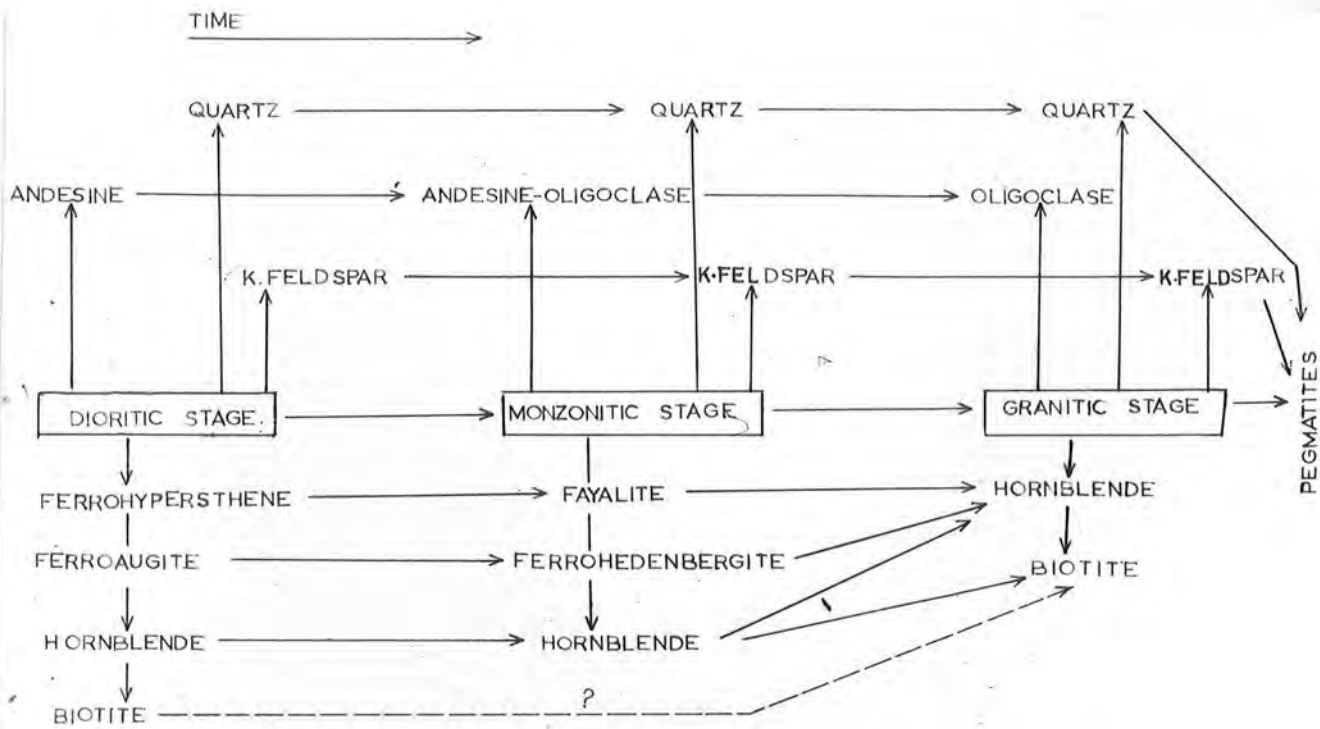
(b)

Fig. 12



Microdrawing of zoned plagioclase showing irregular and disconnected calcic cores (shaded) Specimen ME 226, from near Dugun hill, Bauchi.

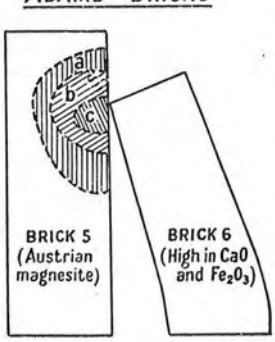
Fig. 13



THE PROBABLE STAGES OF CRYSTALIZATION OF THE BAUCHI ROCKS.

A diagram showing the probable trend of crystallization of a magma that would give rise to the rock series in the Bauchi batholith. The diagram is constructed from the mineralogical assemblages in the three principal rocks.

Fig. 14



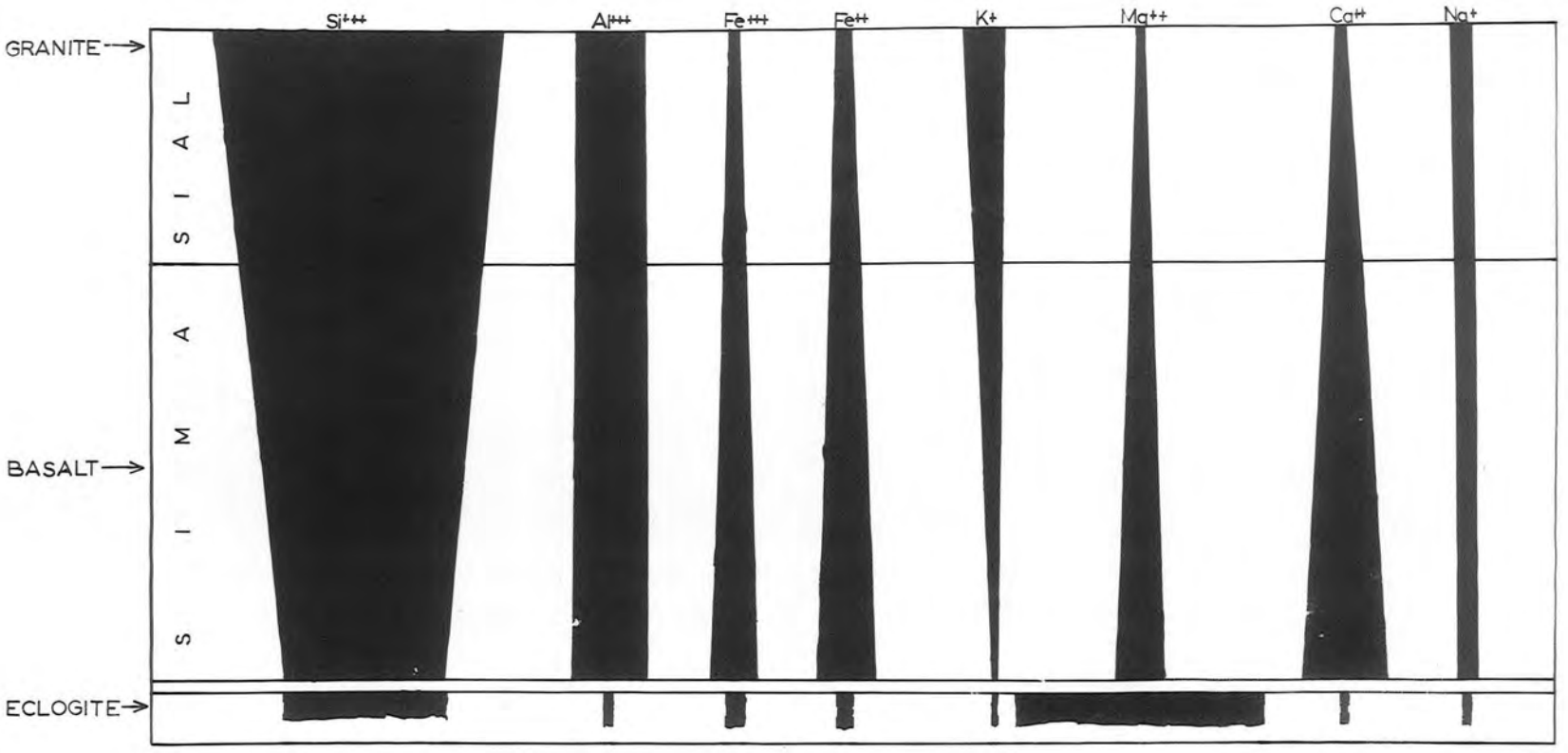
ADAMS' BRICKS

	SiO_2	Al_2O_3	Fe_2O_3	CaO
BRICK 6	1·0	1·0	22·4	8·4
ZONE c	0·6	0·5	17·2	4·0
ZONE b	1·6	1·3	15·6	5·4
ZONE a	3·5	1·7	12·4	6·3
BRICK 5	2·3	0·9	8·3	2·4

Diagram showing the results of Adam's (1930) experiment. The two bricks are heated; one softens and touches the other, and material diffuses through the knife edge contact from one brick to the other. Note the relative speed of diffusion as indicated by the analyses of different parts of Brick 5.

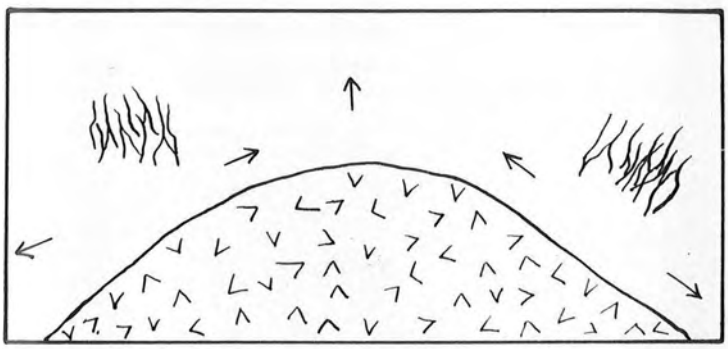
Fig. 15.

The diagram is constructed from the average proportions by weight of the cations of granites, basalts and dunites. The narrow open gap at the top of the eclogite represents the Mohorovicic discontinuity, at which there appears to be a critical change in the relative stability of the elements. The diagram suggests that potassium is more unstable at depth than sodium and that calcium, iron and magnesium are progressively more stable with increasing depth.



HYPOTHETICAL IDEAL DISTRIBUTION OF CATIONS IN THE EARTH CRUST.

Fig. 16



The diagram shows the probably distribution of stresses in rocks, overlying an area undergoing granitization. The granitization causes a volume increase at depth with the doming of the overlying rocks. The diagram is hypothetical.

Fig. 17

The diagram represents an hypothetical cross section through a Plutonic Series. It illustrates the sequence of transformations undergone by metasedimentary rocks altering them to granites and diorites in response to the higher temperature and pressure conditions of regional metamorphism.

Plane 1 : Metasediments with granitic veins resembling segregation veins.

Plane 2 : The veins have widened and increased giving rise to lit-par-lit gneisses.

Plane 3 : Granodioritic gneiss predominates and only patchy relics of the original metasediments remain. Concordant and agmatitic pegmatitic dykes are abundant.

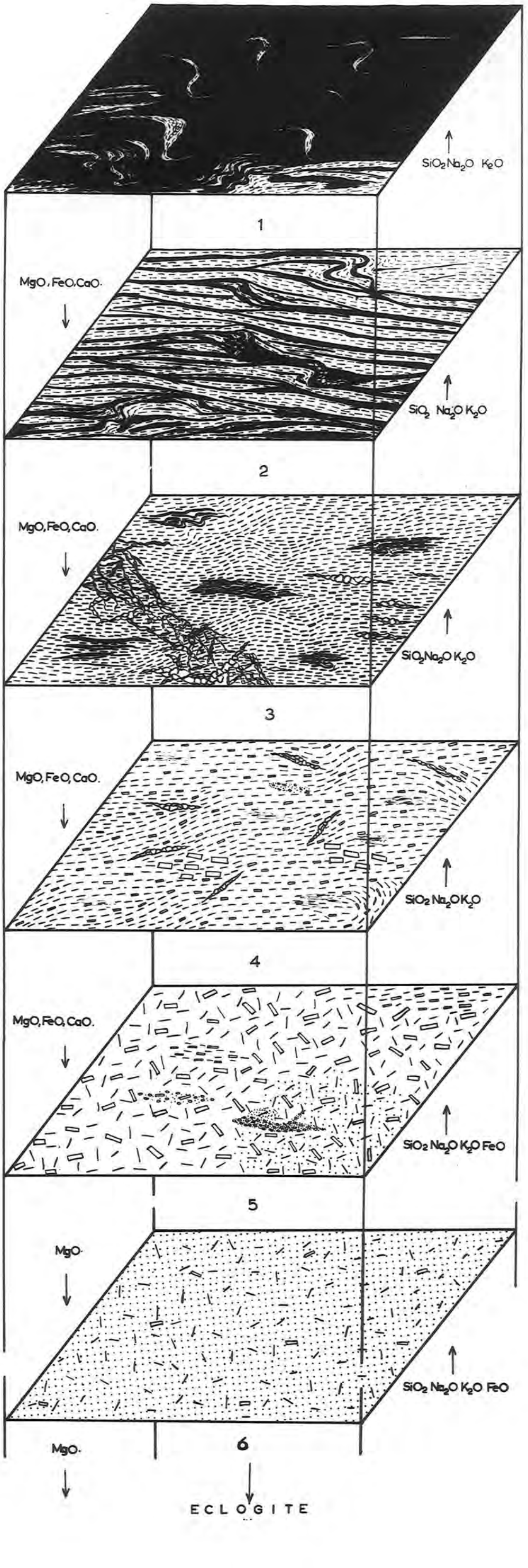
Plane 4 : Small microcline porphyroblasts are developing, with the conversion of the gneisses towards a granitic rock, sporadically the concentrations of microcline porphyroblasts may be considerable. Only ghost relics of the metasediments can be found.

Plane 5 : Coarse granite, monzonite and adamellite predominate with patchy areas of diorite, granodiorite and charnockite. At this stage the original metasedimentary rocks are completely obliterated.

Plane 6 : Zone of diorite and intermediate charnockite This zone loses alkalis to the higher zones and receives iron, magnesium and calcium.

The intensity of transformation here represented as a function of depth, is to be regarded as a function of temperature and pressure.

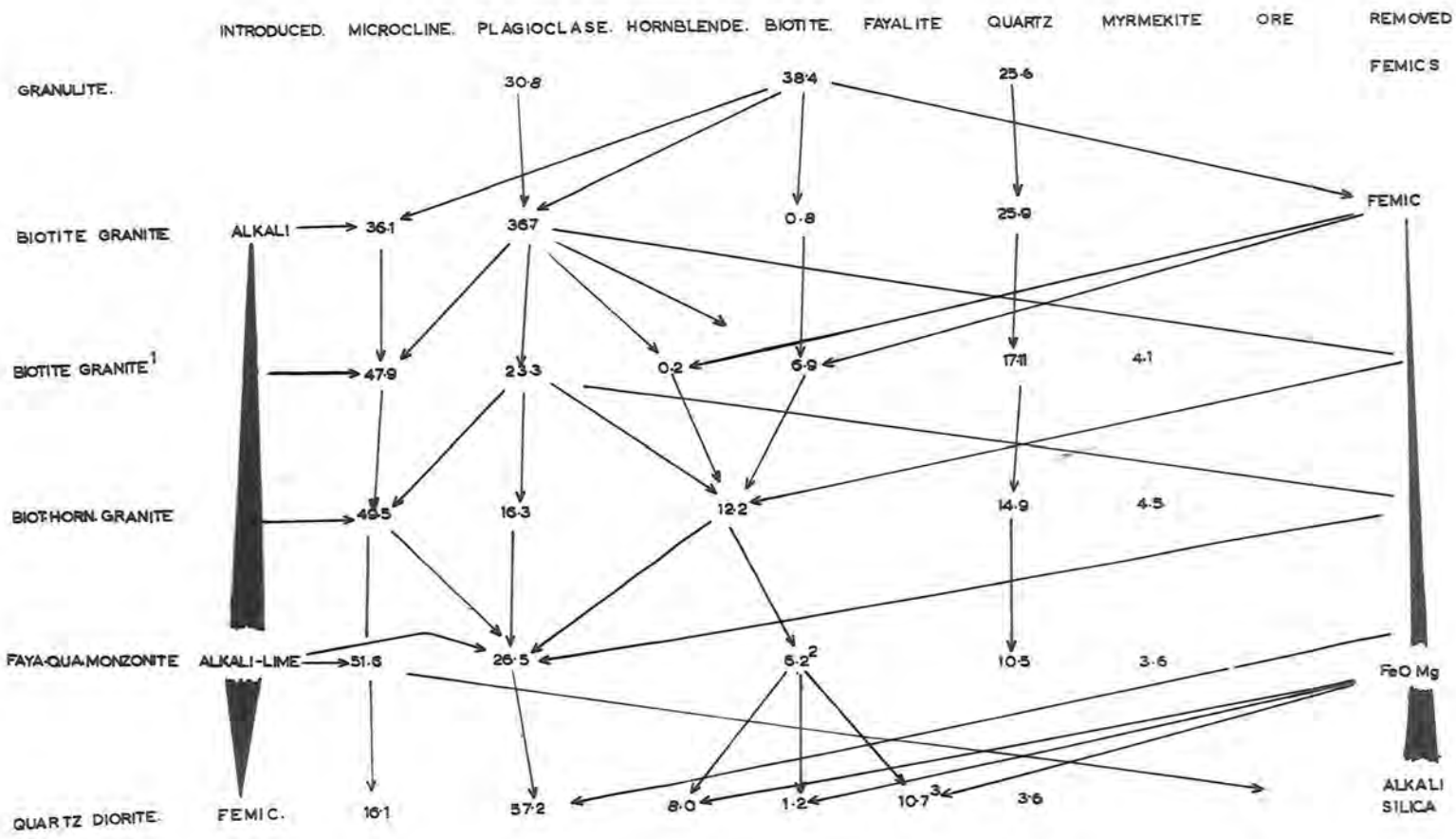
SECTIONS THROUGH ROCK SERIES IN PLUTONIC SETTING



MIGMATITES — GRANITES — DIORITES

Fig. 18.

Diagram showing the mineralogical changes in the rocks of the Bauchi district during the transformation of metasedimentary rocks to granites and subsequently to diorite. It is suggested by the diagram that the changes represent only a redistribution of components. Note the increase in Alkali with increasing femic components.



1 Tara type.
2 Fayalite+hornblende+pyroxenes
3 Pyroxenes

CHANGES IN THE MODAL COMPOSITIONS FROM GRANULITE TO QUARTZ DIORITE, BAUCHI DISTRICT.

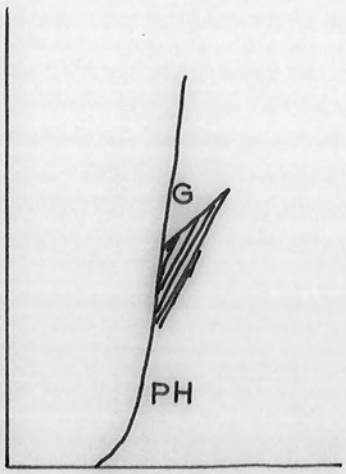
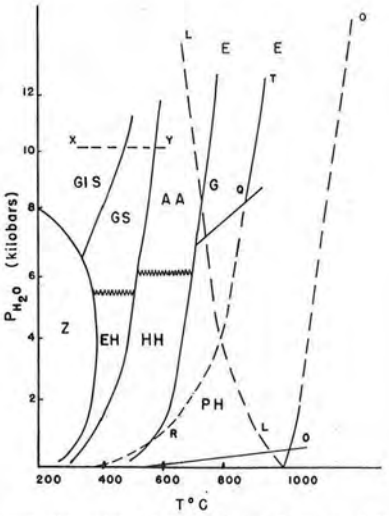

G
PH

Fig. 19



–Schematic Representation of Possible Pressure-Temperature Fields of Metamorphic Facies and of Granitic Magmas (Migmatites); All Curves Hypothetical

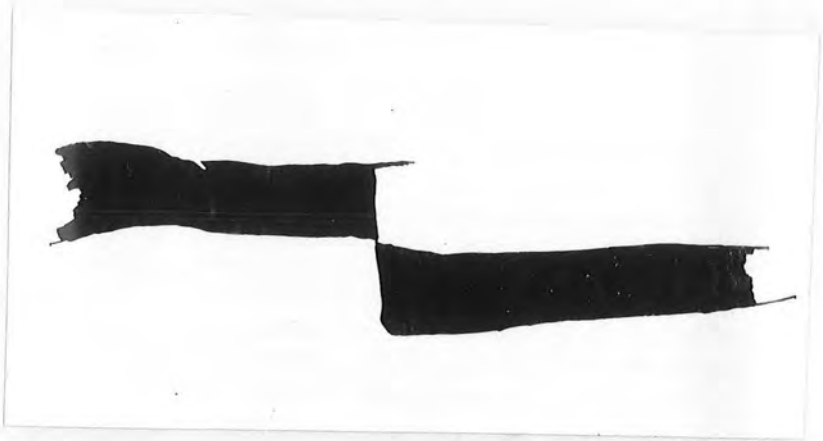
AA = almandine amphibolite. CG = cordierite granulites. E = eclogite. EH = albite-epidote hornfels. G = granulite. GS = greenschist. GlS = glaucophane schist. HH = hornblende hornfels facies. PH = pyroxene hornfels. S = sanidinite. Z = zeolite facies. LL, OO are curves of fusion of water-saturated and anhydrous granite respectively.

XY is the possible range of temperature at 30 km. depth for normal thermal gradients according to Birch (1955).

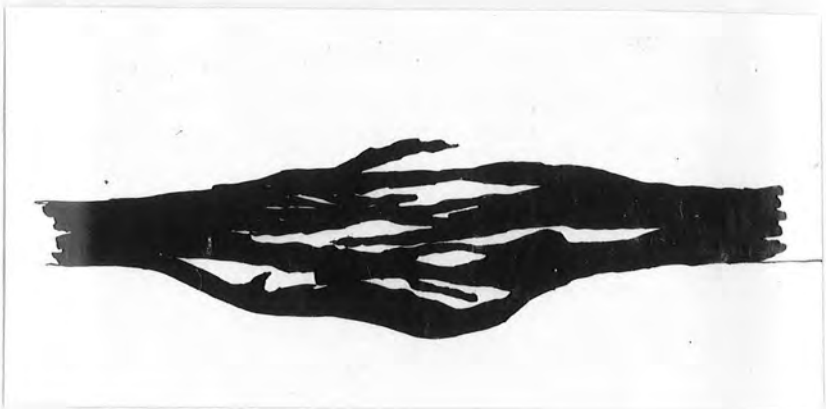
Assuming $P_{CO_2} = P_{total}$, calcite-quartz is stable to the left and wollastonite to the right of the curve RT.

Diagram showing the hypothetical pressure - temperature field of metamorphism (Fyfe and others, p. 237). The writer suggests the modification shown as a shaded area, representing the probable field of charnockites and rocks with Fayalite-Hedenbergite-Quartz assemblages.

Fig. 20

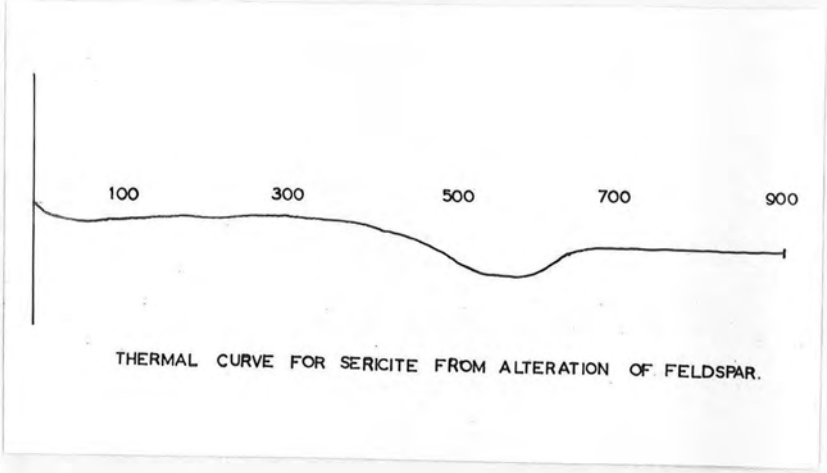


(a) Dolerite dyke showing displacement of about its own width. (North of Magamma Village. The width of dyke is about 12 inches.)



(b) Diagram showing the manner in which 2 feet wide dolerite dyke breaks into numerous veins on encountering an earlier zone of cataclastic deformation in the country rocks.
½ mile west of Zungar hill, near roadside.

Fig. 21



THERMAL CURVE FOR SERICITE FROM ALTERATION OF FELDSPAR.

Curve obtained from the differential thermal analysis of altered microcline from the Biotite Hornblende Granite. The curve is considered to correspond to that of sericite. (Powder from ME 149, 1 mile south-west of Miri Village, Bauchi. Determination by Dr. G. A. L. Johnson.)

NIGERIA

MAP OF AFRICA

SHOWING

PRECAMBRIAN AREAS

LATER GRANITIC ROCKS

(arrow) AREA COVERED BY THESIS

RAN HILL

MAGUNMA HILLS

M.RAN

SHABAWANKE

SCHOOL

RAN GATE

WOMBAI HILLS

KWANCHI

INKIL HILLS

TIRUIN HILLS

KOBI HILL

B A U C H I

MIRI

GURU HILL

JOS ROAD

RUNDE HILL

KASUMA HILLS

KASUMA HILLS

AGRIC. DEPT FARM.

YELWA BRIDGE

YELWA SCH.

JURA HILLS.

GUDUN HILL

DUMI HILLS

DUMI HILLS

※ READ BASKIN HILL

EXPLANATION

- SOIL COVER
- ALTERATION ZONES
- MEDIUM–GRAINED BIOTITE HORNBLENDE GRANITE
- QUARTZ DIORITE
- MEDIUM–GRAINED BIOTITE GRANITE
- FAYALITE HORNBLENDE ADAMELLITE
- BIOTITE HORNBLENDE GRANITE
- GNEISSOID BIOTITE HORNBLENDE GRANITE
- FINE–GRAINED BIOTITE GRANITE
- AGMATITIC GNEISS
- LIT–PAR–LIT GNEISS
- GRANITIC GNEISS
- CALCSILICATE ROCK (?)
- GARNET BIOTITE GRANULITE
- ARKOSIC QUARTZITE
- GARNET BIOTITE GRANULITE (RELIC)
- CALCSILICATE ROCKS (RELIC)
- CATACLASTIC ZONE (AUGEN GNEISS)
- MYLONITE ZONE
- LINEATION STRIKE
- PEGMATITE DYKE
- FAULT
- TOURMALINE VEIN
- TOURMALINE KNOT
- MASSIVE QUARTZ REEF
- Td TRACHYTE DYKE
- d DOLERITE DYKE
- dd UNEXPOSED (INFERRED) DYKE
- Bd BASIC DYKE
- xd XENOLITHIC DYKE
- gd GRANITIC DYKE
- OUTCROPS
- ROAD
- PATH
- CITY WALL
- APPROX. GRADATIONAL CONTACT
- APPROX. DEFINITE CONTACT
- INFERRED CONTACT

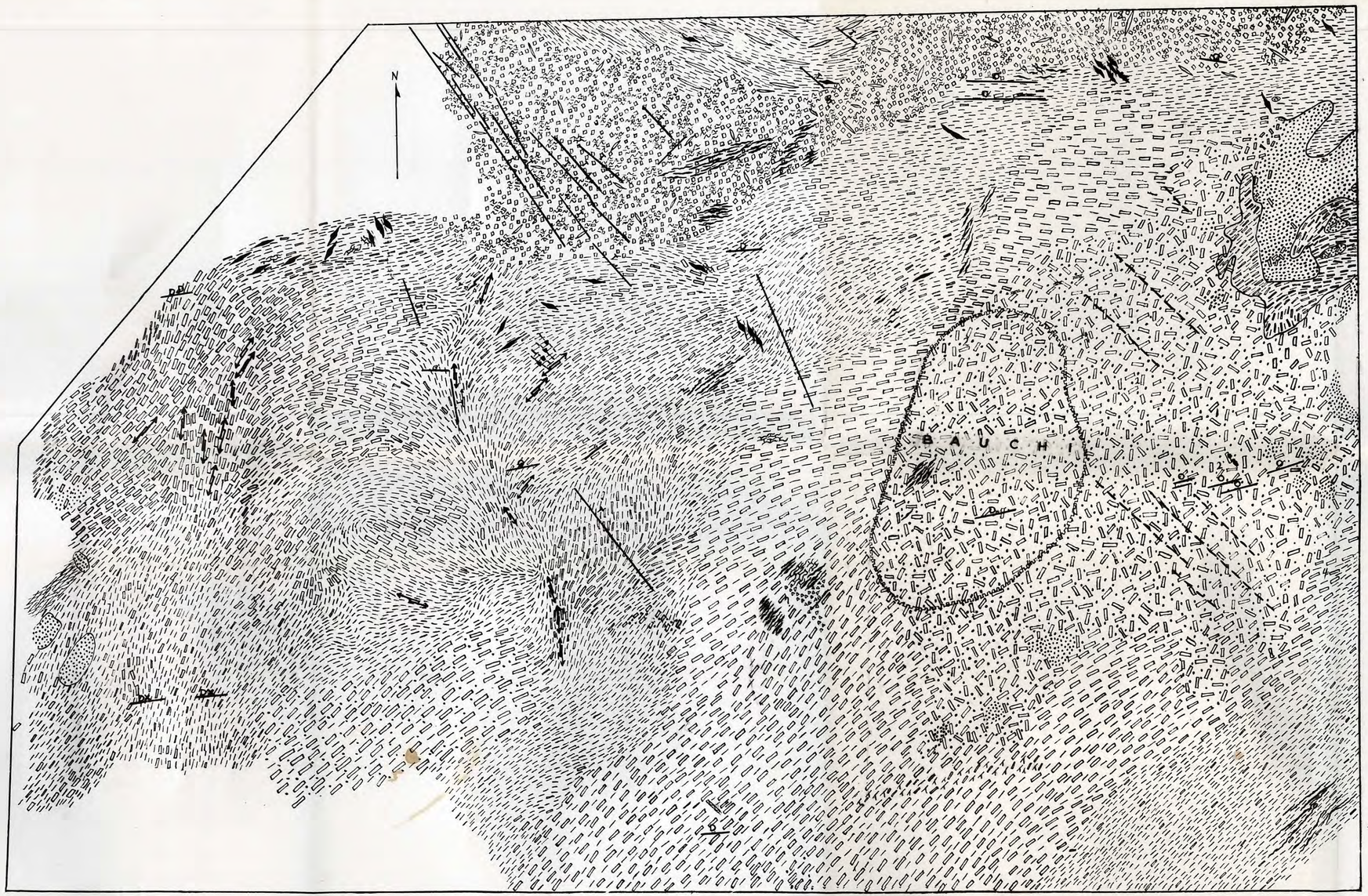
GEOLOGICAL MAP OF THE DISTRICT AROUND BAUCHI

NORTHERN NIGERIA
1958

Scale 1 : 30,000

0 1 2 3 Miles

M. Oyawoye,
Dept. of Geology,
Durham Colleges,
University of Durham.



ORTHO-PYROXENE QUARTZ DIORITE.
FAYALITE HEDENBERGITE MONZONITIC ROCK.
FAYALITE BIOTITE " "
BIOTITE HORNBLENDE GRANITE.
BIOTITE GRANITE (HYBRID?).
BIOTITE GRANITE (PORPHROBLASTIC GNEISS).
BIOTITE GNEISS.
" " WITH PEGMATITE DYKES.
AGMATITIC GNEISS.
LIT-PAR-LIT GNEISS.
GRANULITIC RELIC
CALCSILICATE RELIC.
QUARTZITIC RELIC.
ALTERED ROCKS.
PEGMATITE DYKES.
D — DOLERITE DYKES.
DX — " " WITH XENOLITH.
T — TRACHYTE DYKES
O — OTHER DYKES.
TOURMALINE VEINS.
CATACLASITE
MYLONITE.
PROBABLE FAULT LINE.
~~(NO EXPOSURE IN UNSHADED AREA)~~

GEOLOGY OF BAUCHI TOWN

0 1/2 1 2 MILES