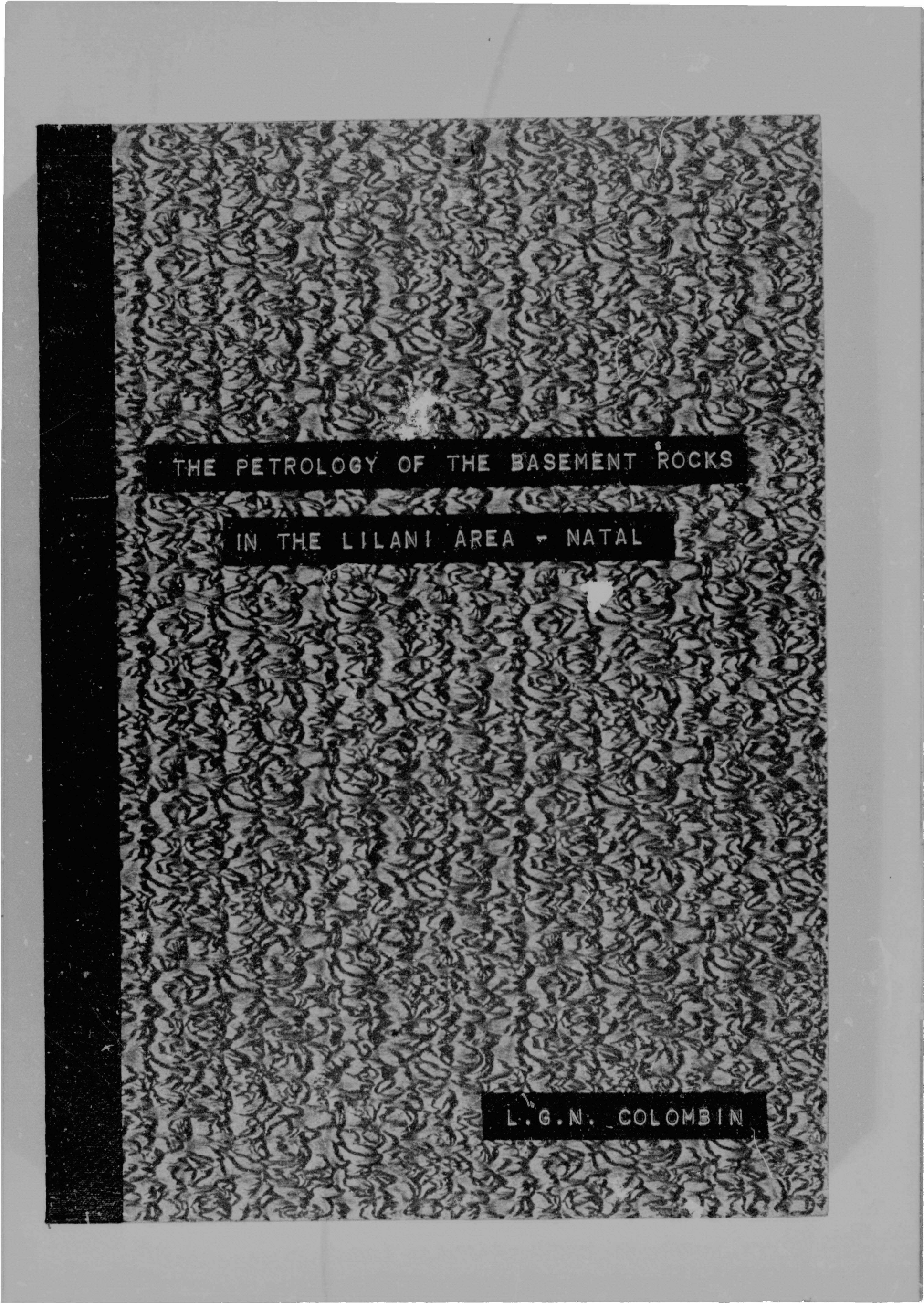


The image shows the front cover of a book. The cover is decorated with a dense, intricate marbled pattern in shades of grey and black. A solid dark vertical band runs along the left edge, representing the spine. Two horizontal black rectangular labels are pasted onto the cover, one above the other, containing the title and subtitle in white capital letters. The author's name is on a third label at the bottom right.

THE PETROLOGY OF THE BASEMENT ROCKS

IN THE LILANI AREA - NATAL

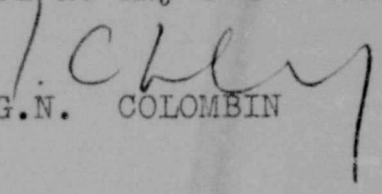
L.G.N. COLOMBIN

THE PETROLOGY OF THE BASEMENT ROCKS
IN THE LILANI AREA, NATAL

by
L. G. N. Colombin

Thesis submitted for the degree of Master of
Science at the University of the Witwatersrand

This is to certify that the thesis presented for the degree of Master of Science at the University of the Witwatersrand is my own work and has not been presented at any other University.


L.G.N. COLOMBIN

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CHAPTER I.- I N T R O D U C T I O N

I.- GENERAL

This work on the Basement Rocks of the Lilani area, Umvoti District, Natal, was undertaken at the suggestion of Prof. T.W. GEVERS who, when studying the thermal springs of this locality, was struck by some remarkably well exposed features of the Basement Complex. He gave a brief outline of these in his paper "Thermal Springs at Lilani, Natal, and their Geological Setting" (1963). The aim of the writer's work is to examine these in greater detail and, in particular, to elucidate the metamorphic history of the area.

II.- LOCATION

The Lilani thermal springs are situated some 20 miles from Greytown, Natal, and 12 miles by road from Ahrens station, on the Greytown-Kranskop railway.

III.- TOPOGRAPHY

This has already been described in some detail by GEVERS (1963). The Basement Complex is exposed in several deep gorges incised by tributaries of the Umvoti river into the horizontal strata of Table Mountain Sandstone. The edges of the gorges are formed by vertical cliffs of TMS contrasting strongly with the softer features of slopes in the Basement Rocks (Plate I, photo I). Eastward from these gorges, the TMS plateau has been completely eliminated by erosion and the Basement Rocks are widely exposed; here, the valleys are broader and filled more extensively with alluvium. The best exposures of Basement Rocks are found in the valleys of active streams below the TMS cliffs, particularly on the floor and sides of the two main streams : the Hlimbitwa and its tributary, the Lilani. GEVERS (1963) has shown the Lilani river to have been incised on a major E-W fault trace.

In general, the granitic rocks and amphibolites of the northern portion of the area give rise to steeper slopes than the banded amphibolites and gneisses in the south. This can be clearly seen in the Lilani valley whose northern slopes are much steeper than southern (Photos I and 2, Plate I). A very weather-resistant sheet of red granite stands out particularly prominently (Photo 2, Plate I).

IV.- GEOLOGICAL SETTING AND PREVIOUS WORK

In 1931, DU TOIT briefly referred to the Lilani area in his description of the Nkandhla sheet (No. 109, Geological Survey of the Union of South Africa). He noted some of the main rock types and recognised the E-W Lilani fault.

The first comprehensive work on the Lilani area was published by GEVERS in 1963. This author observed that the main rock formations of the Basement were aligned in parallel E-W trending belts. He classified the more important units as banded amphibolites, amphibole and biotite gneisses, talc schists, serpentines, marbles, orthoamphibolites and various types of granite. He outlined metamorphic processes and stressed granitisation effects.

On the basis of GEVERS' classification, the writer has distinguished the following E-W belts from north to south :

- (i).- "Granitic" (mostly quartz-dioritic) belt.
- (ii).- Orthoamphibolite belt
- (iii).- Red granite sheet
- (iv).- Central belt along Lilani valley, mostly amphibole gneisses.
- (v).- Southern metasedimentary belt (gneissic with a few amphibolites).

(see GEVERS' 1963 geologic^{al} map and that by the writer, Plate XXXIV).

GEVERS studied the tectonics of the region and showed the main tectonic trend to be E-W. The important E-W Lilani fault he demonstrated to be of the trap-door type, accompanied by several parallel subsidiary graben, indicating conditions of tension during a post-Karoo period of block-faulting. He also showed the Lilani fault to be superimposed on a very ancient zone of structural weakness dating back to the post-Insuzi orogeny. His paper is accompanied by a geologic^{al} map superimposed on an aerial photograph.

V.- AIM, SCOPE AND METHODS

The main aim of the field and laboratory work embodied in this thesis is to delve more deeply into the petrography and petrology of the very varied and complex rock types of the Basement and to elucidate more clearly their genesis and field relationships.

The writer, an exchange student from Belgium, covered in the field an area of approximately 30 square miles, measuring 6 miles from north to south and 5 miles from east to west. Unfortunately, the field work was terminated by an accident, necessitating prolonged medical attention before the writer's return to Europe. The original plan regarding field mapping was therefore not completed; but it sufficed as a basis for detailed laboratory work.

About 600 samples were collected for laboratory examination and 400 thin sections cut. Chemical analyses met with a number of difficulties. Owing to the fundamental inhomogeneity of most rock types due to banding, presence of schlieren, etc., representative analyses necessitated in most cases several pounds of each sample. The writer hence preferred to restrict chemical analyses to definite petrogenic problems. In the majority of cases, modal analyses were substituted for chemical. This procedure was not only rapid but was also found to be adequate for the writer's purpose. JUNG's methods (1958 a) were followed.

The Museum of Tervueren (Belgium) had kindly agreed to attempt age determinations on some of these rocks; but their high degree of alteration at successive periods of their complex tectonic history indicated that the results would be of little value.

In the following chapters the metamorphic belts of the Basement rocks will be described in sequence according to their relative age. The case of the belt of ortho-amphibolites is not quite clear, since their contact relationships with the adjacent central and succeeding southern belts have been obliterated by a sheet of younger red granite emplaced in an ancient shear zone. However, being definitely intrusive, the orthoamphibolites are probably younger than the highly metamorphic rocks of these belts. The sequence of description is thus as follows :

Chapter II.- A.- The southern metasedimentary rocks

B.- The central belt

Chapter III. The ortho-amphibolites

Chapter IV.- The northern "granitic" massif

Chapter V.- The red granite sheet

Chapter VI.- Conclusions

VI.- ACKNOWLEDGMENTS

The writer wishes to express his gratitude to the Department of Education, Arts and Science of the South African Government for the award of an exchange student scholarship which enabled him to carry out this work. He is very much indebted to Prof. T.W. GEVERS for suggesting this study as well as for advice and handing over all relevant material in his possession, such as specimens and thin-sections.

He is also grateful for the assistance provided by M. LEPERSONNE and the Section of Geology of the Central Africa Museum (Tervueren, Belgium) in shipping samples and providing laboratory facilities. Thanks are also due to M. LAMBERT, University of Brussels, for chemical analyses.

CHAPTER IIA.- THE SOUTHERN METASEDIMENTARY ROCKS

I.- INTRODUCTION

This southern belt is by far the most extensive of the various geological units in the Lilani district. Only its northernmost portion, extending E-W for more than 6 miles and about 3 miles from N. to S., is shown on the map (Plate XXIV). Farther southwards the meandering Hlimbitwa valley progressively widens with the development of a flood plain whose alluvium obscures the floor. Also the valley sides become less steep and hence more deeply weathered; outcrops suitable for obtaining fresh rock are greatly reduced.

Complex metamorphic processes have been observed in the rocks of this belt. The metasedimentary rocks will be shown to have been affected by recrystallization and redistribution of silic minerals; and also by incipient granitization with metasomatic enrichment in potash.

II.- THE METASEDIMENTARY ROCKS

A.- STRATIGRAPHY

Though these rocks still exhibit stratification, no marked horizons suitable for establishing the stratigraphic sequence could be identified. Furthermore, distances separating good outcrops are often too great to allow of specific correlation.

B.- STRUCTURE

The layered metasedimentary rocks are made up of biotite or quartzofeldspathic gneiss, easily recognisable in the field by their colour and

* The thickness of individual layers may vary from as little as half an inch to as much as several dozens of feet.

amphibolite layers are not uncommon. Biotite and quartzofeldspathic gneiss is particularly frequent, giving the rock a typically banded aspect (Photos 3 and 4, Plate II). These two rock types often merge one into another (Photo 4, Plate II). Their layers are very continuous and, though very thin, can usually be traced for more than 30 yards over large outcrops (Photo 5, Plate III).

The strike of these layers varies between E-W to N50°E, while the dip is mostly about 90°. Isoclinal folding in the vertical plane is frequent (Photo 6, Plate III). Occasional folds in the horizontal plane plunge 30-40°W. Plastic folding affects biotite gneiss rather more strongly than quartzofeldspathic gneiss, as seen on a small scale in the plications of Photo 7, Plate IV. Careful examination of the photograph shows that the biotite gneiss (dark layers) behaves in a very incompetent way: limbs of folds have thinned out and the material has accumulated in fold hinges. Thick layers of quartzofeldspathic gneiss behave in relatively competent fashion. In Photo 8, Plate IV, predominantly biotitic gneiss has been extensively sheared, while an adjacent massive layer of quartzofeldspathic gneiss has remained relatively unyielding. In plastic folding on a larger scale shearing-out of the limbs of incompetent biotite gneiss folds often takes place, giving rise to arrowhead structures (Photo 9, Plate V) (KRANCK 1957).

Boudinage is the most common type of deformation of amphibolite. It is extensively developed. In a small tributary west of the Hlimbitwa river the writer has observed enormous boudins of amphibolite, up to 4 yards in length and 4 to 5 yards apart, in quartzofeldspathic gneiss (Photo 10, Plate V). This latter, yielding plastically, has flowed in between the boudins. Some amphibolite bands have been disrupted to such an extent that boudin lenses have "floated" apart for 10, or even 20, yards. On small outcrops this may give the puzzling aspect of an inclusion of basic rock isolated in gneiss (Photo II, Plate VI).

C.- PETROGRAPHIC DESCRIPTION

For microscopic study, the following rock types have been distinguished:

- (a).- Amphibolites
- (b).- Banded amphibolites
- (c).- Melanocratic biotitic gneisses
- (d).- Quartzofeldspathic gneisses
- (a).- Amphibolites

The main minerals of these dark, foliated rocks are plagioclase, hornblende, and quartz; accompanied by subsidiary biotite, sphene, epidote, chlorite and ore. Modal analyses of a variety of specimens are very variable (table I).

TABLE I

	<u>I</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
Hornblende	47.2	38.1	64.7	15.6	57.8	45.4	82.4
Plagioclase	32.0	48.5	22.8	47.9	28.7	45.8	4.1
Quartz	20.8	12.5	11.0	28.5	13.5	5.2	13.5
Biotite	-	0.9	1.5	8.0	-	3.6	-
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The amphibole is hypidiomorphic and has the following optical properties :

2V(-) = 78 to 86° Z = bluish green
 Z/c = 16 to 24° Y = olive green
 X = yellowish green

These are the properties of hornblende. It crystallizes in plates or needles 5 mm. long, arranged parallel and giving the rock its foliation. The plagioclase is 1.5 mm. in diameter and amoeboid; its composition varies from andesine ^{An₄₃} ~~43An~~ to oligoclase ^{An₁₅} ~~25An~~. It is albite-twinned and more or less sericitised in the vicinity of microfractures. Quartz grains reach 2.0 mm. and are mostly interstitial. Subordinate biotite occurs in flakes 1.5 mm. long; it usually forms in association with hornblende, sphene, epidote and ore. It is partially altered to sphene and chlorite.

(b).- Banded amphibolites

In these rocks bands of amphibolite alternate with frequent layers of biotite gneiss or, less often, quartzofeldspathic gneiss. Though contacts between the various rock types may occasionally be sharp, more commonly they are gradational.

(c).- Melanocratic biotite gneisses

The main minerals of this rock type are biotite, plagioclase and quartz. Modal analyses are given in table II.

TABLE II

	<u>I</u>	<u>2</u>	<u>3</u>	<u>4</u>
Plagioclase	49.7	41.3	50.8	52.3
Quartz	33.9	39.7	24.4	26.0
Biotite	11.4	19.0	24.8	21.7
	100.0	100.0	100.0	100.0

The plagioclase is up to 3 mm. in diameter; it is amoeboid to rounded and, in the latter case, looks detrital. Its composition ranges from andesine 33An_{33} to oligoclase 27An_{27} . Quartz grains, interlocked with plagioclase, are 5 mm. max. in diameter. Biotite, concentrated in bands and schlieren, displays the following sequence of alteration. In the first stage tiny granules of sphene crystallize in cleavage lines of the flakes, forming alignments parallel to the elongation of these flakes; sometimes rutile crystallizes instead of sphene. In a more complete stage of alteration, mostly in the immediate surroundings of microfractures of the rock, chlorite or, less often, muscovite form from biotite. When altering to chlorite, the biotite progressively takes a greenish colour until completely replaced. Sphene (or rutile) alignments do not disappear, but persist as inclusions in the flakes of chlorite. This can be used as a criterion of origin for chlorite : flakes of chlorite showing aligned inclusions of sphene always result from secondary alteration of biotite. When biotite is replaced by muscovite, it first shows intergrowths of mixed muscovite-biotite flakes arranged parallel in a sandwich-like association. Alteration of biotite to both chlorite and muscovite is not incompatible : both types are often seen to affect the same flake of biotite.

Subsidiary ore and zircon grains are frequently arranged in parallel strings in the matrix of the rock.

(d).- Quartzofeldspathic gneiss

(d).- Quartzofeldspathic gneiss

The main minerals are plagioclase and quartz. Biotite is usually present in volume proportion less than 10%. The gneiss has a greyish color and is fine - to medium-grained. Mineralogical compositions are shown in table III.

[illegible]

Author Colombin L G N

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