Petrography of Pan African Migmatite around Liman Katagum, Bauchi North East Nigeria

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Abstract

The study area Liman Katagum lies within latitudes 10°00'00" N and 10°30'00" N and longitudes 9°30'00" E and 10°30'00" E which is part of sheet 149 Bauchi SW covering a total area of 42 km^2. Based on field relationship and petrography, the area is underlined predominantly by migmatites of different texture such as restite, stromatic metatexite, banded orthogneisses metatexite, melanocratic diatexite, mesocratic diatexite, and leucocratic diatexite. Restite composed of a predominance of mafic minerals because these are harder to melt. Typical minerals are amphibole, biotite, pyroxene, ilmenite or other iron oxides and some plagioclase feldspar. The stromatic migmatites bands of leucosome that are oriented parallel to the major plane of anisotropy in the palaeosome, which are typically compositional layering or a solid-state foliation. It is evident that the individual leucosome bands have melanosome on both sides, while the stromatic type shows evidence of pytgmatic fold and crenulation cleavage. The diatexite migmatite is dominated by pervasive neosome and display a granitic appearance with abundant schlieren. Pre-partial-melting structures are absent from the neosome, and commonly replaced by syn-anatectic flow structures or isotropic neosome. The melt-depleted remains of protolith layers (biotite schlieren) stand out as dark alignment within the diatexites.

Key words: *Diatexite, Stromatic, foliation, Banded Orthogneiss and Liman Katagum area.*

INTRODUCTION

A migmatite is a metamorphic rock formed by anatexis that is generally heterogeneous and preserves evidence of partial melting at the microscopic to macroscopic scale. Migmatites are ubiquitous in deep crustal exposures and are associated with high-temperature metamorphism of various rock types (Yakymchuk, 2020). Migmatites represent the transition from metamorphic to igneous rocks in the rock cycle (Sawyer, 2008). The heterogeneous nature of migmatites at various scales represents the final product of petrological and mechanical processes that create and redistribute anatectic melt with or without accompanying deformation. A first-order division of migmatites is based on the melt fraction; metatexites contained relatively small melt fractions whereas diatexites contained relatively high melt fractions (Sawyer, 2008).

Migmatite outcrop in all part of Nigeria and belong to the termed Migmatite Gneiss Complex of the basement component of Nigerian Geology. The migmatite-Gneiss complex is generally considered as the basement complex that is most widespread (about 60%) of the component units in the Nigeria basement (Rahaman and Ocan, 1978). It has a heterogeneous assemblage comprising migmatites, orthogneisses, paragneisses, and a series of basic and ultrabasic metamorphosed rocks (Rahaman and Ocan, 1978). The migmatite-Gneiss complex has ages ranging from Pan-African to Eburnean. This work is aimed at determining and classifying the rock types in the area using morphological and petrological characteristics.

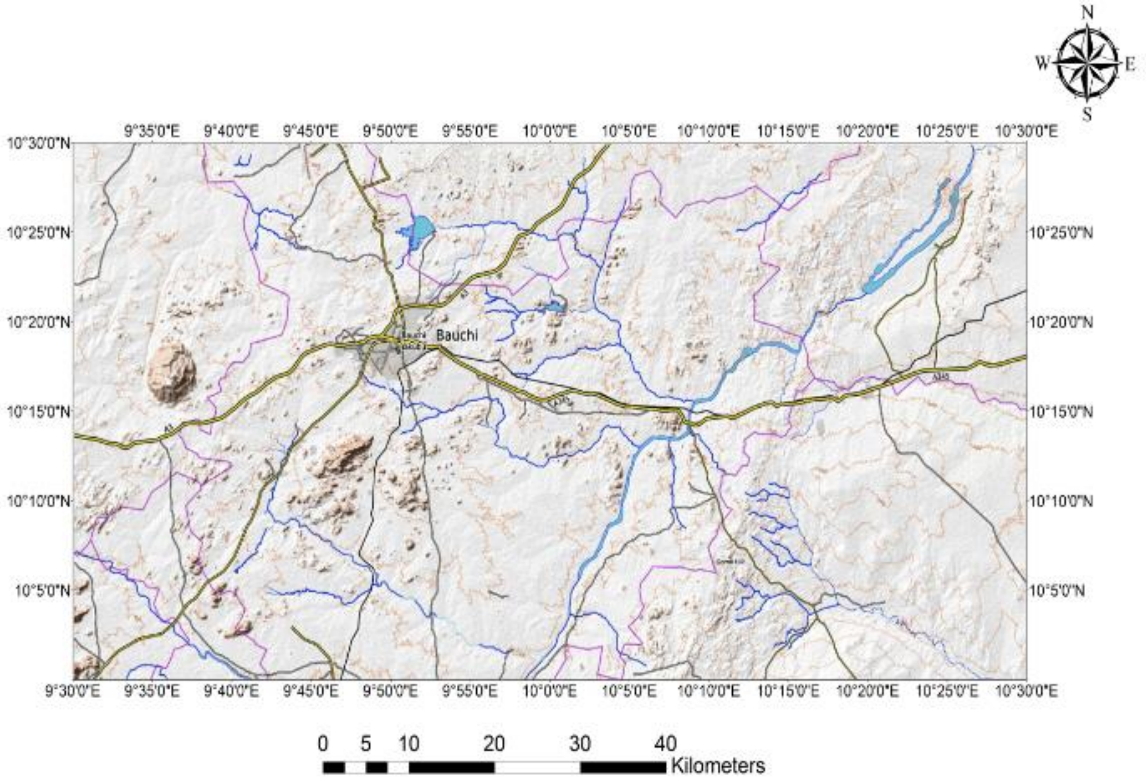

Figure 1: Topographic map of the area

GEOLOGIC SETTING

The Nigerian Basement Complex is situated in the pre-drift mobile belt defined by Kennedy (1964) east of the West African and Sao-Luis Cratons Northwest of the Congo and Sao-Franscisco Cratons which was affected by the 550 ± 100 Ma Pan-African Orogeny. The entire belt lies in the reactivated margin of the West-African Craton and the active Pharusian Continental margin (**Fig. 2)** (Burke and Dewey, 1972; Black and Girod, 1972; Caby et al., 1981). Nigeria is situated within the Pan African mobile belt and sandwiched between the West African Craton to the west, the Tuareq Shield to the north and the Congo Craton to the southeast (**Fig. 2**). About half of the total area of Nigeria landmass is underlain by rocks of the Precambrian age known in the country as the Basement Complex. The remaining half is covered by Cretaceous to Quaternary sediments and volcanics. The Nigerian basement was affected by the 600 Ma Pan-African orogeny and it occupies the reactivated region which resulted from plate collision between the passive continental margin of the West African craton and the active Pharusian continental margin (Burke and Dewey, 1972; Dada, 2006).

2.2 THE BASEMENT COMPLEX

The Basement Complex is one of the major litho-petrological components that make up the geology of Nigeria (Obaje, 2009). It is believed to have been affected by, at least, three major tectonic cycles of deformation, metamorphism and remobilization corresponding to the Liberian (2700 Ma), the Eburnean (2000 Ma) and the Pan- African cycles (600 Ma). These cycles were characterized by intense deformation and isoclinal folding accompanied by regional metamorphism which was followed by extensive migmatization (Obaje, 2009).

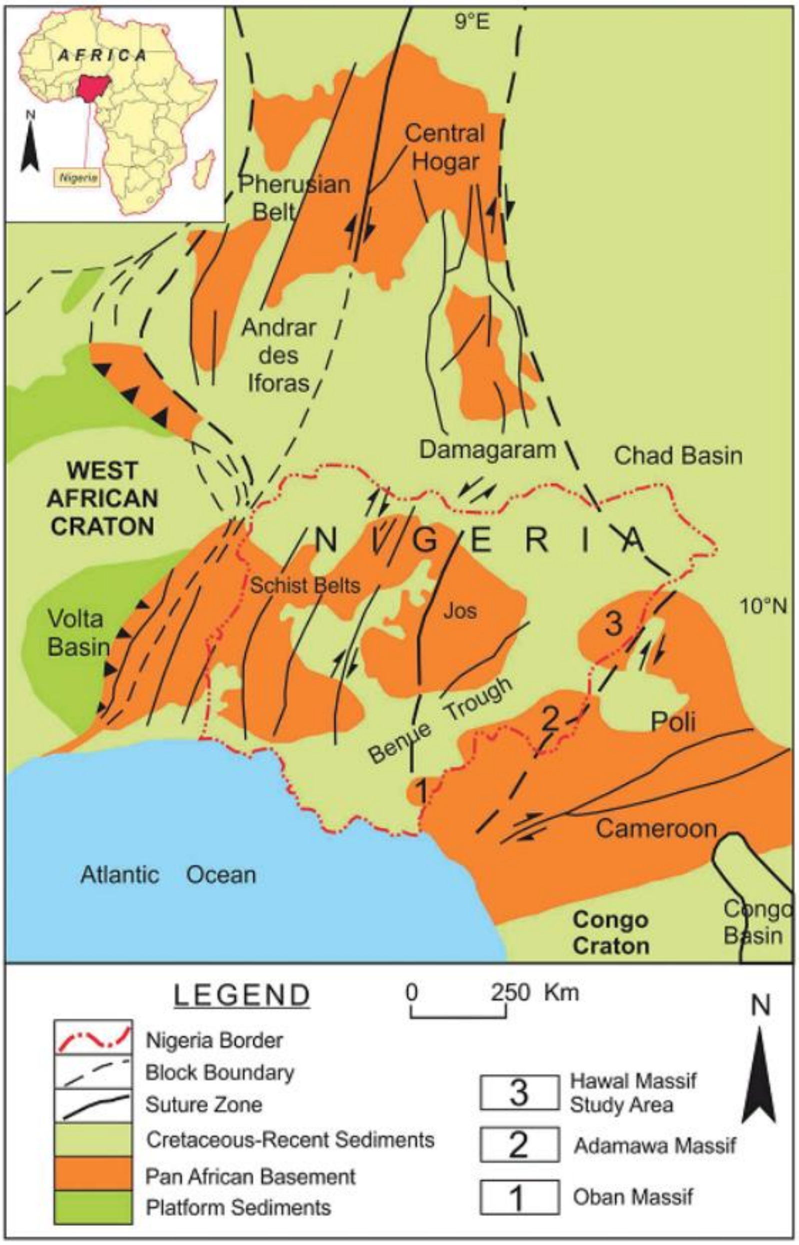

Figure 2. Regional geological setting of Nigeria (after Ferré *et al*. 1996).

Petrographic evidence indicates that the Pan-African reworking led to recrystallization of many of the constituent minerals of the Migmatite–Gneiss Complex by partial melting, with majority of the rock types displaying medium to upper amphibolite facies metamorphism. The polymetamorphic migmatite - gneiss complex with ages ranging from Eburnean to Pan–African is composed largely of gneisses and migmatites of various origin and compositions with a series of metamorphosed basic and ultrabasic rocks represented by amphibolites and talc-schist (Ajibade and Fitches, 1981).

Late tectonic emplacement of granites and granodiorites and associated contact metamorphism accompanied the end stages of this last deformation. The end of the orogeny was marked by faulting and fracturing (Olayinka, 1992). Within the basement complex of Nigeria four major petro-lithological units are distinguishable, namely (Obaje, 2009):

1. The Migmatite – Gneiss Complex (MGC)
2. The Schist Belt (Metasedimentary and Metavolcanic rocks)
3. The Older Granites (Pan African granitoids)
4. Undeformed Acid and Basic Dykes

2.0 METHODOLOGY

Rock Sampling

Traverse system was used for sampling but spacing was irregular due to non-availability of exposures in some of the areas. The whole area was traversed during the detailed sampling and a detailed geological map was subsequently produced. A total of thirty (30) samples were selected for the two basic tests; thin section. The samples were cleaned and variedly labeled for the different tests. For thin sectioning, about 300gm bulk/lump of each sample was labelled, and for chemical analysis, about 200gm of lump samples were labeled.

LABORATORY INVESTIGATIONS

Thin Sectioning

The thin sections were prepared in the petrological laboratory, Modibbo Adama University, Yola. The following stages were involved in the preparation of the thin sections.

RESULTS

The field studies (detailed geological mapping and rock sampling) indicate that the area is underlained predominantly by migmatites of different texture such as restite, stromatic metatexite, banded orthogneisses metatexite, melanocratic diatexite, mesocratic diatexite, and leucocratic diatexite.

Stromatic metatexite migmatite

This type contains numerous thin and laterally continuous bands of leucosome that are oriented parallel to the major plane of anisotropy in the palaeosome, which are typically compositional layering or a solid-state foliation (**Fig. 3**). It is evident that the individual leucosome bands have melanosome on both sides, while the stromatic type shows evidence of pytgmatic fold and crenulation cleavage (Fig. 3.1.a–b). Several models have proposed for the origin of stromatic migmatites. Some, particularly those with melanosome selvedges, are interpreted to be in situ partial melts (Sawyer, 1991; Oliver and Barr, 1997), whereas others are considered to be injection migmatites, where there is lit par lit (literally bed by bed) intrusion of migrating melt (Lucas and St-Onge 1995).

To help distinguish between these two processes, the contacts of any oblique leucosomes should be examined (Pawley et al., 2013). The diffuse and feathery margins displayed by the leucosomes reflect the fine-scale migration of melt along the foliation planes and into the dilational sites (Fig. 3a1). Furthermore, the in situ leucosomes have a darker selvedge that could represent the solid products of the melt reaction (Fig. 3a). In hand specimen, the stromatic metatexite shows contorted foliation and crenulation cleavage (Fig. 3b). i.e., earlier foliation S1 deformed to newly S2 foliation. In thin section, platy mineral shows lepidoblastic texture with mineral assemblages such as Crd, cpx and quartz, all of which show xenoblastic to sub-idioblastic texture (Fig. 3a1–b2). Notably, the coexistence of Bt+Chl is indicative of back reaction.

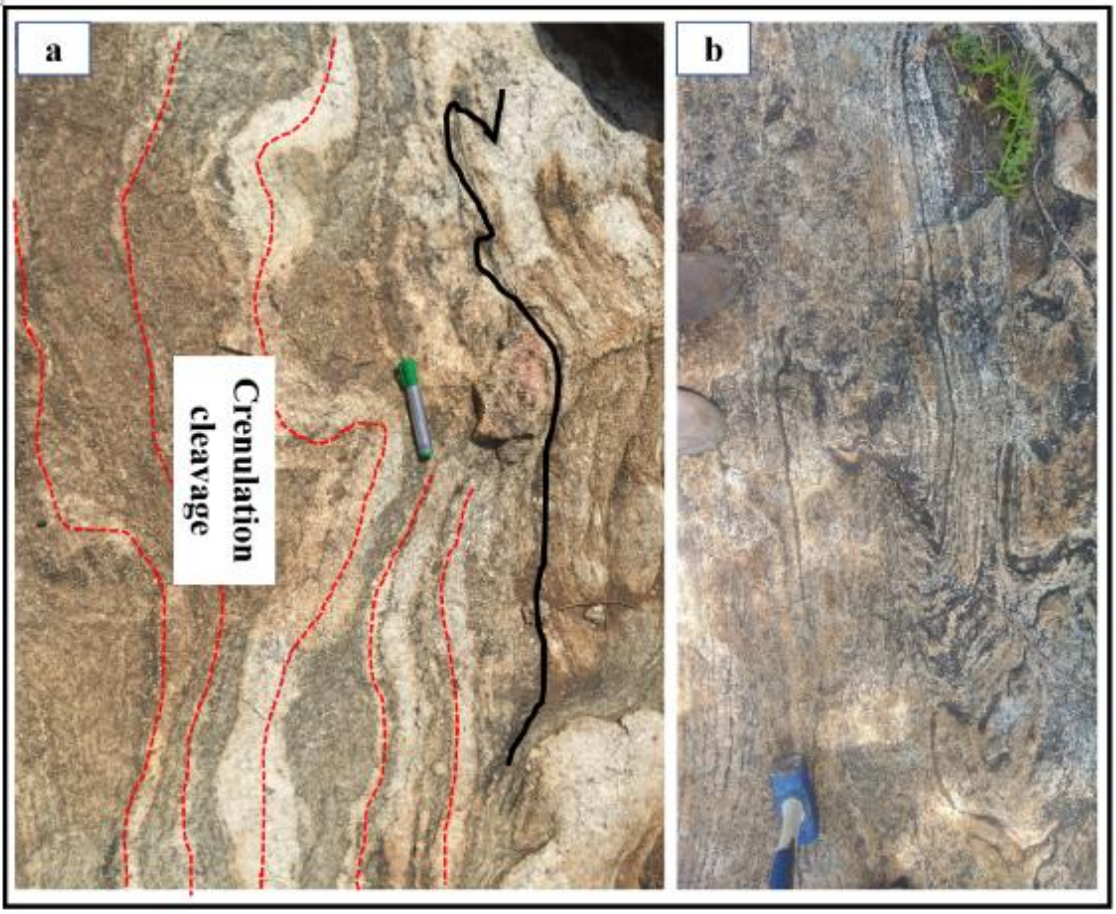

Fig. 3 (a) Field photograph showing stromatic metatexite

Banded Orthogneiss Metatexite

They are banded by discrete discontinuous millimetric thin layer of medium grained quartz and plagioclase leucosomes alternating with centimetric melanosomes (**Fig. 4**). The leucosomes are coarse-grained, white-coloured and can be identified using a two-fold division based on their relationship with the surrounding melanosomes. They are concordant to local foliation. Metatexite in the vicinity of diatexites show a darker colouration and high melanosome/ leucosome ratio with residual composition, substantial leucosomic extraction and passive enrichment in residual minerals after the melt removal. In hand specimen, it is banded by felsic and mafic minerals showing evidence of foliation (Fig. 4). In thin section, the mineral shows lepidoblastic texture as defined by Bt+Sil with clear linear fabrics (Figs. 4a1–b2). The mineral assemblages of crd+Sil (Fig. 4 b1–b2) is indicative of low metamorphic grade.

Melanocratic Diatexite

The diatexite migmatite is dominated by pervasive neosome and display a granitic appearance with abundant schlieren (**Fig. 5**). Pre-partial-melting structures are absent from the neosome, and commonly replaced by syn-anatectic flow structures or isotropic neosome. The melt-depleted remains of protolith layers (biotite schlieren) stand out as dark alignment within the diatexites (Fig. 5). This schlieren gives the rock a Melanocratic appearance although its general abundance gives the diatexite a morphological description known as Melanocratic Diatexite (Fig. 5). Sawyer (2008) describes four main second order divisions of diatexite; nebulite, schollen (raft), schlieren, or diatexite. However, it is important to remember that these represent transitional stages as the rock progresses to high degrees of partial melt and complete disruption of the protolith.

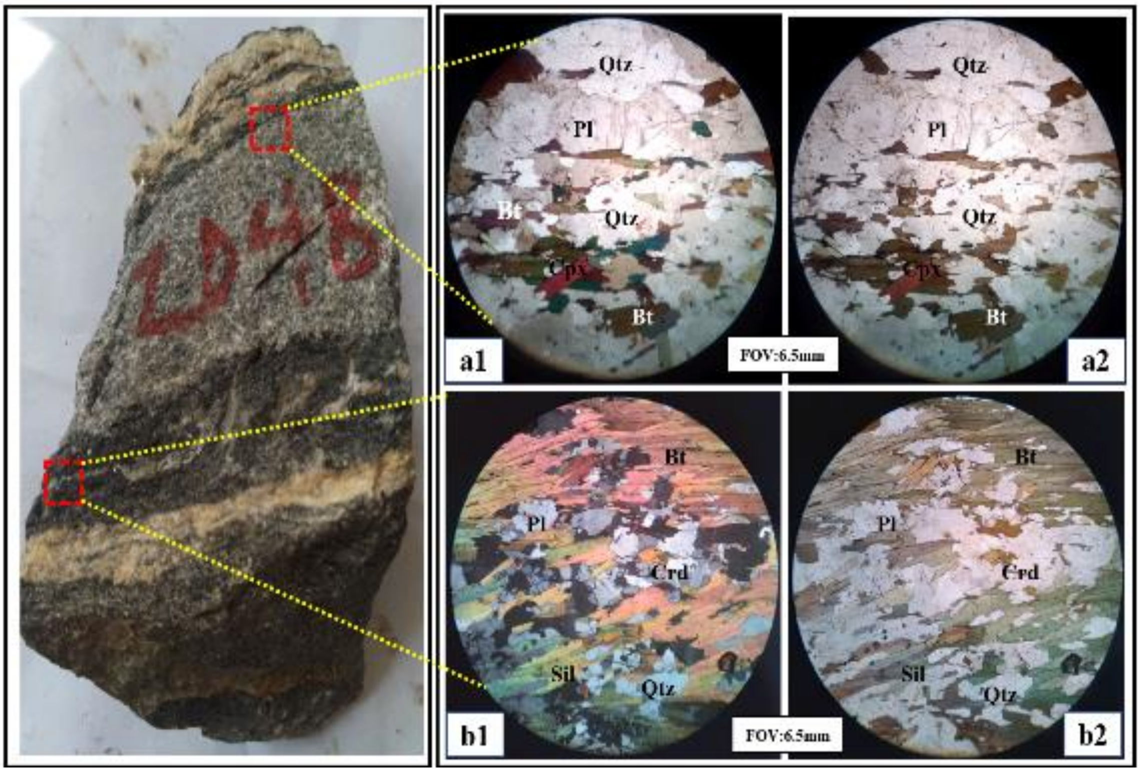

Figure 4. Hand specimen of banded metatexite samples and photomicrographs under plane polarized light (a1 and
b1) and cross polarized light (a2 and b2)

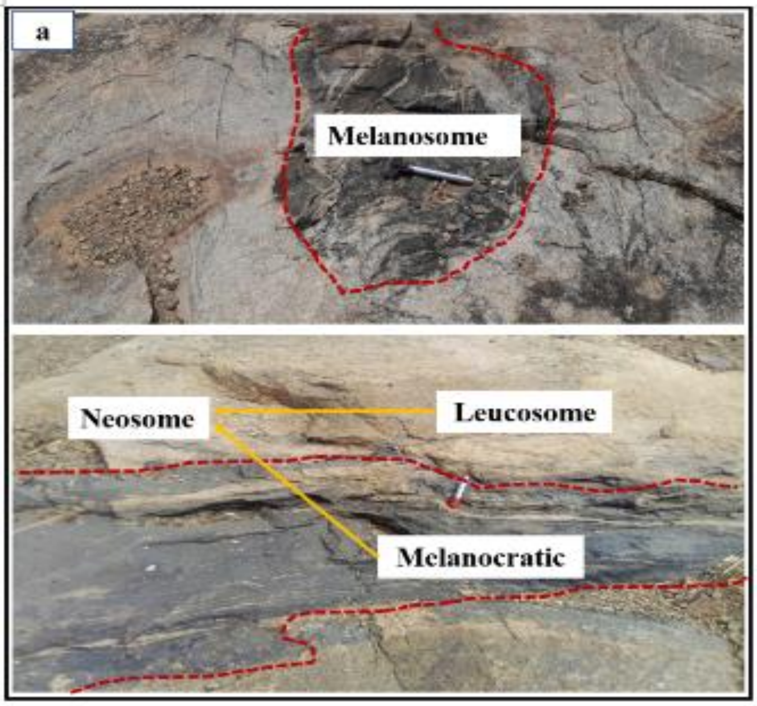

Figure 5. Field photograph showing several aspects of melanocratic diatexites

In hand specimen, the schlieren occur as trains of platy or blocky minerals, typically containing ferromagnesian minerals and accessory phases (Fig. 5). In thin section, the lepidoblastic texture as defined by Bt+Sil is exhibited texture from the primary texture (Fig. 5a1–b2). Linear fabrics is clearly discernable while felsic and mafic mineral occur as cuspate crystal. The reaction of opx+Sil is indicative of medium metamorphic grade.

Mesocratic Diatexite

This schlieren gives the rock a mesocratic appearance although generally abundance gives the diatexite a morphological description Mesocratic Diatexite (**Fig. 6a & b**). In thin section, it shows porphyroblastic texture of K-feldspar in groundmass of mafic mineral preferably biotite. The mineral matrix is composed of dispersed, almost equal amount medium grained crystals of quartz, feldspars and biotite. In thin section, the mineral shows granoblastic texture while the biotite is lepidobastic which defines the Linear fabrics (Fig. 6a1–b2). K-feldspar shows evidence of fracturing (brittle deformation). Wavy extinction in quartz and obliteration of twinning in feldspars is discernable (Fig. 6 a1–b2).

Leucocratic Diatexite

Leucocratic diatexite is medium to coarse grain size comprising quartz, plagioclase, biotite, K-feldspar, apatite, zircon, ilmenite, and graphite (Milord et al., 2001). The Figure 7 shows biotite, quartz, and plagioclase well foliated, indicating clearly the direction of magma flow (Tasco and Moraes, 2019). The mineral matrix composed of dispersed medium grained crystals of quartz, feldspars and rare biotite. However, most of the biotite occurs as schlieren as well as sillimanite and rare garnet (Fig. 7). Hand specimen shows medium- to coarse-grained texture with visible light-coloured minerals (Fig. 7).

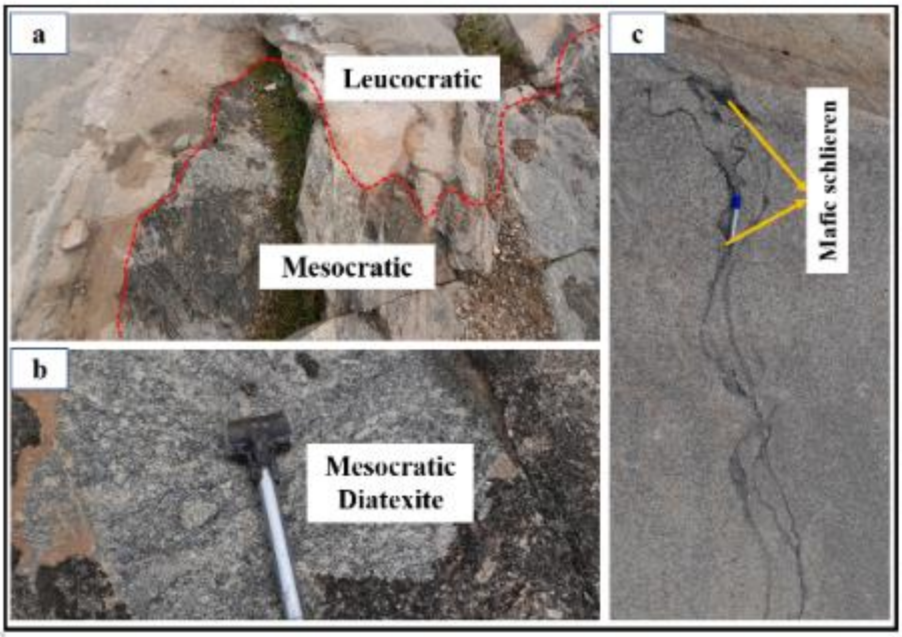

Figure 6. (a–c). Field photographs showing several aspects of mesocratic diatexites

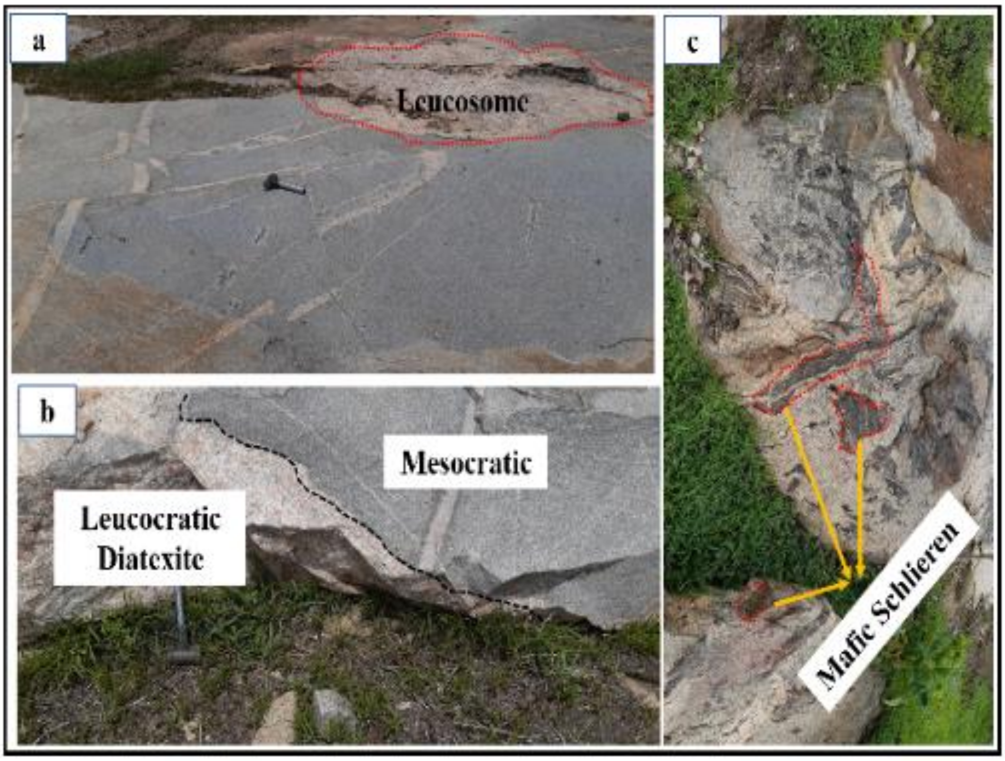

Figure 7. Field photographs showing several aspects of leucocratic diatexites

Petrographic analysis shows that the rock has a medium- to coarse-grained texture (Fig. 7 a1–b2) and is predominantly felsic minerals-quartz, plagioclase, K-feldspar, and small amount of biotite which exhibit strong pleochroic halos. The quartz occurs principally in large irregular masses and in some cases, it shows strain effects. The microcline exhibits a crosshatched twinning, and it sometimes occurs as interstitial grains.

Conclusion

The migmatites of Liman were classified into metatexite and diatexites, the metatexite were further sub divided into Banded orthogneiss and stromatic migmatite based on morphology and petrography, while the diatexite were also sub divided into melanocratic, mesocratic and leucocratic diatexites based on morphology and petrography. Minerolagically, the metatexites composed of amphibole, biotite, pyroxene, ilmenite or other iron oxides and some plagioclase feldspar, while the diatexite composed of more felsic minerals like quartz and feldspar. The enrichment of felsic minerals in the diatexite is an indication of partial melting that consume most of the mafic mineral which favors the formation felsic minerals as the grade of metamorphism increases. The presence of orthopyroxene in the migmatites also indicates the level of metamorphism has reached the level granulite facie metamorphism.

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