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Contribution to the geochronology of the basement of the Central African Republic

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with isotopic analyses by

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Abstract-The age and isotope geology of the most striking geological elements of the basement in the south-central CAR have been investigated. The granite-greenstone belts of Bandas and Dekoa, as well as the amphibolitic complexes and associated gneisses of the Ouham and the Mbomou rivers, belong to the Archaean period. Granitic bodies intruding the post-Archaean Quartzito-schistose or "intermediate" series are of Lower Proterozoic Eburnean age. All former units have suffered on a limited scale from the Panafrican reactivation, as they belong to autochtonous areas constituting either a foreland or lateral ramps relatively to thrust belts developing during the latter period.

The granulitic areas of central CAR are of Panafrican age. They have, together with the associated gneisses, been tectonized during the same period of orogeny. The granulites result from the remobilization of a crustal segment of Lower Proterozoic or older age.

As a result of this tectonic complexity, it is no longer licit to put all the granulitic and gneissic series of the CAR in a single stratigraphic unit.

Résumé- L'âge et la géologie isotopique des principales unités géologiques du socle de la RCA ont été étudiées. Les ceintures de granites-et-roches vertes des Bandas et de Dekoa, de même que les Complexes amphibolitiques de l'Ouham et du Mbomou ainsi que les gneiss qui leur sont associés, sont d'âge archéen. Des massifs granitiques intrudant la série Quartzito-schisteuse post-archéenne ont donné des âges éburnéens; la série date donc du Protérozoïque inférieur.

Constituant un autochtone d'avant pays ou de rampe latérale, ces unités n'ont subi que sur une petite échelle les effets de la réactivation panafricaine. Les unités granulitiques de la partie centrale de la RCA sont d'âge panafricain. Elles ont, de même que les gneiss qui leur sont associés, été tectonisées pendant la même période. Ces granulites proviennent de la remobilisation d'un segment crustal d'âge Protérozoïque inférieur ou plus ancien.

Il résulte de cette complexité tectonique qu'il n'est actuellement plus admissible de rapporter à un seul ensemble stratigraphique les séries granulitiques et gneissiques de la RCA.

INTRODUCTION
GEOLOGICAL BACKGROUND

The basement of the CAR has been assigned to the Central African Mobile belt characterized by radiometric ages in the Panafrican range (Bessoles et Lasserre, 1979, Bessoles and Trompette, 1980). The internal zone of that belt has developed in Cameroon; the CAR is also affected as this zone runs in a ENE direction through the north-eastern part of the country (Cahen *et al.*, 1984). According to the same authors, most of the CAR belongs to the foreland of the belt. This view has been challenged recently by Poidevin (1985) who claims that the restructuration of the CAR during the Panafrican period has followed a much more complex pattern. Following this scheme, the country can be divided in three units according to their structural situation.

The southern part of the CAR belongs to the Congo craton and to the foreland of the Central African Mobile belt. Sedimentary sequences of Upper Proterozoic age deposited in this area are almost unmetamorphozed. Those situated farther on the craton are moreover unfolded. Others, presently found north of, or along the border region between Zaire and the CAR, in the Bakouma basin of central CAR, are gently folded. These series have been deposited on a basement of Archaean or Lower Proterozoic age where the following units can be distinguished (Fig. 1).

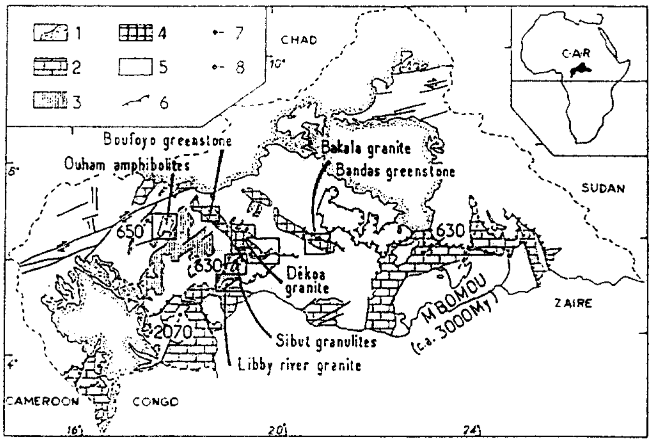

Fig. 1. Geological sketch map of the CAR showing the studied units. The framed areas refer to detailed maps. 1. Phanerozoic cover formations 2. Upper and Lower Proterozoic terrains in the Panafrican foreland 3-5. Lower Proterozoic, Archaean terrains plus thrusted high-grade units of Upper Proterozoic age : 3. Granulites, 4. Granites, 5. Undifferentiated metamorphic series, 6. Panafrican thrust faults, 7-8. Existing age measurements. 7. U/Pb zircon ages on granulites and granites (The Mbomou unit has been dated in Zaïre), 8. Rb/Sr ages on sediments.

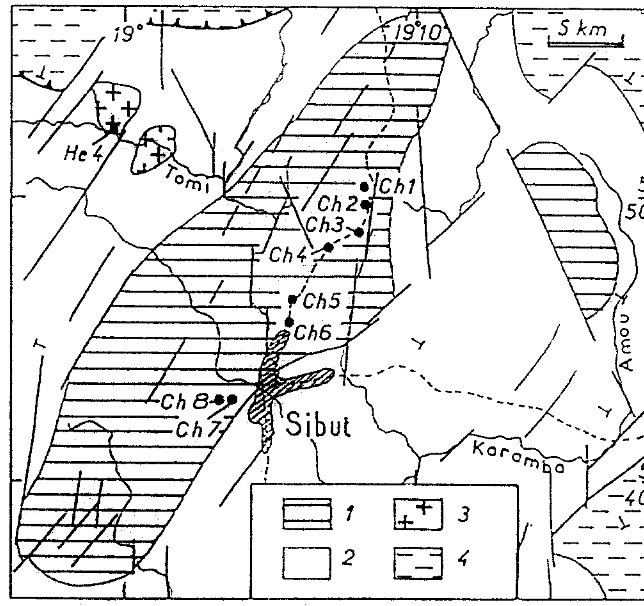

Fig. 2. Geological sketch map of the Sibut granulitic unit. The numbers refer to the location of the analyzed specimens. 1. Granulitic rocks, 2. Gneisses, 3. Granites, 4. Micaschists and quartzites

The Amphibolo-pyroxenic Complex of the Mbomou (Bomu) river is essentially made up of high grade metabasites comprising amphibolites, pyroxenites and amphibolo-pyroxenites, often garnet-bearing. A study of this complex, on the Zaïre side of the Mbomou river, concluded that these mafic gneisses have been metamorphozed 2.9 M.a ago (Lavreau, 1982).

The Gneissic and the Charnockitic Series constitute the greatest part of the lower division of the basement complex on the map of the CAR (Mestraud, 1964). They were shown to comprise several tectonic and sedimentary cycles, the stratigraphic position of which is not yet ascertained. Some members of the Charnockitic Series have been correlated with the granulitic Ntem craton of South Cameroon dated at 2.9 M.a (Lasserre and Soba, 1976), others have yielded Panafrican ages (see below and Pin and Poidevin, 1987). In Zaïre, the gneissic series associated with the Mbomou Complex are older than a 2.5 M.a old intrusive granite, others are older than 3.0 M.a (Lavreau, op. cit.). The correlation between these gneissic series with that of the CAR is, however, only tentative.

The greenstone belts associate komatiites, tholeiitic basalts, andesites, itabirites, greywackes and rhyo-dacitic tuffs. Locally they overlay a sialic basement. The associated granitoids form two bodies elongated in a NNW-SSE direction (the Dekoa and the Bandas belts) in north central CAR, and more isometric Bogoin massif situated NW of Bangui (Poidevin *et al.*, 1981, Cornaccia et Giorgi, 1986). A correlation with the Archaean Kibalian belts of Zaïre, originally based on the geodynamic setting and the general geochemistry, has subsequently been confirmed by geochronology (Lavreau *et al.*, 1979, see also below).

The *Quartzito-schistose Series* has been equated with the widespread "séries intermédiaires" of West-Central Africa, also largely represented in the central part of the CAR. The series comprises a lower unit of muscovite quartzites and muscovite-garnet schists with abundant intercalations of orthogneisses and orthoamphibolites. It is often migmatized or affected by granites. An upper unit is made of chlorite schists with quartzitic and volcano-sedimentary intercalations; it is only moderately affected by granodiorites. An Eburnean age, already presumed for these series, has recently been confirmed: they are indeed intruded by a *ca.* 2.1 M.a old granitic stock (Poidevin and Pin, 1986). The mono-cyclic nature of these series, however, is only assumed.

The axial, median part of the CAR corresponds to a very complex tectonic unit made of restructured Archaean and Lower Proterozoic elements comprising gneisses, migmatites, metasediments, metabasites and granites. The exact extent of the latter relative to the granulites and gneisses of Upper Proterozoic age with which the former has been associated as the result of thrust tectonics is not established. A structural model based on geophysical data (still under development) proposes that this part of the country is made of a superposition of thrust sheets comprising crustal segments belonging to the deepest zones of the Panafrican belt (Poidevin, 1985). The result is the juxtaposition of medium and high grade rocks of similar lithology but of contrasted ages. Most of the present study is devoted to this part of the CAR.

Little will be said about the poorly studied **northern and northeastern parts** of the CAR which are mainly composed of granites of Upper Proterozoic age. The region corresponds to the western extension of the Central African Mobile belt recognized in Cameroon (see above). This belt is limited on the south by extensive late Panafrican wrench faults, subsequently (after mid-Cretaceous times) reactivated as normal faults (Poidevin, 1985).

When compared with formerly published stratigraphical schemes (e.g. Mestraud, 1982, Poidevin, 1979), the present one questions correlations of stratigraphical levels defined on metamorphic or lithologic grounds only. As the discussions below will show, it is principally the mono-cyclic character of the Gneissic and the Granulitic Series of the geological map (Mestraud, 1964) which must be revised.

NEW DATA

The granulite rocks of Sibut

Granulite facies rocks occupy large surfaces of what is known as the Basement Complex of the CAR. Those examined in the present study belong to the Sibut massif (19°05"E, 5°45"N) which is rather small (15 x 50 km^2) when compared with the huge charnockitic massif of Central Oubangui (15,000 km^2) situated about 50 km to the northwest (Mestraud, 1964, Pouit, 1959) (Figs. 1 and 2). Important granulitic units exist in neighbouring countries or areas as the Ntem complex of Cameroon and the high grade Mbomou (Bomu) complex of CAR and Zaïre, both of Archaean age (Lasserre et Soba, 1976, Lavreau, op. cit.).

All the specimens studied belong to the charnockitic kindred (presence of hypersthene, granitoid composition). They, moreover, have in common a strongly developed blastomylonitic texture masking most of the original one. The following types can be distinguished :

a) originally coarse grained rocks, some probably porphyroid, of charnockitic (CH4, CH5), quartz mangeritic (CH6, CH7) and enderbitic (CHl) composition. Mylonitization and subsequent blastesis transformed them into gneisses with amygdales of feldspar mosaiks, xenoclasts of orthoclase, mesoperthites or plagioclase, quartz lenses and hypersthene replaced by biotite. Sample CH5 moreover shows garnet relicts.

b) originally medium grained rocks of mafic (hyperite, CH2) or intermediate (CH3) composition. The former has not been cataclased, the latter appears as a zono-lenticular gneiss with diopside (partly transformed into hornblende), hypersthene (partly transformed into biotite) and hornblende, also displaying a sheared quartz vein.

U/Pb results on zircon and Nd model age

Geochronological work has recently been undertaken on the granulitic rocks from western CAR including the Sibut unit (Pin and Poidevin, 1987): five zircon fractions have been extracted from Sibut sample CH7, an iron-rich charnockite. They are prismatic, clear and orange-coloured, i.e. one-cycle appearence. Although three fractions plot above the Concordia curve (what may be explained by U loss during the long leaching time), the $^{207}Pb/^{206}Pb$ ratios are quite coherent and the average date of 638 ± 3 M.a is therefore considered as the best estimate for the minimum age of the crystallization of these zircons. Moreover, the mutual position of the points indicates that no inherited older lead is present.

Sample CH7 has also given a Nd model ages of about 1600 (ref. Chur)-2000 (ref. Depleted Mantle) M.a, with an ε_{Nd} value of -8.6, 638 M.a ago, thus reflecting the minimum age and the composition of an old crustal source.

The granulitic bodies of Mpoko and Léré studied by the same authors have yielded U/Pb zircon ages and Nd model ages similar to those from Sibut.

Rb/Sr results

Two groups can be distinguished on the base of the Rb and Sr contents (Fig. 3) :

1. CH4 and 5 with high Rb and low Sr values, correspond to the specimens with a granitic composition,
2. CH1-3 and 6-7, constituting a continuous basic-acid suite with correlated Rb and Sr values.

No satisfactory regression line can be fitted to the entire data set (MSWD = 14.1). When two points (CH2 and 5) are excluded on geometric grounds, one obtains :

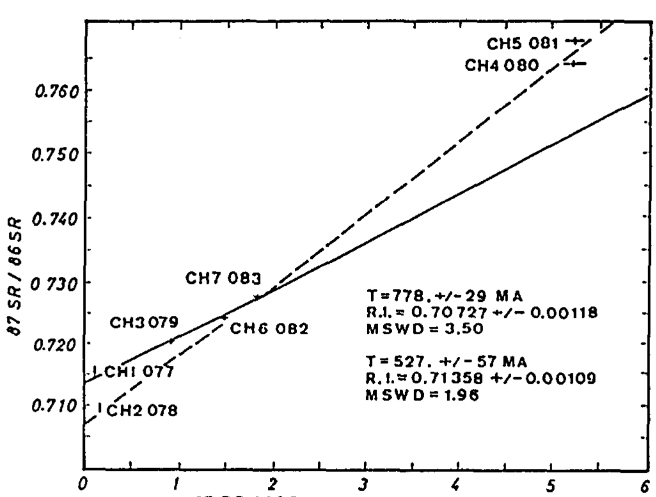

Fig. 3. $^{87}Rb/^{86}Sr$ versus $^{87}Sr/^{86}Sr$ diagram. The data points do not define a unique isochron. Two possible lines encompassing each four or five data points have been drawn, yielding only dates of indicative value in the Panafrican age range.

t = 673 ± 28 M.a (2 σ error, λ^{87}Rb : 1.42.10^{-11}.a^{-1}), (^{87}Sr/^{86}Sr)o or IR = 0.71116 ± 0.00069 (2 σ error), MSWD = 10.91

which is only slightly better. When the geochemically coherent group 2 is used (with the exception of CH2), an isochron is however defined (the errors have not been enhanced :

t = 527 ± 57 M.a, IR = 0.7136 ± 0.0011, MSWD = 1.96,

while the three excluded points can be grouped, giving :

t = 778 ± 29 M.a, IR = 0.7073 ± 0.0012, MSWD = 3.50

near to which CH6 and 7 plot as well.

No definite conclusion concerning ages can be drawn. Isochron 1 gives an age very close to the value given by the zircons. Isochron 2 may correspond to a disturbance of the system giving rise to an isotopic rehomogenisation (the position of points CH4 and 5 relatively to the average value of the system appears however abnormal in that case: such Rb-rich rocks are more likely to loose their ^{87}Sr* than the others). Isochron 3 may correspond to rocks less affected by this event.

However imprecise, the initial ratio is above mantle values at the relevant time. The data put forward therefore cannot correspond to the intrusions of mantle-derived material; they would represent either a tectono-thermal event affecting a not much older material or a remobilization of such a material: calculated at a date or 778 M.a (the highest Rb/Sr age, but similar values are obtained for a date of for instance 638 M.a, i.e. the age of the zircons), ε_{Sr} values are indeed in the range 28 to 145 (ref. Bulk Earth) or 55 to 172 (ref. Depleted Mantle) (Table I) and point at a crustal source.

The absence of a well-defined isochron can thus be attributed to perturbations affecting an intrusive complex of Upper Precambrian age, the age of emplacement and the strong deformation being both situated within an age bracket of about 150 M.a around 650 M.a.

Pb/Pb results

The isotopic composition of the specimens shows a limited range of values and a non-typical radiogenic character; it is low for granitoids, and rather high for high grade rocks : they are situated above the limit separating typical lower crust from typical upper crust values (Zartman and Doe 1981) (Fig. 4, table 2).

The 7 points define a rather imprecise isochron, the spread of points being small :

t = 3153 +165/-186 M.a, MSWD = 1.27 (λ^{235}U = 9.8485.10^{-10} a^{-1} and λ^{238}U = 1.5455.10^{-10} a^{-1}, individual errors at 0.1 %) (^{238}U/^{204}Pb)o or μ = 8.33 +2.69/-2.33 (for a two stages model).

Excluding points 4 and 5, on the same geochemical grounds as those given above, another isochron can be computed :

t = 2386 +548/-889 M.a, μ = 8.4 +5.1/-4.0, MSWD = 1.17.

If one disregards the wide error margins on the values of μ, all are in the mantle range and the dates may correspond to the age of a mantle/crust differentiation, hence to the age of the precursors of the granitoid series.

Discussion

The U/Pb results on zircons are conclusive, while the results yielded by the applications of the Rb/Sr methods on whole rocks are less instructive.

Nevertheless, the results show an internal coherency which can give some degree of confidence to the interpretation. The age nearest to the last magmatic event is most probably given by the U/Pb results from the zircons of sample CH7, while the age of the deformation (or deformations) is given by the Rb/Sr isochron(s). According to the Sr and Nd ε values at 638 M.a of the latter sample (and of most of the other of the same suite), the source of the magmas has been the continental crust, while the age of the source region can be inferred by the Nd model ages and the Pb/Pb isochron.

The granulitic rocks of Sibut thus appear to correspond to granitoid rocks mobilized in the continental crust in granulite facies conditions during the Late Proterozoic. The age of the source is older than 1600/2000 M.a and may be as old as 3.1 M.a. Subsequently, but during the same period of orogeny, they were subject to an intense

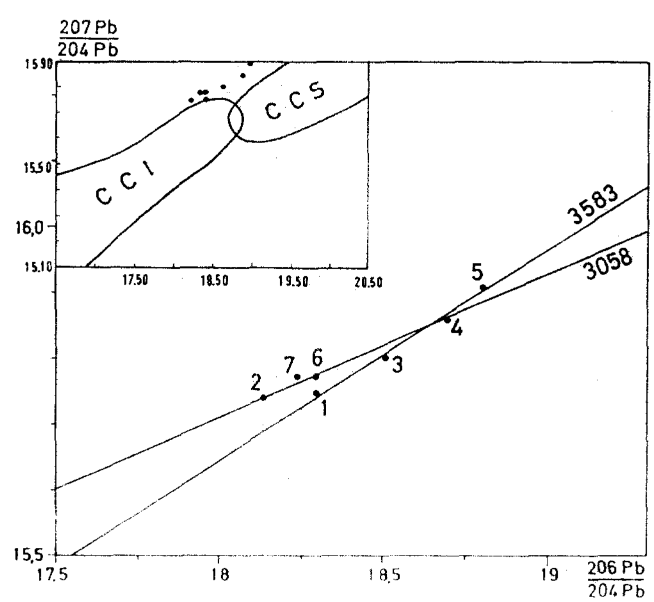

Fig. 4. ^{206}Pb/^{204}Pb versus ^{207}Pb/^{204}Pb diagram. Two possible isochrons are drawn, each passing through four data points, both yielding Archaean ages. The inset shows the position of the data points relatively to the lower (CCI) and the upper (CCS) continental crust fields of Zartman and Doe, and underlines the peculiar character of the analyzed suite.

Table 1. Analytical results and parameters (Rb and Sr).

MRAC RG n°	Rb	Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	t_{isoc}	ε_{be}	ε_{dm}	t_{mbe}	t_{mdm}
	DEKOA GRANITE and BOUFOYO AMPHOLITES								
134011 DE1	90.2	334	0.783	0.7337	2498	53	69	2863	2943
012 DE2	69.7	643	0.314	0.7138	2489	11	27	2738	2978
013 DE3A	112	312	1.042	0.7387	2498	-8	7	2457	2531
014 DE3B	107	415	0.747	0.7282	2498	-6	9	2452	2557
015 DE3C	231	406	1.656	0.7658	2498	62	77	2686	2727
057 BA40	213	82.1	7.703	0.9693	2498	-150	-135	2404	2414
071 BO7A	19.4	153	0.314	0.7147	*2498	24	33	2999	3205
075 BO10	17.5	126	0.402	0.7297	*2498	192	199	5340	5266
134016 DE4	168	48.4	10.308	0.9719	*2498	-1453	-1440	1817	1826
	OUHAM AMPHIBOLITES								
134042 OU1	3.7	72.7	0.147	0.70767	*2400	11	27	3260	3730
043 OU2	4.66	113	0.119	0.70615	2400	3	19	2868	3733
044 OU3	4.50	70.8	0.184	0.70778	2400	-5	10	2135	2771
045 OU6	5.71	496	0.033	0.70397	2400	15	30	1056	-5821
046 OU7	3.11	704	0.013	0.70323	2400	14	30	1462	-1349
046 OU7B	3.53	69.8	0.146	0.70802	2400	17	32	3701	4016
048 OU9A	17.9	663	0.078	0.70406	*2400	-6	10	6027	4123
134049 OU9B	14.23	632	0.065	0.70491	2400	12	28	-489	11871
	SIBUT GRANULITES								
134077 CH1	17.5	500	0.101	0.7153	* 778	145	172	20316	12582
078 CH2	25	421	0.172	0.7092	778	49	77	3544	3837
079 CH3	77.5	247	0.909	0.7203	* 778	91	118	1316	1448
080 CH4	168	93.8	5.212	0.7637	778	28	55	805	830
081 CH5	159	88.6	5.225	0.7672	778	76	103	850	875
082 CH6	113	225	1.456	0.7241	* 778	58	86	987	1076
134083 CH7	131	209	1.818	0.7277	* 778	52	80	926	998

Table 1 continued

MRAC RG n°	Rb	Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	t_{isoc}	ε_{be}	ε_{dm}	t_{mbe}	t_{mdm}
BAKALA GREENSTONES, GNEISSES AND GRANITOIDS									
134019 YPl	106	282	1.092	0.7543	*2831	118	130	3383	3422
020 YP3	138	246	1.632	0.7665	2831	-24	-12	2757	2796
021 DJ14	71.0	210	0.982	0.7453	*2831	54	66	3115	3169
022 DJ21	42.5	364	0.338	0.7157	*2831	8	21	2989	3178
023 DJ22	100	278	1.044	0.7439	2831	-3	10	2818	2879
024 DJ23	48.3	314	0.445	0.7179	2831	-23	-10	2526	2705
025 DJ24	53.4	372	0.416	0.7170	2831	-19	-6	2564	2754
026 DJ26A	79.6	199	1.162	0.7460	*2831	-42	-29	2647	2707
027 DJ26B	116	133	2.546	0.7940	*2831	-167	-154	2509	2538
028 DJ27	70.1	195	1.044	0.7407	*2831	-48	-35	2593	2662
029 DJ28	49.1	388	0.367	0.7153	2831	-14	-1	2595	2811
030 DJ34	27.3	227	0.348	0.7133	*2831	-32	-19	2257	2527
031 DJ37	25.0	214	0.338	0.7128	*2831	-33	-21	2206	2491
032 DJ45	9.0	327	0.440	0.717	*2831	-33	-20	2391	2585
038 HE10	15.3	198	0.223	0.7105	*2831	1	14	2879	3218
134068 BA55	30.5	365	0.242	0.7100	2831	-16	-4	2327	2734
LIBBY GRANITE									
134039 HE14	325	198	4.826	0.8694	*1806	590	611	2404	2420
050 SI5	585	794	2.143	0.7593	1806	15	35	1842	1887
050 SI15	428	778	1.599	0.7500	1806	84	104	2074	2130
052 SI17	34.9	496	0.204	0.7132	*1806	148	168	7605	6937
053 SI23	239	965	0.718	0.7225	1806	19	39	1949	2085
054 SI25	217	879	0.716	0.7249	1806	54	74	2217	2339
055 SI28	278	933	0.864	0.7303	1806	76	96	2274	2371
134034 HE3	257	365	2.057	0.7761	*1806	286	307	2503	2539

The concentrations are expressed in p.p.m. * : Data not included in the calculation of the isochron. t_{isoc} : isochron age from which the ε values are computed.
ε_{be} : ε value calculated relatively to the "bulk earth"; assumed present-day composition : $^{87}Rb/^{86}Sr = 0.86$, $^{87}Sr/^{86}Sr = 0.70477$.
ε_{dm} : same, calculated relatively to a ""depleted mantle"; assumed present-day composition: $^{87}Rb/^{86}Sr = 0.52$. $^{87}Sr/^{86}Sr = 0.70249$.
t_{mbe} : model age calculated relatively to a closed reservoir of "bulk earth" composition. t_{mdm} : same, relatively to a "depleted" mantle.
Error on $^{87}Rb/^{86}Sr$ estimated at 2.10^{-2} rel. Error on $^{87}Sr/^{86}Sr$ variable, usually better than 5.10^{-4} rel. (four digits results) or 5.10^{-4} rel. (five digits results).

Table 2. Analytical data (Pb/Pb)

MRAC RG n°	Pb	$^{206}Pb/^{204}$	$^{207}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$
134077 CHI	10	18.298	15.747	38.434
		3	1	5
078 CH2	5	18.133	15.739	38.716
		3	3	9
079 CH3	15	18.506	15.801	38.865
		2	1	5
080 CH4	51	18.690	15.871	40.283
		2	1	4
081 CHS	49	18.807	15.908	40.607
		3	2	5
080 CH6	23	18.296	15.782	38.568
		5	3	7
134083 CH7	21	18.234	15.774	38.150
		1	1	3

The concentration of Pb is expressed in p.p.m. The ratios are corrected for a 0.1 % A.M.U. fractionation. The errors (on the second line) are at the 2 σ level.

deformation which has resulted in a perturbation of the Rb/Sr system; this deformation may be related to the proposed thrust tectonics (Poidevin, 1985).

In the light of the present results, the correlation proposed until recently between the granulitic rocks of central CAR and those of the Ntem complex of Cameroon must be rejected. The granulites of southwestern CAR, which have not been examinated in recent studies, belong to the Congo craton; the formerly accepted correlation may fit them.

The field relations between granulites and gneisses remains to be ascertained. Small scale interpretations, as those based on the examination of the general map of the CAR (Mestraud, 1964) where the granite-greenstone belts seem to cut through presumably older granulites, must be taken with caution: the gneissic series involved do not constitute a single unit and the geometrical relationship can be an inheritance of tangential tectonics.

THE DEKOA GRANITE-GREENSTONE BELT

The Dekoa granite-greenstone belt covers 4,000 km² and constitutes one of the most important geological features of the CAR. Its granitoid members have been classified as "heterogeneous" because of the abundance of "xenoliths" of granulites, amphibolites, micaschists, quartzites, gneisses, itabirites and gabbro-dolerites (Mestraud, 1964) (Fig. 5).

They are most frequently represented by a sometimes porphyroid monzonitic granite. Granodiorites, tonalites and trondhjemites with idiomorphic plagioclase are also abundant

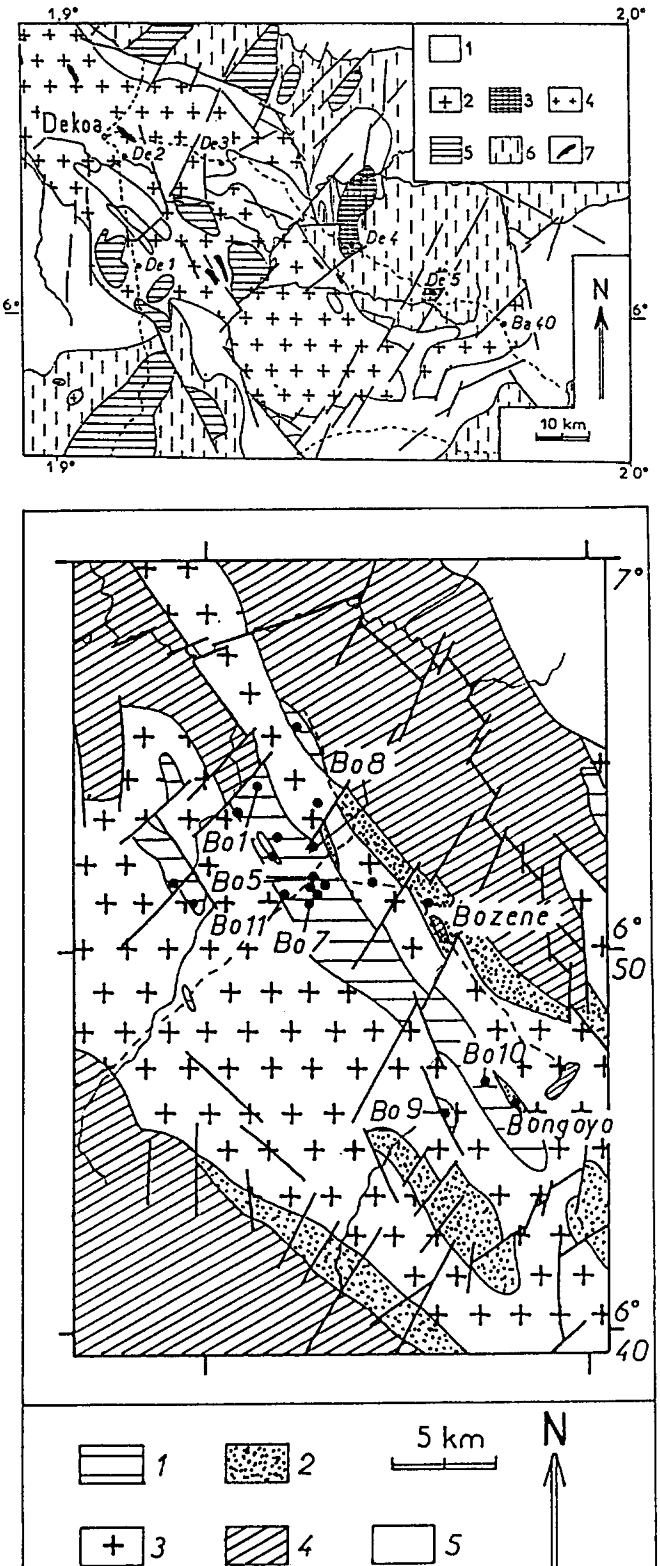

Fig. 5a and 5b. Geological sketch map of the Dekoa-Boufoyo granite-greenstone belt, with location of the analyzed, specimens. 5a. S. Eastern part of the belt (Dekoa region).
1. Micaschists and quartzites, 2. Dekoa granite,
3. Leucogranites, 4. Other granitoids (Mbi type, see text),
5. Granulite facies gneisses, 6. Gneisses and migmatites,
7. Greenstone remnants, itabirites.
Fig. 5b. S. Western part of the belt (Boufoyo region).
1. Metavolcanites (Boufoyo greenstone), 2. Itabirites, 3. Dekoa granite, 4. Gneisses, 5. Micaschists and quartzites.

(Fig. 5a). When observed in the same outcrop, the trondhjemites are older than the tonalites. More mafic facies represented by quartz diorites and gabbros have heen interpreted as differentiated accumulations. Leucocratic, fine-grained, sometimes garnet-bearing, quartz-plagioclase-muscovite-bearing facies have also been described (Pouit, 1959). Two-pyroxene, sometimes garnet-bearing (pyrigarnites), gabbros and dolerites have been observed cutting through some of the granitoids. They may in some instances have been mistaken for xenoliths.

The relationship between granitoids and "xenoliths" is quite variable. Greenstone remnants are restricted to the northern part of the massif as for instance near Boufoyo (Fig. 5b) (see below). They appear as multi-kilometric or metric inliers within the granitoids and show distinct signs of contact metamorphism. They are represented by pillowed metabasalts (with OFB affinity), by metabasites (with CA affinity) and by chlorite-actinolite schists probably derived from basaltic komatiites and pyroxenites. Some gneisses and granulites, which in some instances have been considered as roof-pendants, are also found. The relationship with the quartzites and the micaschists is more ambiguous. Most of them seem to belong to an eroded cover, but in other cases they consitute real xenoliths. The correlation of the latter with the Quartzito-schistose Series, however, is not demonstrated. According to the scheme of Poidevin (1985), they probably correspond to non-eroded nappe remnants.

The analyzed suite comprises granites (as BA40), granodiorites (as DE1), tonalites (as DE2, DE3a and b). They are biotite-bearing granitoids, of different grain size and degree of homogeneity. Quartz is not abundant in BA40 and DE1, and moreover cataclastic in the latter.

The mafic facies are represented by hornblende gabbros, massive (BO10) or schistose (BO7a) and talc-chlorite-actinolite rocks (not analyzed).

Taking into account this large variety of petrographic and geochemical types, the analyzed specimens may not represent a really cogenetic suite.

The leucocratic, muscovite-bearing, DE4 granite belongs to a distinct intrusion.

Rb-Sr results

The Rb and Sr content is highly variable, a result already anticipated from the lithological variety of the specimens. No *a priori* classification has thus been performed. A reference line of reasonably good fit is obtained with the six granitoids yielding the age (Fig. 6) :

$t = 2498 \pm 81$ M.a, IR = 0.7027 ± 0.0100, MSWD = 9.84

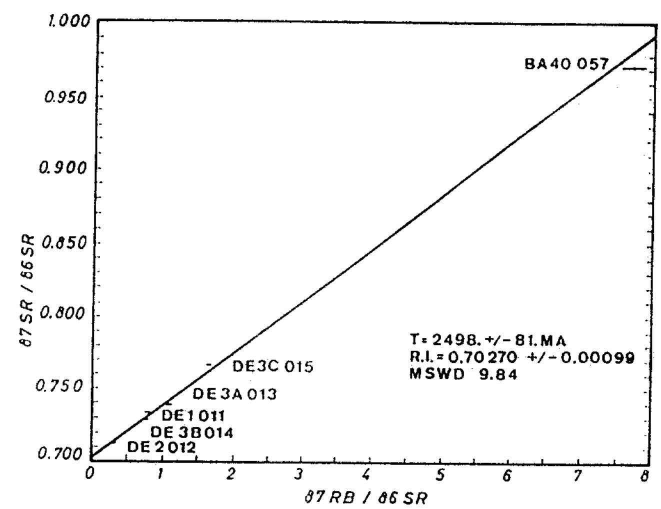

Fig. 6. $^{87}Rb/^{86}Sr$ versus $^{87}Sr/^{86}Sr$ diagram defined by granitoids. A rather poor isochron encompasses the 6 data points. The low MSWD value suggest that the analyzed specimens do not belong to a cogenetic suite. A metabasite from Boufoyo (B07a) plots just above DE2 (see Table 1).

which could be improved by excluding one or other of the specimens. This procedure has not been applied because of the lack of geological criteria. The most radiogenic sample (BA40) and thus the most likely to loose $^{87}Sr^{*}$ plots, not unexpectedly, below the line.

One of the analyzed hornblende gabbros (BO7a) plots near to the same line. This might be of little significance as the granitoids have been collected at the other extremity of the belt.

The age of 2498 M.a must be taken with some caution. As it can be seen from Table 1, the model ages of the samples defining the isochron constitute two groups : one with ages around 2.8 M.a, the other around 2.5. The possibility that the isochron has been built up with two groups of non-cogenetic granitoids can therefore not be excluded. The *ca.* 3 M.a model age yielded by the mentioned greenstone sample may be significant in the same respect.

Leucogranite DE4 falls away from the reference line. According to its model age (Table 1), it bears no relationship with the Dekoa granite-greenstone belt.

Discussion

The data obtained so far point at an Archaean age for the intrusion of the granitoid and mafic rocks associated in the Dekoa granite-greenstone belt. The IR is in the mantel range at the relevant time, the data itself may thus correspond to the crystallization of mantle-derived granites at a period situated close to the limit between the Archaean and the Lower Proterozoic.

The dispersion of the points (high errors and MSWD) results probably both from the heterogeneity of the analyzed suite and from subsequent perturbations of the isotopic systems.

The chronological homogenity of the Dekoa granitic belt can thus be questioned. The northern part, where greenstone inclusions are frequent, can be compared with the (2.8 M.a old) granitoids of the Bandas belt (see below) where such rocks are also abundant. The southern part, where the association with the quartzitic and schistose rocks is intimate, may belong to a complex magmatic association, comprising elements of both 2.8 and 2.5 M.a.

Nevertheless, the age of the Dekoa granite-greenstone belt fits in the scheme known from other belts in the CAR (see below and Lavreau *et al.*, 1979) and Zaïre (Lavreau, 1982) with two generations of granitoid rocks, often associated in polymagmatic complexes comprising *ca.* 2.5 M.a and ca. 2.8 M.a old granitoids.

THE BANDAS GRANITE-GREENSTONE BELT

The proper geodynamic significance of this rock association has been recognized during the last decade (Poidevin, 1977, 1979, Poidevin, *et al.*, 1981). The greenstones comprise a basal unit with komatiites (very rare), andesites (rather rare), basalts (frequent) and gabbros (infrequent) plus some volcano-sedimentary tuffs and itabirites. It is overlain by greywackes and rhyodacitic pyroclastites. Gneisses have also been encountered; they have been interpreted as basement inliers (Fig. 7).

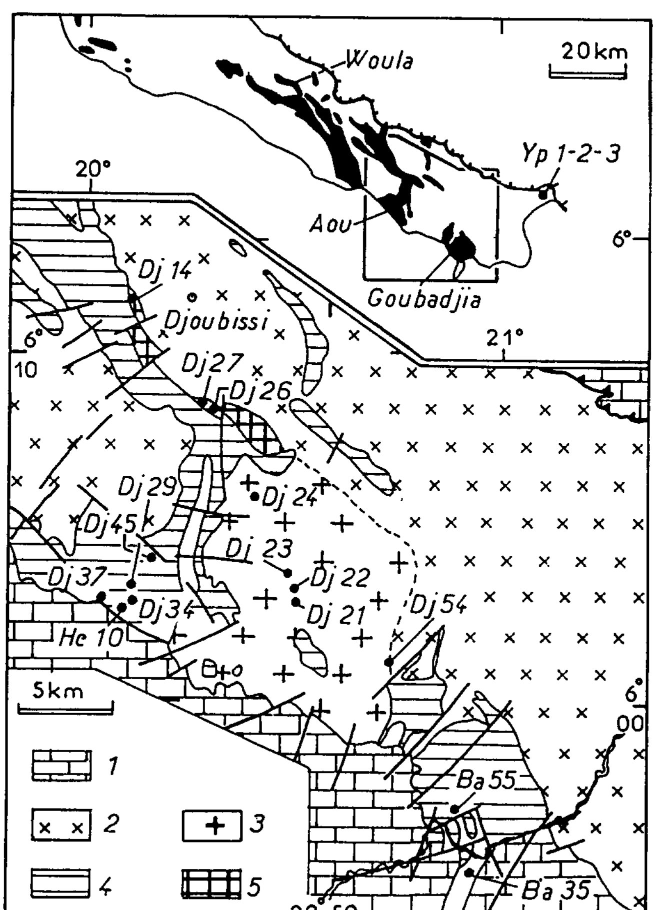

Fig. 7. Geological sketch map of the S. Eastern part of the Bandas granite greenstones belt. 1. Post-greenstone micaschists and quartzites, 2. Bakala foliated granitoids, 3. Djoubissi non-foliated granitoids, 4. Bandas greenstones : metavolcanites, itabirites, 5. Basement gneisses

In the studied region, two types of granitoids are found: a well foliated muscovite and biotite granite on the one hand, and massive granodiorites and tonalites on the other hand. A continuous transition between the two types has been suggested (Foglierini and Mestraud, 1958).

RB-SR RESULTS

The granitoids

Most data pertinent to the granitoids of this belt have been published formerly (Lavreau *et al.*, 1979). It was concluded that mantle-derived tonalites and granodiorites (IR = 0.7002 ± 0.0006, a value rather too low) were intruded *ca* 2.8 M.a ago, into an association of metabasites and itabirites (Fig. 8). The dated specimens came from the main belt and from satellite plutons also emplaced into greenstones. Some foliated granitoids were not included in the calculation of the isochron but they plot very near to it. The belt has thus undergone some disturbance. Note that BA55 is a subvolcanic granitoid which has been included into the calculation.

The metabasites

For technical reasons, only the metabasites with Rb higher than 10 ppm have been analyzed. They belong to the small Aou greenstone unit studied

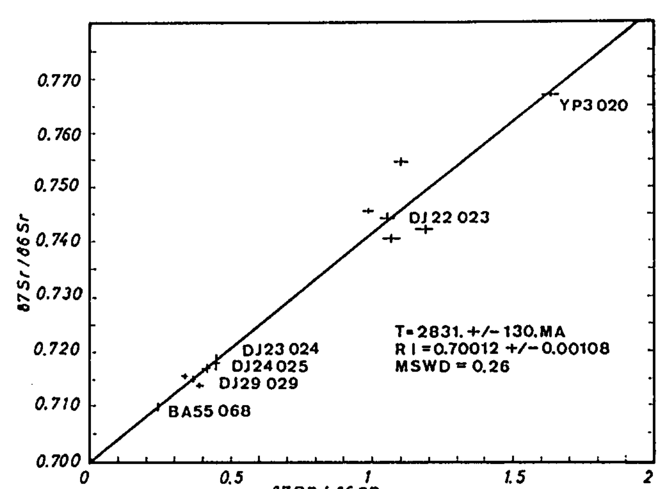

Fig. 8. $^{87}Rb/^{86}Sr$ versus $^{87}Sr/^{86}Sr$ diagram defined by six granitoids. The isochron is well defined and dates the time of intrusion of the mantle-derived magma. Three of the rocks plotting near to DJ22 belong to the «gneisses of Bembi» (see text). The non-numbered points are not included in the calculation of the isochron.

and described formerly (Poidevin *et al.*, 1981). It is situated along the southern margin of the belt. The samples, which probably do not belong to a single magmatic suite are tholeiitic basalts (DJ45, HE10) on the one hand and andesites on the other hand (DJ34, 37).

The data points show great dispersion about their "best-fit" line, neither does a line encompass a particular geochemical suite. All points (except DJ45), nevertheless, plot within 2-3 σ of the regression line defined by the granitoids (as do the deformed granitoids mentioned above) (Fig. 9). Granitoids and metabasites have probably been influenced by similar processes, the grade of consequent disturbance appearing higher for most of the metabasites. A poorly defined line passing through the four least radiogenic samples and giving an age of about 900 M.a may correspond to such an event.

The gneisses

A few fine grained quartz-feldspar, mica-rich gneisses are found in the central part ot the main belt. They have been considered as possible basement relics retained as xenoliths witnin the granitoids (Poidevin, 1977).

The samples (DJ14, 26a, 26b and 27) do not define an acceptable isochron. Three of them cluster around a tonalite (DJ22) belonging to the isochron defined by the granitoids, the fourth one (DJ26b) plots below it (Fig. 8).

The highest model age recorded among these specimen is about 3 M.a (Table 1).

Discussion

The isochron determined by the granitoids is well established. Its age also corresponds well with data obtained elsewhere on similar rock types belonging to similar geological settings (Cahen *et al.*, 1976).

The metabasites may be about the same age and cogenetic with the granitoids as they plot near to the isochron of the granitoids. No isochron, however, can be obtained from the metabasites. This may be a consequence of the pertubations undergone subsequently by the system, possibly a retrograde metamorphism during the Upper Proterozoic.

Nothing conclusive can be said about the gneisses of Bembi. They may, as presumed, belong to the sialic basement of the greenstone belt.

THE GRANITE OF THE LIBBY RIVER

The granite body crossed by the Libby river 30 km WSW of Sibut is a milestone in the geology of the basement of the CAR (Wacrenier et Wolf, 1965). It is in tectonic contact with the Bangui Series of Upper Proterozoic age (Poidevin, 1985) and crosscuts the Quartzito-schistose Series the age of which has long been followed by a question mark (Fig. 10).

The Libby granite has an overall monzonitic composition (cf. sample HE14); alkalic varieties are encountered along its southeastern margin. Pegmatitic veins with fluorite, molybdenite and, sometimes, uraninite crosscut the granite. Quartzo-feldspathic hornfels constitute decametric xenoliths. Analyzed specimens SI5, 15, 17, 23, 28 and 35 belong to the alkalic facies; they have been collected within one and the same

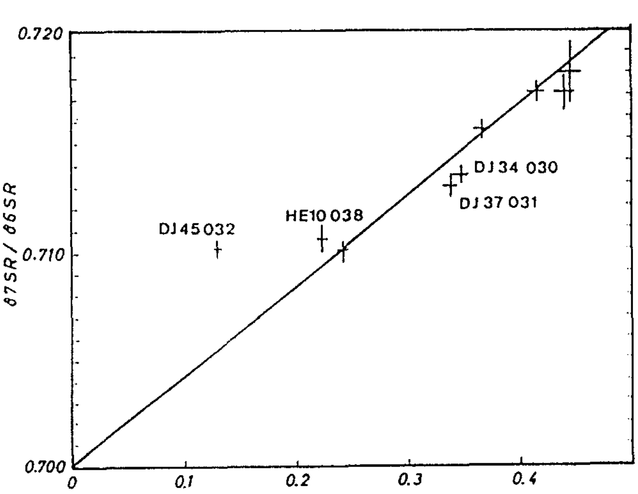

Fig. 9. ^{87}Rb/^{86}Sr versus ^{87}Sr/^{86}Sr diagram defined by a suite of greenstones. No isochron can be defined. The one determined by the intruding granitoids is drawn for reference (non-numbered points).

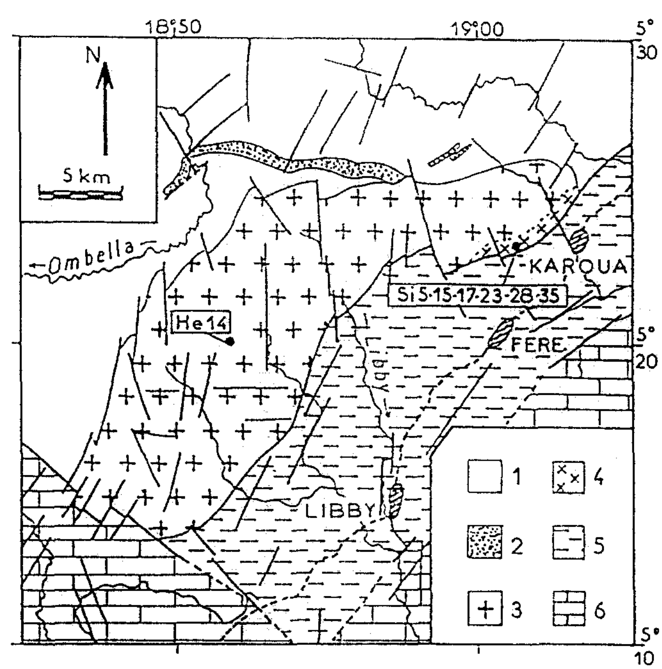

Fig. 10. Geological sketch map of the Libby granite, with location of the analyzed specimens. 1. Gneisses, 2. Muscovite quartzites, 3-4. Libby granite. 3. monzonitic facies, 4. alkalic facies, 5. Micaschists and quartzites, 6. Pelitic and calcareous formations of the Upper Proterozoic.

quarry where xenoliths of the Quartzito-schistose Series can also be observed. The specimens are coarse grained cataclased (sometimes mylonitized) rocks (a feature attributed to the tectonic relationship with the Bangui Series and thus of "later" age), mainly composed of (secondary ?) albite (sometimes oligoclase) with various amounts of microcline and chloritized biotite. Fluorite, apatite, allanite, sometimes calcite, are constant accessories. Specimen HE14 is of monzonitic composition; it has been sampled on an inselberg considered as belonging to the centre of the main body and thus represents the intrusion better. HE3 comes from a separate intrusion situated 10 km to the NNW where it is associated with gneisses of unknown age. The last specimens are granites; they are cataclased as well.

Rb/Sr results

The analyzed specimens show a high content both in Rb (except SI17) and in Sr (except HE14); the spread of Rb/Sr values is thus rather narrow. Notwithstanding the fact that the samples of the alkalic series have been collected quite near to each other, the data points are widely dispersed about the best-fit line.

Excluding point SI17, this line yields an age (Fig. 11) :

t = 1806 ± 126 M.a, IR = 0.7057 ± 0.0020, MSWD = 5.42

Considering the rather high IR and MSWD, the age corresponds more probably to a disturbance of a not much older system. The model ages of the same series of samples indeed is in the range 1842 to 2274 M.a (Table 1).

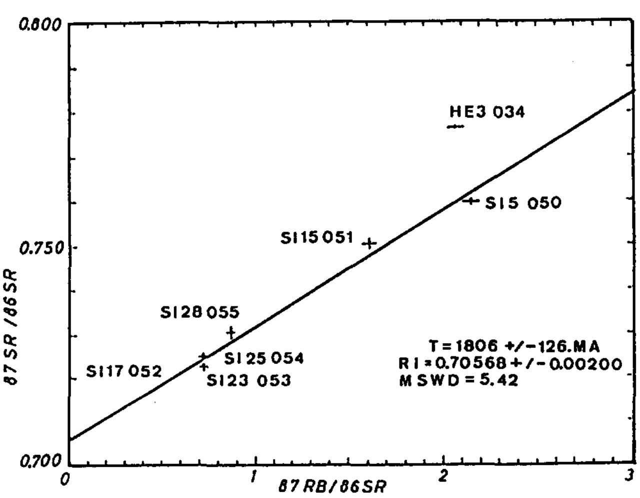

Fig. 11. $^{87}Rb/^{86}Sr$ versus $^{87}Sr/^{86}Sr$ diagram defined by granitoid rocks belonging to an alkalic border facies of the Libby granite. A rather poor isochron encompasses five specimens; the age most probably refers to a late disturbance of the intrusive body. SI17 may belong to the country-rock, while HE14 (not plotted), typical for the calc-alkalic facies of the intrusion, is distinctly older (see table 1).

Granite specimens HE3 and 14 plot away from the regression line. Their model ages are 2503 and 2404 M.a respectively. As there is no reason to exclude a crustal origin for these granites, this information is not conclusive and the figures represent merely maximum values for their age. Together with SI17, they define a line giving an age of 2235 M.a, the signification of which can hardly be assessed as no geological reason for grouping them exists.

Discussion

However unsatisfactory, the geochronological data obtained so far indicate that the sedimentary and volcano-sedimentary series intruded by the Libby granite are older than 1.8 M.a. They are thus of Lower Proterozoic age or older, i.e. a stratigraphic position long suspected (for instance Poidevin, 1979, Lavreau, 1982 b). An age in this range has recently been confirmed by a zircon extracted from the Nbi granite (NW of Bangui, in a similar litho-stratigraphic setting), yielding a date of 2081 M.a (upper Concordia intercept, the lower one yielding a, probably significant, date of 635 M.a), likely to correspond to the date of crystallization of the granite body (Poidevin and Pin, 1986).

Granite HE3 and maybe HE14 seem to be older than 1.8 M.a, either because of their model age, or because they define an isochron at 2.2 M.a. HE3 is intrusive into gneissic series and does not affect the Quartzito-schistose Series, whereas HE14 is reputed to be typical for the monzonitic nucleus of the Libby granite. From petrographical and chemical points of view, HE14 is distinct from the alkalic specimens dated; moreover, it shows a post-magmatic orientation which is absent from the alkalic members. The monzonitic types and particularly sample HE14 may thus well be older than the alkalic ones and, possibly, represent the unaltered substrate of a possible metasomatic process. It is, unfortunately, not known whether or not the monzonitic nucleus is intrusive into the Quartzito-schistose series.

The date of 1.8 M.a may represent the age of emplacement of the alkalic suite or, if all geochemically similar granites are of the same age, another event, e.g. the mentioned phase of metasomatism affecting a unit the age of which could be 2.2 M.a (Rb/Sr model age) or 2.1 M.a (U/Pb age). Sample SI17 could then, with its peculiar composition and high $^{87}Sr/^{86}Sr$ ratio, represented a country rock.

THE AMPHIBOLITES OF THE OUHAM RIVER

This vast amphibolitic body has been defined as composed of amphibolites, generally quartz-bearing, and subsidiary plagioclasic gneisses, sometimes biotite-bearing. Quartzites with epidote and two micas gneisses from the neighbouring crystallophyllian complex are observed as xenoliths within the amphibolites (Gérard, 1963).

A detailed field and geochemical study (Poidevin, 1985) allows the following units to be distinguished (Fig. 12).

a. Mafic to intermediate calc-alkalic volcanites now metamorphozed to more or less feldspathic amphibolites, with frequent hornblendic cumulates (samples OU6 and 7).

b. Volcano-sedimentary formations always intimately associated with the former. They are now metamorphozed to epidote-, epidote and magnetite-, magnetite-garnet-quartzites or to two mica gneisses (not sampled).

c. Tonalitic to granodioritic plutons constituting more than 60 % of the complex and generally intruding the former units. A geochemical study points at a close relationship between the different units, both in time and in space. There is no sharp limit to be drawn between these granitoids (OU9a and 9b) and the orthogneisses of the country rock.

d. Infrequent ultramafic non-feldspathic amphibole-schists, chemically akin to komatiitic basalts (OU7b).

e. Almost underformed gabbros and well preserved dolerites, chemically akin to K-tholeiites, cutting the former units (OUl, 2 and 3).

All five units have experienced several tectonic phases. A schistosity, faint to the north and the south, becomes very penetrative in the central part of the unit. Gérard defined the affected rocks as para-amphibolites. They more probably constitute east-west oriented blastomylonitic belts.

As a whole, the amphibolites of the Ouham river constitute a complex unit, the different members of which are, according to the geochemical and petrographical data, intimately linked with each other.

Rb/Sr results

No well-defined line can be drawn through all points. Grouping points OU6, 7, 7b and 9b of calc-alkalic affinity, a line can be computed, giving an age of (Fig. 13) :

t = 2400 ± 138 M.a, IR = 0.70278 ± 0.00010, MSWD = 3.46

near to which OU1 plots as well. Quartz diorite OU9a plots unexpectedly far away from the line.

No well-defined line encompasses the samples of tholeiitic affinity either. The composition of the series being similar to that of the present day mantle, no significant model age can be computed.

DISCUSSION

The age of the emplacement of the volcano-intrusive complex of the Ouham rover remains imprecise : a minimum age of 2.4 M.a is probable. The IR is significantly above mantle values at that time; the date may thus represent either the age of intrusion of crust-contaminated magmas or that of

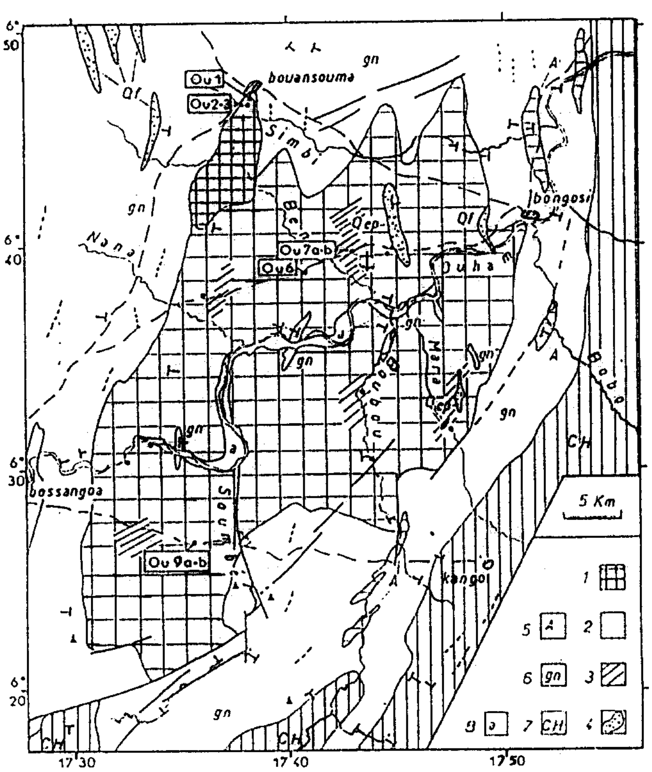

Fig. 12. Geological sketch map of the Ouham amphibolitic unit, with localisation of analyzed specimens. 1-4. Ouham complex proper, 5-7. surrounding gneisses, 1. Tholeiitic gabbros and dolerites, 2. Granitoid intrusives, 3. Meta volcanites, 4. Volcano-sedimentary formations, 5. Amphibolites, 6. Gneisses, 7. Granulitic rocks, 8. Alluvials.

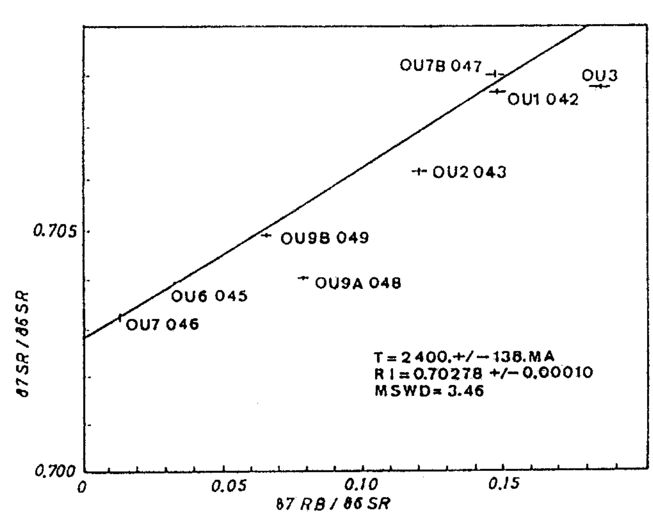

Fig. 13. $^{87}Rb/^{86}Sr$ versus $^{87}Sr/^{86}Sr$ diagram defined by a suite of metagranitoids and metabasites from the Ouham amphibolitic unit. The analyzed suite is obviously heterogeneous. The isochron is drawn through points belonging to the calc-alkalic suite. If significant, the isochron age probably refers to a late perturbation of the system.

an isotopic disturbance affecting on older system, the age of which cannot be ascertained.

The association of sediments with volcanites and intrusions of calc-alkalic affinity (moreover probably contaminated by a continental crust) points at a geodynamic setting akin to a compressed plate margin.

Situated close to the limit of the Panafrican domain of mobility, a vicinity which is testified by a penetrative mylonitization affecting the unit, the Ouham unit and the gneisses surrounding it must thus belong, according to the model of Poidevin (1985), to the edge of the less disturbed Archaean basement above which the nappes characterisitic of the median domain of the CAR have been thrusted.

CONCLUSIONS

The present study has contributed to strenghten a revised scheme of the structure of the CAR. It has allowed to modify a stratigraphic model built mainly in near absence of geochronological data (Poidevin, 1979, Lavreau, 1982 b, Cahen *et al.* 1984).

Some important gaps still exist; they concern principally the exact structural position and the age of particular gneissic members of what is called the Basement complex of the CAR. However, as the present study has only dealt with samples collected in central CAR, the conclusions can hardly apply to the eastern part of the country where the field data moreover are scarce.

Typical features for the Archaean period are the development of the granite-greenstone belts. Several have been identified and some have been dated, mainly with the aid of the associated granitoids. Periods of development around 2.8 M.a (Bandas belt), 2.8 M.a and (?) 2.5 M.a (Dekoa belt) have thus been recognized. The Ouham amphibolitic complex which may present some affinity with these granite-greenstone belts was already in existence at the end of this Archaean period.

The high grade terrains are for a great part of Archaean age as well. The granulites of the SW of the CAR are a probable extension eastwards of the Ntem Complex of Cameroon, the Amphibolo-pyroxenic Complex of the Mbomou and associated gneissic series is similarly an extension northwards of the Zairese Archaean basement. An important part of the gneisses and the granulites encountered in central CAR is nevertheless of Late Proterozoic age and testifies to the importance of the Panafrican event for most of the country.

The Quartzito-schistose Series are older than 2 M.a and thus of Lower Proterozoic age. The monocyclic character of this series must however be questionned too, as some of its members could be of Archaean age, although this needs confirmation both in the field and in the laboratory.

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