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GEOCHRONOLOGY OF THE PRECAMBRIAN IN THE AMAZONAS REGION OF SOUTHEASTERN COLOMBIA (WESTERN GUIANA SHIELD)[1]

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ABSTRACT

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The Amazonas region of southeastern Colombia is underlain by the western part of the Guiana Shield. Isotopic age measurements are reported on granites and gneisses of the shield basement, mafic intrusives, and a sequence of rhyodacitic lavas overlying the shield. Rb-Sr whole-rock analysis of 46 granites and gneisses and U-Pb analysis of two suites of zircons and a monazite reveal that during its development the Guiana Shield passed through at least two major orogenic episodes. The present basement was essentially formed during the Parguazan tectonomagmatic episode by large-scale granitic plutonism and metamorphic reconstitution of older crustal material, about 1560-1450 Ma ago. Most of the older isotopic record was obliterated during the Parguazan reworking, but some Rb-Sr whole-rock and U-Pb zircon systems indicate relict ages of at least 1850-1800 Ma, suggesting that the pre-Parguazan crust may be related to the Trans-Amazonian Orogenic Cycle. Rb-Sr and K-Ar analyses of 37 micas from basement rocks which are widely distributed over the area display ages cluster between about 1350 Ma and 1250 Ma; they are attributed to a general resetting of the isotopic systems by the Nickerie Metamorphic Episode about 1300 Ma ago. Evaluation of the Rb-Sr whole-rock data from five mafic intrusives and a suite of six samples from the rhyodacitic lavas suggest ages of about 1200 Ma and 920 Ma, respectively.

INTRODUCTION

From 1974 to 1979 geological reconnaissance mapping was carried out in the Amazonas region of southeastern Colombia, south of the Rio Guaviare. The mapping formed part of PRORADAM (acronym for Proyecto Radargramétrico del Amazonas), a project initiated by the Colombian government to conduct a reconnaissance survey of the region. This survey, which consisted of the interpretation of side-looking radar imagery and subsequent field work, was concluded in 1979 with the publication of the final report (PRORADAM, 1979).

The project area, referred to as the Amazonas region in this paper, is located in southeastern Colombia between 4°09' N. and 4°13.5'S., and between 66°50.9' W. and 75°24' W. It measures approximately 380,200 square kilometres, and covers the administrative districts of Guainía, Vaupés, Guaviare and Amazonas, and parts of Caquetá and Putumayo. The region is largely covered by Amazonian rain forest and affected by deep tropical weathering. Access is difficult. The scarce exposures are mainly confined to rivers. Before PRORADAM, the region was virtually unmapped in terms of regional geology. The geological survey conducted by PRORADAM was executed by geologists from the Instituto de Investigaciones Geológico-Mineras (INGEOMINAS) and the Centro Interamericano de Fotointerpretación (CIAF), both in Bogotá, and by a geological mission of The Netherlands. In conjunction with this project isotopic age studies (Rb-Sr, K-Ar, U-Pb) were undertaken by the Z.W.O. Laboratorium voor Isotopen-Geologie, Amsterdam, in the eastern part of the PRORADAM area, roughly between the Rio Guaviare and the Rio Caquetá east of 73° W. (Fig. 1). This paper presents the results of the geochronological work.

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GEOLOGICAL SETTING

The Amazonas region of southeastern Colombia is underlain by the western extension of the Guiana Shield, the Precambrian craton which covers more than 1.5 million square kilometers and forms the nucleus of South America north of the Amazon basin. Outcrops of basement rocks occur mainly along the borders with Venezuela and Brazil. Much farther to the west, large exposures of the Guiana Shield are also found in the Andes as allochthonous fragments.

Among the Precambrian rocks of the project area the following lithological units are distinguished (HUGUETT ET AL., 1979):

- Complejo Migmatítico de Mitú, felsic, metapelitic and meta-arenaceous gneisses and migmatites, and homogeneous granites. Rocks that belong to this unit occupy the greater part of the basement in the project area. The granites often form prominent inselbergs.
- Formación Roraima, ridges of folded arenaceous sediments which are speculatively correlated with the Roraima Formation which overlies large areas of the shield basement in Venezuela, Brazil, Guyana and Suriname.
- Formación La Pedrera, ridges of arenaceous (meta)sediments which are tentatively correlated with the Formación Roraima. The deposits continue into Brazilian territory as Formação Tunui (DE MONTALVÃO, 1974).
- Formación Piraparaná, dark red arenaceous sediments and pyroclastics, and rhyodacitic lavas. The sequence overlies discordantly the Complejo Migmatítico de Mitú.
- Granófiros del Tijereto, granophyric granites intrusive into the Complejo Migmatítico de Mitú and tentatively correlated with the volcanic rocks of the Formación Piraparaná.
- Diques Diabásicos, doleritic dikes intrusive into the Complejo Migmatítico de Mitú and the Formación La Pedrera.

Towards the west parts of the shield basement are overlain by the Formación Araracuara, a sequence of arenaceous sedimentary rocks which constitute a number of mesas; in the lower part fragments of trilobites have been found, indicative of a Paleozoic age. Near San José in the northwestern part of the project area a few isolated outcrops of nepheline syenite occur, which has an age of about 420 Ma (PINSON ET AL., 1962). In between the inselbergs of the Complejo Migmatítico de Mitú and the ridges and mesas of the (meta)sedimentary sequences, the greater part of the Amazonas region is occupied by various Tertiary and Quaternary deposits.

ANALYTICAL PROCEDURES AND CONSTANTS

The techniques utilized are Rb-Sr whole-rock dating, Rb-Sr and K-Ar dating of micas, K-Ar dating of a hornblende and sieve fractions (125 - 250 μm) of whole-rocks, and U-Pb dating of suites of zircons and a monazite.

Rb and Sr contents and Rb/Sr ratios of whole-rocks were measured on pressed-powder pellets by X-ray fluorescence spectrometry, using a Philips PW 1450/AHP automatic spectrometer. Mass-absorption corrections for both sample and external standard are based upon the Compton scattering of the Mo-Kα primary beam (VERDURMEN, 1977). For micas, the Rb and Sr contents were determined by isotope dilution. The isotopic composition of Sr was determined directly on unspiked Sr for the whole-rocks and calculated from the isotope-dilution analyses for the micas. All Rb and Sr isotope measurements were made on a computer-controlled Varian CH5 mass-spectrometer with Faraday cage collector and digital output.

The K contents were determined by flame photometry with a lithium internal standard and caesium chloride-aluminium nitrate buffer. Argon was extracted in a bakeable glass vacuum apparatus and determined by isotope dilution under static conditions in a Reynolds-type mass-spectrometer.

Zircons and monazite were recovered from ground samples by, successively, density separation using bromoform and di-iodomethane with a large overflow centrifuge (modified after VERSCHURE & IJLST, 1966), removal of the magnetic opaque grains, density separation using Clerici solution with a small laboratory overflow centrifuge (IJLST, 1973), and magnetic separation with a modified Frantz isodynamic separator (VERSCHURE & IJLST, 1969). Chemical decomposition and separation of uranium and lead were essentially according to the method described by KROGH (1973), followed by purification of the lead by anodic deposition (ARDEN & GALE, 1974). U and Pb contents were determined by isotope dilution. The U and Pb isotope measurements were made on a computer-controlled Teledyne SS-1290 mass-spectrometer with Faraday cage collector and digital output. Lead was mounted as nitrate on a single zone-refined Re filament with silica gel and phosphoric acid, and measured according to BARNES ET AL. (1973). Uranium was loaded as nitrate on the two zone-refined Re side-filaments of a triple filament source (SHIELDS, 1966).

The analytical accuracy is believed to be within 1% for XRF Rb/Sr, 1% for isotope dilution Rb and Sr, 0.05% for $^{87}Sr/^{86}Sr$, 1% for K, 2% for radiogenic Ar, 1% for U and Pb, and 0.5% for $^{208}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$. These estimated overall limits of relative error are the sum of the known sources of possible systematic error and the precision of the total analytical procedures. Best-fit lines through the suites of Rb-Sr data were calculated by means of a least-squares regression analysis according to YORK (1966, 1967). The discordia lines through the U-Pb data-points were fitted according to YORK (1969), using the correlation coefficients and variances calculated for each point according to BOELRIJK ET AL. (1979). The values of the Mean Squares Weighted Deviation (MSWD) were calculated according to MCINTYRE ET AL. (1966).

Throughout this paper the age calculations are based upon the constants $\lambda^{238}U = 1.55125.10^{-10}a^{-1}$, $\lambda^{235}U = 9.8485.10^{-10}a^{-1}$, $^{238}U/^{235}U = 137.88$, $\lambda^{87}Rb = 1.42.10^{-11}a^{-1}$, $\lambda_e{}^{40}K = 0.581.10^{-10}a^{-1}$, $\lambda_\beta{}^{40}K = 4.962.10^{-10}a^{-1}$ and abundance $^{40}K = 0.01167$ atom percent total K. Where necessary, quoted ages have been recalculated using these constants.

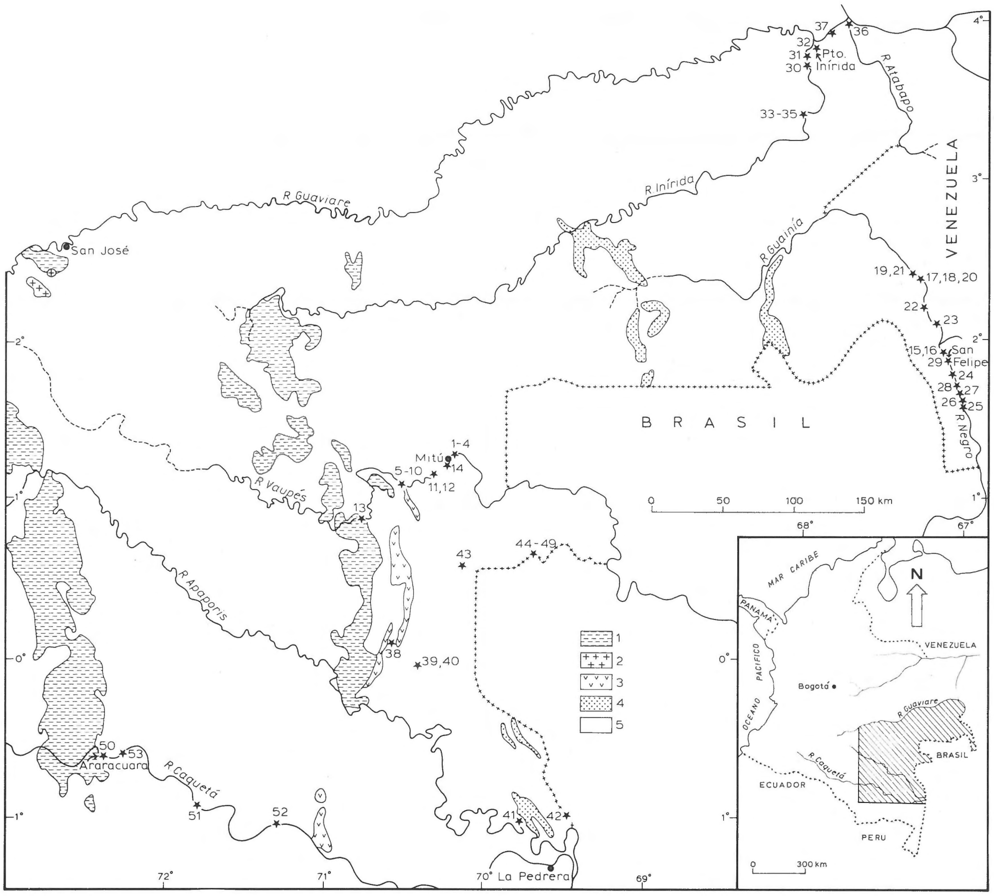

Fig. 1
Geological sketch map of southeastern Colombia between Rio Guaviare and Rio Caquetá east of 73° W. (after PRORADAM, 1979), showing the locations of the investigated samples (asterisks). Legend: 1, Formación Araracuara, Paleozoic arenaceous sediments; 2, outcrops of nepheline syenite (420 Ma old); 3, Formación Piraparaná, pyroclastics, rhyodacitic lavas and arenaceous sediments; 4, Formación La Pedrera (in the south) and Formación Roraima (in the east), arenaceous (meta)sediments speculatively correlated with the Roraima Formation overlying the eastern part of the Guiana Shield; 5, basement of the Guiana Shield, granites, gneisses, migmatites, schists and subordinate quartzites, taken together as the Complejo Migmatítico de Mitú and largely covered by Tertiary and Quaternary sedimentary sequences of variable thickness. Minor intrusive granites of the Granófiros del Tijereto are not differentiated from the shield basement. The numbers 1 through 53 correspond to sample numbers PRA 1-53 in Table I.

RESULTS AND DISCUSSION

Isotopic investigations were made of the following rocks:

1. Gneisses, granites and pegmatitic segregates from the Complejo Migmatítico de Mitú: Rb-Sr whole-rock analyses of 45 samples from different parts of the project area, U-Pb analyses of two suites of separated zircons and a monazite, Rb-Sr and K-Ar analyses of 37 separated micas, and K-Ar analysis of one separated hornblende.
2. Rhyodacitic lavas from the Formación Piraparaná: Rb-Sr and K-Ar whole-rock analyses of a suite of six samples from a large exposure in Rio Vaupés.
3. A granophyric granite from the Granófiros del Tijereto: Rb-Sr whole-rock analysis of one sample from Rio Caquetá.
4. Mafic intrusives from the Diques Diabásicos: Rb-Sr whole-rock analysis of samples from five intrusives between Rio Vaupés and Rio Apaporis.

The investigated rocks along with the sampling sites are listed in Table I. The locations are shown in Fig. 1. In order to obtain samples of unweathered material most outcrops were blasted. The analytical data are given in Tables II-VII and plotted in the diagrams of Figs. 2-9.

1. *Complejo Migmatítico de Mitú*

The samples investigated are arranged in three groups according to their geographical distribution (Fig. 1):
– 20 samples from the area between Rio Vaupés and Rio Caquetá,

TABLE I

Investigated samples

Sample Nr.	Location* (see also Fig. 1)	Rock type
PRA 1-4	Finca La Urania, Rio Vaupés	biotite granite
PRA 5-10'	village of Yaca-Yaca, Rio Vaupés	different flows of rhyodacitic lava
PRA 11, 12A	village of Miriti, Rio Vaupés	gneissose two-mica granite
PRA 12B	idem	granite-pegmatitic segregation
PRA 13	Rio Vaupés, ca 10 km upstream from confluence with Caño Ti	granophyric augite gabbro
PRA 14	Mitú Sueño, ca 5 km S of Mitú	biotite granite
PRA 15A, 15B	Isla Moriche, Rio Negro	biotite gneisses
PRA 15A/Pe	idem	granite-pegmatitic segregation
PRA 16	West Bank Rio Negro, facing Isla Moriche	epidote-rich granite
PRA 17, 18	east bank Rio Guainía, 1-2 km downstream from Rdal Corocoro	mylonitic biotite gneiss
PRA 19, 21	Rdal Corocoro, Rio Guainía	biotite gneiss, rich in thorogummite
PRA 20	east bank Rio Guainía, ca 3 km downstream from Isla Corocoro	mylonitic biotite gneiss
PRA 22	village of Sta Rita, Rio Guainía	biotite gneiss
PRA 23	island facing the village of Catacuname, Rio Guainía	biotite augengneiss
PRA 24	island facing the village of Chaqueni, Rio Negro	gneissose two-mica granite
PRA 25	village of Galilea, Rio Negro	biotite gneiss
PRA 26	west bank Rio Negro, ca 1 km N of the village of Galilea	biotite gneiss
PRA 27	island facing the village of Cabezón, Rio Negro	biotite gneiss
PRA 28	island facing the village of Tucutibapo, Rio Negro	biotite gneiss
PRA 29	S. Felipe, Rio Negro	biotite gneiss
PRA 30	village of Caranacoa, Rio Inírida	biotite granite
PRA 31	Finca Almidon, Rio Inírida	coarsely porhyritic biotite granite
PRA 32	quarry in Pto. Inírida	biotite granite
PRA 33-35	Cerros de Mavecure (inselberg), Rio Inírida	coarsely porphyritic two-mica granite
PRA 36	Maviso, Rio Atabapo	coarsely porphyritic biotite granite
PRA 37	village of Cuayare, Rio Inírida	biotite granite
PRA 38	Rdal Cuyucuyú, Rio Pira-Paraná	augite spessartite
PRA 39	Rdal Zahuco, Rio Pira-Paraná	hornblende gabbro
PRA 40	Rdal Puño, Rio Pira-Paraná	coarsely porphyritic biotite granite
PRA 41	Rdal La Libertad, Rio Apaporis	coarsely porphyritic biotite granite
PRA 42	Rdal Tente, Rio Taraira	augite dolerite
PRA 43	Rio Papurí, confluence with Caño Paca	augite dolerite
PRA 44A, 45, 47	Rio Papurí, confluence with Caño Cuyu-Cuyu	hornblende-biotite gneiss
PRA 44B, 46, 48, 49	idem	biotite gneiss
PRA 50	Rdal El Diablo, Araracuara, Rio Caquetá	two-mica gneiss
PRA 51	Rdal Quinché, Rio Caquetá	two-mica gneiss
PRA 52	Rdal Tijereto, Rio Caquetá	granophyric granite
PRA 53	Islas del Yari, Rio Caquetá	biotite gneiss

*Caño, brook; Finca, farm; Isla, Island; Rdal = raudal, rapids.

– 17 samples from an about 100 km long stretch along the Rio Negro and the Rio Guainía, upstream and downstream of San Felipe, and
– 8 samples from an about 75 km long stretch along the Rio Inírida and the Rio Guaviare, upstream and downstream of Pto. Inírida.

For each group the Rb-Sr whole-rock data and the mineral ages are treated separately.

Rb-Sr whole-rock data. No true isochron relationship is displayed by the Rb-Sr whole-rock data of the 20 samples from the Rio Vaupés/Rio Caquetá area (Table II, Fig. 2), but such a relationship can hardly be expected in the case of samples collected from different units over an area of some 90.000 square kilometers. Isochron relationships are shown, however, by two suites of samples from restricted areas (Figs. 1 and 2):
– 4 samples of biotite granite (PRA 1-4) from a low inselberg near Finca La Urania, Rio Vaupés, define an isochron of 1561 ± 90 Ma with intitial $^{87}Sr/^{86}Sr = 0.704 \pm 0.008$ (2σ errors; MSWD $\neq$ 1.1).
– 7 samples of (hornblende-) biotite gneiss (PRA 44-49) from a large exposure in the Rio Papurí, at the confluence with Caño Cuyu-Cuyu, define an isochron of 1557 ± 80 Ma with

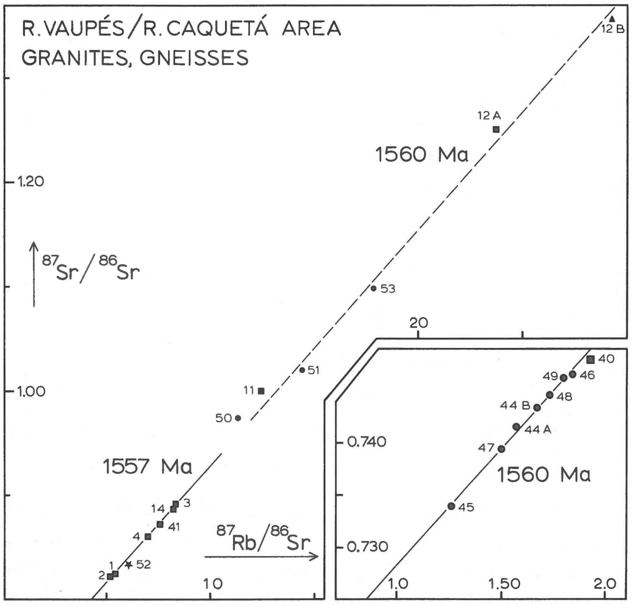

Fig. 2
Plot of Rb-Sr whole-rock data of silicic basement rocks from the Rio Vaupés/Rio Caquetá area (Table II), Squares, (gneissose) granites; circles, gneisses; triangle, granite-pegmatitic segregate; asterisk, granophyric granite from Raudal Tijereto. The numbers 1 through 53 correspond to the sample numbers PRA 1-53 in Table I. From the biotite granite PRA 4 also a suite of zircons was investigated, along with monazite (Fig. 5). Isochrons are defined by two suites of samples, each from a restricted area: biotite granites PRA 1-4 producing an age of 1561 ± 90 Ma with $(^{87}Sr/^{86}Sr)_0 = 0.704 \pm 0.008$, and (hornblende-)biotite gneisses PRA 44-49 producing an age of 1557 ± 80 Ma with $(^{87}Sr/^{86}Sr)_0 = 0.706 \pm 0.001$ (2σ errors). The dashed line represents the average of both isochrons.

initial $^{87}Sr/^{86}Sr = 0.706 \pm 0.001$ (2σ errors; MSWD = 0.3).

Both ages are indistinguishable within the limits of error and can be averaged to 1560 Ma. Of the other nine investigated samples, seven (four granites, one granite-pegmatite and two gneisses) also fit the average 1560 Ma line. The other two samples, a two-mica granite (PRA 11) and a two-mica gneiss (PRA 50), lie well above this line, which is interpreted as signifying an older Rb-Sr history.

A large scatter is shown by the Rb-Sr whole-rock data of the 17 samples from the Rio Negro and the Rio Guainía (Table II, Fig. 3). However, all data-points lie within an envelope bounded by lines corresponding to ages of about 1450 Ma and 1780 Ma, respectively. The simplest interpretation of this pattern is that the Rb-Sr whole-rock systems reflect varying degrees of resetting of older Rb-Sr records by a younger metamorphic event. A minimum value of about 1780 Ma would then be indicated for the age of the original rocks by the upper boundary line, while the lower boundary line would set a maximum age of about 1450 Ma to the metamorphism. No difference in Rb-Sr systematics is apparent between the gneisses on the one hand and the granites and granite-pegmatite on the other hand.

TABLE II
Rb-Sr whole-rock data from granites and gneisses.

Sample Nr.	Rb* (ppm)	Sr* (ppm)	Rb/Sr* (Wt/Wt)	$^{87}Sr/^{86}Sr$	$^{87}Rb/^{86}Sr$
1. Rio Vaupés/Rio Caquetá area					
Mitú area, Rio Vaupés					
PRA 1	280	151	1.848	0.82390	5.41
PRA 2	273	153	1.784	0.82220	5.22
PRA 3	312	111	2.816	0.88956	8.29
PRA 4	238	100	2.374	0.86076	6.97
PRA 11	351	84.2	4.171	1.0030	12.42
PRA 12-A	383	49.3	7.765	1.2497	23.7
PRA 12-B	579	60.7	9.533	1.3549	29.3
PRA 14	327	117	2.805	0.88758	8.26
Rio Pira-Paraná					
PRA 40	208	313	0.6654	0.74791	1.93
Rio Apaporis (La Libertad)					
PRA 41	244	94.6	2.581	0.87133	7.59
Rio Papurí					
PRA 44A	166	307	0.5402	0.74145	1.57
PRA 44B	174	301	0.5759	0.74335	1.67
PRA 45	153	353	0.4332	0.73393	1.26
PRA 46	184	291	0.6333	0.74659	1.84
PRA 47	166	321	0.5168	0.73938	1.50
PRA 48	174	292	0.5957	0.74455	1.73
PRA 49	201	324	0.6194	0.74629	1.80
Rio Caquetá					
PRA 50	327	86.2	3.797	0.97398	11.27
PRA 51	505	105	4.832	1.0197	14.41
PRA 52	268	131	2.058	0.83422	6.03
PRA 53	406	68.4	5.940	1.0982	17.85
2. Rio Negro-Rio Guainía					
PRA 15A	240	179	1.339	0.79841	3.91
PRA15A/Pe	331	191	1.736	0.81801	5.08
PRA 15B	249	191	1.301	0.79828	3.80
PRA 16	348	99.3	3.502	0.91973	10.34
PRA 17	246	143	1.725	0.82843	5.05
PRA 18	302	90.7	3.324	0.93694	9.83
PRA 19	249	146	1.709	0.82784	5.00
PRA 20	279	93.5	2.979	0.89308	8.78
PRA 21	293	177	1.658	0.81300	4.85
PRA 22	215	156	1.382	0.80576	4.04
PRA 23	217	356	0.6102	0.74388	1.77
PRA 24	303	106	2.865	0.91560	8.46
PRA 25	211	172	1.221	0.79603	3.56
PRA 26	245	165	1.482	0.81348	4.33
PRA 27	260	163	1.598	0.82460	4.68
PRA 28	227	169	1.345	0.80613	3.93
PRA 29	183	224	0.8173	0.75699	2.38
3. Rio Inírida-Rio Guaviare					
PRA 30	351	316	1.048	0.76941	3.05
PRA 31	211	221	0.9571	0.77596	2.79
PRA 32	373	253	1.476	0.79862	4.31
PRA 33	376	126	2.985	0.89272*	8.79
PRA 34	370	134	2.766	0.87994	8.14
PRA 35	363	144	2.532	0.86444	7.44
PRA 36	247	180	1.373	0.80642	4.01
PRA 37	266	359	0.7406	0.75248	2.15

*Average of two analyses.

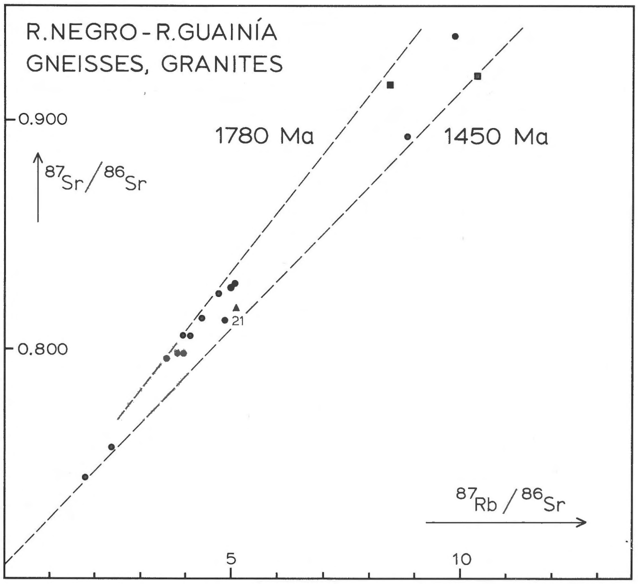

Fig. 3
Plot of Rb-Sr whole-rock data of silicic basement rocks from Rio Negro and Rio Guainía (Table II). Squares, (gneissose) granites; circles, gneisses; triangle, granite-pegmatitic segregate. The data-points scatter within an envelope with boundary lines corresponding to ages of about 1450 Ma and 1780 Ma, respectively. From the biotite gneiss PRA 21 also a suite of zircons was investigated (Fig. 6).

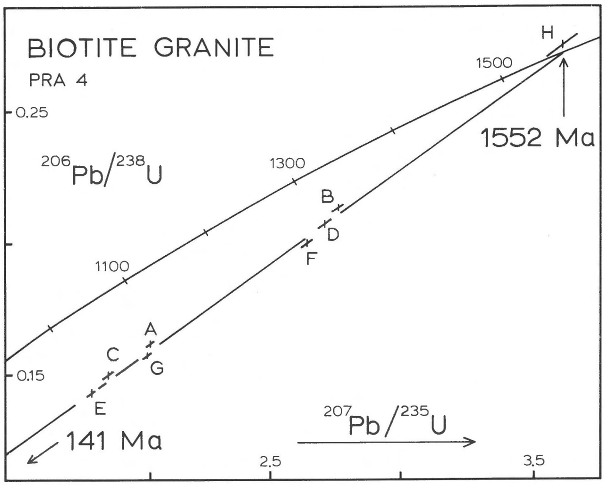

Fig. 5
Concordia diagram showing the U-Pb isotopic relationships of the zircon fractions (A-G) and the monazite data-point (H) from biotite granite PRA 4 (Table III). For the size and magnetic fractions indicated by the letters, see Table III. The best-fit line through the zircon data-points defines upper and lower intercepts of 1552±34 Ma and 141±26 Ma, respectively (2σ). The monazite plots close to the upper intercept.

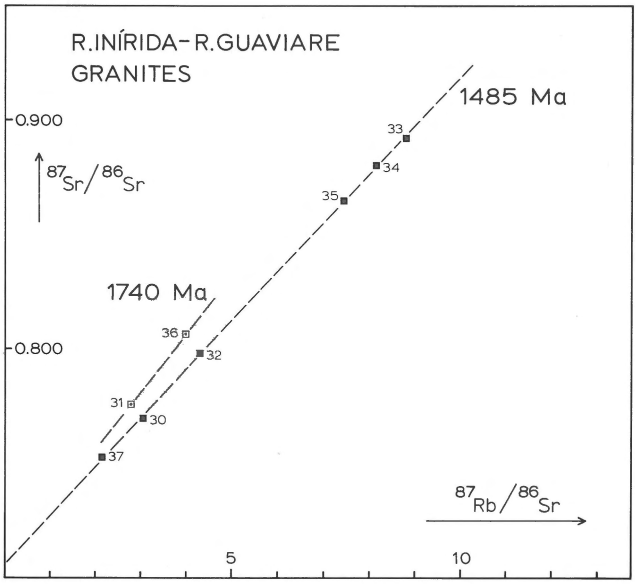

Fig. 4
Plot of Rb-Sr whole-rock data of granites from Rio Inírida and Rio Guaviare (Table II). Six samples (closed squares) display a linear arrangement corresponding to an age of 1485 ± 35 Ma with $(^{87}Sr/^{86}Sr)_0$ = 0.706 ± 0.002 (2σ errors). A line through the other two samples, PRA 31 and 36, corresponds to an age of about 1740 Ma with $(^{87}Sr/^{86}Sr)_0 \doteq 0.706$.

Of the eight granite samples from the Rio Inírida and the Rio Guaviare, six show a linear arrangement of the Rb-Sr whole-rock data-points (Table II, Fig. 4). The best-fit line corresponds to an age of 1485 ± 35 Ma and initial $^{87}Sr/^{86}Sr$ = 0.706 ± 0.002 (2σ errors; MSWD = 1.6). Two samples (PRA 31 and 36) plot above this line, which is again interpreted as betraying the presence of older radiogenic Sr; a line through both data-points would correspond to an age of about 1740 Ma with initial $^{87}Sr/^{86}Sr$ = 0.706.

U-Pb zircon and monazite data. From one of the biotite granites along the Rio Vaupés (PRA 4) that define the Rb-Sr whole-rock isochron of 1561 ± 90 Ma (Fig. 2), zircon and monazite were separated and the U-Pb systematics were investigated (Table III, Fig. 5). All seven analyzed zircon fractions (four size fractions from the magnetic portion and three from the non-magnetic one) are discordant. They display a rather poor linear correlation (MSWD = 19), with a best-fit line intersecting concordia at 1552 ± 34 Ma and 141 ± 26 Ma (2σ errors). Except for the coarsest magnetic fraction, a regular arrangement with respect to grain size along the discordia is shown by the magnetic and the non-magnetic portion. The monazite (which was not split into fractions) is nearly concordant and plots close to the upper intercept of the suite of zircons. Both the monazite and the suite of zircons yield thus U-Pb ages concordant with the Rb-Sr whole-rock isochron age; this age is taken as dating the generation of the magma and the crystallization of zircon and monazite. It is not unlikely that the rather large scatter of the zircon data-points about the best-fit line may reflect some isotopic disturbance in

TABLE III
U-Pb data from zircons and monazite*

Sample, size fraction	Weight in mg unspiked/spiked	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{235}U$	$^{206}Pb/^{238}U$	U (μg/g)	Pb (μg/g)
Granite PRA 4, suite of zircons								
A < 30 μm (M)	7.9/3.9	677	0.1125	0.2710	2.051	0.1616	1404	277
B 30- 40 μm	7.9/4.1	846	0.1103	0.2808	2.762	0.2133	1300	339
C 40- 50 μm(M)	8.0/5.4	691	0.1118	0.2283	1.894	0.1499	1502	266
D 50- 60 μm	3.3/9.7	1088	0.1076	0.1796	2.712	0.2073	1381	322
E 60- 90 μm(M)	8.6/4.1	990	0.1069	0.1478	1.830	0.1429	1534	241
F 90-110 μm	8.0/2.8	1324	0.1064	0.1379	2.643	0.1999	1304	283
G 110-250 μm(M)	4.8/3.1	1271	0.1050	0.1273	2.038	0.1571	1358	229
H *monazite*	7.4/5.6	3910	0.09879	8.0884	3.605	0.2745	2319	5089
Gneiss PRA 21, suite of zircons								
A < 30 μm	11.4/10.5	3293	0.09505	0.1138	2.779	0.2219	2569	596
B 30- 40 μm	11.6/11.3	3235	0.09506	0.1173	2.796	0.2235	2574	603
C 40- 50 μm	10.2/8.5	3604	0.09514	0.1183	2.831	0.2249	2554	603
D 50- 60 μm	10.9/10.5	2965	0.09571	0.1213	2.855	0.2275	2510	601
E > 60 μm	12.6/7.3	3836	0.10063	0.1103	3.289	0.2459	1382	355

*Column 1: (M), magnetic; all others, non-magnetic. Column 2: sample weight in milligrams for unspiked and spiked aliquots. Columns 3 through 5: measured lead isotope ratios. Columns 6 and 7: radiogenic $^{207}Pb/^{235}U$ and $^{206}Pb/^{238}U$ ratios after correction for common lead. Columns 8 and 9: total uranium and lead contents.

relation to the general resetting of the Rb-Sr and K-Ar mica systems in the basement about 1300 Ma ago (see below), although such an influence is not apparent in the upper intercept of the line. The geochronological significance of the lower intercept of the suite of zircons remains a matter of speculation.

A second suite of zircons (five size fractions) was investigated from a biotite gneiss in the Rio Guainía (PRA 21). The gneiss plots between the upper and lower boundary lines of the envelope in the Rb-Sr diagram (Fig. 3). A three-stage isotopic disturbance history is invoked to interpret the U-Pb systematics (Table III, Fig. 6). The four finest fractions are taken as defining a line with the upper intercept at 1480 $\pm^{100}_{70}$ Ma (2σ errors; MSWD = 1.6), but with an ill-defined lower intercept (350 ± 600 Ma) because of the small spread of the data-points and their position rather close to the upper intercept. The upper intercept age of this line is concordant with the lower boundary line of the envelope in the Rb-Sr diagram and may be interpreted as approaching the age of (re)crystallization of the zircon during the gneissification of the rock. Some loss of radiogenic lead after the (re)crystallization was responsible for the discordia arrangement.

The coarsest fraction (> 60 μm) plots outside the best-fit line through the four finest fractions, which is attributed to a significant amount of older radiogenic lead. If the U-Pb system of the older zircon component has not been disturbed by subsequent events, the position of this fraction in the diagram can be explained in terms of mixing of two zircon generations, the undisturbed old component and the isotopically disturbed young zircon. The upper intercept of the 'mixing line' with concordia at about 1850 Ma should then set a minimum value to the age of the old zircon. Some support for the presence of such an undisturbed old component may be found in the much lower uranium-content of this fraction (about 1380 ppm versus about 2550 ppm for the other four fractions, Table III), which implies a very low uranium-

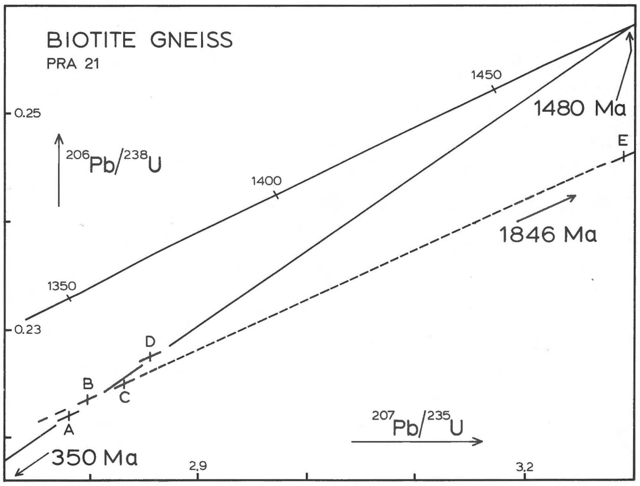

Fig. 6
Concordia diagram showing the U-Pb isotopic relationships of the zircon fractions from biotite gneiss PRA 21 (Table III). For the size fractions indicated by letters, see Table III. A best-fit line through the four finest fractions (A-D) defines upper and lower intercepts of 1480 $\pm^{100}_{70}$ Ma and 350 ± 600 Ma, respectively (2σ). The coarsest fraction (E) plots outside this line, which is interpreted as signalling the presence of some older radiogenic lead. A line through this point and the other four fractions has an upper intercept which concordia at 1846 ± 95 Ma (2σ).

TABLE IV
Rb-Sr and K-Ar mineral data from granites and gneisses

Sample Nr.	Mineral	K* (% Wt)	radiogenic Ar** (ppb)	Rb (ppm)	Sr (ppm)	$^{87}Sr/^{86}Sr$	K-Ar Age	Rb-Sr Age***
Rio Vaupés/Rio Caquetá area								
PRA 1	bio	6.86	873	1435*	9.41*	26.405*	1266	1156
PRA 4	bio	6.84	882	1438	11.43	21.755	1279	1318
PRA 11	bio	6.64	885	1509	12.19	20.695	1309	1314
PRA 11	mu	8.85	1142	1044	12.20	10.080	1279	1370
PRA 12A	bio	5.37	722	1390	11.96	17.792	1317	1320
PRA 12A	mu	8.93	1173	1149	11.46	14.390	1297	1399
PRA 14	bio	6.85	890	1267	12.98	12.114	1286	1329
PRA 40	bio	6.88	822*	1012	13.31	6.6953	1210	1198
PRA 41	bio	6.21	952*	1118	16.53	7.0457	1445	1377
PRA 44B	bio	7.53	996*	985	17.23	4.8993	1302	1253
PRA 45	bio	7.73	1155*	821	13.92	5.1744	1418	1270
PRA 45	hbl	1.23	190*				1447	
PRA 47	bio	7.63	1059*	896	20.97	3.5600	1348	1258
PRA 49	bio	7.38	966*	964	26.56	3.0450	1293	1261
PRA 50	bio			1275	14.23	10.643		1349
PRA 50	mu	8.61	1250*	853	14.29	6.0716	1389	1410
PRA 51	bio	6.59	916*	2309	19.39	17.886	1349	1295
PRA 51	mu	8.43	1140*	1765	19.47	10.119	1323	1298
PRA 53	bio	7.07	975*	2066	16.78	20.409	1340	1314
Rio Negro-Rio Guainía								
PRA 15B	bio	8.03	965*	1400	11.48	17.734	1215	1262
PRA 17	bio	7.79	989	1275	13.82	9.3825	1264	1223
PRA 19	bio	7.86	999*	1345	10.56	19.766	1265	1258
PRA 23	bio	7.70	952	1144	22.14	4.2648	1240	1230
PRA 24	bio	7.55	971	1429	27.49	4.5798	1276	1286
PRA 24	mu	8.84	1136	820	23.73	3.0569	1276	1305
PRA 25	bio	7.73	1085*	947	8.83	13.614	1358	1280
PRA 26	bio	7.54	1031*	1135	9.60	17.360	1333	1291
PRA 27	bio	7.71	998*	1247	27.27	4.0828	1282	1327
PRA 28	bio	7.78	977*	1062	22.58	3.9375	1254	1248
Rio Inírida-Rio Guaviare								
PRA 30	bio	7.64	1033*	1446	14.64	12.462	1323	1334
PRA 31	bio	7.70	924*	1003	23.97	3.6331	1210	1303
PRA 32	bio	8.08	1080*	1946	16.58	17.998	1312	1319
PRA 33	bio	7.71	1031*	1587	13.10	18.980	1312	1303
PRA 33	mu	8.93	1174	933	11.88	8.2213	1296	1327
PRA 35	bio	7.62	1015*	1457	10.95	26.273	1309	1323
PRA 35	mu	9.03	1191*	1047	12.17	7.6244	1300	1152
PRA 36	bio	7.72	1112*	947	12.71	7.7373	1382	1343
PRA 37	bio	8.01	1093*	1311	16.88	7.9051	1331	1311

* Average of two analyses.
** Atmospheric ^{40}Ar less than 20% of total ^{40}Ar for all analysis.
*** With reference to the corresponding whole-rock.

content for the old zircon. This could indicate that the old zircon is the physico-chemically stable z_k-phase according to SOMMERAUER (1976): the non-metamict zircon with undisturbed crystal lattice and low in foreign elements such as uranium. The z_k-phase, for example granulitic zircon, is characterized by a closed-system behaviour towards uranium and lead, so that this phase usually remains more or less concordant.

Age of formation of the shield basement. From the Rb-Sr whole-rock and U-Pb zircon systematics and U-Pb monazite data of the Complejo Migmatítico de Mitú it is concluded that the granitic plutonism and the high-grade metamorphism leading to the formation of the gneisses and migmatites took place between about 1560 Ma and 1450 Ma ago, but that older crustal material with a prolonged Rb-Sr and U-Pb history was involved in these processes. Ages in this range are also widely distributed in basement rocks in the adjoining territories of Venezuela (GAUDETTE ET AL., 1978) and Brazil (DA SILVA PINHEIRO ET AL., 1976), where they are related to an important event of granitic plutonism and metamorphism about 1550-1450 Ma ago, the Parguazan tectonomagmatic episode. This episode affected large parts of the northwestern and southern Guiana Shield, and extended as far south as the Guaporé craton south of the Amazon basin (MARTÍN, 1974; GAUDETTE ET AL., 1978). Parguazan ages have also been reported from basement rocks underlying the Amazon basin (KOVACH ET AL., 1976).

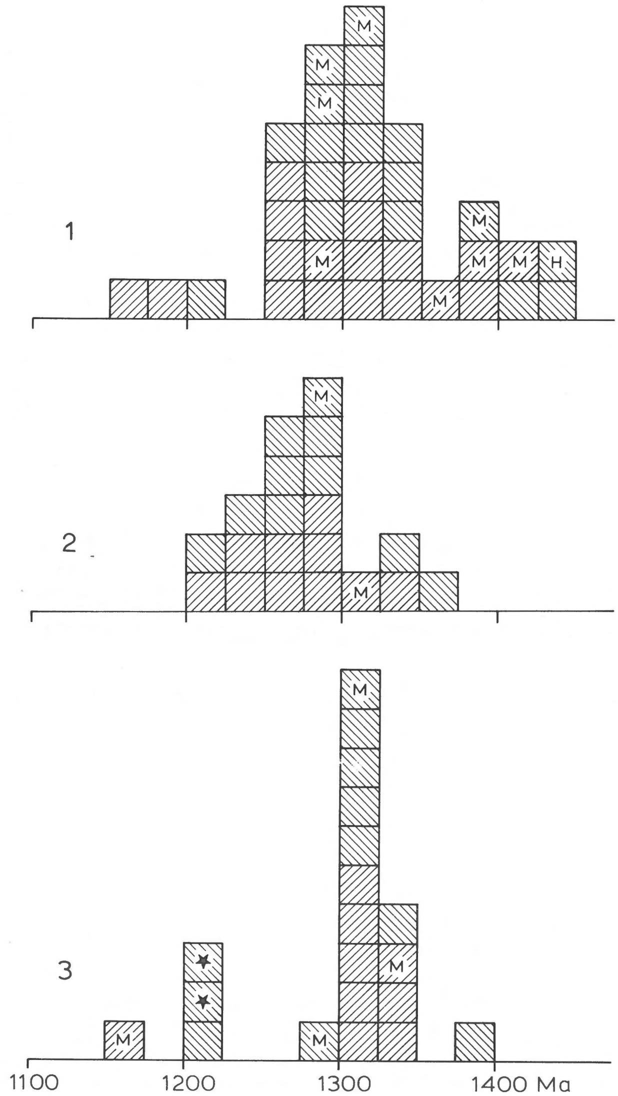

Fig. 7
Histogram of mineral ages from basement rocks in the Amazonas region (Table IV). Left-hand diagonal shading, K-Ar ages; right-hand diagonal shading, Rb-Sr ages. M, muscovite; H, hornblende; all others, biotite. 1, Rio Vaupés/Rio Caquetá area; 2, Rio Negro and Rio Guainía; 3, Rio Inírida and Rio Guaviare. Asterisks, data from Pinson et al. (1962).

Not much of the pre-Parguazan isotopic record has been retained in the rocks of the Complejo Migmatítico de Mitú. Several samples reveal the presence of varying proportions of older radiogenic strontium. For the gneisses and granites along the Rio Negro and the Rio Guainía a minimum age of about 1780 Ma can be inferred from the Rb-Sr systematics. An older zircon component with a possible minimum age of about 1850 Ma was observed in the coarsest fraction of a suite of zircons from a gneiss on Rio Guainía. It seems obvious to relate this pre-Parguazan basement with the Trans-Amazonian Orogenic Cycle 2100-1800 Ma ago, an important episode of granitoid magmatism and metamorphism during which large parts of the Guiana Shield and the Brazilian Shield were formed (HURLEY ET AL., 1967). In Suriname, for example, the greater part of the shield area (granitoid intrusions, silicic volcanic rocks and metamorphic rocks) has an age of 1875 ± 40 Ma (PRIEM ET AL., 1971).

Rb-Sr and K-Ar mineral data. Micas separated from granites and gneisses belonging to the Complejo Migmatítico de Mitú display a wide spread in ages (Table IV, Fig. 7). They range from 1445 Ma (K-Ar age of biotite PRA 41) down to 1152 Ma (Rb-Sr age of muscovite/whole-rock pair PRA 35), but with a clustering between about 1350 Ma and 1250 Ma (Fig. 7). No difference is apparent between the patterns of mica ages from the three areas, between Rio Vaupés and Rio Caquetá, along Rio Negro-Rio Guainía and along Rio Inírida-Rio Guaviare. The general pattern could be explained in terms of 'cooling ages', relating the ages to a prolonged cooling history of the crustal block subsequent to the Parguazan episode of granitic magmatism and metamorphism. An alternative interpretation is that the mica ages register a distinct thermal (metamorphic) event about 1300 Ma ago, leading to a complete or partial isotopic resetting. The latter interpretation is preferred because a distinct, approximately 1300 Ma old event of resetting of mica ages has also been recognized in other areas of the Guiana Shield. For example, the ages around 1300 Ma characterizing the micas in basement rocks along the eastern margin of the Shield in Guyana and western Suriname are interpreted to reflect an event of low-grade metamorphism, designated as the Nickerie Metamorphic Episode and related to the development of mylonite belts and shear zones (PRIEM ET AL., 1971). An approximately 1300 Ma old event of resetting of mica ages has also been reported from northern Brazil, in the territory south of the Colombian Amazonas region, where it is designated as the Jari-Balsino Episode and related to faulting, development of wide mylonite and cataclastic belts, local metamorphism and intrusion of alkali syenites (DE ALMEIDA ET AL., 1981). The same event of resetting of mica ages has thus also affected the whole shield basement of the Amazonas region in Colombia, but it is unknown whether this resetting was likewise concurrent with phenomena such as shearing, mylonitization, alkali syenitic magmatism, etc.

Three biotites (PRA 1, 31, and 40) display Rb-Sr and/or K-Ar ages considerably lower than 1250 Ma. Presumably, they may be attributed to local effects such as, for example, a nearby dike intrusion, some leaching of radiogenic strontium, etc.

From the Rio Guaviare, two K-Ar biotite ages of about 1210 Ma have been reported previously (PINSON ET AL., 1962). They are included in the histogram of Fig. 7. A number of K-Ar biotite ages and one hornblende age between about 1400 Ma and 1180 Ma has also been determined in Brazil east and south of Mitú (DA SILVA PINHEIRO ET AL., 1976).

The investigated hornblende, from a hornblende-biotite gneiss in Rio Papurí (PRA 45), yields a K-Ar age of about 1450 Ma. This age lies not too far below the Rb-Sr isochron age of 1557 ± 80 Ma yielded by the gneisses from this exposure (Fig. 2), and may be interpreted as approximating the time at which the cooling rock at the end of the Parguazan episode passed through the closure temperature of hornblende to K-Ar (generally taken at about 550-490°C; HART ET AL., 1968; ANDRIESSEN, 1978).

2. *Formación Piraparaná*

Rb-Sr and K-Ar analyses were made on a suite of six samples from the rhyodacitic lavas exposed over an area of about 300 m^2 in the Rio Vaupés at the village of Yaca-Yaca. The Rb-Sr whole-rock data (Table V, Fig. 8) define a crude linear array (MSWD = 4.4). The best-fit line corresponds to an age of 920±90 Ma, but with a high initial $^{87}Sr/^{86}Sr$ ratio of 0.734±0.01 (2σ errors). Sieve fractions (125-250 μm) from the whole-rocks produce K-Ar ages ranging from 795 Ma to 732 Ma (Table VI), averaging 765 Ma.

The high initial $^{87}Sr/^{86}Sr$ ratio could be explained in terms of Sr redistribution due to a metamorphic event about 920 Ma ago, leading to a fairly high degree of Sr isotopic equilibration through the lavas. If so, the extrusion of the lavas must be older: assuming an initial $^{87}Sr/^{86}Sr$ ratio of 0.705, the whole-rock model ages would lie between 1220 Ma and 1110 Ma. However, the Rb-Sr and K-Ar mica systems in the surrounding basement granites do not reflect a metamorphic event about 920 Ma ago. Nor do the sediments of the Formación Piraparaná show any effects of metamorphism; the nature of the rhyodacitic lavas (phenocrysts of potassium feldspar, sericitized oligoclase and quartz embedded in a very fine-grained groundmass largely consisting of altered feldspar) does not allow the recognition of a possible metamorphic reconstitution. It is therefore preferred to interpret the crude linear arrangement of the Rb-Sr data-points as approaching the age of the volcanism. The high initial $^{87}Sr/^{86}Sr$ ratio then indicates a significant involvement of strontium derived from older crustal material. Probably, the rhyodacitic magma has

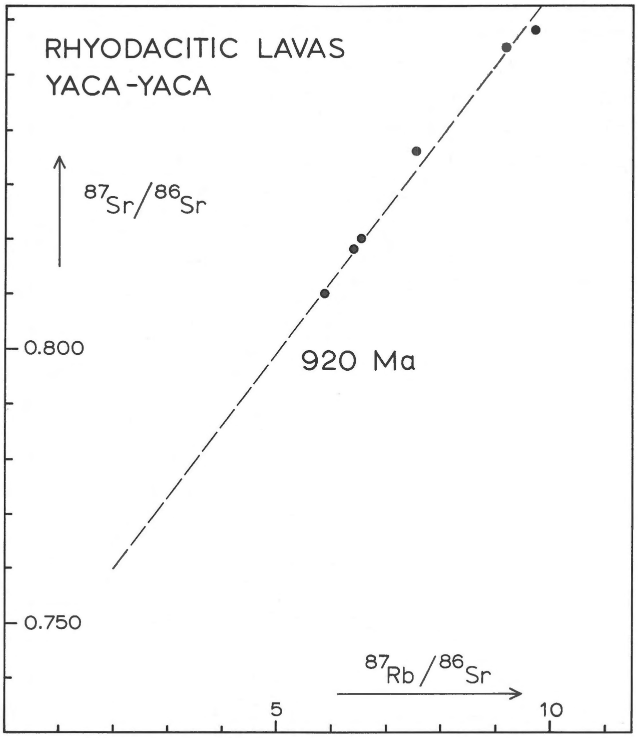

Fig. 8
Plot of Rb-Sr whole-rock data of a suite of rhyodacitic lavas from the Rio Vaupés at the village of Yaca-Yaca (Table V). A best-fit line through the data-points corresponds to an age of 920±90 Ma with $(^{87}Sr/^{86}Sr)_0$ = 0.734±0.01 (2σ).

TABLE V
Rb-Sr whole-rock data from rhyodacitic lavas at Yaca-Yaca, Rio Vaupés

Sample Nr.	Rb* (ppm)	Sr* (ppm)	Rb/Sr* (Wt/Wt)	$^{87}Sr/^{86}Sr$	$^{87}Rb/^{86}Sr$
PRA 5	194	88.8	2.181	0.81829**	6.38
PRA 6	198	98.8	2.003	0.81014	5.85
PRA 7	237	106	2.233	0.82037**	6.53
PRA 8	192	58.1	3.297	0.85828	9.68
PRA 9	225	87.7	2.564	0.83639	7.51
PRA 10	206	66.1	3.118	0.85498**	9.15

* Average of two analyses.
** Average of three analyses.

TABLE VI
K-Ar whole-rock data* from rhyodacitic lavas at Yaca-Yaca, Rio Vaupés

Sample Nr.	K** (% Wt)	radiogenic ^{40}Ar (ppb)	atmospheric ^{40}Ar (% total ^{40}Ar)	Age
PRA 5	4.07	274	4	776
PRA 6	4.13	273	4	766
PRA 7	4.60	318	2	795
PRA 8	4.14	259	3	732
PRA 9	4.40	281	8	745
PRA 10	4.03	269	3	772

* Sieve fractions 125-250 μm.
** Average of two analyses.

been contaminated with strontium derived from the granitic-gneissic basement, which was already at least some 600 Ma old at the time of the volcanism. The scatter of the Rb-Sr data-points about the best-fit line could be explained by a variable addition of contaminant older strontium to subsequent lava flows.

Whether the K-Ar ages have any geological meaning remains a matter of speculation. The rather narrow range in the ages might suggest that they date the expulsion of previously accumulated radiogenic argon, possibly due to a mild thermal event about 750-700 Ma ago. However, a major component of the rock is potassium feldspar, a mineral known for its poor retentivity to radiogenic argon. Loss of radiogenic argon may also have taken place during devitrification of the groundmass. As no other isotopic evidence for an about 750-700 Ma old event is available, it is assumed that the narrow range in K-Ar ages is fortuitous.

3. *Granófiros del Tijereto*

This unit has been named after the exposure of Raudal Tijereto in the Rio Caquetá. The Rb-Sr data of a sample from the granophyric granite at this 'type location' (PRA 52) plot slightly below the 1560 Ma line of the Complejo Migmatítico de Mitú (Table II, Fig. 2). Taking into account the limits of error, it cannot be decided whether this granite should be included in the granitic suites of the Complejo Migmatítico de Mitú, or is significantly younger (model age of the sample: 1495 Ma). The latter interpretation finds support in the intrusive nature of the granophyric granite towards the surrounding gneisses of the Complejo Migmatítico de Mitú. However, a correlation of this granite with the silicic volcanic rocks of the Formación Piraparaná, as suggested by HUGUETT ET AL. (1979), becomes highly unlikely considering the Rb-Sr data.

4. *Diques Diabásicos*

Rb-Sr investigations were made on five samples of mafic rocks (four gabbroic/doleritic and one hybrid rock designated as spessartite) from five intrusions distributed over a distance of some 250 km between Rio Vaupés and Rio Apaporis. All have intruded granites and gneisses of the Complejo Migmatítico de Mitú, but for three intrusions (PRA 13, 38 and 43) the poor exposure of the outcrop makes it impossible to decide whether they represent dikes or larger intrusive bodies. The other two (PRA 39 and 42) are clearly dikes. No isochron relationship is shown by the Rb-Sr whole-rock data-points (Table VII, Fig. 9).

An interpretation of these data remains a matter of speculation. It is possible that the intrusions are genetically unrelated and represent separate episodes of mafic magmatism: assuming an initial $^{87}Sr/^{86}Sr$ ratio of 0.705, the Rb-Sr model ages range from 1590 Ma to 1020 Ma. An alternative interpretation favoured in this paper is that all mafic intrusions are of the same age. If so, the scatter of the data-points may be accounted for by contamination of the intruding magma with varying proportions of strontium derived from the Parguazan granitic-gneissic basement. All samples plot in a zone bounded by lines corresponding to ages of about 1180 Ma and 1225 Ma, which could be interpreted as indicating an intrusion age of about 1200 Ma with initial $^{87}Sr/^{86}Sr$ ranging from about 0.704 to 0.707.

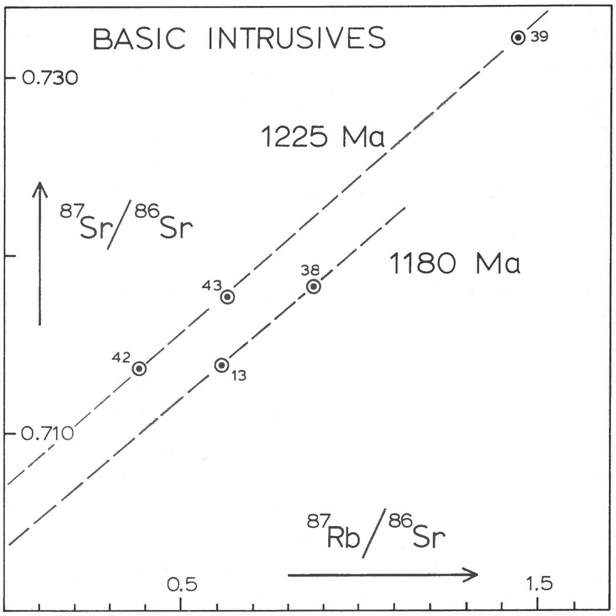

Fig. 9
Plot of Rb-Sr whole-rock data of mafic intrusive rocks (Table VII).

CHRONOLOGY AND CONCLUSIONS

On the basis of the isotopic age data reported in this paper, the following generalized chronology of the Guiana Shield in southeastern Colombia is set up:

1. *Pre-Parguazan (older than about 1560 Ma)*

No distinct ages older than about 1560 Ma have been observed, but many granites and gneisses betray the presence

TABLE VII
Rb-Sr whole-rock data from mafic intrusives

Sample Nr.	Rb* (ppm)	Sr* (ppm)	Rb/Sr* (Wt/Wt)	$^{87}Sr/^{86}Sr$	$^{87}Rb/^{86}Sr$
PRA 13	68.4	327	0.2092	0.71384	0.606
PRA 38	82.7	275	0.3009	0.71831	0.871
PRA 39	103	207	0.4955	0.73221	1.44
PRA 42	30.7	235	0.1307	0.71364	0.378
PRA 43	54.0	251	0.2157	0.71769	0.625

* Average of two analyses.

of older radiogenic strontium. Also, some zircons contain older radiogenic lead, possibly with a minimum age of about 1850 Ma. From the Rb-Sr systematics in the granitic/gneissic basement along the Rio Negro and the Rio Guainía a minimum age of about 1780 Ma may be inferred for the pre-Parguazan basement. The older basement is probably related to the Trans-Amazonian Orogenic Cycle 2100-1800 Ma ago.

2. *Parguazan high-grade metamorphism and granitic magmatism (about 1560-1450 Ma ago)*

U-Pb zircon and Rb-Sr whole-rock studies indicate an age of about 1560 Ma for the granitic magmatism near Mitú and the high-grade metamorphism (gneissification) along the Rio Papurí, an age of about 1480 Ma for the granitic magmatism near Puerto Inírida, and a (maximum) age of about 1450 Ma for the high-grade metamorphism (gneissification, migmatization) along the Rio Negro and the Rio Guainía. The shield basement in the whole region was thus principally formed during a major episode of high-grade metamorphism, migmatization and granitic plutonism between about 1560 Ma and 1450 Ma ago, an episode also recognized in Venezuela and Brazil and designated as the Parguazan tectonomagmatic event. Most of the older, pre-Parguazan age record has been obliterated by isotopic resetting during this episode.

3. *Nickerie Metamorphic Episode (about 1300 Ma ago)*

Biotites and muscovites of the Parguazan granites and gneisses all over the region display younger Rb-Sr and K-Ar ages, clustering between about 1350 Ma and 1250 Ma. These ages are attributed to isotopic resetting due to an event of regional low-grade metamorphism about 1300 Ma ago. The event is also recognized in the eastern and southern Guiana Shield, where it has been designated as the Nickerie Metamorphic Episode and the Jari-Balsino Episode, respectively.

4. *Mafic magmatism (? about 1200 Ma ago)*

The Rb-Sr whole-rock systematics of samples from a number of mafic intrusives are interpreted as registering an age of about 1200 Ma, with initial $^{87}Sr/^{86}Sr$ ranging from about 0.704 to 0.707.

5. *Piraparaná volcanism (about 920 Ma ago)*

The Rb-Sr whole-rock systematics of a suite of rhyodacitic lavas from the Rio Vaupés suggest an extrusion age of about 920 Ma. Rhyodacitic lavas, pyroclastics and sediments of the Formación Piraparaná overlie the shield basement in a narrow, about 250 km long, SSW trending zone south of Mitú.

From the isotopic age data reported in this paper it is thus concluded that the Guiana Shield (which underlies the Amazonas region of Colombia) during its development passed through at least two major orogenic episodes. The first episode can probably be related to the Trans-Amazonian Orogenic Cycle, about 2100-1800 Ma ago. A thorough metamorphic reworking of the Trans-Amazonian basement took place during the Parguazan tectonomagmatic episode about 1560-1450 Ma ago. The formation of the Guiana shield basement results essentially from the high-grade metamorphism and large-scale granitic plutonism in Parguazan time. This stresses again the importance of the Parguazan tectonomagmatic episode in the evolution of the Precambrian crustal nucleus of northern South America (cf. GAUDETTE ET AL., 1978).

The overprinting of mica ages due to the Nickerie Metamorphic Episode extends over a large area, from the Colombian Amazonas region into western Venezuela (HURLEY ET AL., 1973; GAUDETTE ET AL., 1978) and northern Brazil (DA SILVA PINHEIRO ET AL., 1976; DE ALMEIDA ET AL., 1981). Similar overprint ages have been reported from basement rocks underlying the Amazonas basin (KOVACH ET AL., 1976). It seems probable that this area of Nickerie overprint ages links with that of western Suriname and Guyana (PRIEM ET AL., 1971), but to the authors' knowledge no mica age determinations are available at the present from basement rocks between these two widely separated areas. In any case, it can scarcely be doubted that the Nickerie low-grade metamorphism about 1300 Ma ago affected much of the Guiana Shield.

The thorough metamorphic reworking of the whole shield basement in the Colombian Amazonas region between about 1560 Ma and 1450 Ma ago raises doubts about the alleged correlation of the ridges of arenaceous (meta)sediments overlying the basement, designated as the Formación Roraima and the Formación La Pedrera, with the Roraima Formación in Venezuela, Brazil, Guyana, and Suriname. According to HUGUETT ET AL. (1979), both sequences begin with a basal conglomerate overlying the granitic-gneissic basement. These authors also report that pelitic layers in the Formación La Pedrera and the lower part of the Formación Roraima display an incipient very-low-grade (thermal) metamorphism, but that the higher part of the latter sequence is non-metamorphic. This absence of a significant metamorphic resetting is incompatible with the migmatization in the alleged basal conglomerate of the Formación Roraima reported from some places between the Rio Inírida and the Rio Guainía (COGEMA, personal communication); it seems therefore likely that these migmatized conglomerates do not represent the basal conglomerate of the Formación Roraima, but form part of the underlying basement: metaconglomerates, partially migmatized, have been observed at many places in the Complejo Migmatítico de Mitú (HUGUETT ET AL., 1979). The very-low-grade metamorphism or unmetamorphosed nature of the Formación La Pedrera and the Formación Roraima (HUGUETT ET AL., 1979) suggests that it is hardly likely that the sequences should have gone through the Parguazan event of high-grade metamorphism that reconstituted the underlying basement. Both sequences must therefore have been deposited *after* the termination of the Parguazan episode about 1450 Ma ago, when the originally deep-seated Parguazan basement was already brought to the Earth's surface by erosion of the higher-lying crust. The very-low-grade metamorphism is probably related to the Nickerie Metamorphic Episode about 1300 Ma ago, which implies that the sequences were deposited between about 1450 Ma and 1300 Ma ago. If so, this would preclude a correlation of the Formación La Pedrera and the Formación Roraima with the lithologically similar Roraima Formation that overlies the eastern Guiana Shield: the age of this Formation, which was deposited upon a 2000-1800 Ma old, Trans-Amazonian basement, has been established at 1655 ± 18 Ma (PRIEM ET AL., 1973; HEBEDA ET AL., 1973).

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