

Prealpine and alpine metamorphisms and kinematics in the Petite Kabylie Massif (Eastern Algeria)

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Abstract: In Petite Kabylie Massif of eastern Algeria, two superposed high grade tectono-metamorphic (D1-M1) events have been recognized and investigated in two distincts crystalline units: upper crystalline units and lower crystalline units-named Beni Ferguene units.

The first one event studied in upper units is associated with high temperature (HT) and Low pressure (LP) metamorphism ($P=4 \text{ kb}$, $T=725^{\circ}\text{C}$) and is synchronous of granite emplacement dated at $274 \pm 6 \text{ Ma}$ (U-Pb on zircon). The east shearing is associated with granite emplacement developed during decompression. Final retrograde evolution corresponding to decompressional cooling following this granite emplacement is associated with extensional shear zones.

The second high grade deformational (D2-M2) event ($P=9 - 10 \text{ Kb}$, $T=550 - 650^{\circ}\text{C}$) affects mainly lower crystalline units and corresponds to the northward shearing. Previous assemblages (M1) are transformed as andalousite by kyanite in metapelites and muscovite by secondary white mica and kyanite in metagranites (High pressure assemblages (M2)). In these lower units, the HP event clearly involved 270 - 280 Ma old granites.

Field observations, petrological, structural and radiometric data led to suggest that (D2-M2) tectono-metamorphic event overprinted LP variscan basement before upper Eocene deformation. Thus, late hercynian or coalpin ages for this HP event is debated in this study.

Key words: Kinematic -Shear criteria - Deformation- Metamorphism- Geochronology - Alpin belt - Variscan belt - Petite Kabylie -Algeria.

Cinématique et métamorphisme anté-alpins et alpins dans le Massif de la Petite Kabylie (Algérie orientale).

Résumé: L'analyse cinématique dans le Massif de la Petite Kabylie (Algérie nord-orientale) a montré un empilement de deux édifices de nappes alpines: un édifice supérieur, formé d'unités cristallophylliennes reposant sur un édifice de nappes issues de bassins de flyschs kabyles (unités infra-kabyles maurétaniennes, massyliennes et telliennes).

L'édifice supérieur («socle kabyle» *sl.*) comprend du Nord au Sud :

- (1) l'unité lherzolitique et kinzigitique de Bougaroun «enclavée» dans le granite d'âge miocène de Bougaroun;
- (2) les unités métapélitiques et orthogneissiques des Beni Ferguène caractérisées par un métamorphisme de type barrovien de haute pression (HP), se superposant à un métamorphisme de basse pression (BP) et haute température (HT) ;
- (3) les unités de «socle kabyles» *ss.*, marbres et paragneiss de base affectés par un métamorphisme de basse pression (BP) et haute température (HT) et leur couverture grésopélitique et carbonatée épimétamorphique.

Les ensembles (2) et (3) renferment les leucogranites tardi-hercyniens qui ont été datés à 270 - 280 Ma par la méthode U-Pb sur zircon (Drareni, 1988). Ils sont caractérisés par la succession de deux déformations à haute température :

(i) la première D1, à vergence est, associée à un métamorphisme de basse pression (BP) - $P = 4 \text{ Kb}$ et $T = 725^\circ\text{C}$ - et synchrone de la mise en place des granites datés à 270 - 280 Ma (U-Pb sur zircon) ;

(ii) la deuxième D2, chevauchante vers le NW, associée à un métamorphisme de plus haute pression (HP) - $P = 9 - 10 \text{ Kb}$ et $T = 550 - 650^\circ\text{C}$ (unités inférieures des Béni Ferguène) et chevauchantes vers le Sud-Est à P et T proche du point triple des alumino-silicates (base de l'édifice supérieur).

La mise en place post-épaississement des granites tardi-hercyniens est thermo-mécaniquement bien contrainte dans l'unité supérieure. La tectonique extensive post-mise en place qui affecte cette unité, semble être associée au uplift accompagnant l'exhumation de la chaîne.

Dans l'édifice inférieur des Béni Ferguène, l'âge hercynien ou éo-alpin de la structuration D2, responsable d'un épaississement d'ampleur crustale (30 à 35 km, estimé à la base de l'édifice) et ses relations avec la granitisation sont discutés en fonction des contraintes pétrologiques, structurales et géochronologiques (âges Rb-Sr sur micas).

Enfin, l'histoire alpine s.l du domaine kabyle méridional, liée à l'ouverture de l'Atlantique, révèle le rôle déterminant des mouvements transtentifs au cours du Mésozoïque et jusqu'à l'Eocène et transpressifs à partir de l'Eocène supérieur, les déplacements E - W étant guidés par les directions de cisaillement hercyniens anciens.

Mots clés: Cinématique - Critères de cisaillement - Déformation - Métamorphisme - Géochronologie - Chaîne alpine - Chaîne varisque - Petite Kabylie - Algérie

INTRODUCTION

of the alpine metamorphism is controversial.

The Kabylia massifs belong to internal zones of the Maghreb chain in northern Algeria (Fig.1). In these massifs, the influence

Some authors considered that the alpine metamorphism could be neglected within the crystalline rocks (Durand Delga and Fontbôte,

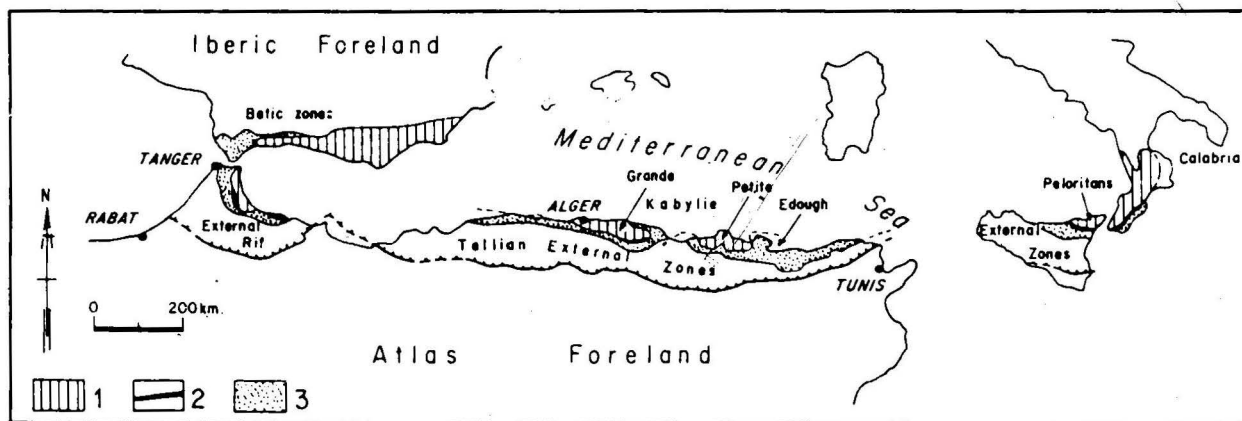


Fig. 1 Structural sketch map showing the Alpin belt in the Western Mediterranean (after Durand Delga, 1969).
(Situation du massif de Petite Kabylie dans la chaîne alpine occidentale (d'après Durand Delga, 1969).

1- Hercynian metamorphic basement. (Socle métamorphique hercynien). 2- Ouerthrusting Paleozoic and Mesozoic units. (Terrains mésozoïques et paléozoïques formant les unités de Dorsale Kabyle). 3- Mesozoic and Cenozoic Flysch units. (Unités de flyschs mésozoïques et cénozoïques).

1980; Bossière, 1980; Peucat and Bossière, 1981; Bouillin *and al.*, 1984; Bossière and Peucat, 1985, 1986). However, others suggested an alpine age for high temperature (HT) regional metamorphism that affects the basement gneisses and for blastostomylonitic high pressure (HP and HT) Sidi Ali Bou Nab (SABN) in Grande Kabylie (Caby, 1982; Monié *and al.* 1984, 1988 and Saadallah, 1992).

In the Petite Kabylie (eastern Algeria), field observations and recent petrological, structural and radiometric data (Drareni, 1988) led to the conclusion that HP-HT alpine metamorphism overprinted Low Pressure - High Temperature (LP-HT) hercynian metamorphic basement before upper Eocene alpine deformation (Mahdjoub, 1991).

I. Structural units in the Petite Kabylie

Alpine structures are mainly characterized by a large thrust of the basement overlying the sediments of infra-kabylian units both intruded by Tertiary granites (Bouillin, 1978; Vila, 1980), fig.2.

I.1 - Infra-kabylian units

They are composed by :

1- Units of reduced Mesozoic cover of variscan or older basement «Dorsale kabyle» units of Dj. Rhedir and Sidi Driss area (Raoult, 1974);

2 - Mauretanian unit, the first unit under the thrust made by upper Jurassic-early Cretaceous basic volcanics, pelagic limestones and terrigenous turbidites «Albo-Aptien» flysch and Cretaceous to Eocene flyschs (Bouillin, Kornprobst and Raoult, 1977; Bouillin, 1978; Andrieux and Djellit, 1989).

3- Massylian and Tellian units (Raoult, 1974; Bouillin, 1978 and Vila, 1980).

I.2 The basement nappe *sl.*

The crystalline basement *sl.* may be divided from S to N into three units (Mahdjoub, 1991), (fig. 2) :

1- *basement units ss.* These units represent the uppermost unit of paragneisses - marble underlying the upper sericite - chlorite phyllite. Hercynian and older events are particularly important in these upper units: intrusive granite (455 ± 1 Ma on zircon from orthogneisses of Skikda area) and intrusive late hercynian peraluminous granites of South Collo (274 ± 6 Ma U-Pb on zircon).

The bottom of these upper units is constituted by khondalito - kinzigite gneisses of Texenna area. The later are overlayed by Paleozoic sedimentary series.

2 - *Beni Ferguene units.* At the northern boundary of the massif, Beni Ferguene units are overthrust by basement units ss. These blastomylonitic lower units display the same characteristics as the Sidi Ali Bounab (SABN) in Grande Kabylie (Bouillin, 1982). Peraluminous granites in these units have been also dated at 274 ± 6 Ma (U - Pb on zircon), (Drareni, 1988; Peucat *and al.*, submitted).

3 - *Bougaroun unit (Collo).* This unit is constituted by upper mantle serpentized lherzolites (Bouillin and Kornprobst, 1974; Le Blanc and Temagout, 1989) and kinzigitic gneisses with calco-silicates lenses. This unit is embedded in the Tertiary granite of Bougaroun. The relations with other units are unknown and the age of emplacement is controversial.

II- Deformation and metamorphic history

The thermotectonic history is analyzed in basement pile and infra - kabylian units.

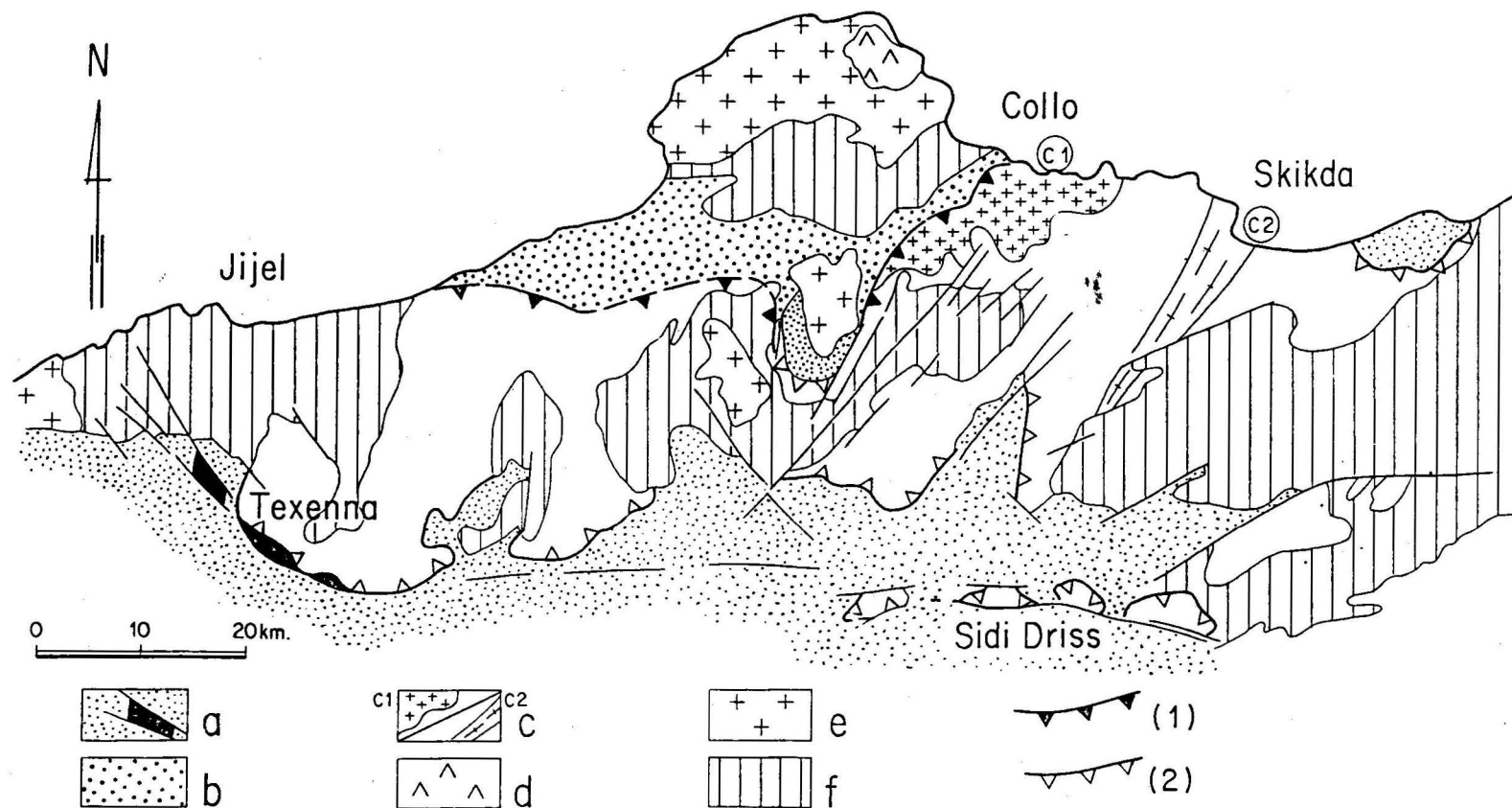


Fig. 2 - Schematic Structural map of the Petite Kabylie Massif.

(Carte schématique montrant l'empilement des principales unités structurales du massif de Petite Kabylie).

a - Mesozoic and Cenozoic Flysch and Tellian units (Infra-Kabyle Unit), in black, Jurassic basics volcanics (*flyschs mésozoïques et cénozoïques et unités telliennes (unités infra-kabyles), en noir, volcanisme basique d'âge jurassique*), **b** - metamorphic basement, lower units (Beni Ferguene units) (*édifice inférieur: unités inférieures métamorphiques des Béni-Ferguène*). **c** - metamorphic basement, upper units (*édifice supérieur: "unités de socle ss"*); **c**₁ = Late Hercynian Collo granites (*granite tardi-hercynien de Collo*); **c**₂ - Ordovician Skikda orthogneiss (*orthogneiss ordovicien de Skikda*); **d** - Bougaroun ultrabasic unit (*unité ultrabasique de Bougaroun*); **e** - Miocene granites (*granites miocènes*); **f** - Oligo-Miocene and Pliocene deposits (*Oligo-Miocène et dépôts pliocènes*); **g** - basement thrusting limits (*contacts chevauchements intra - socle*); **h** - alpine thrusting limits (*contacts chevauchants alpins*).

II.1 Deformations associated with high grade metamorphism.

High grade metamorphism affects only the basement piles. Only the two later most events (D1-M1) and (D2-M2) occurring under high metamorphic conditions have been analyzed. The first (D1) is associated to LP metamorphism (M1) the second (D2) to HP metamorphism (M2). The main debate deals with the relationships between emplacement of late hercynian granite and HP blastomylonitic metamorphism (M2).

II.1-1 LP metamorphism M1, deformation D1 and emplacement of late hercynian granite

In the Petite Kabylie, field observations and structural patterns suggest that the late hercynian granites are syntectonic. These granites are emplaced into the paragneisses of upper units and metapelitic rocks of lower Beni Ferguene units.

In the upper units, perturbations of regional strain field (D1) are related to granite emplacement (fig.3): finite strain trajectories exhibit virgation of regional structures conformable or slightly oblique to granite boundary and contemporaneous and continuous internal and regional structures.

Syntectonic emplacement during eastward shearing D1 is suggested by (1) ENE - WSW long axis orientation of granite body, (2) N060 to N080 stretching direction (L1) and (3) C-S kinematics indicators (Berthe and Choukroune, 1979).

Magmatic assemblages in granite (Garnet-Alm⁷⁸ + biotite + sillimanite + KF + primary plagioclase and deuteritic muscovite) and syntectonic growth in paragneiss granite boundary (Garnet + Sillimanite + biotite + cordierite + andalousite) are characteristic of HT - LP syntectonic emplacement. Migmatic rocks may be observed locally.

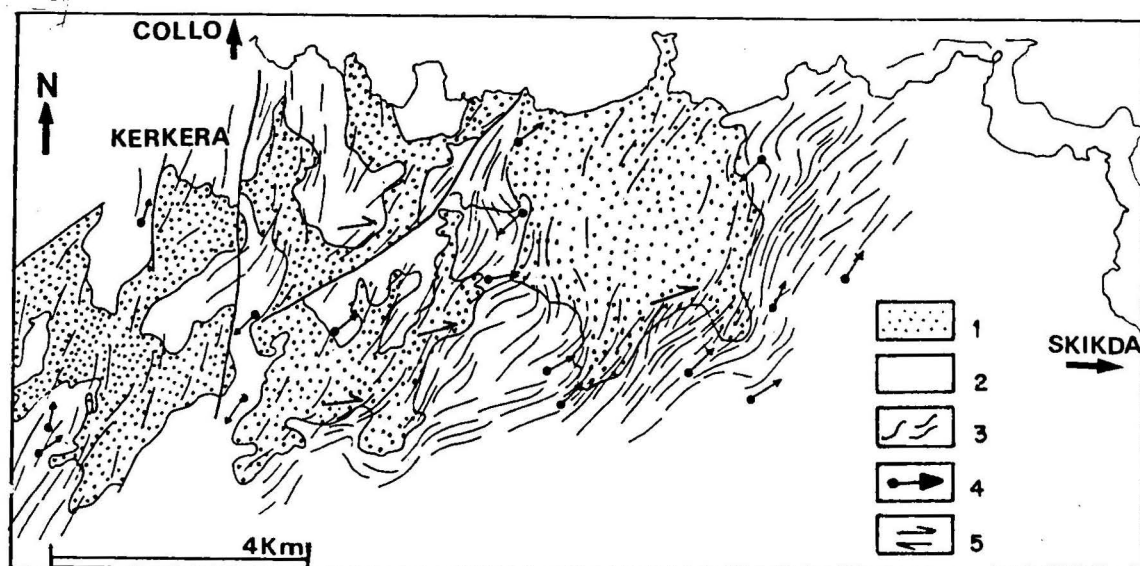


Fig. 3 - Schistosity trajectories (lines) and stretching lineations showing syn-emplacement deformation of late hercynian (274 ± 6 Ma, U-Pb, zircon), basement units (USs.), South of Collo.

(Trajectoires des schistosités montrant le caractère syn-cinématique des granites datés à 274 ± 6 Ma et affleurant au Sud de Collo "Unités supérieures de socle kabyle USK").

1- granites (granites); 2- paragneiss host rocks (encaissant paragneissique); 3 - Schistosity (schistosité); 4- stretching lineations (linéation d'étirement), 5- shear sens (sens de cisaillement).

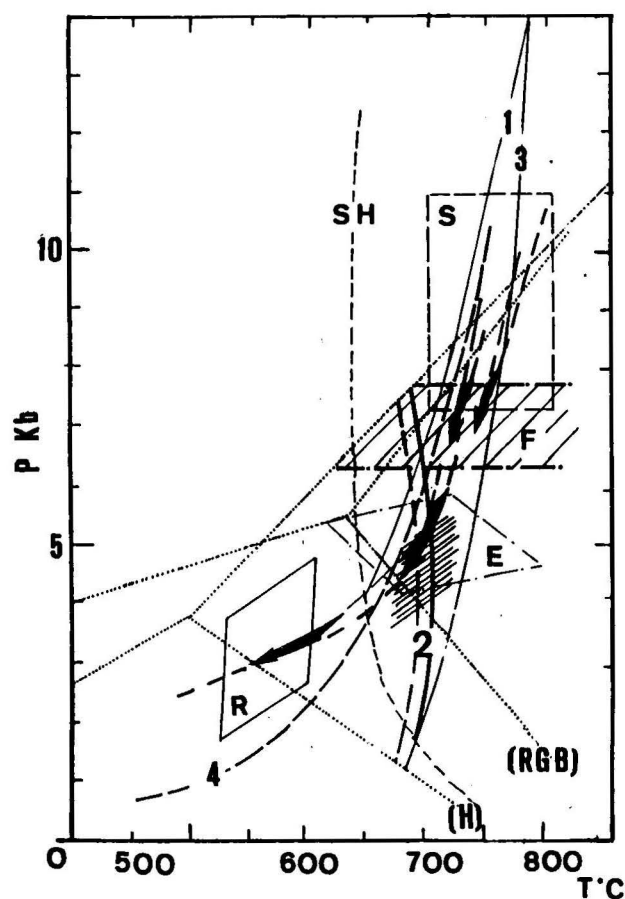


Fig. 4 - Pressure - Temperature evolution of bottom of basement unit, synchronous of late-Hercynian granite emplacement, south of Collo.

(Evolution P,T synchrone de la mise en place des granites tardi-hercyniens du Sud de Collo (base de l'édifice d'unités supérieures de socle kabyle ss. "USs").

S: magmatic source: melting; (F) of kandalito - kinzigitic source (S) during uplift episode contemporary with post-thickening continental convergence (Source khondalito-kinzigitic supposée des granites, F: fusion de cette source S (présence de migmatites), durant le uplift (stade convergence post-épaississement); E: P, T condition of granite emplacement, (a) after metapelite country rocks assemblages, Almandine + Sillimanite + Cordierite + Hercynite thermometer and Hercynite + Sillimanite + Cordierite + Corindon barometer (Harris, 1981) and (b), after early assemblages in granites, Garnet-Biotite thermometer (Holdaway and Lee, 1977) and Garnet-Plagioclase barometer

(Newton and Haselton, 1981), hatched area: (champ P,T de l'emplacement des granites d'après les assemblages thermobarométriques, (a)- de l'encaissant métapélitique, thermomètre Almandine + Sillimanite + Cordierite + Hercynite et baromètre, Hercynite + Sillimanite + Cordierite + Corindon (Harris, 1981) et (b), d'après assemblages précoces dans les granites, thermomètre Grenat-Biotite (Holdaway et Lee, 1977) et baromètre Garnet-Plagioclase (Newton et Haselton, 1981), zone hachurée); R: Retrogressive evolution (Evolution rétrogressive). (H): Alumino-silicate phase relation after Holdaway, 1977 and (RGB) after Richardson et al., 1969. - (SH), H₂O-saturated metapelite, solidus after Thompson, 1982; (1). muscovite dehydration melting, Mus + PL + Qz → Bi + KF + Liq (Petö, 1976), (2) biotite melting, Bio + Als + Pl + Qz → Gt + KF + Liq (Clemens, 1984), (3) biotite dehydration, Bio + Sill + 2Qz → KF + Gt + H₂O, late Hercynian Collo granite data, XH₂O calculated = 0,36; (4), Mus + Qz → Or + Als + V equilibrium; (H): courbe des alumino-silicates de Holdaway et Lee, 1977, (RGB) d'après Richardson et al., 1969; (SH), courbe du solidus hydraté de métapélites, Thompson, 1982; (1) courbe de déshydratation de la muscovite, Mus + PL + Qz → Bi + KF + Liq (Petö, 1976), (2) courbe de fusion de la biotite, Bio + Als + Pl + Qz → Gt + KF + Liq (Clemens, 1984); (3) courbe de déshydratation de la biotite, Bi + Sill + 2Qz → KF + Gt + H₂O, calculée d'après nos données X_(H₂O) = 0,36; (4), équilibre Mus + Qz → Or + Als + V.

P, T conditions of emplacement (M1) have been evaluated at P = 4 - 5 Kbar and T = 650 - 720 °C

(Geothermobarometry from magmatic and paragneiss assemblages; X_{H₂O} = 0,30 by calibration in granite of reaction: Bio + Sill + Qz → Alm + KF + H₂O, (fig. 4).

Microstructural patterns and deformation mechanisms of orthogneissification process of granite are related to the decreasing temperature during the reequilibration between granite and country rocks. Final temperature associated with the uplift of the variscan belt is in the andalusite stability field in upper unit (fig. 4).

II.1.2 - HP Metamorphism (M2)

The lowest Beni Ferguene unit shows a dominant deformation D2 associated with Barrovian

metamorphism. Deformation D2 corresponds to a major ductile NW vergent thrust where flat lying shearing, zone several tens of meters thick, separate low-strain domains (fig. 5). These are represented by lenses limited by anastomosed shear zones. Relics of primary EW shearing (D1) and LP assemblages

(M1) are locally preserved within low strain domains.

New mineral associations M2 of metapelitic rocks include biotite (Bi2) + phengite + grossulaire - Pyrope rich garnet (G2) + Staurolite + Kyanite

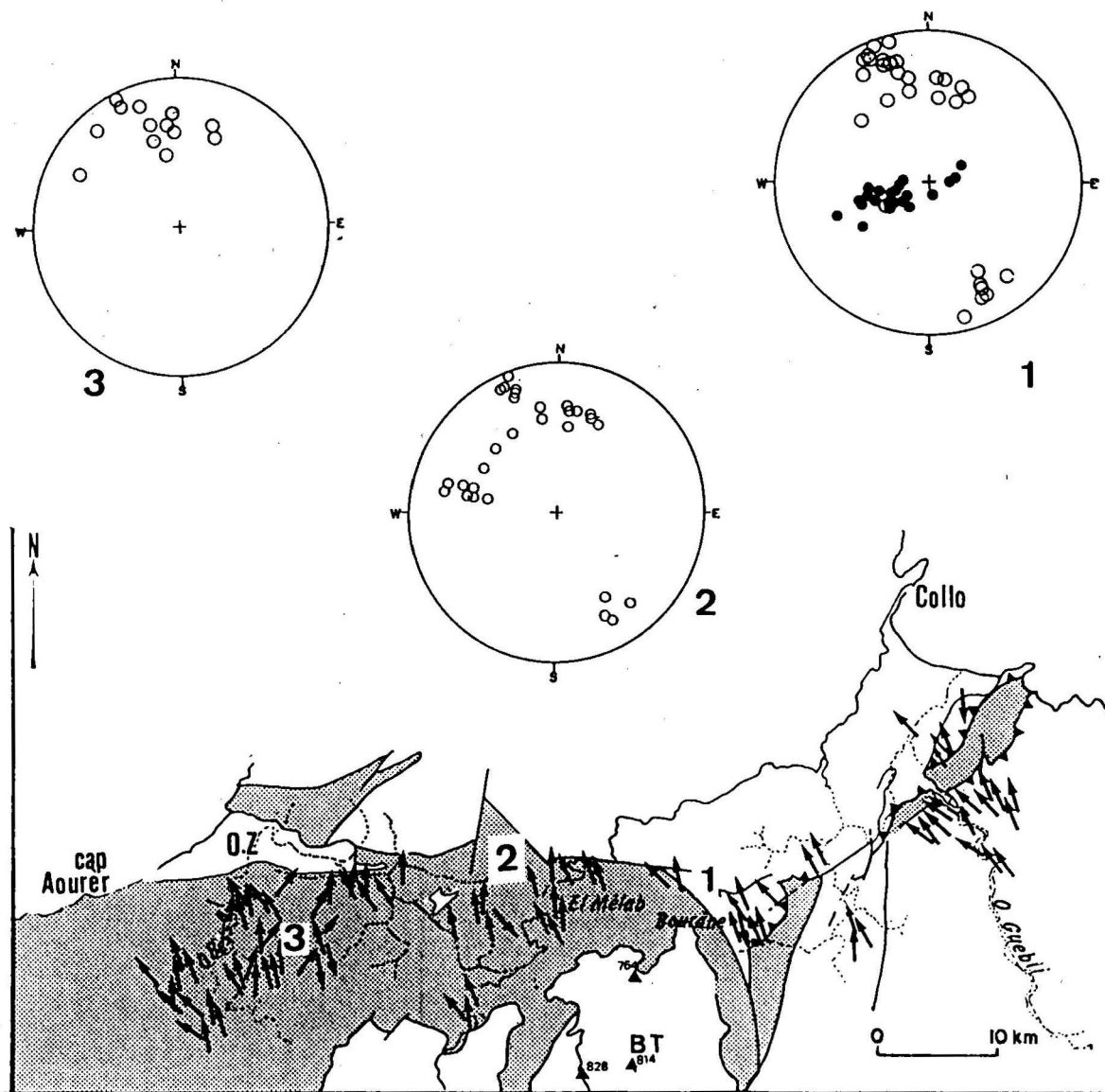


Fig. 5 - Map of stretching lineation in Beni Ferguene units and equal - area stereographic projection on to the lower hemisphere showing distributions of shear direction L and the normal N to the shearing plane (shear zone walls).

(Carte des linéations d'étirement dans les unités de l'édifice des Beni Ferguène et projection stéréographique des directions de cisaillement L et des pôles aux plans cisailants N).

1. Bourâne area (région de Bourâne); 2. Mela'b area (région Mela'b); 3. Oued Zhour area (région de Oued Zhour). L. white circle (cercle blanc); N. solid circle (cercle noir).

+ rutile + graphite - Kyanite substitute late kinematic andalusite porphyroblasts-; those from peraluminous hercynian granites and pegmatites, include biotite + grossularite - Pyrope rich garnet + Kyanite.

Detailed microprobe analysis and geothermobarometry (barometer, Newton, Haselton, 1981; GRAIL equilibrium Bohlen *et al.*, 1983; S_i^{+4} content of phengite, Massonne and Schreyer, 1987, and thermometer, Holdaway and Lee, 1977) give minimum pressure $P = 8\text{Kb}$ and $T = 550^\circ\text{C}$ (fig. 6a). The zonal arrangement of garnet inclusions and the progressive compositional changes of ferro-magnesian phases record part of prograde P, T path, before the «peak» of metamorphism at about $T = 600 - 650^\circ\text{C}$ and $P = 8 - 10\text{Kb}$. The

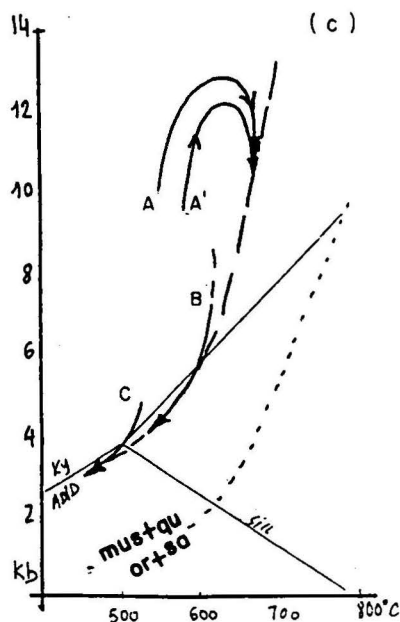
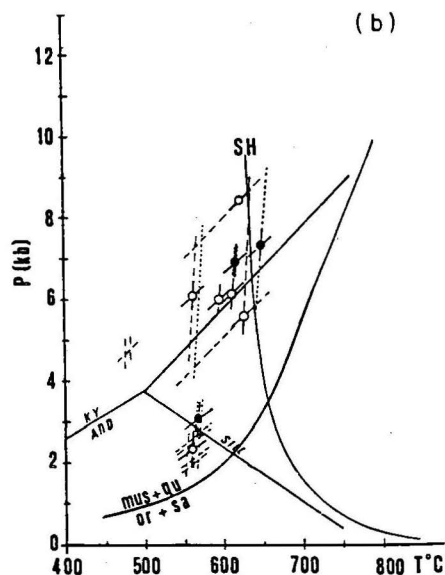
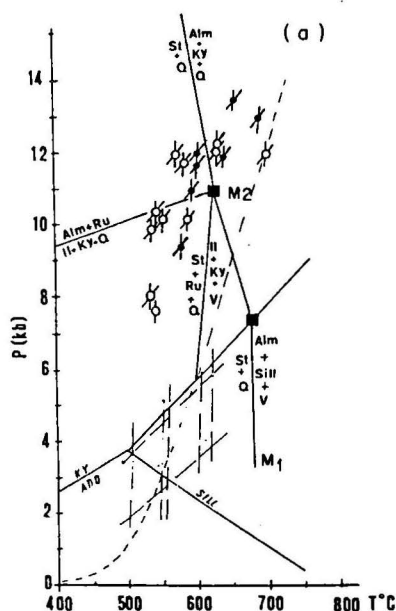


Fig. 6- Pressure-Temperature evolution of the Lower Beni Ferguene Units.

Phase relations in $\text{FeO-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O}$ system (Bohlen *et al.*, 1983).

(Thermobarometrie des granites orthogneissifiés et des métapelites montrant le recouvrement de leurs champs P, T (M2).

Équilibres dans le système $\text{FeO-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O}$ (Bohlen *et al.*, 1983).

a) $P-T$ conditions of metamorphism M1 and prograde evolution during early stage of metamorphism M2 (stade prograde du métamorphisme M2 - (M1) métamorphisme précoce de basse pression), b) = retrogressive evolution M2 (stade retrogressive du métamorphisme M2); c) P, T paths evolution during metamorphism M2 = early prograde evolution (A) in metapelites and (A') in late-hercynian granites (lower Beni-Ferguene units); (B) retrograde evolution (lower Beni Ferguene units) and (C) in bottom of upper basement units. Prograde evolution M2 within the stability field of kyanite ($P = 9-10\text{Kb}$) is followed by isothermal decompression before cooling. (cheminements P et T au cours du métamorphisme M2: (a) et (b) dans l'édifice inférieur des Beni Ferguène et (c) dans l'édifice supérieur (A) dans métapelites, (A') dans les granites tardi-hercyniens et (C) dans l'unité de base de l'édifice supérieur. L'évolution prograde M2 dans le champ du disthène ($P = 9-10\text{Kb}$) est suivie par une décompression quasi-isotherme précédant le refroidissement).

retrograde isothermal path ($T = 600^{\circ}\text{C}$ and $P = 4,5\text{Kb}$ at the top of lower unit) which records the uplift is represented by staurolite (St2) and sillimanite assemblages synchronous with distensive shear zones (fig. 6b).

Deformation D2 is also observed in the lower part of upper crystalline units. It corresponds to sharp ductile flat-lying shear zones (Mahdjoub, 1991), fig. 7a.

The later indicate east-west thrust zones that form a high angle with N-S direction of older late Hercynian structures. Southeast stretching lineation (fig. 7b) and shear indicators show South vergence on opposite sense of the northern shear of lower units.

Metamorphism M2 synchronous of shearing zones is characterised by KF, oligoclase, phengite and kyanite assemblage. P,T conditions are

approximately $P = 4,5\text{Kb}$ $T = 500^{\circ}\text{C}$ (fig. 6c).

II.2 Ductile deformation associated or not with low grade metamorphism.

Overlying basement nappe on infra-kabylian units has, on mapping basis traditionally been regarded as southward vergent (Bouillin, 1977), but without linking with the internal deformation.

New structural data (stretching lineation and kinematic maps) indicate two superposed alpine deformation events (D3) and (D4) responsible of

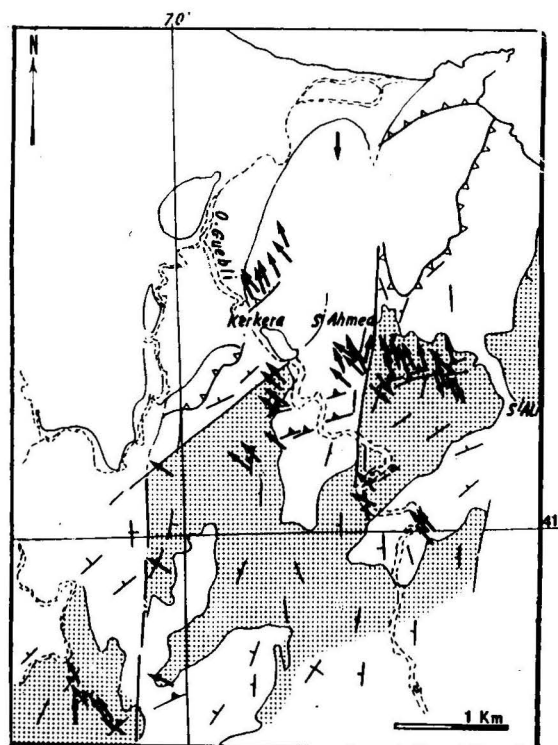
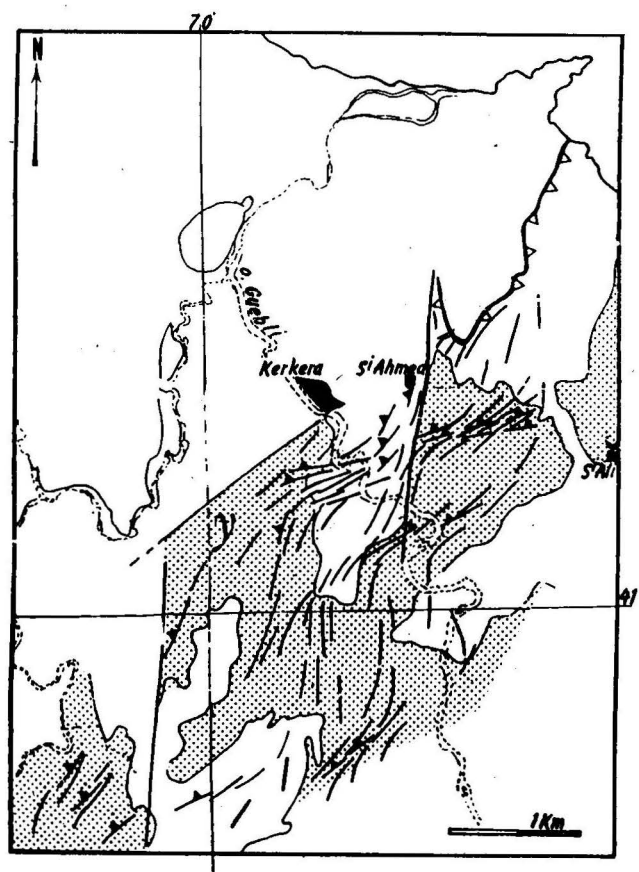


Fig. 7- Deformation (D2) in upper basement units, South of Collo: Heterogeneous deformation (D2) affect late-Hercynian granite.

(Déformation hétérogène (D2) affectant les granites tardi-hercyniens de Collo et leur encaissant dans les unités de socle ss, (édifice supérieur de Petite Kabylie).

a) Foliation trajectories (*Trajectoires des foliations "D2"*) and b) map of stretching lineation (*carte des linéations d'étirement*).

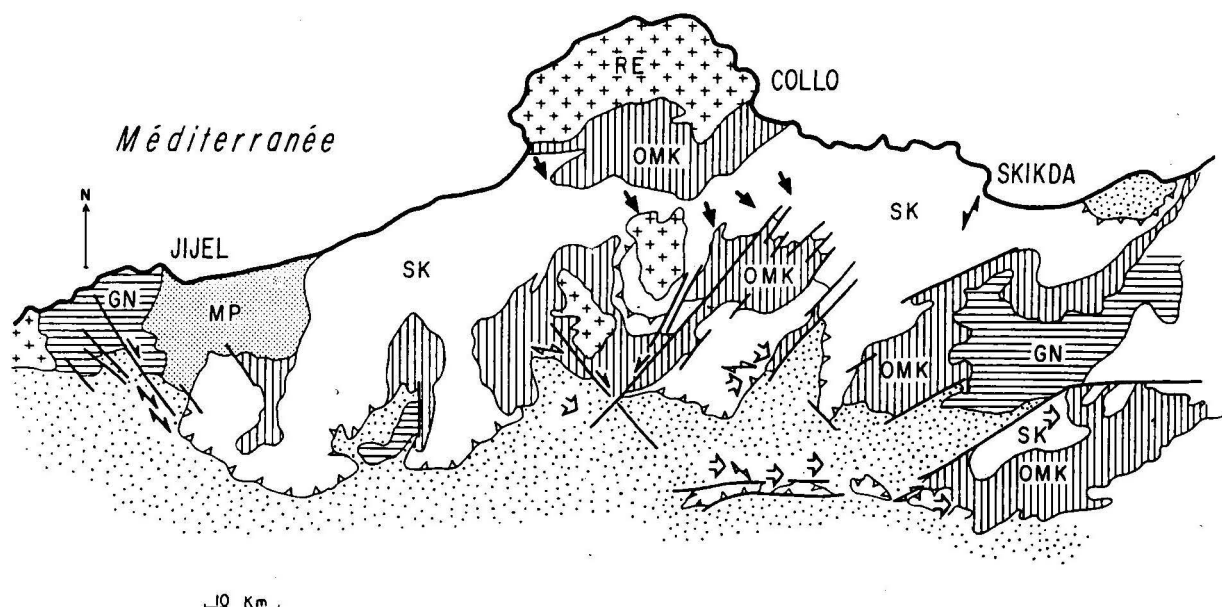


Fig. 8- Direction and shear senses during alpine deformation in Petite Kabylie Massif.
(Direction et sens de cisaillement des deux directions alpines successives en Petite Kabylie).

White arrows: Upper Eocene (*Flèches blanches: Eocène supérieur*); Black arrows: Lower Miocene (*Flèches noires: Miocène inférieur*). (a) thrusting (*chevauchement*), (b) wrenching (*décrochement*).

nappes emplacement (Mahdjoub and Merle, 1989, 1990), (fig.8).

II.2.1. Upper Eocene deformation (D3)

Corresponds to a thrusting with Eastward vergence, fig.8. It is recognized in basement units and Mesozoic to upper Eocene (Lutetian) sediments (Mauretanian, Massylian and Tellian units). It does not affect the Oligo-Miocene units (Kabylean Oligo-Miocene (OMK) and Numidian sandstone).

Low grade metamorphism (upper greenschist facies) synchronous with this event affects only sedimentary mauretanian unit and their base volcanogenic sediments underlying the basement unit (Texenna, Moul El Demamene and Beni Touffout areas). In contact of thrusting zone, high grade older granulitic rocks of Texenna area are retro-morphosed (overprint by sericite and chlorite-biotite assemblage).

In the basement pile, phyllite unit shows also flat shearing zones with Eastern vergence, competent orthogneisses exhibit local east-west dextral sharp strike-slip shear bands.

The southern boundary of internal zones (Sidi Driss area) dips steeply and indicates a major EW dextral strike-slip component. It is interpreted as the lateral ramp.

II.2.2. Lower Miocene age deformation (D4)

Is described as a NS compression responsible of a conjugate dextral and NE-SW sinistral transcurrent shear faults (fig. 8). The bulk deformation is accommodated by overthrusting from N toward S. The displacement is evaluated to about 15 Km (Bouillin, 1979) and corresponds to a minor component of total motion during nappe emplacement.

DISCUSSION - CONCLUSION

Our petrology and structural data suggest for Petite Kabylie two different major Variscan and alpine tectono-metamorphic histories.

As proposed for Grande Kabylie by Bossiere and Peucat (1985), the late hercynian history is characterized by syntectonic peraluminous granites and HT - LP syn to late kinematic metamorphism.

However, in Grande Kabylie, Bossiere and Peucat considered that granite intrusion is generated during the development of post-dated the HP-HT blastomylonitic metamorphism and predated the final stage of LP-HT.

Our observations emphasize that granite emplacement in Petite Kabylie is synchronous with LP M1 and does not post-date HP syn-blastomylonitic M2.

These results are constrained by:

1 - compatibility of strain field D1 and P,T path M1 both in granite and country rocks (fig. 4);

2 - abrupt change of pressure between metamorphic conditions M1 (synchronous with granite intrusion) and M2 (PM1 = 4-5 Kb and PM2 = 8 - 10 Kb), figure 6a. Consequently distinct P,T paths M1 and M2 indicate two superposed events and not a continuum of single evolution.

3 - P,T path obtained from metamorphic assemblage in granite in the same as that obtained from metapelitic country rocks (fig. 6). Prograde evolution M2 is recorded in late hercynian granite and is represented by M2 assemblage substituted to magmatic assemblage (Sill $\rightarrow$ Kyanite, Muscovite $\rightarrow$ Phengite + Kyanite; normal zoning of garnet G2).

4 - P,T conditions estimated at about P = 10 Kb

and T = 650°C (peak of metamorphism M2) are unlikely able to generate melt or granite emplacement at this low temperature and great depth. According to some authors (e.g. Whyllie, 1975 and Thompson and Algor, 1977), substantial amount of melting would not occur at HP and T = 650°C - the amount of fluid required to saturate the melt would be greater than at lower pressure (Huang and Wyllie, 1975; Le Breton and Thompson, 1988).

5 - Generation of melt during decompression requires higher temperature leading P,T path to intersect melting reactions and dehydration melting reactions. In our example, decreasing pressure at constant temperature indicates that conditions are not released and that generation of melt could not occur.

The fact that upper Eocene major alpine structure overprints grade event (M2-D2) suggest for this a post-Hercynian age and probably early alpine age.

In deed, Early alpine event of upper Cretaceous have been identified in the more external tellian domain (Babor and Zaccar massif, Maluski *et al.*, 1979) and in upper unit of Grande Kabylie and Algeria Massif (Monié *et al.*, 1985; 1987). The Rb-Sr ages (Peucat and Bossiere, 1983) and ^{39}Ar - ^{40}Ar ages (Monié *et al.*, 1985, 1987) about 81 Ma are obtained on biotite of Oued Ksari orthogneisses and paragneisses and marble. Muscovite indicate also ^{39}Ar - ^{40}Ar well definite plateau age.

However, both in Grande Kabylie and Petite Kabylie, muscovite Rb-Sr ages (176 to 67,7 Ma) show a great dispersion suggesting partial opening of system to lower temperature as blocking temperature of Rb-Sr system (T = 500°C), fig. 9. The main inconvenience to the eoalpine interpretation is high temperature 550°C < TM2 < 650 estimate for metamorphism M2 in lower Beni Ferguene unit.

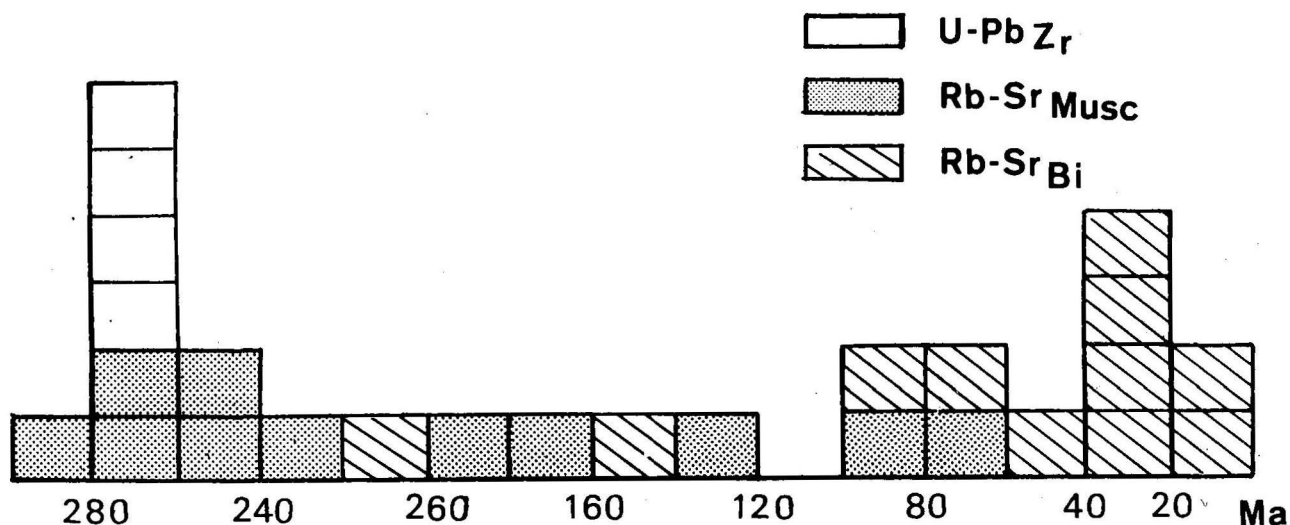


Fig. 9- Distribution of U-Pb zircon ages and Rb-Sr micas ages obtained from upper cristalline units and lower cristalline units (Petite Kabylie massif, North Algeria)

(Distribution des âges U-Pb sur zircon et Rb-Sr sur biotites et muscovites dans le massif de Petite Kabylie).

Dispersion ages are obtained on partial recrystallized coarse muscovite extracted from sample of pegmatites and orthogneisses in low strain domains (fig. 9). We suggest as Chopin and Maluski (1980) that the importance of pervasive deformation related fluid and P conditions may critically affect the diffusion of radiogenic isotopes. Thus, lack of strong penetrative deformation, limited amount of fluid and incomplet recrystallisation could have favored the preservation of older ages.

As the SABN in Grande Kabylie, Younger ages (20 to 25 Ma) are obtained on biotite (Rb-Sr method) in lower Beni Ferguene unit (fig. 9). The temperature of opening biotite Rb-Sr system is about $T=300^{\circ}\text{C}$ that we interpret these lower Miocene ages as those of Aquitanian southward overtrusting associated to low grade metamorphism in this area.

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