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THE AGE OF THE VISTA ALEGRE PLUTON AND THE UNITY OF THE WEST CONGO SEQUENCE [1]

by

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(2 figures)

RESUME.- Le pluton de Vista Alegre (Angola du Nord-Ouest) consiste en une intrusion post-tectonique et post-métamorphique complexe, d'âge pan-africain, dérivant d'un Eburnéen remanié ou d'un substrat plus ancien. Il renferme des zircons hérités d'une source dont l'âge remonte à 2000 Ma au moins et montre des " errorchrons" Rb-Sr impliquant un âge similaire modifié par un événement postérieur. Il est intrusif dans les couches plissées et métamorphisées du Sansikwa, groupe de base de la séquence pan-africaine Ouest-Congolienne. Cette succession recouvre en discordance le Complexe de base et forme une unité géosynclinale. Une tentative récente de diviser la Séquence Ouest-Congolienne en plusieurs systèmes indépendants est réfuté.

ABSTRACT.- The Vista Alegre pluton (NW Angola) is a composite post-tectonic post-metamorphic intrusion of Pan-African age, derived from reworked Eburnean or older basement. It contains zircons inherited from a source at least 2000 Ma old and yields confused Rb-Sr errorchrons pointing to a similar age modified by a subsequent event. It intrudes folded and regionally metamorphosed atrata belonging to the Sansikwa, the basal group of the Pan-African West Congo Sequence. This succession unconformably overlies an older Basement Complex and forms a geosynclinal unit. A recent attempt to break up the West Congo Sequence into a number of independent systems is refuted.

INTRODUCTION

Recently, Cahen *et al.* (1979) have reinterpreted the stratigraphy of the West Congo Sequence. They claim that the Vista Alegre pluton in Northwest Angola is of pre-West Congo age and that it intrudes much older strata. They transpose their view of Bas-Zaïre stratigraphy to an area some 300 km to the south, where they insert two major unconformities into an unbroken stratigraphic succession. They erect a succession comprising four supergroups separated by three diastrophisms : Kimézian - Zadinian - Mayumbian - West Congo, and assert that two of these supergroups and two important discordances have gone unnoticed in Angola.

This is in total opposition to all the geological (stratigraphic, sedimentological, structural, metamorphic, igneous and tectonic) evidence in the countries to the north and south of Bas-Zaïre. Here a much simpler Precambrian stratigraphy based on fieldwork, was set up, as fig. 1 shows.

THE WEST CONGO SEQUENCE IN ANGOLA

The West Congo Sequence (called system before 1972, see Schermerhorn 1981 and in preparation) was deposited in a basin 1400 km long, half of it lying in Angola and about 10 °/o in Bas-Zaïre (fig. 1). Deformation and plutonism affected West Congo strata and the basement to the west, constituting the *West Congo orogen* of Pan-African age, a strongly asymmetrical orogen whose western flank lies in Brazil ; this orogen combines the two aspects of, and is therefore a key to, Pan-African thermotectonism (Schermerhorn 1981).

In Angola the *West Congo Sequence* is complete and well developed, reaching an aggregate thickness exceeding 14 km. It is called a Sequence, following Allen

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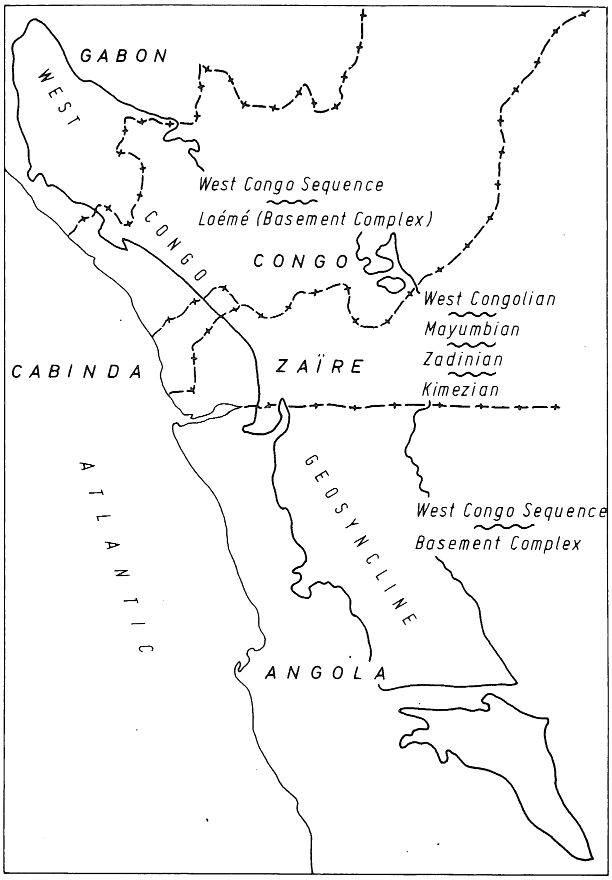

Figure 1 : Precambrian stratigraphies in the West Congo geosyncline in Congo, Bas-Zaïre and Angola.

and Reedman's (1968) recommendations, because it is something more than a supergroup, being comprised between two major unconformities of orogenic rank. The West Congo Sequence is composed of four groups (earlier called series) divided into subgroups (earlier subseries) and comprises over 50 formations described in detail in the memoirs accompanying the Angolan map sheets. It must be pointed out that the geology of the West Congo Sequence in Northwest Angola is based on fieldwork : some 82,000 km^2 have been mapped and most of this work is available as geological map sheets at 1 : 250,000 and 1 : 100,000, complete with descriptive memoirs, published by Geominas, the Geological and Mining Service of Angola (Stanton, Korpershoek and Schermerhorn 1962, Schermerhorn and Stenton 1963, Stanton 1963, 1964, 1972, Stanton and Schermerhorn 1964, Korpershoek 1964, 1965, 1974, Schermerhorn 1964). No such complete coverage, together with detailed petrographic studies, exists for Bas-Zaïre. As a result, much of the geological knowledge accumulated in Angola concerning the West Congo orogen stops at the frontier with Zaïre. For example, it is not known how the metamorphic zones, facies and isograds mapped in Northwest Angola continue northwards across Bas-Zaïre (Schermerhorn 1981, fig. 3).

In most of the West Congo formations there is a remarkably high degree of lateral persistence and constancy of facies over hundreds of kilometres, even in carbonate or quartzite horizons only a few metres thick. In fact, the main subdivisions can be recognized over most of the length and width of the West Congo basin, from Gabon to Angola and even beyond it.

No orogenic discordances occur within the West Congo Sequence : the breaks separating the groups and some subgroups are of an epeirogenic nature, having been caused by uplift in some parts of the basin and subsidence elsewhere, but they are not associated with orogenic folding movements. The accuracy of mapping (using air photographs) in Angola was such that feeble regional unconformities amounting to only a few degrees could be distinguished. No major breaks could have escaped observation.

The groups represent sedimentary cycles, in some cases with subgroups constituting minor cycles, composed of conformable successions of sediments. In each cycle initial subsidence is followed by infilling of the basin, shallow-water deposition and emergence. The lithostratigraphic subdivisions and the various lithologies of the West Congo Sequence have been described in the Angolan memoirs quoted above and more briefly in reviews (Stanton, Schermerhorn and Korpershoek 1963, Schermerhorn 1981, in prep.). Of interest here is the *Sansikwa Group* at the base of the geosynclinal succession, since this is the unit affected by the reinterpretation put forward by Cahen *et al.* (1979).

Sedimentation in the West Congo geosyncline started with the Sansikwa Group which reaches 4700 m thickness in Angola. At its base, the *Lulumba Subgroup* is mostly composed of shallow-water quartzites and arkoses, locally accompanied by mafic and felsic volcanics. Next is the *Uonde Subgroup,* a succession of carbonaceous silty shales with thin graded bedding : regional metamorphism produced the Uonde Schists, chlorite-muscovite schists. The uppermost *Terreiro Subroup* is an alternation of shales, quartzites and carbonate rocks (cf. fig. 2).

Deposition in the West Congo basin was brought to an end by the *West Congo Orogeny*, a major diastrophism comprising folding, thrusting and faulting, associated with regional metamorphism up to the amphibolite and

ANGOLA		BAS-ZAÏRE		CONGO
WEST CONGO SEQUENCE	*Haut Shiloango*	OUEST-CONGOLIEN	*Haut-Shiloango*	*Série de la Louila*
				S. de la Mossouva
				S. de la Mvouti
Sansikwa	*Terreiro*		*Sansikwa*	
	Uonde		*Mayumbien*	*S. de la Loukoula*
	Lulumba		*Zadinien*	*S. de la Bikossi*
	Basement Complex		*Kimézien*	*S. de la Loémé*

Figure 2 : Stratigraphic and tectonic divergences between Bas-Zaïre and the countries to the north and south.

hornblende granulite facies, igneous intrusion and ore deposition. The West Congo intrusives, mainly emplaced in the basement west of the geosynclinal outcrop (the reason for this is given in Schermerhorn 1981), are mostly granites, but range from granite to gabbro and norite.

THE BASEMENT COMPLEX

The West Congo Sequence is underlain by older Precambrian crystalline rocks, called the Basement Complex in Angola, Série de la Loẽmẽ in Congo and Série de la Doussa in Gabon.

The Basement Complex occupies a broad belt west of the main West Congo outcrop and is also exposed as inliers in the latter. It consists of metasedimentary and subordinate meta-igneous crystalline rocks. Most of the former is paragneiss. These rocks are strongly folded and trend largely northeast, at a high angle to the West Congo orogenic strike.

The Basement Complex metasediments represent a very thick geosynclinal pile largely composed, originally, of greywacke, with levels of arkose and subordinate interbedded shales, quartzites and carbonate rocks. No unconformities are known within this succession. Folding and regional metamorphism of these strata, with the emplacement of granites, took place during the *Basement Orogeny*. The West Congo metamorphism was later superposed on the basement metamorphism and the paragneisses now are polymetamorphic.

THE VISTA ALEGRE AREA AND SANSIKWA STRATIGRAPHY

This area, insofar as it concerns this discussion, consists of folded and metamorphosed Lower and Middle Sansikwa strata (Lulumba and Uonde Subgroups, respectively) overlying Basement Complex gneisses and granites and intruded by the Vista Alegre and Quibaxe plutons. The area was mapped in detail, much petrography was done, and the geological relationships are clear and unequivocal (Schermerhorn 1964, 1976).

Cahen *et al.* (1979) wish to separate the Lulumba and Uonde Subgroups from the West Congo Sequence, comparing them to their "Kimézian" and Lower "Zadinian" units in Bas-Zaïre. A gap corresponding to the "Mayumbe" orogeny should exist between Uonde and Terreiro and "the age and stratigraphic relationships as inferred by Schermerhorn (1976) and Stanton *et al.* (1963) are erroneous . . ." (Cahen *et al.* 1979).

Can one really separate the Lulumba and Uonde from the Terreiro and the rest of the West Congo Sequence and insert two major diastrophisms (cf. fig. 2) between them ? Field geology and laboratory studies show conclusively that this is totally impossible. The evidence is ironclad : these formations are well known geologically and petrographically as they have been mapped in considerable detail over a strike length of some 400 km south of the frontier with Zaïre.

Stratigraphically the Lulumba grades conformably, over some tens of metres, up into the Uonde (Schermerhorn and Stanton 1963, p. 38, 39, Korpershoek 1964, p. 86, 110, 111, 114, Schermerhorn 1964, p. 26, 27) and the Uonde into the Terreiro. These are conformable, gradational junctions : *within the Sansikwa there are no major internal unconformities,* hence no diastrophisms. Further, unmistakable Lulumba lithologies recur in the lower Uonde succession and Uonde lithology continues into the Terreiro (so much so that the Uonde-Terreiro boundary is arbitrarily placed at the first appearance of limestone beds). No Mayumbe or other orogeny could have occurred between the Uonde and Terreiro or between the Uonde and Lulumba Subgroups.

Structurally, everywhere in Angola all Sansikwa rocks have been folded and deformed together during the West Congo orogeny. Folds and cleavages are continuous in the Sansikwa and no earlier folds, cleavages or other deformation structures exist in the Lulumba and Uonde. There is therefore no structural break, hence no separate orogenies.

Also, the Sansikwa underwent the West Congo regional metamorphism together with the rèst of the West Congo Sequence and there are no signs of an earlier metamorphic event. Only the Basement Complex was affected by an earlier, pre-West Congo metamorphism. In particular, the Vista Alegre area is crossed by an important West Congo isograd, the chlorite-out isograd which separates the low biotite zone from the high biotite zone and these metamorphic zones affect all the West Congo formations. This isograd cuts indiscriminately across the Sansikwa subgroups but is itself cut by the Vista Alegre granite. As the metamorphic map shows (Schermerhorn 1981, fig. 3), there is a regular progressive increase of metamorphism in the West Congo strata but there is only one metamorphic episode as can be easily verified petrographically. Thus there is no break in metamorphism either.

It should be evident that the Sansikwa forms an integral part of the West Congo Sequence and that the Mayumbe System and orogeny do not exist.

THE MAYUMBE MYTH

One of the most tenacious misconceptions concerning stratigraphy and tectonics in the West Congo orogen is constituted by the so-called Mayumbe System and orogeny. At the root is the old notion that higher metamorphic strata are older than less metamorphosed beds.

The Mayumbe system and orogeny were set up by Cahen in 1945 on the basis of an unpublished reconnaissance survey and the system was said to be separated by a major unconformity from the Sansikwa (Cahen 1954). The Mayumbe structures strike NNW, parallel to the later West Congo folding and all metamorphism and granite intrusion was due to the Mayumbe orogeny, while the West Congo orogeny only caused folding.

Later Cahen (1961-62, 1962-63) changed the Mayumbe fold strike through ninety degrees to ENE and transferred part of the metamorphism to the West Congo orogeny. Cahen *et al.* (1963) dated the Mayumbian orogeny between 1480 and 1800 Ma ; this was based on feldspar from gneisses which continue south into where they were shown to belong to the Basement Complex (Korpershoek 1964). Finding much younger isotopic ages in the Mayumbe, Cahen *et al.* (1963) claimed that the influence of the 615 Ma West Congo orogeny was "extremely potent", causing most of the metamorphism as well as migmatization and some granite and pegmatite emplacement, though they still ascribed some metamorphism and many granites to the Mayumbian.

Cahen (1962-63) furthermore introduced a still older "pre-Mayumbe" orogeny which was dated at 2760 ± 500 Ma by Cahen *et al.* (1963). Cahen and Lepersonne (1966) next divided the old Mayumbe system into two new units, an upper "Mayumbian" and a lower "Zadinian". The fold trend of the Mayumbe, now much reduced in extent, was no longer ENE but N 50 W while the Zadinian strikes were very variable, often E-W or N-S, and the West Congo trend was N 35 W. From photo interpretation they inferred the existence of angular unconformities between Zadinian, Mayumbian and West Congo strata, not thrust or fault contacts. field work using air photos at 1 : 20,000 in Angola evidenced a multitude of faults and thrusts in this tectonically complicated area (Korpershoek 1964).

The Mayumbe problem was discussed at length and the conclusion was reached that the terms Mayumbe system and orogeny should be discarded since compelling geological evidence from Angola demonstrates their lack of reality (Stanton, Schermerhorn and Korpershoek 1963, Korpershoek 1964). Apart from the lack of field mapping in the Mayumbe area and its tectonic complications, another reason for the confusion attending the Mayumbe is that the Sansikwa Group in the area in Bas-Zaïre where it was defined is incomplete, due to geanticlinal movements, as discussed in Stanton, Schermerhorn and Korpershoek (1963).

To verify the existence of Mayumbe system and orogeny, Scolari and van Daalhoff (1965) carried out fieldwork in the Congo Republic but found no evidence in favour. Likewise Dadet (1969) saw no great orogenic unconformity and he reinterpreted the Mayumbe system as belonging to the West Congo succession.

Delhal and Ledent (1976), having dated gneisses and migmatites in the west of Bas-Zaïre at 2080-2105 Ma (recalculated for λ^{87} Rb = $1.42 \times 10^{-11} a^{-1}$) gave them the name of *Kimézian* and assigned the migmatites to the Tadilian orogeny separating the Kimézian from the Zadinian. This is just across the border from Angola and these rocks continue in the Basement Complex of Angola (Korpershoek 1964). We can therefore equate Kimézian and Basement Complex, and Tadilian orogeny and Basement Orogeny. The ages indicate an Eburnean age for the basement to the West Congo geosyncline, at least in this area.

In the Congo Republic, a large area astride the western boundary of the West Congo geosyncline was surveyed by Hossié (1980) and he concluded that there was no evidence for the existence of separate systems and orogenies between the Série de la Loémé (Basement Complex) and the West Congo strata, thus the Mayumbe and Zadinian of the Belgian authors must be abandoned. Radiometric ages between the Eburnean age of the basement rocks and the Pan-African age of the West Congo orogeny reflect plutono-volcanic events during this interval, not linked to orogenic phases. Tangential tectonics generated important thrusts causing anomalous contacts ; they are not due to orogenic discordances. This accords very well with the results obtained in Angola.

Thus, the existence of the major orogenic unconformity due to the Basement Orogeny, between basement and West Congo Sequence, known and surveyed in Angola since 1954, was only discovered in 1966 in Bas-Zaïre (by Massar, unpublished) and given the name of Tadilian orogeny in 1976 (Delhal and Ledent 1976). The existence of important thrusts in a zone along the border between basement and geosyncline has likewise been know for a long time in Angola.

A succession of post-basement deformational phases ("orogenies") was conjured up by Cahen and co-workers from age determinations but lacks factual ground. Cahen *et al.* (1978) dated the Yoyo granite in Bas-Zaïre which is the continuation of the Lufico Gneiss in Angola (Korpershoek 1964) as was admitted by Tack (1973) in his description of the Yoyo massif. The Yoyo granite extends 11 km into Bas-Zaïre while the Lufico Gneiss in Angola forms a discontinuous belt 135 km long and up to 12 km wide. It is a West Congo orthogneiss and belongs to the group of earliest West Congo syntectonic (pretectonic would be more apt) calc-alkaline granites (Korpershoek 1964). It is a strongly sheared, homogeneous, coarse porphyritic granite with the gneissosity dipping 10-50° W, a West Congo structure. The granite is intrusive into Lulumba Subgroup rocks : the Lucango rhyolites and the Upper Arkose which grades up into the Uonde Subgroup (Korpershoek 1964). Cahen *et al.* (1978) obtained a 4-point whole rock Rb-Sr isochron giving an age of 743 ± 16 Ma (for λ^{87} Rb = 1.42 x 10 $^{-11}a^{-1}$) with $^{87}Sr/^{86}Sr$ = 0.7253 ± 0.0022 and a MSWD of 1.942. They interpret the high initial strontium ratio as indicating isotopic rehomogenization of Sr at a time much later than intrusion, without stating on which grounds, and attribute this to a principal tectonic phase (735 Ma) of the West Congo orogeny. They omit however to show that the shearing of solid granite under low-grade conditions did cause rehomogenization of strontium.

Further, two zircon fractions from one sample of Yoyo granite yielded a discordia chord intercepting concordia at 885 and 133 Ma. These ages are taken to indicate lead loss by Cahen *et al.*(1978), for other granites yield an upper intercept of 1027 ± 56 Ma which they consider to be the age of intrusion or slightly younger (though the Rb-Sr whole rock isochrons furnish ages around 740 Ma !). Therefore, these must be Mayumbe granites and the rocks they intrude cannot be West Congo strata. It seems more likely that the isochron age of the Yoyo granite is the age of intrusion, that the high initial Sr ratios reflect its crustal origin and that the zircons with their discordant higher ages were inherited from older rocks (with loss of lead)

Similarly, Cahen *et al.* (1976) interpreted U-Pb data from the Noqui peralkaline granite as showing an intrusion age of 752 Ma (upper intercept ; this granite contains inherited zircons according to these authors). They thought this age, together with the Rb-Sr data, would date two tectonic phases and the West Congo metamorphism. To arrive at this age, however, they juggled the data which was severely criticized by Hossié (1980). Now, this granite is a massive unstrained rock with slightly deformed margins, attributed to protoclasis during intrusion by Korpershoek (1964), though it was emplaced into strongly deformed rocks west of the Yoyo granite. Thus it cannot have the same geological age as the Yoyo granite but must postdate the shearing of this granite.

Delhal *et al.* (1971) give an isochron age of 552 ± 11 Ma (recalculated for $\lambda^{87}Rb = 1.42 \times 10^{-11}a^{-1}$) for the Noqui granite, with very high $^{87}Sr/^{86}Sr = 0.8633 \pm 0.0096$ which is attributed to rehomogenization. Still, the Noqui granite lies across the boundary between greenschist and amphibolite facies metamorphism in Angola (Korpershoek 1964, Schermerhorn 1981) and appears to be post-tectonic and post-metamorphic (as riebeckite granites usually are). If the 552 Ma age for the Noqui massif is at all to be trusted (new measurements seem desirable) it indicates neither a tectonic phase (Cahen *et al.* 1976) nor a metamorphic event but quite simply the intrusion age. To conclude that the main West Congo tectonic phase occurred at 740 Ma, with a later phase at 550 Ma, is unfounded.

This seems sufficient to show that there is a lack here of field knowledge and feedback to geological data without which radiometric datations risk to lose their link to reality.

THE AGE OF THE VISTA ALEGRE PLUTON AND ITS Rb–Sr AND Pb–U SYSTEMATICS

Cahen *et al.*,(1979) present Rb-Sr data for eight whole-rock samples and four mineral fractions from the Vista Alegre pluton and from these they derive no less than four "isochrons" yielding ages ranging from 625 ± 25 Ma to 1958 ± 35 Ma and $^{87}Sr/^{86}Sr$ ratios varying from 0.7041 ± 0.0003 to 0.7314 ± 0.0005. That is to say, from a cloud of 12 data points they picked any three or more points that happened to be aligned, thus arriving at four "isochrons". Moreover, they indiscriminately mixed whole-rock and mineral data from two different rock units, a biotite-hornblende-quartz diorite locally carrying pyroxene as well and a porphyritic potash granite, the Vista Alegre granite proper. This is not correct, for they have different ages. Also, it is unsound statistics to pick only data which fit one's preconceptions, discarding inconvenient data.

Recalculating the Rb-Sr analytical data given by these authors, the following values ar obtained :

	Age	$^{87}Sr/^{86}Sr$ (1σ)	MSWD
4 granites	2548 ± 486 Ma	0.68873 ± 0.0099	17.9
4 diorites	1853 ± 218	0.70429 ± 0.0016	22.5
granites plus diorites	1820 ± 100	0.70420 ± 0.0014	24.4

Clearly, these data do not define isochrons but "errorchrons". Attention is drawn to the very large error margins of the ages and to the horrendously high MSWD (mean square of weighted deviates, a statistical parameter) values which indicate the presence of strong geological error far outside the limits of experimental error (Brooks *et al.* 1972). A MSWD of 1 or less shows a good fit of data points to the regression line (isochron) and values up to 2,5 indicate an acceptable fit still within the experimental error, hence still representing a genuine isochron.

Al this is a far cry from the 2000 Ma age which Cahen *et al.* extract from their "isochrons" : no unique isochron nor separate granite and diorite isochrons can be fitted to the data for they are in disarray, in fact no reliable age can at all be obtained.

Next, U-Pb analyses on five zircon fractions from these rocks produced a discordia chord intercepting concordia at 1940 Ma (representing the time at which the system originated, that is, crystallization of the zircons) and at -328 Ma (normally the lower intercept records the time at which loss of lead, or possibly gain of uranium, occurred). Cahen *et al.* correct this awkward negative age by rotating the chord within its one-sigma error envelope to a more meaningful lower intercept of 536 Ma and a new upper intercept of 2047 Ma, respectively (not rotating as far) 0 Ma and 1967 Ma. I have my doubts about the statistical correctness of this procedure since it involves juggling the data to obtain a more pleasing fit (negative ages have no geological meaning, neither has a thermal event causing lead loss at zero Ma).

Anyhow, Cahen *et al.* infer that the pluton intruded between 1967 and 2047 Ma and they reckon that it could not have a post-tectonic West Congo age, as I contend, for then the zircons would be inherited and there should have occurred some lead loss at intrusion in West Congo times. That is certainly correct but they next state that in that case the U-Pb data points would plot on a chord linking about 2000 Ma with any post-West Congo age and they claim that this is not so. Yet this is the case exactly, as shown above (original lower intercept at -328 Ma corrected to between 0 and 536 Ma).

If the zircons truly have an Eburnean age of about 2050 Ma (but more data are needed), then a lower intercept at about 540 Ma would ideally represent the intrusion age of the magma containing the inherited zircons, and this Pan-African age would fit the geological data quite well, also in view of the fact that no extensive later thermal event took place. As regards the postgranitic ultramafic intrusions which Cahen *et al.* invoke as disturbing the system, a single small plug of plagioclase actinolitite 200 m in diameter could not have reset the isotopes in a 10 by 12 km pluton.

Then, if the pluton was emplaced at 2000 Ma, it would have borne the brunt of West Congo deformation and metamorphism. This means that the rocks would have become strongly sheared, like the arkose and gneiss country rocks, with shearing planes striking and dipping in the same way, which is not at all the case. The quartz diorite and norite masses are mostly unstrained and the granite displays an unstrained interior with a protoclastic border zone which defines a funnel-like structure (see cross-section in Schermerhorn 1976), not a regional tectonic structure. Further, the pluton cuts across an isograd of the West Congo regional metamorphism and effected contact metamorphism in already regional-metamorphic wall rocks. The related Quibaxe granite in the same area similarly cuts across another isograd (Schermerhorn 1976).

THE GEOLOGICAL MEANING OF DISCORDANT RADIOMETRIC AGES

All the geological and petrological evidence thus indicates that the Vista Alegre pluton is a post-tectonic, post-regional metamorphic West Congo intrusive, hence of Pan-African age. It contains zircons inherited from a source at least 2000 Ma old and yields confused errorchrons pointing to a similar source age modified by a subsequent event.

How do these discordant ages fit in with the Pan-African age of intrusion clearly shown by the geology ?

In the first place, such a state of affairs is neither unique nor new. The statement by Cahen *et al.* (1979) that inherited zircons with traces of their origin are extremely rare in intrusives of deep-seated origin needs correction. The more geochronology advances, the more cases of a similar nature are brought to light. Many igneous rocks contain zircons whoses U-Pb systematics yield discordant ages older than the true geological (crystallization) ages of their hosts, and such zircons often are clear and euhedral, not visibly enclosing older cores or inclusions. It means that sialic basement involved in later anatexis contributed relict zircon seed crystals to newly generated magmas.

This was clearly shown for a granite from Normandy (Pasteels 1970), for the Bergell Massif in the Alps (Gulson and Krough 1973), for the Carn Chuinneag granite of Scotland (1500 Ma zircons in a 550 Ma granite, Pidgeon and Johnson 1974), for Appalachian granites (Higgins *et al.* 1977 ; see also following discussion by Seiders and reply by Zartman, G.S.A. Bull., v. 89, p. 1115-1117, 1978).

Pankhurst and Pidgeon (1976) described Caledonian granites for which *both* Rb-Sr whole-rock and U-Pb zircon systems (partly preserving 1300 Ma ages in 500 Ma granites) are strongly discordant : old zircons (xenocrysts) were incorporated in granite magmas without complete isotopic resetting and the Rb-Sr data scatter about an errorchron resulting from incomplete homogenization of Sr isotopes during partial fusion of sialic basement. Inherited zircons in granites (for instance, 1600 Ma zircons in 400 Ma Caledonian granites), in part accompanied by inhomogeneous Sr, are further described by Pidgeon and Aftalion (1978), Halliday *et al.* (1979) and Pankhurst (1979).

Anomalous ages older than the true ages were also exhibited by Rb-Sr whole-rock isochrons (errorchrons, rather) of some Australian granites, due to incomplete homogenization of Sr. According to Roddick and Compston (1977) the anomalous ages are to be seen as inherited "isochrons" which demonstrate that Sr isotopes were not well-mixed within the plutons during their emplacement and during the partial melting that formed the magma, and that the range of Sr isotopic equilibration is spatially limited, even during anatexis.

The foregoing discordant ages refer to granite intrusions, that is, magmas moved away from the site where they were generated. Data on pre-intrusion granites are rare. Söllner and Schmidt (1981) described a migmatite body in the Ötztal massive, where a fine-grained granitic rock has been produced in situ by anatexis and still encloses residual rafts of biotite-plagioclase gneiss and biotite schist. A whole-rock Rb-Sr isochron furnishes an age of 463 ± 37 Ma. U-Pb data from eight zircon fractions yield a lower discordia intercept at about 465 Ma, according with the Rb-Sr age. Therefore, local anatexis associated with high-grade metamorphism caused (1) homogenization of Sr isotopes and (2) disturbance of the U-Pb system.

CONCLUSIONS

1. Evidently, the Vista Alegre and related plutons are post-deformational and post-metamorphic Pan-African intrusives, not overprinted by later tectonothermal events. Their source is reworked Eburnean (or older) basement, remobilized by anatexis in Pan-African times along the lines sketched by Schermerhorn (1981). No homogenization of Sr isotopes was effected during anatexis and subsequent intrusion : the Rb-Sr and U-Pb systems were disturbed but not reset.

2. The existence of separate systems and orogenic discordances within the Sansikwa Group of Angola is ruled out by the evidence listed, expecially the conformable, gradational junctions between subgroups and the structural and metamorphic continuity troughout the Sansikwa and following formations. The Lower Sansikwa (Lulumba Subgroup) and Middle Sansikwa (Uonde Subgroup) cannot be separated from the West Congo Sequence as independent Zadinian and Mayumbian systems : *the West Congo Sequence is a unit.*

   Fieldwork in the Congo Republic north of Bas-Zaïre similarly rules out the existence of unconformities or separate systems within the lower part of the West Congo Sequence.

   What then of Zaïre ? Does it seem likely that solely in Bas-Zaïre, only 10 °/o of the strike length of the

West Congo outcrop, stratigraphy and tectonics would assume additional complexities, producing two more systems and two more discordances absent in the countries to the north and south ? It rather appears that the Zadinian and Mayumbian in Bas-Zaïre are thrust slices of metamorphosed Sansikwa : southwards into Angola and northwards into Congo they merge into less deformed Sansikwa strata, and the unity of the West Congo Sequence, starting with the Sansikwa resting unconformably on the Basement Complex, is seen.

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