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PAN-AFRICAN AND PRE-PAN-AFRICAN HISTORY OF THE HOGGAR (ALGERIAN SAHARA) IN THE LIGHT OF NEW GEOCHRONOLOGICAL DATA FROM THE ALEKSOD AREA

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ABSTRACT

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The main results of structural and geochronological investigations carried out in the Central part of the Hoggar:
— confirm the existence and the great extent of a basement of Eburnean age (ca. 2000 m.y.);
— indicate the existence of a Kibaran orogeny;
— and show a minimal Pan-African imprint upon gneisses and migmatites underlying the Hoggar East of the major NW—SE fault running from Amguid to the western edge of the Aïr; the eastern limit of this domain has still to be defined.

These results are discussed in the setting of available geochronological data concerning the whole Hoggar and an attempt is made to define structural domains within the shield. A picture of the internal constitution of this segment of the Pan-African mobile belt is proposed.

INTRODUCTION

The Hoggar is located to the East of the West African craton, where Precambrian terranes are continuously exposed over many hundreds of kilometres. The region is undoubtedly a key area for understanding the Pan-African mobile belt (Kennedy, 1964; Black, 1966, 1967; Caby, 1970).

The main purpose of this paper is to fit new structural and geochronological results from the Central Hoggar (Aleksod region) into a regional context and to examine the internal constitution of the Pan-African belt. The exciting question as to whether or not this belt may be related to a subduction or collision process (Burke and Dewey, 1970; Caby, 1970; Hurley, 1972) will not be dealt with here.

DEFINITION OF STRUCTURAL DOMAINS*

The previous definition of two orogenic cycles — Suggarian and Pharusian —

*All ages are calculated or recalculated with the Rb decay constant $\lambda Rb = 1.47 \cdot 10^{-11}\ yr^{-1}$.

was based on large-scale reconnaissance mapping and on the occurrence of unconformities, emphasized in some places by metamorphic conglomerates (Kilian, 1932; Lelubre, 1952). Both Lelubre (1969) and Gravelle (1972) introduced a new cycle, older than the Suggarian, named the Ouzzalian, outcropping essentially in the "Mole In Ouzzal", which is constituted mainly of granulites and high-grade gneisses. More recently Caby (1970) and Allègre and Caby (1972) have proved, following Gravelle (1970), the Pan-African age of the Pharusian orogeny in the western half of the Hoggar.

In the light of these results and of some other work not yet published or in progress by R. Caby, L. Latouche, G. Vitel, B. Guérangé, P. Vidal, and J. Lancelot, and assuming that one can extrapolate results obtained in small well-studied areas to larger regions, ten structural domains, generally separated by large mylonite zones, can be distinguished. They are indicated on the sketch map (Fig.1) and the corresponding available ages are given in Fig.2 and discussed in the Appendix (p. 357).

The main features of these domains from West to East can be briefly summarized as follows:

1 — *The West African craton* is characterized by its stability since the Eburnean, the last granitic emplacement being ca 1700 m.y. (Lasserre et al., 1970; Vachette et al., 1973). All biotite ages are in this age range. In the Hoggar region, the craton outcrops in the Northwestern horn of the Precambrian shield.

2 — *Western Hoggar.* Three palaeogeographic units have been distinguished (Caby, 1970) and these are tectonically juxtaposed with nappe structures. An Eburnean basement 2000 m.y. old is overlain by a platform cover, very similar to that of the West African craton, and which has been affected in places by an oceanisation process with injection of basic and ultrabasic rocks preceding the extrusion of a large volume of calc-alkaline volcanics which generated greywackes. The whole was afterwards deformed and metamorphosed during the Pan-African orogeny. The area is partly overlain by a molassic formation of Cambrian age (Série Pourprée de l'Ahnet).

3 — *The "Mole In Ouzzal".* High-grade gneisses and granulites have given Rb isochron ages ca 3000 m.y. (Ferrara and Gravelle, 1966; Allègre et Caby, 1972) but recent zircon analyses (Lancelot et al., 1973) indicate a strong Eburnean event in this area (ages of 2170 m.y.).

4 — *The central Pharusian domain.* On a poorly known basement, two different formations (Pharusian I and II) are separated by an unconformity. They are both constituted mainly of volcanics, greywackes and clastic rocks. Syntectonic granites were intruded 650 m.y. ago (Picciotto et al., 1965) but the youngest post-tectonic granites are dated at 560 m.y. (Boissonnas et al., 1969). Some small occurrences of molasse-type deposits have also been identified (Série intermédiaire).

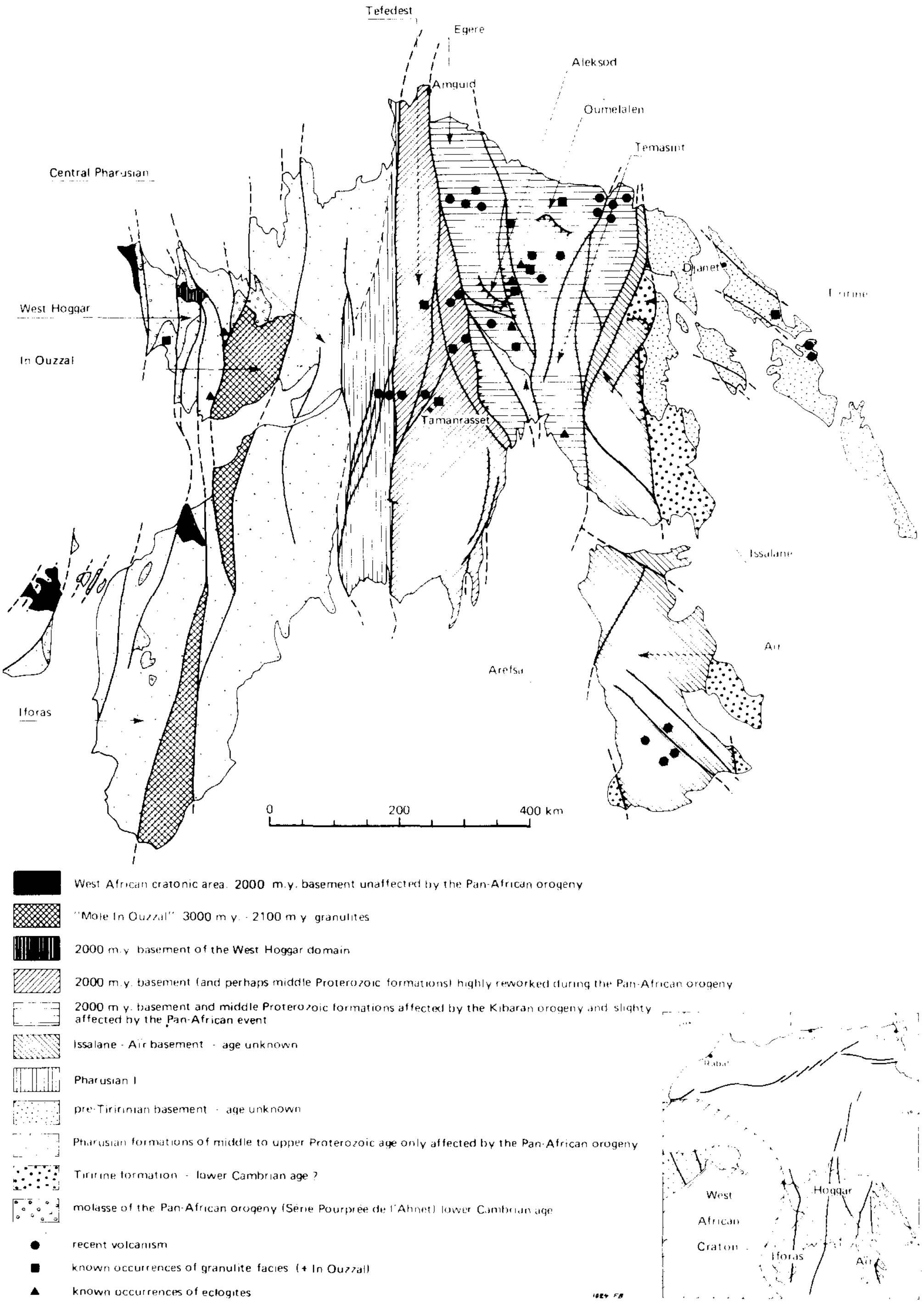

Fig.1. Sketch map of the structural and geochronological domains in the Hoggar.

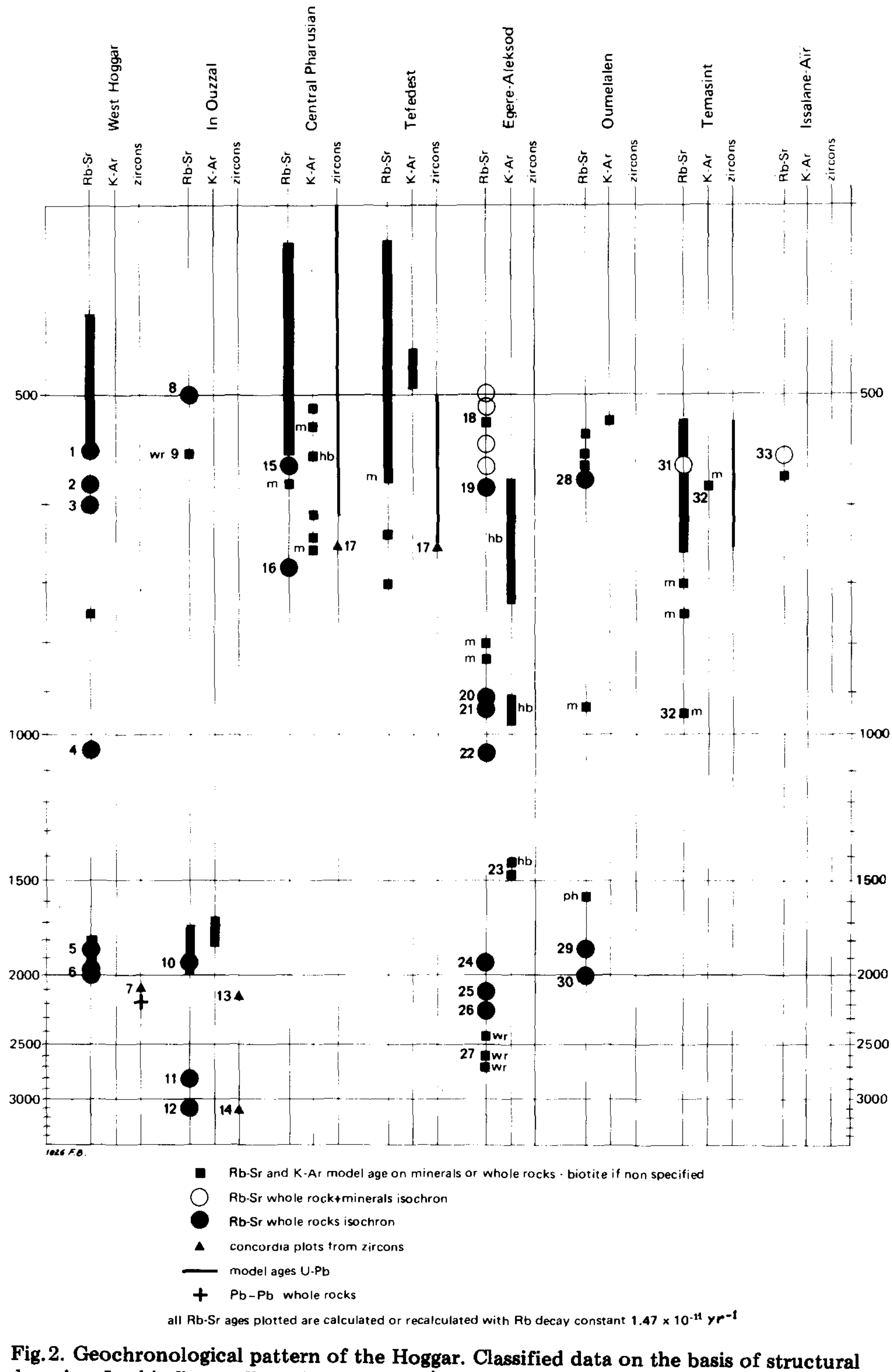

Fig. 2. Geochronological pattern of the Hoggar. Classified data on the basis of structural domains. In this figure all model ages with *Sr < 15% have been omitted. Model ages analysed in Clermont-Ferrand are calculated with an initial ratio of 0.709. For legend see Appendix, p. 357.

5 — *The Tefedest domain* is mainly composed of high-grade gneisses, including small remnants of granulites, in a sea of granites reputed to be of Pan-African age but no reliable datings are available.

6 — *The Egere-Aleksod domain* will be discussed in greater detail in the next section. Folding and metamorphism of Kibaran age (ca 1000 m.y.) are the most important characteristics of this domain.

7 — *The Oumelalen domain.* Granulites of Eburnean age ca 2000 m.y. (Latouche and Vidal, 1974) give way by retrogressive metamorphism to amphibolite-facies gneisses. This superimposed metamorphism could be of Kibaran age. Later "Pharusian" retrogressive metamorphism (greenschist facies) occurs within narrow strongly deformed "corridors" (Latouche, 1975).

8 — *The Temasint domain* is characterized by the great extent of the low- to medium-grade metasedimentary cover unconformably overlying Oumelalen-type basement. A comparison of the structural sequence with the Aleksod region suggested that the folding and metamorphism of the cover may be of Kibaran age.

9 — *The Issalane—Aïr domain.* Lithology and structure are very different from the westernmost domains, but no geochronological investigations have yet been carried out.

10 — *The Tiririne—Djanet domain.* The detailed survey is just beginning, but one must emphasize the existence of a molasse-type formation (Tiririne Formation) which is progressively metamorphosed with a North—West gradient and which lies unconformably upon a "Pharusian"-like basement. Ages are not yet available.

STRUCTURE AND GEOCHRONOLOGY OF THE ALEKSOD AREA

The field work, carried out in the Aleksod area since 1966, has been followed by geochemical and geochronological investigations.

Our results (Bertrand et al., 1972; Bertrand and Lasserre, 1973; Bertrand, 1974) may be summarized as follows:

(1) Terranes previously attributed to the Suggarian must now be divided into two distinct formations which are separated by an unconformity and emphasized by the emplacement of basic dykes (Ouadenki dykes). The two formations are together involved in a polyphase deformation (Figs.3 and 4):
(a) The older formation, "Série de l'Arechchoum", consists of tonalitic banded gneisses, partly ortho-derived augen gneisses, and interlayered metasediments (marbles, quartzites, pelitic gneisses). Ouadenki dykes cross-cut the banding, which displays undeniable traces of an earlier folding accompanied by metamorphic differentiation and partial melting, and they are themselves

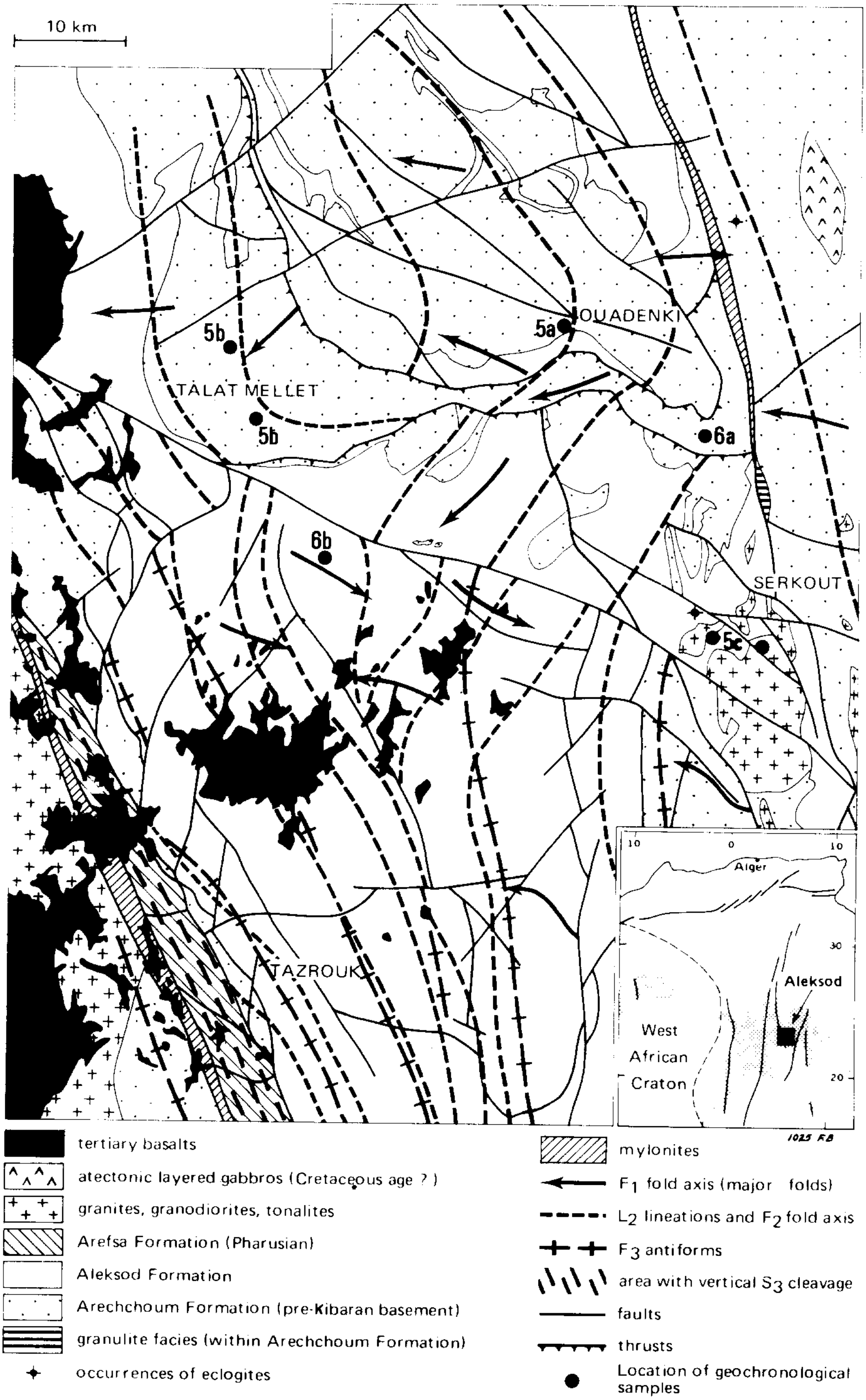

Fig.3. Structural map of the Aleksod area showing locations of samples.

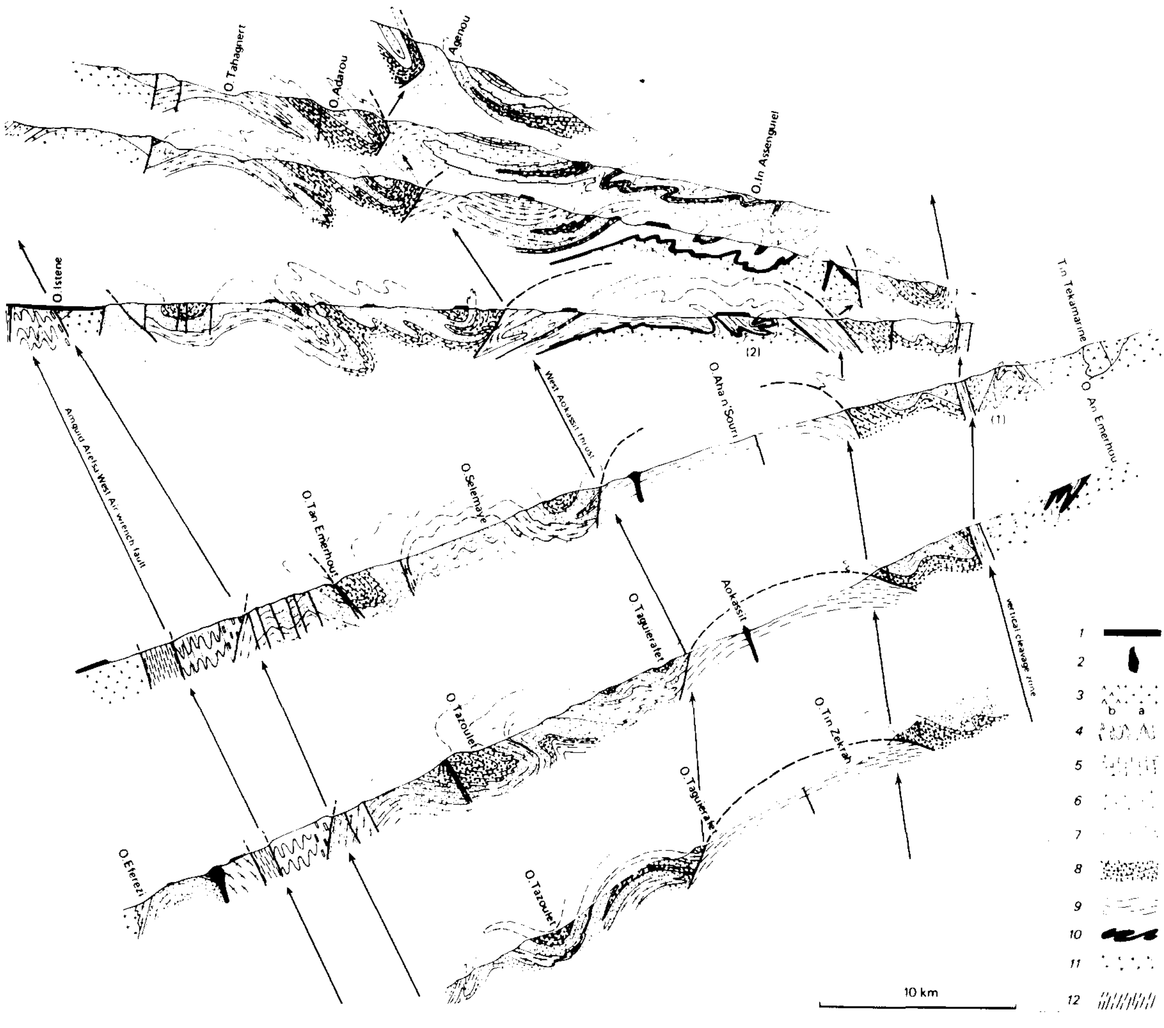

Fig.4. Sections across the southern part of the Aleksod area (South of the NW—SE trending fault).
1, Tertiary basalts; *2*, phonolites and trachytes; *3*, Aha'n'Souri granites (a) and granodiorites (b); *4*, Pharusian greenschists; *5*, upper metasedimentary unit; *6*, dioritic veined gneisses; *7*, Tazoulet metasedimentary unit; *8*, migmatized amphibolites interlayered with paragneisses; *9*, muscovite-bearing veined gneisses; *10*, basal massive amphibolites; *11*, Arechchoum banded gneisses.
4 is related to the Arefsa Pharusian Formation,
5—10 are related to the Aleksod Formation,
11 is related to the Arechchoum Formation.

implicated in the post-Arechchoum folding sequence. The Rb-Sr whole-rock isochron results are as follows (Fig.5 a, b; 6 a):
2222 ± 60 m.y. (initial ratio : 0.707) from banded gneisses and their pegmatoïd mobilisates;

2110 ± 40 m.y. (initial ratio : 0.701) from quartzo-feldspathic gneisses intimately interlayered within metasediments (mica-rich metasediments giving a younger age, see below);
1940 ± 50 m.y. (initial ratio: 0.718) from augen gneisses.
(b) The younger formation, "Série de l'Aleksod", is composed of amphibolites and metasediments (alumina-rich kyanite-bearing schists, quartzites, marbles, calc-silicate gneisses). Two phases of folding have been distinguished, belonging to the Kibaran cycle as is proposed in the discussion. The first phase (F_1) produced large-scale recumbent isoclinal folds of Pennine type and the second (F_2) various folds of smaller amplitude. During these two phases, amphibolite-facies metamorphism of Barrovian type prevailed. In the particular case of the ancient basement reworked by Kibaran deformation and metamorphism, local anatectic remobilisation may be accompanied by the appearance of eclogite or granulite-facies parageneses (meta-dolerites displaying corona structures, cordierite-garnet-kyanite paragenesis). The following ages are related to these metamorphic events (Fig.5 b; 6 a, b, c):
1050 ± 35 m.y. (initial ratio: 0.702), Rb-Sr whole-rock isochron from migmatized metasediments;
910 ± 35 m.y. (initial ratio: 0.730). Rb-Sr whole-rock isochron from blastomylonitic samples associated with Arechchoum augen gneisses whose deformation is related to the F_1 phase;
930 ± 15 m.y. (initial ratio: 0.701), Rb-Sr whole-rock isochron from mica-rich gneisses belonging to the Arechchoum Formation, the main deformation and mobilisation of which were related to the F_1 phase;
K-Ar ages on the range 900—1000 m.y. on hornblendes from amphibolites belonging to the lower part of the Aleksod Formation.

(2) The structural significance of the Arefsa Pharusian is not completely clear. This formation, composed of volcanics and volcanoclastic sediments metamorphosed in the greenschist facies, occurs in a NNW—SSE trending corridor with predominant late F_3 folding and tight folds with vertical axial-plane cleavage, which, in the adjacent basement, gradually become more open in style and superimposed on F_1 and F_2 with the gradual disappearance of the vertical axial-plane cleavage.

Rare granites in the basement, principally granodiorites and tonalites, are clearly related to or are in part later than F_3 deformation. In some cases, they can develop a late low-pressure-type metamorphism (as in the Serkout area) superimposed on the older Barrovian amphibolite facies. In the southeastern part of the Aleksod area three magmatic stages have been defined: (*a*) dolerites and synkinematic (F_3) tonalites; (*b*) late-kinematic granodiorites; (*c*) post-kinematic subalkaline granites with concentric structure. These stages occurred between F_3 folding and successive offsets of N—S wrench faults.

Two reference Rb-Sr whole-rock isochrons from granodiorites are given (Fig.5 c). The interpretation of these data is difficult, due to the low values of the $^{87}Rb/^{86}Sr$ ratios in whole rocks and of the similarities of the initial ratio obtained from either whole rocks or minerals. The post-emplacement

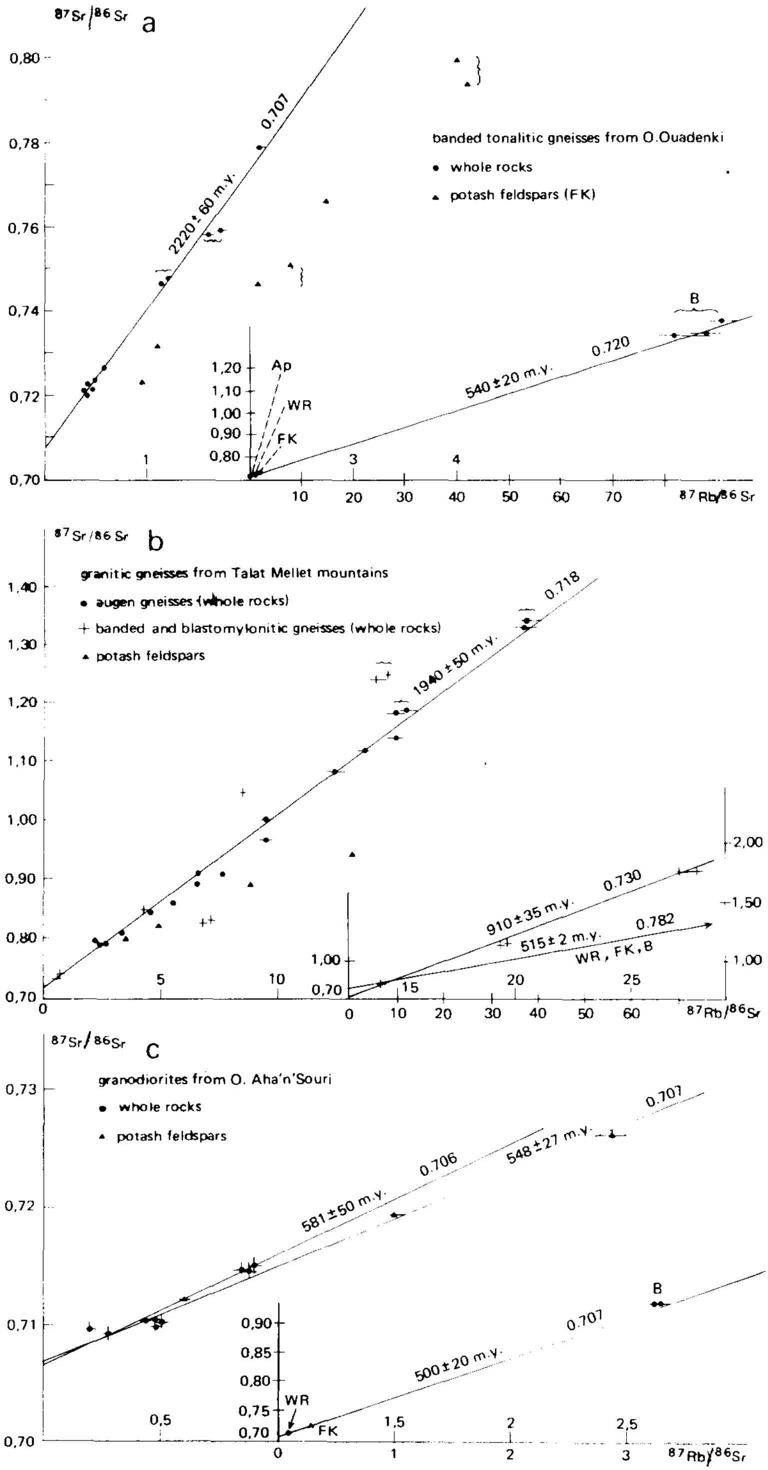

Fig.5. Aleksod geochronological results ($\lambda Rb = 1.47 \cdot 10^{-11}\ yr^{-1}$). a, banded tonalitic gneisses from the Arechchoum Formation; b, granitic gneisses from the Arechchoum Formation; c, Aha'n'Souri late Pan-African intrusive granites and granodiorites.
The braces are joining two different measurements on the same sample.

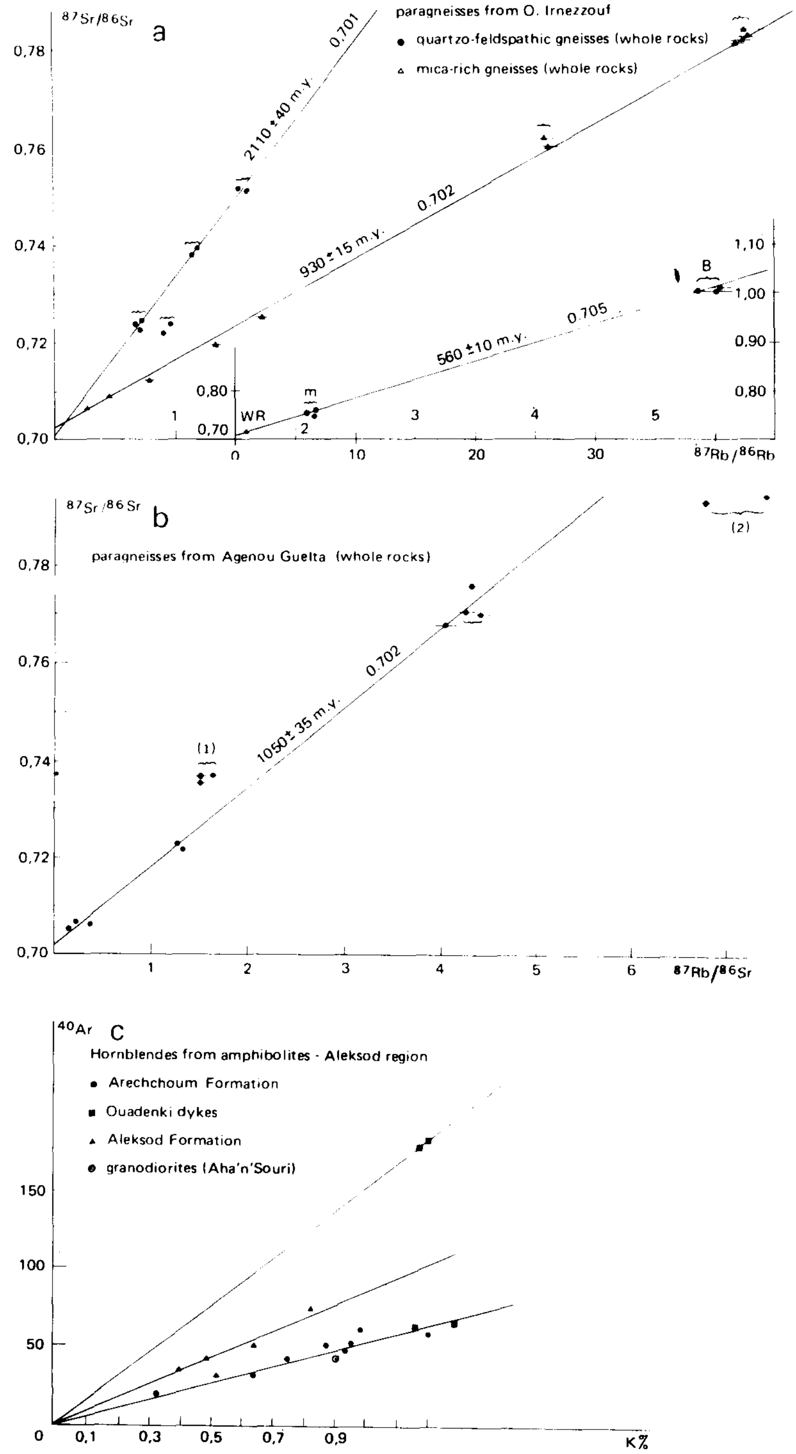

Fig.6. Aleksod geochronological results ($\lambda Rb = 1.47 \cdot 10^{-11}$ yr^{-1}). a, paragneisses from the Arechchoum Formation; b, paragneisses from the Aleksod Formation; c, K-Ar ages obtained from hornblendes.
The braces are joining two different measurements on the same sample.

history, however, seems to be short and it is impossible with the available data to fix with precision the true emplacement age within the range 500—580 m.y.

DISCUSSION

An Archean basement in the Hoggar?

In Africa the end of the Archean era is generally marked by an orogenic event at ca 2700 m.y. If, as argued by Lancelot et al. (1973), the Rb-Sr isochrons from the In Ouzzal rocks are not related to the granulite facies metamorphism but rather are related to a sedimentation process (clastic zircons in some granulites according to these authors), then true Archean rocks do not exist in the Hoggar or have only a very restricted extent. The In Ouzzal granulites could then be in part of Lower Proterozoïc age.

There are however some indications of the presence of Archean ages or of suggestive lithologies in other domains:
(a) in the Egere—Aleksod domain the significance of the 2220 m.y. isochron age is not completely clear. Indeed, it must be compared with the two points lying above the isochron in Fig.5 b and then the question arises: is it possible to interpret an isochron plot with data from two different petrological phases, in this case banded gneiss and pegmatoïd mobilisates? One could argue that the mobilisates, giving the higher three points on Fig.5 a are related to the same partial melting process as for the 1940 m.y. old granite-gneisses (Fig.5 b). Then the host banded gneiss could be older (Archean) than the granites and pegmatoïd mobilisates which are clearly related to the Eburnean event;
(b) the possibility of an Archean basement in the Oumelalen domain has been pointed out by Latouche (1972); a formation of heterogeneous potash-rich granite gneisses unconformably underlies the Oumelalen Formation (2000 m.y. old).

The Eburnean event ca 2000 m.y.

The tectonic and metamorphic evolution of the Arechchoum Formation during the Suggarian cycle is complex: the Suggarian imprint is only recognisable in relict fabrics which have escaped complete obliteration. The early phase of folding probably groups several events, but all of these are earlier than the

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K-Ar and Rb-Sr age measurements (whole rocks and minerals) have been made in Clermont-Ferrand (Laboratoire associé de Géochronologie, C.N.R.S.) with an AEI MS10 mass spectrometer (K-Ar) and an AEI MS2 mass spectrometer (Rb-Sr). The constants adopted are as follows:

$\lambda_\beta = 4.72 \cdot 10^{-11}\ yr^{-1}$
$\lambda_e = 0.584 \cdot 10^{-10}\ yr^{-1}$
$^{40}K = 0.0119$ atoms %
$\lambda Rb = 1.47 \cdot 10^{-11}\ yr^{-1}$

A detailed description of analytical methods and computing programs is given by Bonhomme (1962) and Cantagrel (1973).

intrusion of post-tectonic basic dykes (Ouadenki dykes). Similarly the reigning metamorphic conditions are known only indirectly through the presence or regional migmatization of this age. Taking into account the different methods and the ^{87}Rb decay constants used, there is a good agreement in the data from all the domains where granitic rocks have been analysed: 1940 m.y. (Tassendjanet granites and Talat Mellet augen gneisses). Slightly greater ages have been found in an In Ouzzal granulite (zircon age: 2170 m.y.; Lancelot et al., 1973), but the Oumelalen granulites seem to be younger (1870 m.y. with $\lambda Rb = 1.47 \cdot 10^{-11}$ yr^{-1}; Latouche and Vidal, 1974).

Within all the previously defined domains (except perhaps in the Djanet—Tiririne domain) a Tassendjanet-Arechchoum-type basement can be defined which leads to the conclusion that the whole of the Hoggar is underlain by basement of Eburnean age or older.

The effects of the Kibaran orogeny in the Hoggar

Considering that the decay constant (1.47), ages in the Kibaran range are nearer to the Grenville orogeny (1200 m.y. with 1.39; Krogh and Hurley, 1968) than to the Kibaran orogeny as defined by Cahen (1974): 1300 m.y. (with 1.47). Kibaran ages from the Hoggar are comparable with those proposed by Clifford et al. (1975) in Namaqualand (1200—1260 m.y. with 1.39) and in Malawi (1122 m.y. with 1.39).

At the moment, these 1 b.y. ages are restricted to the Aleksod area except for a few data on muscovites (Rb—Sr model ages) and the 1040 m.y. old rhyolite from West Hoggar (Allègre and Caby, 1972).

In the Aleksod region, paragneisses, structurally unconformable on the Eburnean basement, have been strongly folded, metamorphosed and migmatized. Different aspects of mobilisation or remobilisation can be assigned to the Eburnean and Kibaran cycles. There is a strong contrast in behaviour between the basement and the cover: the former is polycyclic and partly remobilised, the latter monocyclic with two phases, $F_1 + F_2$. Migmatites occur in both units but structural and geochronological studies allow one to distinguish two events: in the basement the main migmatization is of Eburnean age, whereas in the cover it is of Kibaran age. The last orogenic event which has affected the central Hoggar (Pan-African orogeny) has not produced any mobilisation in the Aleksod region. The conclusion that the 1 b.y.-old ages are related to this polyphase metamorphism affecting the cover rocks of the Aleksod Formation is supported mainly by the isotopic readjustments observed in older rocks of the Arechchoum Formation. Indeed, the scattering of points from the isochron of the Aleksod paragneisses (Fig.6 b) is not conclusive, although the two samples above and below the isochron are intensely chloritized and calcitized. In the Eburnean basement the differential isotopic rehomogeneisation observed between quartzo-feldspathic gneiss (e.g. banded tonalitic gneisses and augen gneiss) and mica-rich paragneisses can be explained by the effects of the secondary anatexis occurring during the F_1 and F_2 phases of folding.

From the trace-element differentiation (especially Mg/Li and K/Rb) one can consider that within quartzo-feldspathic gneisses, the biotites remain stable during the anatectic process which gave way to a constant Mg/Li ratio in the different phases of the same rock (melanosome, leucosome, separated biotite) and to an increase of the K/Rb ratio in mobilisates (Bertrand, 1974). On the contrary, in mica-rich paragneisses the Mg/Li ratio is constant in all the mobilisates and scattered in palaeosomes. Then the biottie was congruently melted in the paragneisses during the F_1 metamorphism and gave way to isotopic rehomogeneisation during this event. One can suppose that the melting is possible because of the presence of a potential water supply within the mica phase.

On the other hand, Abbott (1972) has demonstrated the possibility of large-scale isotopic rehomogeneisation in mylonitic rocks. The blastomylonites occurring within Eburnean augen gneisses (cf. Fig.5 b) are clearly related to slides occurring at the same time as the F_1 folding. Within the Talat Mellet augen gneisses it is possible to see all intermediate textures from granoblastic augen gneisses to mylonites. One can follow this evolution in the recrystallisation processes observed on biotite and microcline. A study of the partitioning of Rb between these two minerals (Dupuy and Bertrand, 1973) has shown a good correlation between the partition coefficient, the texture, and the presumed age: two different partition coefficients are defined, the higher corresponding to "fresh" primary biotite-bearing augen gneisses, plotting on the main isochron of 1940 m.y. (Fig.5 b), the lower corresponding to mylonitic or submylonitic rocks, with secondary biotite, plotting below the main isochron on Fig.5 b.

The low initial $^{87}Sr/^{86}Sr$ ratios defined in the paragneisses both from basement and cover are surprising.

The extent of the Kibaran orogeny in the Hoggar is not easy to determine at the moment. As pointed out in the first part of this paper, one can expect that the Egere—Aleksod, Oumelalen and Temasint domains could represent the main Kibaran belt. This assumption is based particularly on the similarity of the F_1 and F_2 phases of folding within these three domains. Elsewhere in Hoggar, no data are really conclusive, but it is possible that the unconformity between Pharusian I and Pharusian II in the Central Pharusian domain could be related to this event (the age measurement of the quartz diorite crosscutting Pharusian I is urgently needed).

The differential imprint of the Pan-African orogeny

When Gravelle (1969b) and Caby (1970) showed the prevalence of the Pan-African event in the Western half of the Hoggar, it was reasonable to generalize and to follow Black's hypothesis (1966) that the entire Hoggar is essentially a Pan-African belt. This is why Caby (1969) argued that the Suggarian was a structural facies corresponding to the highly metamorphosed "infrastructure" of the Pan-African belt; Suggarian and Pharusian being stratigraphically equivalent in many cases. However, more detailed studies have shown that the Suggarian is in most cases made of older material affected by the Eburnean orogeny and the polycyclic history of these rocks begins to be understood.

The Pan-African tectonic evolution is now well known in the western part of the Hoggar. The two main chronological markers are the synkinematic granite ages (650 m.y. Pb/Pb ages on zircons, Lancelot, 1975; Picciotto et al., 1965) and the postkinematic granite ages (560 m.y., Rb/Sr whole rock isochron, Boissonnas et al., 1969).

When discussing the eastern extension of the Pan-African imprint it must be taken into account that:

(1) All mineral ages (both by the K-Ar and Rb-Sr method) and Rb-Sr mineral isochrons on the same samples define a "Pan-African province", but biotite ages seem to be very young (maximum in the range 500—550 m.y. and some younger ages) compared to the granite ages and two different interpretations can be proposed:
(a) this age is mainly a "slow cooling" age related to the post-Pan-African uplift and the genesis of the pre-Ordovician peneplain (Bertrand, 1974);
(b) they could reflect a younger orogenic belt (of Cambrian age?) localised to the East as suggested by a new hypothesis concerning the eastern part of the Hoggar (Riffault et al., 1975).

(2) The tectonic regime generating N—S to NNW—SSE-trending folding with vertical axial planes and the fracture pattern is very similar from West to East. However, in the central part of the Hoggar, N—S folding seems to be less penetrative than in the Western Hoggar and is localised in "corridors" (Latouche, 1975; Bertrand, 1974) with relatively inert blocks in between.

(3) It would appear in the light of available data that most of the granites seem to be related to the last tectonic events and therefore to the Pan-African orogeny.

CONCLUSIONS

Numerous problems remain to be solved about the structure, orogenic evolution and chronology, but the data available at present strongly suggest a polycyclic evolution.

Two orogenic events have a regional extent: the Suggarian orogeny (ca 2000 m.y. = Eburnean) and the Pharusian orogeny (ca 600 m.y. = Pan-African), while two other events are more local or less well known), namely the Archean remnants of Ouzzalian (ca 3000 m.y.) and the Kibaran orogeny (ca 1000 m.y.).

Except for the In Ouzzal block, where biotite ages are in the Eburnean range, and which may be considered as a micro-craton, the whole of the Hoggar has been affected by the Pan-African orogeny. However, it is clear from structural data that there is large variation in the intensity of the Pan-African imprint from one domain to another and that this variation is not related to the proportion of old basement and newly formed material of

Upper Proterozoic age. The Aleksod area, for example, has preserved an important part of its pre-Pan-African structure and, except at the mineral scale, the Rb—Sr systems remained closed. On the contrary, other domains such as Tefedest, mainly constituted by old gneisses, and probably Issalane—Aïr, seem to have suffered large-scale reworking emphasized by the general imprint of a late high-grade, low-pressure type metamorphism related to the emplacement of large Pan-African batholiths.

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APPENDIX

Legend to Fig. 2

West Hoggar

1, 580 m.y. and 545 m.y. (620 m.y. and 580 m.y. with 1.39 Rb decay constant; Allègre and Caby, 1972). Rb—Sr whole-rock isochron from post-kinematic subalkaline granites emplaced prior to the deposition of the molassic "Série Pourprée".

2, 600 m.y. (640 m.y. with 1.39 Rb decay constant): age of the Pharusian orogeny from the emplacement of calc-alkaline synkinematic granites and gneissic peralkaline granites (Rb—Sr isochron by Allègre and Caby, 1972).

3, Biotite model age (Picciotto et al., 1965) from a migmatitic granite of the Tassendjanet basement (as defined by Caby, 1967b) zircons of the same provenance gave model ages Pb/Pb and U/Pb in the range 1885 m.y. to 1100 m.y. Muscovite from a nearby sample gave a Rb/Sr model age of 1795 ± 50 m.y.

4, 1040 m.y. (1100 m.y. with 1.39 Rb decay constant; Allègre and Caby, 1972). Rb—Sr whole-rock isochron from rhyolites interlayered in the presumed equivalent of Caby's Stromatolite series. It is interesting to note the existence of magmatism of Kibaran age in this zone.

5, 1840 m.y. (1960 m.y. with 1.39 Rb decay constant; Allègre and Caby, 1972). Rb—Sr whole-rock isochron from a muscovite-bearing granite intruding the Tassendjanet formation.

6, 1970 m.y. (2090 m.y. with 1.39 Rb decay constant; Allègre and Caby, 1972). Rb—Sr whole-rock isochron from Tassendjanet granites. More recent data from the same rocks gave Rb—Sr isochron ages in the range 1960—2090 m.y. (Dupré et al., 1975).

7, 2080 m.y. Pb—Pb age on feldspars and whole rocks from Tassendjanet granites. U—Th—Pb zircon ages from the same rocks gave an age of 2090 m.y. (Dupré et al., 1975).

In Ouzzal

8, 500 m.y. (530 m.y. with 1.39 decay constant, Allègre and Caby, 1972). Rb—Sr whole-rock isochron from In Zize rhyolites. This age seems to confirm the Cambrian age of the "Série Pourprée" but such a determination must be used with caution.

9, 550 ± 30 m.y. model age from the In Zize rhyolitic complex (Picciotto et al., 1965).

10, 2050 m.y. Rb—Sr whole-rock isochron from anatectic melts within In Ouzzal granulites (Rousseau et al., 1975). Minerals from the same rocks gave ages in the range 1900—2100 m.y.

11, 2860 ± 60 m.y. (Ferrara and Gravelle, 1966) Rb—Sr whole-rock isochron with an initial ratio 0.709. This is the first Archean age to have been published in the Hoggar. It should however be reexamined and compared with (12) because among the published data one point is clearly below the isochron and on the other hand, the low $^{87}Rb/^{86}Sr$ ratio plots are from gneisses, whereas high $^{87}Rb/^{86}Sr$ ratio plots are from charnockitic granitoïds.
12, 3100 m.y. (3300 m.y. with 1.39 Rb decay constant; Allègre and Caby, 1972). Rb—Sr whole-rock isochron from high-grade gneisses.
13, 2170 m.y. U—Th—Pb on zircons from a granulite (Lancelot et al., 1973). The same age was obtained on apatite from a granulite by Allègre et al., 1972. U—Pb data from zircons plot on a Discordia crossing the Concordia at 2170 ± 30 m.y. Lancelot et al. (1973) interpret this age as a metamorphic age: only the clearly recrystallized yellow zircons plot on this line; brown zircons, of clastic aspect, gave older apparent ages.
14, 3100 m.y. U—Th—Pb ages from inherited zircons in granulites. Recrystallized zircons from the same rocks, metamorphic zircons from quartzites, fluor-apatites and ouvarovites from pegmatites gave ages 2100 m.y. old (Rousseau et al., 1975).

Central Pharusian and Tefedest
15, 560 ± 40 m.y. and 564 ± 40 m.y. (Boissonnas et al., 1969). Rb—Sr whole-rock isochrons from two late-kinematic granites (initial ratio = 0.705). From one of these granites (Tioueine) a good isochron can also be defined with all the whole rocks, four biotites and one potash feldspar. The age obtained (526 m.y.) is close to that of the In Zize rhyolites.
16, 680 m.y. (Gravelle, 1969a, b) Rb—Sr whole-rock isochron from a Pharusian synkinematic granite (initial ratio = 0.700). This age must be used carefully as the author himself says that the rock giving the higher plot defining the isochron slope is deformed.
17, Discordia intersect at 650 m.y. (Picciotto et al., 1965) obtained from zircons sampled from different granites of the Central Pharusian and the Tefedest:
— within the central Pharusian, Tinnirt and Tin Touafa granites, are synkinematic diapirs (Boissonnas, 1973);
— within the Tefedest domain: Anfeg granodiorite and Tamanrasset muscovite-biotite granite.
The Discordia based upon zircons from different and distant granites seems to be artificial, but it is interesting to compare with the 640 m.y. old age proposed by Allègre and Caby for the syntectonic granites of the Western Hoggar.

Egere—Aleksod
18, Rb—Sr whole-rock and mineral isochron from different rocks (Bertrand, 1974):

WR, KF, Bi	500 ± 20 m.y.	Ri = 0.707	granodiorite
WR, KF, Bi	510 ± 3 m.y.	Ri = 0.844	augen gneiss
WR, KF, Bi	510 ± 5 m.y.	Ri = 0.717	banded gneiss
WR, KF, Bi	515 ± 2 m.y.	Ri = 0.782	augen gneiss
WR, KF, Bi	520 ± 25 m.y.	Ri = 0.707	granodiorite
WR, P1, KF, Bi	545 ± 30 m.y.	Ri = 0.720	banded gneiss
WR, P1, Bi	555 ± 17 m.y.	Ri = 0.711	migmatized paragneiss
WR, Ms, Bi	560 ± 10 m.y.	Ri = 0.705	migmatized paragneiss

19, 581 ± 50 m.y. (Ri = 0.706) Rb—Sr whole-rock isochron from Aha'n'Souri tardikinematic granodiorites (Bertrand, 1974). This isochron is not reliable because of the low range in $^{87}Rb/^{86}Sr$ values.
20, 910 ± 35 m.y. (Ri = 0.730) Rb—Sr whole-rock isochron from three blastomylonites belonging to the Talat Mellet augen-gneiss complex (Bertrand, 1974).
21, 930 ± 15 m.y. (Ri = 0.702) Rb—Sr whole-rock isochron from mica-rich paragneisses highly migmatized during the main Kibaran metamorphic event. Quartzo-feldspathic rocks from the same formation have given an isochron age of 2110 ± 40 m.y. (Ri = 0.701 — 3 points isochron). See discussion in the text.
22, 1050 ± 35 m.y. (Ri = 0.702). Rb—Sr whole-rock isochron from migmatized paragneisses of the Aleksod formation.

23, 1435 and 1460 m.y. Two K—Ar ages on hornblendes from the inner part of Ouadenki dykes cross-cutting the banded Arechchoum gneisses. Independently of the possibility of an excess argon in these rocks (Bertrand et al., 1972) these ages are interesting to compare with similar ages from ancient dolerites of the West African craton (Tagini, 1971).
24, 1940 ± 50 m.y. (Ri = 0.718). Rb—Sr whole-rock isochron from augen gneiss of the Arechchoum formation (Talat Mellet augen gneisses, Bertrand, 1974).
25, 2110 ± 40 m.y. See (18) quartzo-feldspathic gneisses associated with highly mobilized mica-rich gneisses.
26, 2220 ± 60 m.y. (Ri = 0.707). Rb—Sr whole-rock isochron from banded tonalitic gneisses of the Arechchoum Formation (Bertrand and Lasserre, 1973). The three higher points of this isochron are pegmatitic mobilisates. See discussion in the text.
27, Three model ages from whole rocks gave ages around 2500 m.y. (Bertrand, 1974). These rocks are banded gneisses associated with the Talat Mellet augen gneisses.

Oumelalen
28, 570 m.y. reference isochron given by Latouche and Vidal (1974) from Tissellilline post-kinematic granite.
29, 1870 ± 30 m.y. (Ri = 0.704). Rb—Sr whole-rock isochron from hypersthene-bearing pegmatoïds and leucogranulites (Latouche and Vidal, 1974). It is interpreted as a metamorphic age.
30, 2000 m.y. reference isochron from high-grade gneisses and granulites (Latouche and Vidal, 1974).

Temasint
31, 561 ± 56 m.y. (Ri = 0.734) whole-rock + mineral isochron (Ms—Bi) from an orthogneiss (Guérangé and Lasserre, 1971).
32, Two ages on the same muscovite (Guérangé and Lasserre, 1971)

Rb—Sr model age	949 ± 36 m.y.
K—Ar	578 ± 15 m.y.

Issalan—Aïr
33, The only data available in the extreme East Hoggar 553 ± 15 m.y. (Ri = 0.724) whole-rock + mineral isochron (KF, Bi) from a late granite emplaced along a major fault (Guérangé and Lasserre, 1971).

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