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Metamorphic zircons from North Cameroon; implications for the Pan-African evolution of Central Africa

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With 8 figures and 2 tables

Zusammenfassung

Eine kristallmorphologische Bearbeitung von Zirkonen aus Glimmerschiefern des Rôniers-Tals (Westlich von Poli, Nord-Kamerun) wurde mit Durchlicht- und mit Raster-Elektronen-Mikroskopie (Rückstrahl Elektronen) ausgeführt. Verbunden mit einer Bearbeitung des strukturgeologischen und metamorphen Rahmens führt sie zu der Vorstellung einer massiven Auskristallisation der Zirkone anläßlich eines tektono-metamorphen Ereignisses mittlerer Stärke in der Granat-Disthen Fazies. Dieses Ereigniss ist von einer Deformationsphase (D1) und der Platznahme eines basischen bis intermediären Gesteinsverbandes (BIP) begleitet worden. Eine U/Pb Datierung dieser Zirkone ergibt praktisch konkordante pan-afrikanische Alter (630 M.J.) Diese Resultate klären eine Ungewissheit in Bezug auf das Alter des stärksten metamorphen Schieferung, die hier als Resultat des Ereignisses D1 gedeutet wird. Je nach der geographischen Stellung innerhalb der zentral-afrikanischen mobilen Zone wurde bis jetzt das Alter dieser Schieferung als pan-afrikanisch oder als unter- bis mittelproterozoisch gegeben. Ein chronologischer Ablauf kann somit für die Entwicklung des nordkamerunischen Gebietes vorgeschlagen werden.

Abstract

Morphoscopic studies of zircons, including optical microscopic and SEM (backscattered electron mode), from the Rôniers valley (West-Poli, Northern Cameroon) indicate an important crystallization of zircon during a medium-grade garnet-kyanite metamorphic event. This was associated with a deformation (D1) and with the emplacement of a basic and intermediate plutonic suite (BIP). U-Pb dating of these zircon gave almost concordant Pan-African ages (630 Ma) which contribute to a solution of a major regional uncertainty about the age of the regional D1 event, which, in the mobile belt of Central Africa, has been considered previously either as Pan-African or as Lower to Middle Proterozoic. A chronological framework is proposed for the evolution of northern Cameroon.

Résumé

Une étude morphologique de zircons provenant des micaschistes de la vallée des Rôniers (ouest de Poli, Nord Cameroun) a été menée aussi bien en microscopie optique qu'en microscopie à balayage (électrons rétrodiffusés). Combinée à l'étude de l'environnement structural et métamorphique, elle conduit à l'idée d'une cristallisation massive du zircon pendant un événement tectono-métamorphique de degré moyen dans le faciès à grenat-disthène. Cet épisode s'accompagne d'une phase de déformation (D1) et de la mise en place d'une association basique à intermédiaire (BIP). Une datation U/Pb de ces zircons donne des âges panafricains (630 Ma) pratiquement concordants. Ces résultats permettent de lever une ambiguïté sur l'âge de la foliation métamorphique principale interprétée comme résultant de l'événement D1: elle est considérée selon les endroits de la zone mobile d'Afrique centrale soit d'âge panafricain soit d'âge protérozoïque inférieur à moyen. Une chronologie de l'évolution du domaine nord camerounais est proposée.

Краткое содержание

С помощью обычного светового и растового электронного микроскопа определили морфологию кристаллов циркона из слюдяного сланца долины Rôniers (западнее Поли, северный Камерун). Полученные данные, как и исследования структуры и метаморфизма цирконов разрешили составить себе представление о процессе их массивной выкристаллизации во время некого тектоно-метаморфного события средней силы, что соответствует гранато-дистеновой фации. Эти процессы сопровождались фазой деформации (D 1) и внедрением пород базического до среднего состава (BIP). Возраст этих цирконов, определенный с помощью метода урана-свинца, фактически совпадает с возрастом пан-африканского события (630 милл. лет). Эти данные устраняют неясности относительно возраста самого мощного метаморфного сланцевания, которое здесь рассматривают, как результате этого события D 1. В зависи-

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мости от географического положения в центрально-африканской подвижной зоне возраст этого сланцевания относят теперь к пан-африканскому событию, или к периоду от нижне до средне-протерозойского времени. Предлагается описание хронологической последовательности событий при развитии этой области северного Камеруна.

1. Introduction

U/Pb dating of zircons has proved its efficiency in the study of magmatic rocks where the ages usually obtained can be interpreted as emplacement ages. In metasedimentary rocks, the interpretation of the results are not always clear because of the complex modification of the zircons during subsequent metamorphic events. In best cases, the upper intercept on the concordia diagram gives the age of the detrital source (PEUCAT et al., 1985) and the lower intercept gives the age of an episodic lead loss which may correspond to a younger metamorphic event; such episodic loss was shown to be possible at 300 °C (GEBAUER & GRUNENFELDER, 1976). Other complications may occur such as overgrowth of young zircons on inherited cores, recrystallization of old zircons or crystallization of new zircons. Such processes seem to occur especially during anatexis and sometimes in the sillimanite zone (GRAUERT et al., 1974; GUPTA & JOHANNES, 1985; PEUCAT, 1986). However, in most cases, the relative volume of inherited grains is large enough to control isotope systematics, even when new grains crystallized.

In this paper, we present petrographical and isotopic data from micaschists of the Rôniers valley formation (West of Poli, North Cameroon) which support an important crystallization of zircon during a medium grade garnet-kyanite metamorphism and contribute to give the solution of a major regional uncertainty in the mobile belt of Central Africa, about structures which were previously considered either as Pan-African or as Lower to Middle Proterozoic.

2. Geological setting: the problem of Pan-Africain structures

Until recently, the Precambrian basement complex of North Cameroon, which is composed of medium to high-grade migmatitic gneisses, orthogneisses and syntectonic granites, was considered to be Archaean to Lower Proterozoic in age. During the Pan-African orogeny it underwent, together with its assumed Middle Proterozoic cover (the Poli schists), a thermal or tectono-thermal rejuvenation (BESSOLES & TROMPETTE, 1980; CAHEN et al., 1984). Discrepancies from this model appeared when Pan-African ages were found in migmatites of South Cameroon (LASSERRE & SOBA, 1979). Recently, the Poli schists and large orthogneiss units belonging to the «basement complex» (BESSOLES & LASSERRE, 1977) have been shown to be Upper Proterozoic in age (TOTEU et al., 1987).

The structural behaviour of the region (DUMONT et al., 1985; TOTEU, 1987; TOTEU et al., 1988) is characterized by the presence of two successive tectonic events (D1 and D2) observed both in the »basement complex« and in the Poli schists. D1 corresponds to an originally flat-lying foliation S1, locally preserved in this position and showing rotational structures; no conspicuous regional movement direction has been observed for D1 because of later tectonic and thermal events. D2 is characterized by upright folds associated with a vertical axial plane foliation (S2), intensively transposing the former surfaces. Its N-S to NE-SW regional trend also corresponds to the orientation of syn- to late-D2 batholiths. Late deformation is associated with polyphase wrench-faulting which may, in some cases, be interpreted as resulting from a late-D2 regime.

The main petrographic units (Fig. 1) as defined by TOTEU (1987) are: (1) medium to high-grade gneisses and micaschists (part of the »basement complex«); (2) low-grade schists (Poli schists); (1) and (2) show the two S1 and S2 foliations, present dominant greywacke compositions and contain interlayered tholeiitic to alkaline metavolcanics (metarhyolites yielding 830 Ma, U/Pb on zircons); (3) syn-D1 plutonic rocks including a basic to intermediate plutonic suite (BIP) dated at 630–620 Ma (U/Pb on zircons) and foliated granites both showing calcalcaline compositions and low $^{87}Sr/^{86}Sr$ initial ratios (0.7024 to 0.7063); (4) syn- to late-D2 intrusions such as anatectic granites (initial $^{87}Sr/^{86}Sr$ ratio 0.707 to 0.710) which derived from the melting of an immature protolih, and large batholiths of porphyritic granites, the age of which has been estimated between 600 and 580 Ma; (5) post-tectonic circular alkaline plutons (Godé granite: 546+/–9 Ma, whole rock Rb/Sr, Ri=0,70687).

In the Pan-African belt of Central Africa, D2 structures and their later developments corresponding to N-S to NE-SW trends are considered by many workers, particulary in Nigeria as the only products of the Pan-African tectonics (GRANT, 1978; ANNOR & FREETH, 1985; EKWUEME, 1987). Older structures and related metamorphic assemblages which may be compared to our D1 are interpreted by these authors as pre-Pan-African, or at least in Cameroon, older than the deposition of the Poli schists as suggested by NGAKO (1986). An alternative interpretation, ie. a Pan-African age for D1, was recently defended by TOTEU et al. (1986, 1987). It is based upon syn-D1 tectonic setting of the BIP suite, dated precisely between 630 and 620 Ma. Furthermore, although both schists and gneiss units often show tectonic contacts, D1 and D2 structures appear to be similar and correlatable. Such an interpretation implies that the »basement complex« of North Cameroon is composed partly of a young Upper Proterozoic crust. The new data presented here support this interpretation in dating precisely the D1 metamorphic assemblage.

3. The Rôniers valley micaschists

The micaschists from the Rôniers valley (Western Poli area), part of the previous »basement complex«, form small units of pelitic rocks intercalated within the orthogneisses (syn-D1 BIP suite). In contrast with the ubiquitous tectonic contact and metamorphic break occuring between schists and gneisses, they represent an apparent continuity in metamorphic grade between schists to the East and migmatitic gneisses to the West. Similarly, it must be stressed that the studied samples are from areas where syn-D2 migmatization is not developed.

3.1 Structural and metamorphic features

The most obvious structure in the field is the S2 foliation, but in thin sections, small domains exist where a relic S1, defined by elongated biotites and muscovites, has been preserved. Retromorphic shear zones (quartz-chlorite) of microscopic to macroscopic scale appear as late D2 deformation. The mineral assemblage includes quartz, muscovite, biotite, plagioclase (An 15–26), K-feldspar, almandine-rich garnet, kyanite, rare staurolite, rutile, tourmaline and zircon. Of these minerals, only kyanite, garnet, rutile and some of the muscovite may eventually represent, from microstructural evidence, the primary S1 metamorphic assemblage.

3.1.1 Kyanite

Kyanite is present in the micaschists as truncated and boudinaged crystals within the S2 foliation (Fig. 2). It always shows fracturing and undulose extinction. Many grains are pseudomorphosed by muscovite which may define the S2 foliation. These features suggest the pre-D2 character of kyanite and its resorption during this phase.

3.1.2 Garnet

Garnet appears as porphyroblasts wrapped around by S2. It contains inclusions of quartz, biotite, muscovite and sometimes rutile; chlorite may also be present. The more aboundant included mineral is quartz which defines straight or weakly curved internal fabrics (S_i). There is no continuity between S2 and S_i which are rarely parallel to each others, but, on the other hand, no clear relationship has been observed between S_i and relic domains of S1.

Rotational garnets similar to those described by SCHONEVELD (1977) were observed in the surrounding gneisses (TOTEU, 1987). They display strongly curved internal structures which incorporate quartz of pressure shadows. These features are indicative of a strong shear component during growth. The nature of included minerals (S_i defined by Qtz, Ep, Chl) supports a prograde growth of garnet. As no structure older than S1 has been found in these rocks, it may be assumed that S_i in the garnet is equivalent to the relic S1 of the matrix which was progressively incorporated in the mineral during of just after the D1 deformation for the gneisses and the micaschists respectively.

The discontinuity between S_i and the S2 of the matrix is the result of the transposition of S1 during the D2 phase. Most of the garnets are replaced by a biotite-plagioclase assemblage. Biotite flakes are, mostly, misorientated relative to S2 but some of them clearly underline S2 (Fig. 3). This suggests that the resorption of garnet began during D2 and continued after it.

This two-stage evolution of the garnet is confirmed by its chemistry. Data from three samples are presented here. Two of them (Go 77a and Go 77b) are from the upper-grade-zone, close to D2 migmatites (near Fignolé) while the other one (Go 76b) is closer to the contact with the Poli schists (near Garé in the Rôniers valley). Go 77a garnet is nearly euhedral and does not show any replacement along its edge, but it is completely enclosed in syn-D2 biotites (MgO/FeO = 0.43 to 0.48). It also contains in its core tiny inclusions of quartz. Inclusions of plagioclases (An 15 to 26) are present in some grains. A microprobe profile across the garnet (Fig. 4a) shows a classical trend: increase of FeO and MgO, decrease of CaO and MnO, but the most external plots show significant decrease in MgO and increase of MnO. This evolution is clearly seen on the figure 5a; a similar evolution is recorded on garnet Go 77b (Fig. 4b and 5b) which shows in addition an important corrosion by biotite. The first stage is related to a normal growth of garnet during metamorphism, the variation of ele-

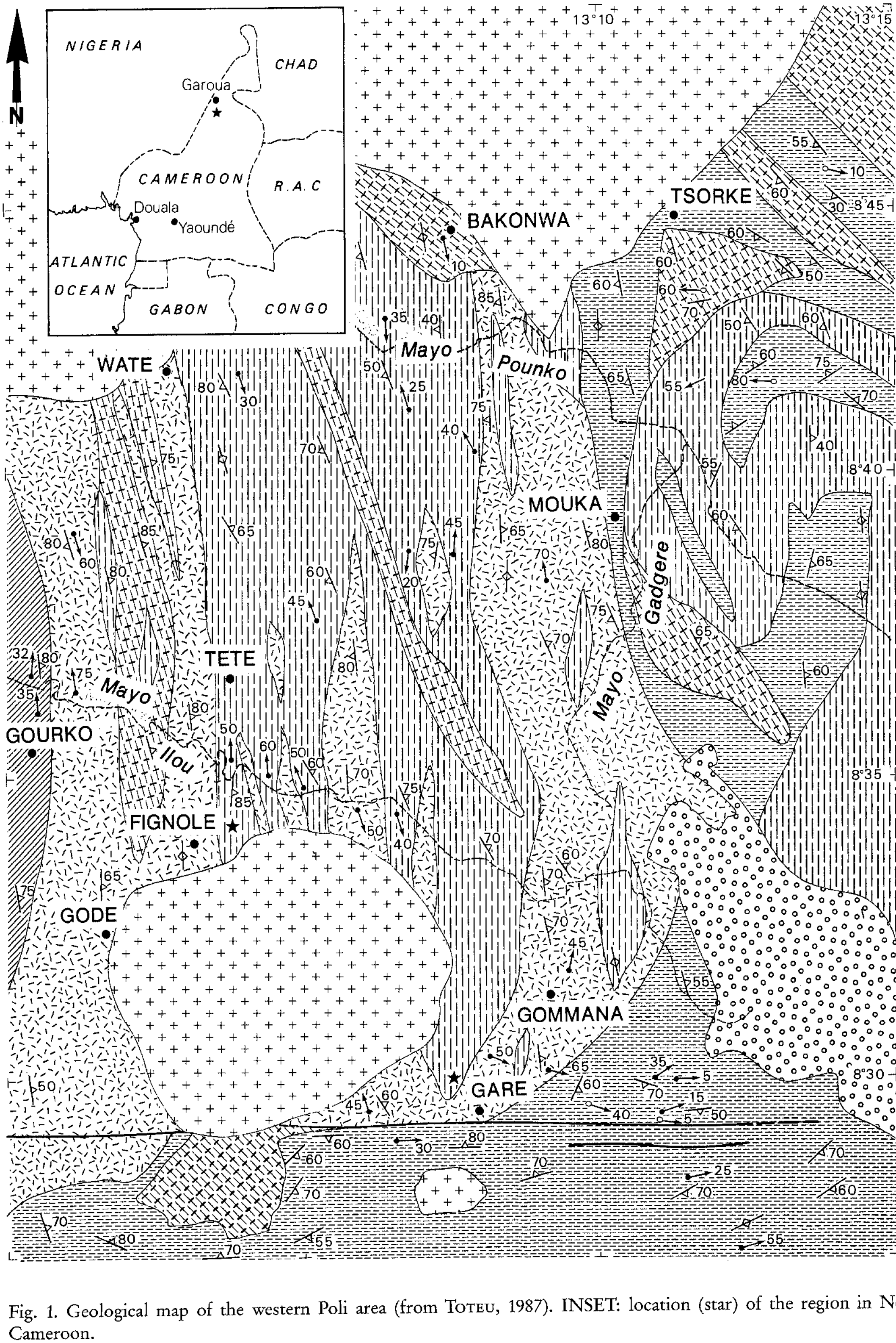


Fig. 1. Geological map of the western Poli area (from TOTEU, 1987). INSET: location (star) of the region in North Cameroon.

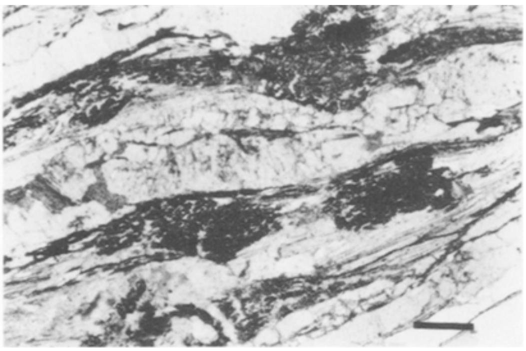


Fig. 2. Relic kyanite in the S2 foliation. Kyanite is boudinaged in the S2 foliation, shows undulose extinctions and is retrogressed into muscovite (scale bar = 0.5 mm).

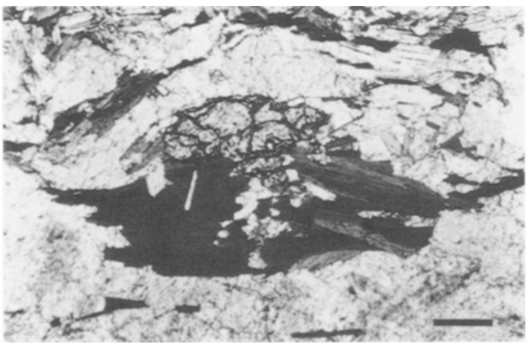


Fig. 3. Relic garnet in the S2 foliation. Syn-D2 biotite has replaced garnet.

ments being explained either by Raleigh fractionation (HOLLISTER, 1966), or more likely by growth during prograde metamorphism. The second stage is compatible with a change in the garnet chemistry during retrogression as shown by many authors (GRANT & WEIBLEN, 1971; BETHUNE & LADURON, 1975; PETRAKAKIS, 1986).

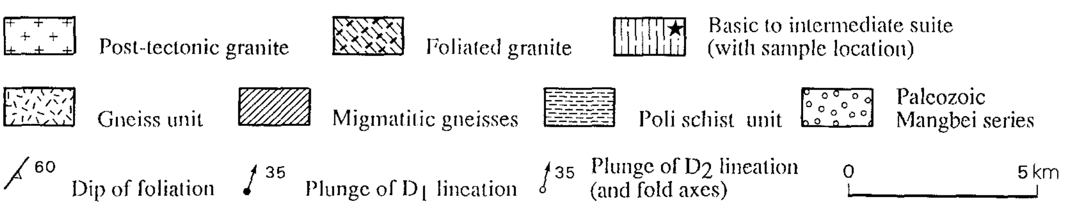
Go 76a garnet shows a large biotite rim with small relic garnet patches all around the central large grain. The profile across the central garnet is nearly similar to those from the other samples, but the small garnets show more variable compositions and the clear tendency towards low MgO/FeO and low CaO values is not observed; some data display similar high CaO and low MgO/FeO as the core of the central garnet (Fig. 6). Such a behaviour may be explained by the relative conditions of the D2 event: unlike the garnets from Fignolé situated closer to the migmatitic zones, the thermal conditions of the retrogression of Go 76a garnet were not high enough to permit maximum diffusion.

3.1.3 Zircon

Zircon was studied as separated grains using optical microscope and SEM (backscattered mode). Most grains appear as subhedral (Fig. 7a and 7b) and elongate (max. 150mm); A dark central zone observed under the microscope may resemble an inherited core but under SEM consists of relatively large inclusions of quartz, K-feldspar and rare biotite. Some grains (less than 20%) are rounded, xenomorphic and inclusion-poor. Many others clearly show a finely zoned and rounded core similar to those of magmatic zircons, surrounded by a light-colored rim tending to euhedral shapes and crowded with inclusions (20 to 40%). An outer limpid rim may also occur. The alternation of large light and dark coloured zones contrasts with the fine regular zoning observed in the magmatic-like cores (Fig. 7c, d and e). This suggests that the later growth occurred in solid state. In some cases, a light-coloured zone occupies the core itself (Fig. 7f) and inclusions may be central, patchy, or excentric and located in one sector of the grain.

These observations suggest that inherited cores, with apparently magmatic characteristics (fine regular zoning), rounded as clastic heavy minerals from sediments, may have been surrounded by a rim of metamorphic zircon and partly recrystallized. The control of the external shape of grains (euhedral or more rarely rounded or xenomorphic) is probably a result of interaction with the surrounding minerals. The cores do not exceed 1/3 of the whole.

The zircons are different in morphology and internal structure to other zircons from gneisses and orthogneisses analyzed in northern Cameroon. The latter may or may not have a thin recrystallized rim but they show a well individualized core with mag-



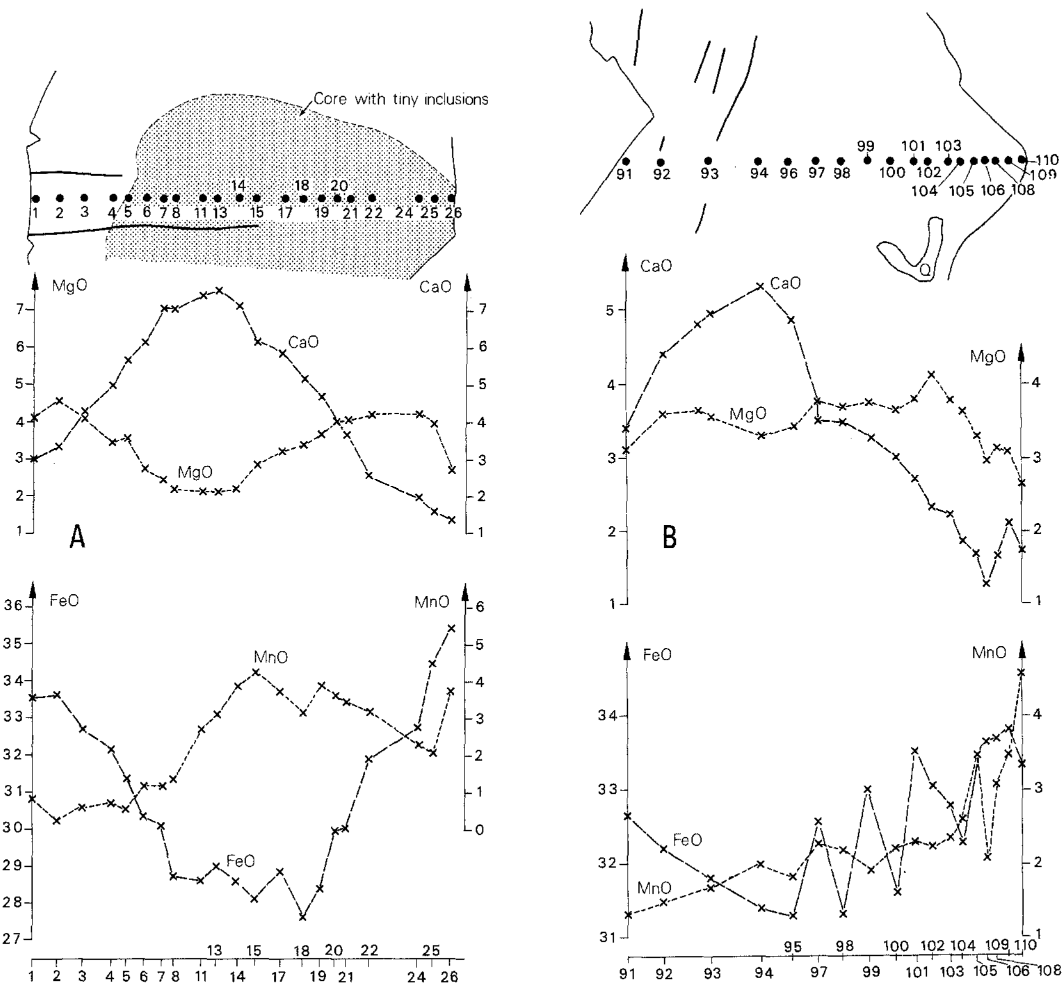


Fig. 4. Representative chemical zoning profiles across garnets (vertical scale, weight percent oxydes; profile width, 1.5 mm):
4a – Sample GO 77a
4b – Sample GO 77b

matic zoning and they usually contain apatite inclusions interpreted as high-temperature primary inclusions.

The observed features suggest that a large part of the zircon is of metamorphic origin or results from a metamorphic recrystallization of detrital grains. This implies an unusally large mobility of zirconium if compared with that in most geological environments and with its low solubility in melts. According to the geological setting of the micaschists which appear as enclaves of various sizes within orthogneisses (syn-D1 intrusives deformed during D2), a hydrothermal-like behaviour may explain the crystallization and recrystallization of zircon under P/T conditions very close to those prevailing during the BIP emplacement.

3.1.4 Metamorphic constraints

Thermometric calculations using the garnet-biotite pair (FERRY & SPEAR, 1978) were executed on samples Go 77 and Go 76 but the results cannot be used to estimate the D1 conditions because most of the biotite is related to D2. However, relic kyanite and rutile permit an estimate of the pressures of at least 6kb for a temperature close to that of the emplacement of the granodioritic body.

To conclude about the metamorphic history, a two-stage evolution is recorded both in the textures and the chemical zoning of garnet; the Rôniers valley micaschists reached their highest metamorphic conditions during D1 and the BIP emplacement and zircon may have grown at this time. As no petrographical, chemical or structural evidence

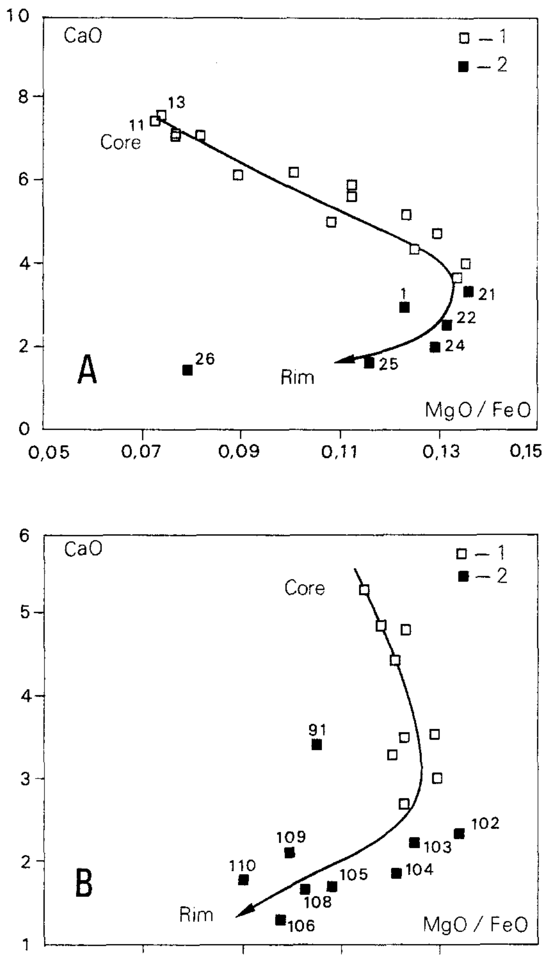


Fig. 5. CaO versus MgO/FeO diagrams from garnets:
5a – Sample GO 77a – (1) from the core; (2) from the rim.
5b – Sample GO 77b – (1) from the core; (2) from the rim.

supports a pre-D1 evolution, we thus conclude that zircon grew together with garnet and kyanite during the D1 event.

3.2 Analytical results

3.2.1 U/Pb dating of zircon

U/Pb dating of zircon was performed at the C.R.P.G. Nancy (analytical method previously described in Toteu et al., 1987). The results of four fractions (Table 1) show much lower ^{208*}Pb/^{206*}Pb (around 0.012) compared to zircons from the same area (Toteu et al., 1987) which yielded ratios more than ten times higher; the zircons are thorium-poor, whereas the micaschists show a normal U/Th ratio (0.34); thus the zircons do not have the same source as those from the metasedimentary gneisses, hence supporting a non-detrital origin for the zircon from the Rôniers valley. On a concordia diagram (Fig. 8), plots are almost concordant, confirming the predominant role of crystallization and recrystallization processes considering the low proportion of inherited grains (about 1/3). The plots define an age around 630+/–5 Ma.

3.2.2 Rb/Sr dating

Rb/Sr dating (Table 2) was performed both on biotite and on whole rock sample of Go 76 from which the zircons studied were obtained. The reference line using the whole rock and the biotite corresponds to an age of 518 Ma (Ri=0.70553).

3.2.3 Discussion of the results

The 630 Ma U/Pb age on zircon fits well with the ages found for the broadly syn-D1 BIP suite. It is thus interpreted as the age of the crystallization of zircons which corresponds to the age of the metamorphism associated with D1. In contrast, the 518 Ma Rb/Sr date is too young to be explained by the D2 event or by a late D2 cooling: an U/Pb sphene age of 571 +7/–8 Ma was already available on a metasedimentary migmatitic gneiss from Mayo Bandilé, West of Fignolé (Toteu et al., 1987); these gneisses are invaded in places by a swarm of large dykes associated with a syn to late-D2 anatectic granite. Thus it is reasonable to consider the 571 Ma as dating the end of D2 event. To explain the

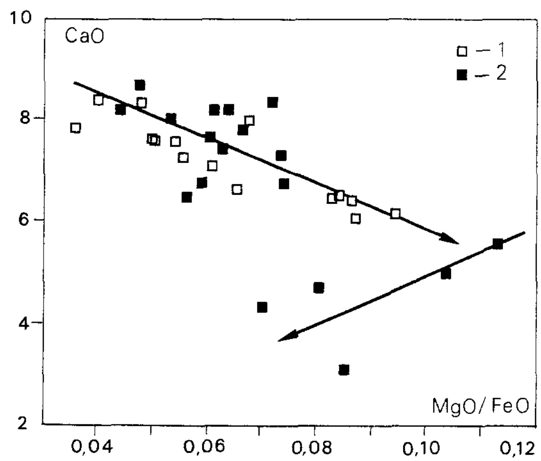


Fig. 6. CaO versus MgO/FeO diagram for sample GO 76b: (1) from the core of the main crystal; (2) from the rim of the main crystal and from small grains scattered in biotite.

Grain size	Pb ppm	U ppm	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{235}U$ (1)	$^{206}Pb/^{238}U$ (2)	$^{207}Pb/^{206}Pb$ (3)	Apparent (1)	ages (2)	Ma (3)
>45	39.8	437	1113	0.8225	0.09800	0.06043	609	607	619
>75	35.0	391	2100	0.8068	0.09673	0.06050	600	595	621
>75 (2)	35.3	387	4290	0.8282	0.09876	0.06081	613	607	633
>100	-	-	1056	0.8099	0.09687	0.06063	602	596	626

Table 1.: U-Pb Analytical results: Rôniers valley micaschists (Go 76) Only 10 grains of >100 fraction were analyzed.

	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
whole rock	62	213	0.840	0.711724(43)
biotite	137	43	9.270	0.773925(39)

Table 2: Rb-Sr analytical results: Rôniers valley micaschists (Go 76).

518 Ma age of the biotite, it must be stressed that the micaschists studied (together with surrounding orthogneisses) are very close to the post-tectonic Godé granite which yielded a Rb/Sr whole rock age of 546+/-9 Ma, Ri=0,70687 (Toteu et al., 1986). A previous isochron published for the same massif gave 516+/-6 Ma (Lasserre et al., 1981), very similar to the biotite age. Close to the granite intrusion, the micaschists are rich in unorientated post-D2 biotites growing around resorbed garnets. Thus, the age of biotites from these rocks may correspond to the cooling age of the granite and mark the very end of the Pan-African thermal activity in the region.

4. Discussion – conclusion

4.1 Metamorphic crystallization of zircon

Considering the problem of zircon stability, two opposite opinions can be found in literature:
- 1) Zircon can resist to high-grade metamorphism without appreciable change in shape and in isotopic composition. The change begins only under anatectic conditions (Peucat, 1986; Gastil et al., 1967). Our own experience on other North Cameroon zircons has shown that the development of euhedral shapes and of external rims is restricted to migmatitic and granulitic domains.
- 2) Zircon can recrystallize and change its isotopic composition at low temperature (300–400°C, Gebauer & Grunenfelder, 1976). This happens for highly radiation-damaged crystals under the conditions of a high fluid phase concentration. Zircon has also been synthetized under hydrothermal conditions (Caruba et al., 1975).

In the case of the Rôniers valley formation, petrographic and isotopic data support an important crystallization or recrystallization of zircons during medium-grade metamorphism of Pan-African age. This is an important new point because zircons described as metamorphic are uncommon (Speer, 1982). Indications supporting this metamorphic crystallization of zircon are as follows:
- 1) There is no isotipic trace of inheritance.
- 2) Two morphological types however coexist (rare rounded and common euhedral shapes) and intermediate shapes can occasionally be found. For the more common euhedral forms, the frequency of inclusions (some reaching the surface of the mineral), the embayements on the faces are more likely to be explained by solid state crystallation with incorporation of some neighbouring minerals than by crystallization in a silicate melt.
- 3) The minerals included (mainly quartz and less often feldspar) are different from those in high-temperature zircons which are commonly apatite. The inclusions are similar to those in garnet and are similarly arranged.
- 4) The presence of the (110) form corresponding to the G1 morphological type of Pupin (1980) would indicates temperature around 600°C if grown in a granitic melt.

Compared with all the examples of metamorphic imprint on zircons described by Peucat (1986), an interesting feature is the position of the plots on

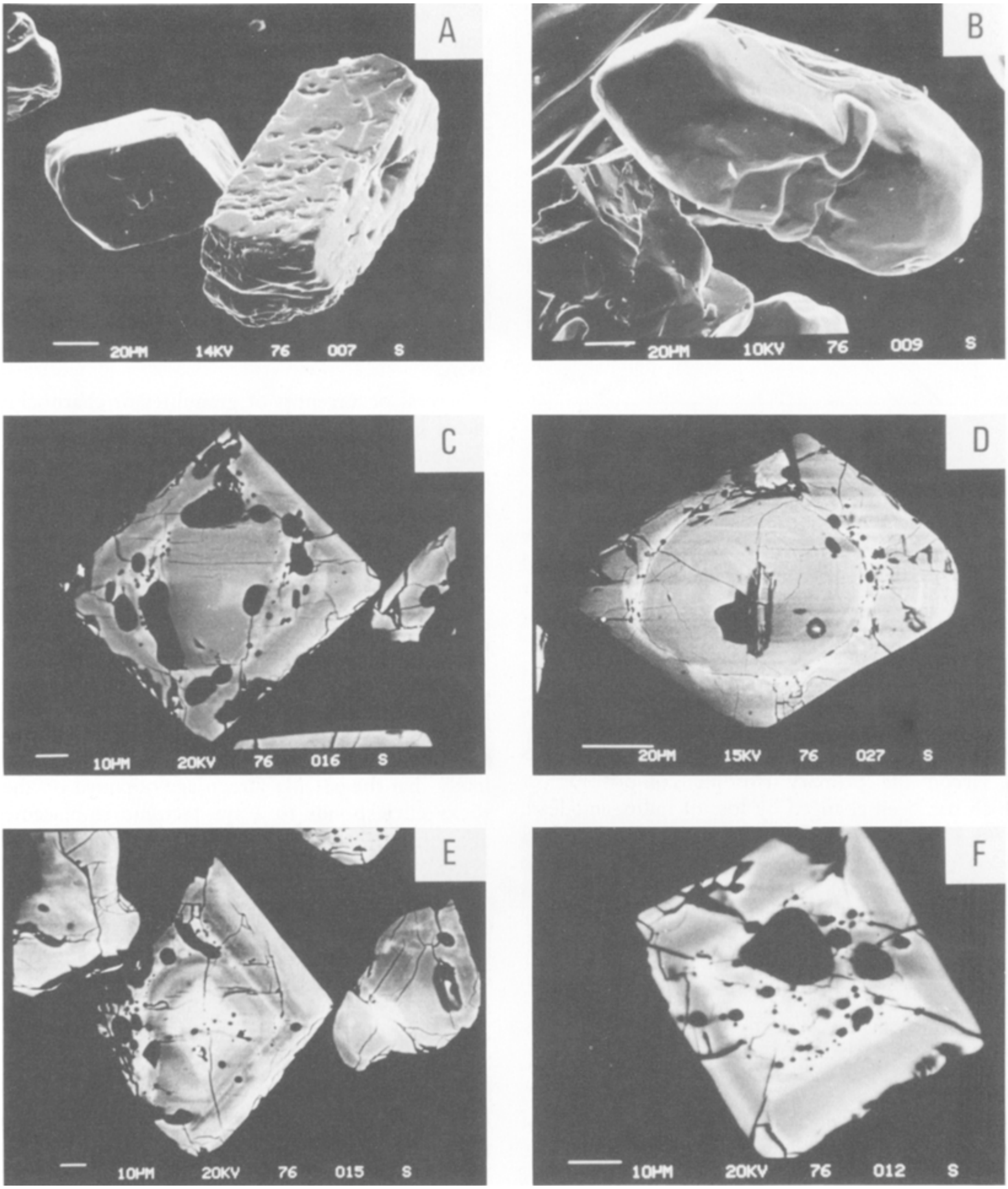


Fig. 7. Morphology of zircon from the micaschists (backscattered mode).
7a – subhedral prism crowded with inclusions, some reaching the faces of the crystal.
7b – subhedral (110) rounded grain showing embayement features due to neighbouring minerals,
7c – polished section showing an irregular core surrounded by a light-coloured rim crowded with large inclusions of quartz and K-feldspar. The outer rim is perfectly euhedral,
7d – the core is characterized by a fine regular zoning of magmatic type and the morphology of the crystal is subhedral,
7e – the inclusion-rich rim is excentric and the core is invaded by a light cloud suggesting late recrystallization,
7f – the prism is euhedral and there is no visible core but only an inner zone, crowded with inclusions and resembling the outer zone of fig. 7c.

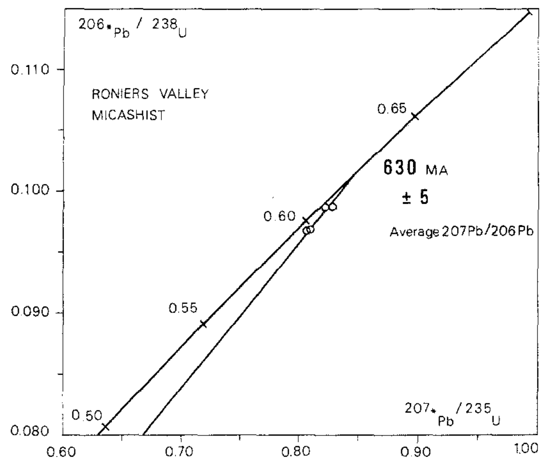


Fig. 8. Concordia diagramm for sample GO 76.

the concordia diagram: our data are concordant or slightly discordant in spite of some morphological evidence of inheritance; those studied by PEUCAT (1986) are systematically highly discordant and plot near the lower intercept.

All these characteristics could be easily explained by the inclusion of the micaschists in a large plutonic complex. The zoned central part of the crystal could correspond either to a recrystallized inherited zircon the primary isotopic composition of which has been changed by loss of radiogenic lead, or to a newly crystallized zircon, or to inherited zircon only slightly older. The nearly idiomorphic minerals or parts of minerals would correspond to the end of crystallization in conditions of water saturation during the crystallization of the BIP granitic melt.

4.2 Implications for the regional tectonics

The problems still under debate in North Cameroon deal with: (1) the age of the D1 event, and (2) the structural and petrographical characteristics of a possible pre-Poli-Schist basement.

Until now a Pan-African age of the D1 event was assumed from the ages obtained on the BIP suite (TOTEU et al., 1987). The present data from micaschists (included in the previous »basement complex«) demonstrate this Pan-African age both for D1 and for the related MP to HP metamorphism.

Recent studies in the Oban massif in SE Nigeria (EKWUEME & ONYEAGOCHA, 1986; EKWUEME, 1987) show many petrographical and metamorphic similarities with the Western Poli region. Available Rb-Sr whole rock ages on schists, gneisses and amphibolites range from 784 to 527 Ma (EKWUEME, 1987) and they are interpreted in term of reactivation (producing N-S to NE-SW structures) of Kibaran structures (NW-SE). Of particular interest is the 784+/−31 Ma age on amphibolite; such rocks are common in Northern Cameroon (TOTEU, 1987; PENAYE, 1988) where they are considered as chronologically equivalent to the Poli volcanic suite emplaced at 830 +11/−10 Ma (TOTEU et al., 1987). An alternative and preferred interpretation is that the 784+/−31 Ma age corresponds to the emplacement age of the protolith of amphibolites and that the assumed Kibaran structures are Pan-African and actually equivalent to D1 in Northern Cameroon.

Several occurrences of granulites or charnockitic rocks have been recorded in northern Cameroon (KOCH, 1957; NGAKO, 1986; PENAYE, 1988; NGANGOM, personnal communication). Granulitic remnants in the Eastern part of the Poli area (PENAYE, 1988) are considered as older than D1 and give 2100 Ma ages with a Pan-African imprint. They show similar evolution than those described in South Poli (NGAKO, 1986). They constitute the true old part of the so-called »basement complex«.

On the other hand charnockitic plutons quoted by KOCH (1957) are likely to be equivalent to Pan-african charnockitic rocks from SW Nigeria (TUBOSUN et al., 1984). From the descriptions given, it is likely that the 631 Ma zircon age obtained on these rocks corresponds to a syn-tectonic emplacement age, equivalent to our D1 event, prior to the N-S to NE-SW structures (equivalent to our D2).

Granulites are also known in South Cameroon (NZENTI, 1987; NZENTI et al., 1988) and represent the high-grade part of passive margin metasediments thrust onto the Congo Craton. From a two-stage deformation history only the late migmatitic event (local D2) is dated at ca. 570 Ma (LASSERRE & SOBA, 1979). But the 630 Ma age of the granulitic metamorphism in Centrafrican Republic (PIN & POIDEVIN, 1987) might be reasonably extended to all of the granulitic metamorphic events recorded elsewhere along the northern edge of the Congo craton, especially in South Cameroon. In contrast, recent data from North Cameroon point out to a Lower Proterozoic granulite-facies metamorphism (PENAYE, 1988). Similar epicontinental-type formations and N-S verging nappe tectonics were observed in both countries (POIDEVIN, 1983; NZENTI et al., 1987). This corresponding HP/HT event may be comparend in age to the D1 event in North Cameroon.

The new results obtained on the Rôniers valley micaschists, combined with already published data

(TOTEU et al., 1987) allow a well constrained model for the tectonic and magmatic activity associated with Pan-African orogeny in North Cameroon to be presented. The key dates are: (1) emplacement of volcanic rocks in the Poli Schists, ca 800 Ma; (2) D1 deformation event, MP to HP metamorphism and BIP suite emplacement, 630–620 Ma; (3) D2, anatexis and emplacement of granitoids, 600–580 Ma; (4) end of D2 metamorphism, 571 Ma; (5) emplacement of the post-tectonic alkaline Godé granite, 545 Ma; (6) cooling of the Godé granite, 518 Ma. It is reasonable to consider 620–630 Ma as the peak of metamorphism and emplacement of syncollisionnal granitoids rather than the time of initiation of D1. This history ended in North Cameroon around 520 Ma after a period of about 100 Ma of intense tectonic and thermal activity.

There is an impressive similarity in the age of the tectonic and magmatic activity in a large domain between the West African craton and the Congo craton (LIEGEOIS & BLACK, 1984; BERTRAND et al., 1986; TUBOSUN et al., 1984; VAN BREEMEN et al., 1977; PEGRAM et al., 1976; TOTEU et al., 1988), in spite of the fact that recent data support the presence of more than one pre-Pan-African block (COSSON et al., 1987, TOTEU et al., 1987, PENAYE, 1988). The high intensity of the Pan-African imprint in such a large domain, even where old rocks are recognized (BERTRAND et al., 1986, PENAYE, 1988) may indicate that the belt was formed by the collision of small continental blocks.

References

ANNOR, A. E. & FREETH, S. J. (1985) Thermo-tectonic evolution of the basement complex around Okene, Nigeria, with special reference to deformation mechanism. – Precambrian Res., **28**, 269–281.

BERTRAND, J. M., MICHARD, A., BOULLIER, A. M. & DAUTEL, D. (1986): Structure and U/Pb geochronology of the Central Hoggar (Algeria): A reappraisal of its Pan-African evolution. – Tectonics, **5**, 955–972.

BESSOLES, B. & LASSERRE, M. (1977): Le complexe de base du Cameroun. – Bull. Soc. Géol. Fr., **7**, 1085–1092.

– & TROMPETTE, R. (1980): Géologie de l'Afrique. La chaîne panafricaine »zone mobile d'Afrique centrale (partie sud) et zone mobile soudanaise«. – Mémoire B.R.G.M., **92**, 394 pp, Orléans.

BETHUNE, P. de, LADURON, D. & BOCQUET, J. (1975): Diffusion processes in resorbed garnets. – Contrib. Mineral. Petrol., **50**, 197–204.

CAHEN, L., SNELLING, N. J., DELHAL, J. & VAIL, J. R. (1984): The geochronology and evolution of Africa. – Clarendon press, 512 pp, Oxford.

CARUBA, R., BAUMER, A. & TURCO, G. (1975): Nouvelles synthèses hydrothermales du zircon; substitutions isomorphiques; relation morphologie-milieu de croissance. – Geochim. Cosmochim. Acta, **39**, 11–26.

COSSON, Y., ROCCI, G. & BOULLIER, A. M. (1987): Rock deformation at a Pan-African plate boundary outlined by ophiolites in Aïr (Niger). – Terra Cognita, **7**, abstract, 119.

DUMONT, J. F., TOTEU, S. F. & PENAYE, J. (1985): Ensembles structuraux et principales phases de déformation panafricaines dans la zone mobile du Nord Cameroun, région de Poli. – Rev. Sci. Tech., Sci. de la Terre, **1**, 9–23, Yaoundé.

EKWUEME, B. N. (1987): Structural orientations and Precambrian deformation episodes of Uwetarea Obam massif, SE Nigeria. – Precambrian Res., **34**, 269–289.

EKWUEME, B. N. & ONYEAGOCHA, A. C. (1986): Geochemistry of metasedimentary rocks of Uwet area, Obam massif, Southeastern Nigeria. – Geol. Rundschau, **75**, 411–420.

FERRY, J. P. & SPEAR, F. S. (1978): Experimental calibration of the partitioning of Fe and Mg between biotite and garnet. – Contrib. Mineral. Petrol., **66**, 113–117.

GASTIL, R. G., DE LISLE, M. & MORGAN J. R. (1967): Some effects of progressive metamorphism on zircons. – Geol. Soc. Amer. Bull., **78**, 879–906.

GEBAUER, D. & GRUNENFELDER, M. (1976): U-Pb zircon and Rb-Sr whole-rock dating of low-grate metasediments. Example: Montagne Noire (Southern France). – Contrib. Mineral. Petrol., **59**, 13–32.

GRANT, J. A. & WEIBLEN, P. W. (1971): Retrograde zoning in garnet near the second sillimanite isograd. – Amer. J. Sci., **270**, 281–296.

GRANT, N. K. (1978): Structural distinction between a metasedimentary and an underlying basement in the 600 m.y.-old Pan-African domain of northwest Nigeria, West Africa. – Geol. Soc. Amer. Bull., **89**, 50–58.

GRAUERT, B., HANNY, R. & SOPTRAJANOVA, G. (1974): Geochronology of a polymetamorphic and anatectic gneiss region: the Moldanubicum of the area Lamdeggendorf, Eastern Bavaria, Germany. – Contrib. Mineral. Petrol., **45**, 37–63.

GUPTA, L. N., & JOHANNES, W. (1985): Effect of metamorphism and partial melting of host rocks on zircons. – J. Metamorphic Geol., **3**, 311–323.

HOLLISTER, L. S. (1966): Garnet zoning: an interpretation based on the Raleigh fractionation model. – Science, **154**, 1647–1651.

KOCH, P. (1957): Contribution à l'étude géologique du socle de l'Afrique. Le Précambrien de la frontière occidentale du Cameroun central. – Bull. Dir. Mines et Géol. Cameroun, **3**, 302 pp, Yaoundé.

LASSERRE, M. & SOBA, D. (1979): Migmatisation d'âge panafricain au sein des formations camerounaises appartenant à la zone mobile d'Afrique centrale. – C. R. Somm. Soc. Géol. Fr., **2**, 64–68.

– TEMPIER, P. & SUIRE, J. (1981): Age (Rb/Sr) cambrien supérieur de quelques granites camerounais situés au sein de la zone mobile de l'Afrique centrale. – C. R. Acad. Sci., II, **292**, 903–908, Paris.

LIEGEOIS, J. P. & BLACK, R. (1984): Pétrographie et géochronologie Rb/Sr de la transition calco-alcalin alcalin fini-panafricaine dans l'Adrar des Iforas (Mali): accrétion crustale au Précambrien supérieur. – In: African Geology, Musée royal d'Afrique centrale, J. Klerkx & J. Michot édit., 115–146, Tervuren.

NGAKO, V. (1986): Evolution métamorphique et structurale de la bordure sud-ouest de la »Série de Poli«. (Segment carmerounais de la chaîne panafricaine). – Memoires et documents du C.A.E.S.S., **5**, 185 pp, Rennes.

NZENTI, J. P. (1987): Pétrogenèse des migmatites de Yaoundé (Cameroun). Eléments pour un modèle géodynamique de la chaîne panafricaine nord-équatoriale. – Thèse Univ. Nancy I, 147 pp, Nancy.

– BARBEY, P., MACAUDIERE, J. & SOBA, D. (1988): Origin and evolution of the high-grade Yaoundé gneisses (Cameroon). – Precambrian Res., **38**, 91–109.

PEGRAM, W. J., REGISTER, J. K., FULLAGAR, P. D., GHUMA, M. A. & ROGERS, J. J. W. (1976): Pan-African ages from a Tibesti massif batholith, southern Libya, – Earth and Planet. Sci. Lett., **30**, 123–128.

PENAYE, J. (1988): Pétrologie et structure des ensembles métamorphiques au Sud-Est de Poli (Nord Cameroun). Thèse Institut National Polytechnique de Lorraine, 196 pp, Nancy.

PETRAKAKIS, K. (1986): Metamorphism of high-grade gneiss from the Moldanubian zone, Austria, with particular reference to the garnets. – J. Metamorphic Geol., **4**, 323–344.

PEUCAT, J. J. (1986): Behaviour of Rb-Sr whole rock and U-Pb zircon systems during partial melting as shown in migmatitic gneisses from the St Malo massif, NE Brittany, France. – J. Geol. Soc. London, **143**, 875–885.

– TISSERANT, D., CABY, R. & CLAUER, N. (1985): Resistance of zircons to U-Pb resetting in a prograde metamorphic sequence of Caledonian age in East Greenland. – Can. J. Earth Sci., **22**, 330–338.

PIN, C. & POIDEVIN, J. L. (1987): U-Pb zircon evidence for Pan-African granulite facies metamorphism in Central African Republic. A new interpretation of the high-grade series of the Northern border of the Congo craton. – Precambrian Res., **36**, 303–312.

POIDEVIN, J. L. (1983): La tectonique panafricaine à la bordure nord du craton du congo: l'orogenèse des »Oubanguides«. – 12th Coll. African Geology, abstract, p. 75, Brussels.

PUPIN, J. P. (1980): Zircon and granite petrology. – Contrib. Mineral. Petrol., **73**, 207–220.

SCHONEVELD, C. (1977): A study of some typical inclusion patterns in strongly paracristalline-rotated garnets. – Tectonophysics, **39**, 453–472.

SPEER, J. A. (1982): Zircon. – In P. H. Ribbe (editor), Review in mineralogy, Ortho-silicates, second edition, Mineral. Soc. Amer., **5**, 67–112.

TOTEU, S. F. (1987): Chronologie des grands ensembles structuraux de la région de Poli. Accrétion crustale dans la chaîne panafricaine du Nord Cameroun. – Thèse de Doctorat d'Etat, Univ. de Nancy I, 197 pp, Nancy.

– MICHARD, A., MACAUDIERE, J., BERTRAND, J. M. & PENAYE, J. (1986): Données géochronologiques nouvelles (U/Pb et Rb/Sr) sur la zone mobile panafricaine du Nord-Cameroun. – C. R. Acad. Sci., II, **303**, 375–378, Paris.

– MICHARD, A., BERTRAND, J. M. & ROCCI, G. (1987): U/Pb dating of Precambrian rocks from the Northern Cameroon, orogenic evolution and chronology of the Pan-African belt of Central Africa. – Precambrian Res., **37**, 71–87.

– BERTRAND, J. M. PENAYE, J., MACAUDIERE, J., ANGOUA, S. & BARBEY, P. (1988): Cameroon, a tectonic keystone in the Pan-African network. – GAC Spec. Paper on Trans-Hudson Orogen, J. Lewry & Stauffer edit., Toronto (in press).

TUBOSUN, J. R., LANCELOT, J. R., RAHAMAN, M. A. & OCAN, O. (1984): Ages of two charnockitic granite associations from southwestern Nigeria. – Contrib. Mineral. Petrol., **88**, 188–195.

VAN BREEMEN, O., PIDGEON, R. T. & BOWDEN, P. (1977): Ages and isotopic studies of some Pan-African granites from North-central Nigeria. – Precambrian Res., **4**, 307–319.