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On the age of the Late Cretaceous tonalitic/gabbroic batholith on Aruba, Netherlands Antilles (southern Caribbean borderland)

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Abstract

Rb-Sr data of tonalitic whole-rocks and biotites and K-Ar data of hornblendes, biotites and mafic whole-rocks are reported from the crystalline core of Aruba, a remnant of a Late Cretaceous oceanic island arc that collided in the Santonian (between approximately 88 Ma and 83–84 Ma ago) with the passive margin of northern South America. The age data are interpreted to indicate that the intrusion of the composite (tonalite/gabbro) batholith took place 88.5 ± 0.8 Ma ago, in the Coniacian or around the Turonian/Coniacian boundary. This confirms that the intrusion has occurred prior to the collision. The tonalites of the batholith have an initial $^{87}Sr/^{86}Sr$ ratio of 0.70351 ± 0.00014. Thermal events about 72 Ma and possibly about 62 Ma ago have led to some isotopic resetting.

Introduction

Aruba is the easternmost island of the Leeward Netherlands Antilles (Fig. 1) which, along with the Venezuelan islands of the Aruba-Balnquilla island chain, are interpreted as remnants of a late Cretaceous oceanic island arc that collided with the South American continental margin in the Coniacian/Campanian interval (Beets et al., 1984). The crystalline core of the island of Aruba consists of a composite tonalite/gabbro batholith, which is intrusive into a metamorphic sequence of predominantly basic volcanics (Fig. 2). The latter sequence, designated the Diabase-Schist-Tuff Formation by Westermann (1932) and recently renamed the Aruba Lava Formation by Beets et al. (1984), is an approximately 3 km thick, folded and low-grade metamorphic succession of (pillowed) lavas, sills and pyroclastics of basaltic composition with intercalations of volcaniclastic sediments and pelagic cherty limestones (Westermann, 1932; Helmers & Beets, 1977; Beets et al., 1984). Ammonites in

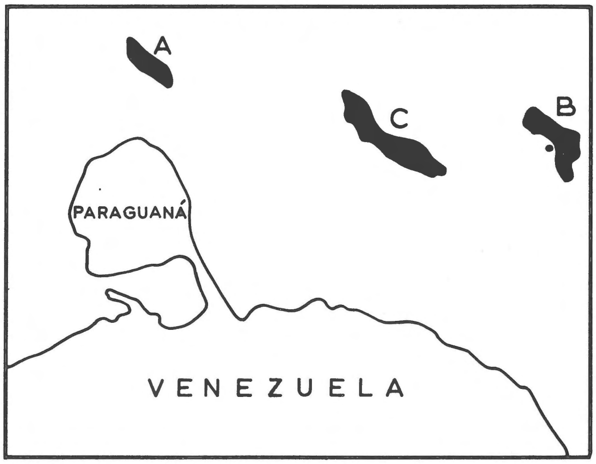

Fig. 1. Location of the leeward islands of the Netherlands Antilles north of the South American continent (scale 1:3,200,000). A, Aruba; B, Bonaire; C, Curaçao.

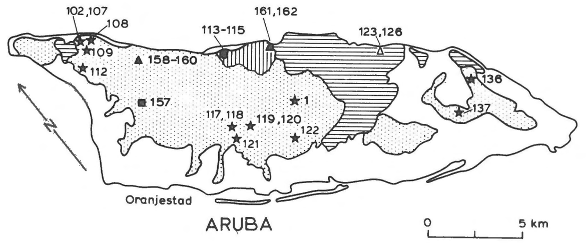

Fig. 2. Simplified geological map of Aruba (after Westermann, 1932, and Beets & Helmers, 1977). Horizontal shading, Aruba Lava Formation; vertical shading, Matividiri (quartz) norite to quartz-hornblende gabbro; stippled, tonalite; blanc areas, Late Tertiary and Quaternary deposits (mainly coral reefs). The figures 1 and 102 through 157 refer to the sample numbers ARU 1 and ANT 102 through 157 (Table 1). Open triangle, diabase; closed circle, Matividiri quartz-hornblende gabbro; closed triangle, semi-lamprophyric dike; asterisk, tonalite; square, pegmatite.

sedimentary intercalations indicate a Turonian age for the Formation (Mac Donald, 1968; J. Wiedman in Beets et al., 1984). The metamorphism is attributed to the heating by the intruding batholith and ranges from hornblende-hornfels facies at the contact to prehnite-quartz facies at a distance of about 4 km from the contact (Helmers & Beets, 1977; Beets et al., 1984). The composite batholith is constituted by hornblende tonalite with schlieren of trondhjemite and granitic pegmatite, minor masses of melatonalite (hooibergite), and roof pendants of a slightly older intrusion of (quartz) norite to quartz-hornblende gabbro (Westermann, 1932; Helmers, 1977; Helmers & Beets, 1977; Beets et al., 1984). Mafic dikes (semi-lamprophyres and (quartz) diorite porphyres) are intrusive into the Aruba Lava Formation, the (quartz) norite to quartz-hornblende gabbro, and the tonalite; they are thought to the associated with the tonalitic magma (Helmers & Beets, 1977). Both the Aruba Lava Formation and the composite batholith are unconformably overlain by Eocene limestones (Beets et al., 1984).

The stratigraphic age of the batholith intrusion lies thus in the Turonian-Eocene time interval. Previous isotopic dating of whole-rocks and separated biotites from tonalitic rocks of the batholith by the Z.W.O. Laboratory of Isotope Geology, Amsterdam (Priem et al., 1966, 1977a, 1978) was inconclusive for the whole-rock analyses because of the low Rb/Sr ratios (eleven samples, isochron age 79 ± 42 Ma, error 95% confidence level). The biotites reveal two ages, however, about 85 Ma for the northwestern part (two biotites, both Rb-Sr) and about 72 Ma for the central part of the batholith (three biotites, all Rb-Sr and one also K-Ar). These two distinct ages were tentatively interpreted in terms of an episodic intrusion of the batholith (Priem et al., 1978), although this solution was considered not very satisfactory in view of the geological relationships, such as the close association and similarity of all the investigated tonalitic samples.

Since the completion of the studies mentioned above, the following additional age data have been obtained:

1. K-Ar data of the biotites previously only dated by the Rb-Sr method,
2. K-Ar data of four hornblendes from tonalites in different parts of the batholith, and of three hornblendes from the Matividiri quartz-hornblende gabbro, and
3. K-Ar data of whole-rocks (sieve fractions $+125-250\,\mu$m) of semi-lamprophyric dikes (five samples), the Matividiri quartz-hornblende gabbro (three samples), and diabases of the Aruba Lava Formation (two samples).

These data are reported and discussed in the present paper, along with the previously reported Rb-Sr and K-Ar biotite ages (Priem et al., 1966, 1978), Rb-Sr whole-rock data (Priem et al., 1977a, 1978) and Rb-Sr data of a granitic pegmatite (note added in the proof of Priem et al., 1978).

Experimental procedures and constants

Biotites and hornblendes were separated and purified by means of a laboratory overflow-centrifuge using stabilized heavy liquids (IJlst, 1973a, 1973b), and magnetic separation. 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
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the Compton scattering of the Mo-Kα primary beam (Verdurmen, 1977). For the biotites the Rb and Sr contents were determined by isotope dilution. The isotopic composition of Sr was measured directly on unspiked Sr for the whole-rocks and calculated from the isotope dilution analyses for the biotites. All Rb and Sr isotope analyses were made on a computer-controlled Varian CH5 mass-spectrometer with Faraday cage collector and digital output, except for the biotite data ARU 1 which represent older analyses with less precise equipment. 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 Varian GD-150 mass-spectrometer, except for the data of ARU 1 which represent older analyses with a Reynolds-type glass apparatus.

Analytical uncertainties are estimated to be within 1.0% for XRF Rb/Sr, 1.0% for isotope dilution Rb and Sr (2.0% for ARU 1), 0.05% for $^{87}Sr/^{86}Sr$ (0.2% for ARU 1), 1.0% for K, and 3.0% for radiogenic ^{40}Ar (4.0% for ARU 1). 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 Rb-Sr data-points were calculated by means of a least-squares regression analysis according to York (1966, 1967). Errors in the isochron ages and initial $^{87}Sr/^{86}Sr$ ratios are given at the 95% confidence level. The age calculations are based upon the constants $\lambda^{87}Rb = 1.42.10^{-11}a^{-1}$, $\lambda_e{}^{40}K = 0.581.10^{-10}a^{-1}$, $\lambda_\beta{}^{40}K = 4.962.10^{-10}a^{-1}$ and abundance $^{40}K = 0.01167$ atom percent total K.

Results and discussion

The locations of the investigated samples are shown on the map of Fig. 2 and listed in Table 1, along with the nature of the rocks. All isotopic data presently available from the Cretaceous crystalline core of Aruba are listed in Tables 2, 3 and 4; these data include those reported previously (all Rb-Sr and one biotite K-Ar, Priem et al., 1966, 1977a, 1978) and the new K-Ar data.

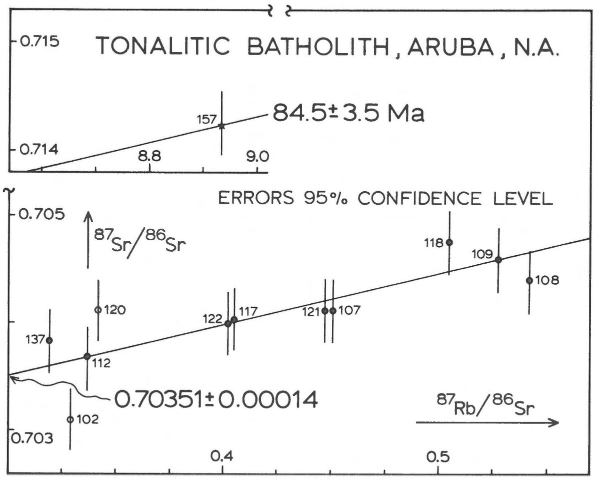

Fig. 3. Isochron plot of the whole-rock Rb-Sr data. Circle, tonalite; asterisk, pegmatite. The figures refer to the sample numbers ANT 102 through 157. Open circles, samples omitted from the isochron calculation.

The K-Ar ages of all biotites agree with the corresponding Rb-Sr ages, which confirms the age difference of some 15 Ma between the biotites in the northwestern part of the batholith and those in the central part. However, four hornblendes from tonalitic rocks all over the batholith (one in the northwestern, one in the central and two in the southeastern part), as well as two hornblendes from the Matividiri gabbro, have rather consistent K-Ar ages similar to the older Rb-Sr and K-Ar biotite ages in the northwestern part. This rules out an interpretation of the difference in biotite ages between the northwestern and central part of the batholith in terms of an episodic intrusion of the tonalitic magma, as suggested by Priem et al. (1978).

Age of the tonalitic/gabbroic batholith intrusion

As has already been noted, the eleven Rb-Sr whole-rock data of the tonalite define an inconclusive isochron of 79 ± 42 Ma with initial $^{87}Sr/^{86}Sr = 0.7035 \pm 0.0003$ (MSWD = 0.60). Inclusion of the pegmatite sample ANT 157 in the calculation results in an essentially 'two-point isochron' of eleven tonalites on the one side and one pegmatite on the

Table 1. Investigated samples.

Sample Nr.	Nature	Location (see map Fig. 1)
ARU 1	quartz-hornblende-biotite tonalite	Ceru Compa, N of Urataka
ANT 102	quartz-hornblende-biotite tonalite	Ceru Muskita
ANT 107	porphyric quartz-diorite dike in main tonalitic mass	Ceru Muskita
ANT 108	quartz-biotite tonalite	Ceru Grandi
ANT 109	quartz-tonalite dike in main tonalitic mass	Ceru Tres Cabes
ANT 112	quartz tonalite	Rooi Santu
ANT 113, 114, 115	quartz-hornblende gabbro	Matividiri
ANT 117, 118	quartz tonalite	W of Hooiberg
ANT 119	hooibergite	Hooiberg
ANT 120	quartz-hornblende-biotite tonalite	Hooiberg
ANT 121	aplitic vein in hooibergite	S of Hooiberg
ANT 122	quartz-biotite tonalite	Macuarima
ANT 123, 126	diabase	Dos Playa
ANT 136	quartz-hornblende tonalite	W of Rincon
ANT 137	quartz-hornblende tonalite	Ceru Blanco, north of San Nicolas
ANT 157	granitic pegmatite	NE of Noord
ANT 158, 159, 160	semi-lamprophyric dikes in quartz tonalite	Altovista
ANT 161, 162	semi-lamprophyric dikes in Matividiri gabbro	Andicouri

Table 2. Rb-Sr whole-rock data.

Sample Nr.	Rb[1] (ppm Wt)	Sr[1] (ppm Wt)	Rb/Sr[1]	^{87}Sr/^{86}Sr[2]	^{87}Rb/^{86}Sr
Ant 102	18.0	444	0.0405	0.70298	0.1171
				0.70321	
ANT 107	52.3	250	0.2098	0.70414	0.6074
ANT 108	54.3	162	0.3356	0.70440	0.9716
ANT 109	55.5	176	0.3163	0.70460	0.9158
ANT 112	15.4	299	0.0516	0.70367	0.1494
	15.7[+]				
ANT 117	28.8	196	0.1466	0.70404	0.4244
ANT 118	44.9	158	0.2848	0.70476	0.8246
ANT 120	15.6	271	0.0575	0.70411	0.1663
	15.6[+]				
ANT 121	13.6	66.3	0.2050	0.70413	0.5935
ANT 122	26.5	186	0.1422	0.70400	0.4117
ANT 137	6.06	220	0.0276	0.70383	0.0799
	6.08[+]				
ANT 157	143	46.3	3.0860	0.71426	8.934

[1] X-ray fluorescence spectrometric data, except for the figures marked [+] which were obtained by isotope dilution analysis.

[2] Direct measurement on unspiked sample.

Table 3. Rb-Sr biotite data and ages.

Sample Nr.	Rb[1] (ppm Wt)	Sr[1] (ppm Wt)	^{87}Sr/^{86}Sr[2]	^{87}Rb/^{86}Sr	Age[3] (Ma)
ARU 1	305	10.9	0.7884	81.59	72.8 ± 4.3
ANT 102	214	6.95	0.81157	89.84	85.2 ± 2.0
	212	7.02	0.80964	88.18	
	213	7.00	0.81132	89.05	
ANT 108	352	3.62	1.0584	291.7	85.3 ± 1.9
	354	3.61	1.0582	294.0	
ANT 120	175	15.4	0.73833	32.84	73.9 ± 2.3
	174	14.7	0.74029	34.47	
ANT 122	294	6.19	0.83959	139.3	68.8 ± 1.6
	294	6.21	0.83956	138.9	

[1] Isotope dilution.

[2] Calculated from isotope dilution run.

[3] Calculated with respect to the corresponding whole-rock sample, except for ARU 1 for which an initial ^{87}Sr/^{86}Sr ratio of 0.704 is assumed. Errors based upon estimated errors of 1.0% in Rb and Sr and 0.05% in ^{87}Sr/^{86}Sr, except for the older analyses ARU 1 for which the estimated errors are 2.0% and 0.2%, respectively.

other side. If the slightly deviating samples ANT 102 and 120 are omitted, the 'two-point isochron' becomes 84.5 ± 3.5 Ma with initial ^{87}Sr/^{86}Sr = 0.70351 ± 0.00014 (MSWD = 0.22).

The hornblende K-Ar ages of four tonalites all over the batholith (ANT 102, 119, 136, 137) and of two out of three dated samples from the Matividiri quartz-hornblende gabbro (ANT 113, 114), as well as the biotite K-Ar and Rb-Sr ages of two tonalites from the northwestern part of the batholith (ANT 102, 108), all lie in the range 83.5 – 89.5 Ma. Two of the corresponding whole-rocks of the Matividiri gabbro (ANT 113, 115) have slightly lower K-Ar ages of 81.3 and 83.0 Ma, respectively, but the third gabbro sample (ANT 114) and all dated diabases (ANT 123, 126) and mafic dikes (ANT 158, 159, 160, 161, 162) have much lower whole-rock K-Ar ages, between 62.0 and 78.1 Ma. Biotites of three tonalites in the central part of the batholith (ARU 1, ANT 120, 122) also have K-Ar and Rb-Sr ages in this lower range, whereas the third dated hornblende from the Matividiri gabbro (ANT 115) has a much higher K-Ar age of 129 Ma.

Except for the whole-rock K-Ar ages, three biotite ages, and one hornblende age, all age data of the batholith are thus rather consistent:

tonalites-pegmatite Rb-Sr 'two-point isochron'	84.5 ± 3.5 Ma
biotite Rb-Sr ages NW part tonalitic mass	85.2, 85.3 Ma
idem, corresponding K-Ar ages	87.6, 88.0 Ma
hornblende K-Ar ages all over the tonalitic part of the batholith	89.5, 89.2, 83.5, 85.0 Ma
hornblende K-Ar ages Matividiri gabbro,	83.7, 88.0 Ma

Taking into account the error limits, one could average the eleven age data to an age of 86.5 ± 2.2 Ma. When related to the current numerical time-scales of the Late Cretaceous (Table 5), this age falls in the (Early) Santonian or around the Coniacian/Santonian boundary. However, the eleven values do not show a Gaussian distribution, as there is a concentration at the higher end of the range. Moreover, there is evidence for younger isotopic resetting (see next paragraph), so the lower age data in the above list may also very well reflect some resetting. The best approximation of the intrusion age of the batholith is therefore probably given by the highest five hornblende and biotite ages, averaging 88.5 ± 0.8 Ma (Coniacian or around the Turonian/Coniacian boundary, Table 5).

According to Beets et al. (1984) the Matividiri

Table 4. K-Ar data and ages.

Sample Nr.[1]	K (% Wt)	radiogenic ^{40}Ar (ppm Wt) × 10^3	atmospheric ^{40}Ar (% total ^{40}Ar)	Age[2] (Ma)
ARU 1 bio	6.41			
	6.41	34.6		
		32.9	7	74.2 ± 3.0
			10	
ANT 102 bio	6.50	40.6	14	87.6 ± 3.5
	6.54			
ANT 102 hbl	0.327	2.06	39	89.5 ± 3.6
	0.322			
ANT 108 bio	7.16	44.8	14	88.0 ± 3.5
	7.18			
ANT 113 WR	0.205	1.19	66	81.3 ± 3.3
	0.207			
ANT 113 hbl	0.249	1.47	43	83.7 ± 3.4
	0.247			
ANT 114 WR	0.248	1.13	50	75.9 ± 3.0
	0.248			
ANT 114 hbl	0.386	2.41	29	88.0 ± 3.5
	0.386			
ANT 115 WR	0.247	1.46	53	83.0 ± 3.3
	0.250			
ANT 115 hbl	0.454	4.21	28	129.0 ± 5.2
	0.454			
ANT 119 hbl	0.222	1.41	53	89.2 ± 3.6
	0.223			
ANT 120 bio	6.85	35.5	15	73.0 ± 2.9
	6.91			
ANT 122 bio	6.88	34.1	19	70.7 ± 2.3
	6.77			
ANT 123 WR	0.181	0.989	70	78.1 ± 2.3
	0.181	1.015	73	
ANT 126 WR	0.756	3.26	53	62.0 ± 1.9
	0.756	3.35	53	
ANT 136 hbl	0.128	0.761	66	83.5 ± 3.3
	0.129			
ANT 137 hbl	0.144	0.875	59	85.0 ± 3.4
	0.146			
ANT 158 WR	0.412	2.09	36	71.6 ± 2.9
	0.413			
ANT 159 WR	0.428	2.13	37	70.1 ± 2.8
	0.430			
ANT 160 WR	0.401	1.99	43	70.1 ± 2.8
	0.403			
ANT 161 WR	0.583	2.73	47	66.2 ± 2.7
	0.584			
ANT 162 WR	0.311	1.50	60	68.3 ± 2.7
	0.311			

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[1] WR, sieve fraction (+125 − 250 μm) of the whole-rock; bio, biotite; hbl, hornblende.

[2] Errors based upon estimated errors of 1.0% in K and 2.0% (duplicate analysis) or 3.0% (single analysis) in radiogenic Ar. For ARU 1 the error in the mean value of the duplicate radiogenic Ar analysis is estimated at 3.0%.

Table 5. Current numerical time-scales of the Late Cretaceous.

Stage boundaries	Age (Ma)		
	Obradovich & Cobban (1975)[1]	Odin & Kennedy (1982)	Harland et al. (1982)
Maastrichtian/Tertiary	66–67	65	65.0
Campanian/Maastrichtian	72–73	72 ± 1	73.0
Santonian/Campanian	84 ±	83 ± 1	83.0
Coniacian/Santonian	88 ±	(86)	87.5
Turonian/Coniacian	89 ±	88 ± 1	88.5
Cenomanian/Turonian	91–92	91	91.0
Albian/Cenomanian	96 ±	95 ± 1	97.5

[1] Recalculated with the potassium constants used in this paper and the other time-scales.

quartz-hornblende gabbro represents a separate intrusion, only slightly older than the tonalite in which it now occurs as roof pendants. The age of 129 Ma displayed by hornblende ANT 115 has therefore to be interpreted as a case of excess radiogenic Ar.

Younger ages

Three biotites from the central part of the batholith and all whole-rocks of mafic rocks display lower Rb-Sr and/or K-Ar ages, ranging from 83.0 down to 62.0 Ma. The three younger biotites (ARU 1, ANT 120, 122) have, except for the somewhat lower Rb-Sr age of 68.8 Ma of ANT 122, fairly consistent Rb-Sr and K-Ar ages in the range 70.7–74.2 Ma. This range is some 14–18 Ma younger than the best approximation of the intrusion age of the batholith and is therefore interpreted to reflect a (nearly) complete resetting of the Rb-Sr and K-Ar systems. The two dated diabase samples (ANT 123, 126) are from the Aruba Lava Formation with a Turonian (between about 92 and 89 Ma, Table 5) paleontological age, so it is clear that the whole-rock K-Ar ages of 78.1 Ma and 62.0 Ma also reflect (partial) resetting. The semi-lamprophyric dikes intrusive into the tonalitic mass (ANT 158, 159, 160) and the Matividiri gabbro (ANT 161, 162) have whole-rock K-Ar ages of 70.1–71.6 Ma and 66.2–68.3 Ma, respectively, younger than the 88.5 ± 0.8 Ma old country rock. However, Helmers & Beets (1977) have demonstrated on the basis of various field observations (for example, the occurrence of angular fragments of dike rock in the tonalite, and the gradation of the dikes in the direction of the strike into a magmatic breccia) that the intrusion of the semi-lamprophyric dikes was related to the tonalitic magmatism, so the ages of the dike rocks have likewise to be interpreted in terms of (partial) resetting of the whole-rock K-Ar systems.

The consistency of the younger biotite ages in the central part of the batholith at about 71–74 Ma indicates that resetting took place about 72 Ma ago, probably in relation to an episode of increased ambient temperature. During the thermal event the temperature in this part of the crust must have reached the level at which the biotite Rb-Sr and K-Ar systems are reset completely, i.e. a temperature of the order of 400° C (Verschure et al., 1980), whereas a lower temperature prevailed in the northwestern part of the batholith where the biotite ages have not been affected. The whole-rock K-Ar systems of the semi-lamprophyric dikes in the tonalitic mass apparently were also completely reset during the 72 Ma old event, but several other mafic whole-rocks and probably also a number of hornblendes display K-Ar ages intermediate between about 72 Ma and the intrusion age of the batholith, taken at 88.5 ± 0.8 Ma. These intermediate ages can be attributed to varying degrees of partial resetting of the K-Ar system.

The ages below about 72 Ma (mafic whole-rocks K-Ar and one biotite Rb-Sr) may be interpreted to reflect varying degrees of isotopic resetting during another, younger event of crustal heating. Possibly, the time of this event is approximated by the youngest observed age, the whole-rock K-Ar age of 62.0 ± 1.9 Ma of diabase sample ANT 126. In this respect it may be significant that evidence for a weak thermal event 61 ± 4 Ma ago has been found on Bonaire (Priem et al., 1979) another island of the island chain of the Leeward Netherlands Antilles some 200 km ESE of Aruba (Fig. 1), while K-Ar whole-rock ages at about 70–72 Ma and ranging down to about 60 Ma have also been measured on igneous rocks on the neighbouring island of Curaçao (Priem et al., 1977b.; unpublished data ZWO Laboratory of Isotope Geology, Amsterdam). In connection herewith it should be noted that until the Early Tertiary the island chain along the north coast of Venezuela presumably still formed a coherent unit, before the development of the pullapart extensional regime in the Tertiary (Muessig, 1984).

Tectonic implications

According to Maresch (1974) and Beets et al. (1984) the late Cretaceous evolution of the Caribbean-South American plate boundary was dominated by the collision of an oceanic island arc with the passive margin of northern South America. A full discussion of the timing of the collisional event at the site of the Leeward Netherlands Antilles is given by Beets et al. (1984), on the basis of a detailed stratigraphy of the islands. The youngest pre-collision, oceanic island-arc volcanic rocks are found on Bonaire and are dated as Coniacian on the basis of faunas of inoceramids (E.G. Kauffman in Beets et al., 1977) and foraminifera (Smit, 1977) in cherty limestones intercalated in the uppermost part of the Washikemba Formation. The oldest post-collision sediments overlying the oceanic island-arc volcanic sequence are limestones on Curaçao deposited directly upon the Curaçao Lava Formation and containing a rudist fauna of late Santonian to Campanian age (Beets, 1972). From these relationships Beets et al. (1984) infer that the collision has taken place in the Santonian, between approximately 88 Ma and 83–84 Ma ago (Table 5).

From the low initial $^{87}Sr/^{86}Sr$ ratio (0.70351 ± 0.00014, this paper), which suggests a mantle or lower-crustal origin of the magma, and, in particular, from paleomagnetic evidence, Beets et al. (1984) concluded that the batholith intrusion occurred in the oceanic island arc prior to the collision with the South American plate boundary. The paleomagnetic data of the batholith (Stearns et al., 1982) indicate an about 90° clockwise rotation since its emplacement. As similar anomalous easterly declinations are also reported from the Mesozoic volcanics on the other islands along the north coast of Venezuela and from the allochthonous Vila de Cura Group (interpreted as an overthrust remnant derived from the same island-arc environment as the Leeward Netherlands Antilles, Beets et al., 1984) in the Caribbean Mountain System of northern Venezuela (Skerlec & Hargraves, 1980; Stearns et al., 1982), a megatectonic clockwise rotation with regard to stable South America is apparent. According to Skerlec & Hargraves (1980) and Beets et al. (1984) such a rotation can be expected if an originally N–S oriented island arc were to move into the Caribbean and collide with the northern margin of South America. An alternative explanation, suggested by Burke et al. (1984), relates the rotation to complex strike-slip movements along the southern Caribbean margin over the last 38 Ma. However, such an explanation is unlikely in view of the N90–N135 strike of the fold planes in the Mesozoic rocks of the Leeward Netherlands Antilles (Beets, 1972), while it is not applicable to the Vila de Cura Group volcanics, as these are overlain by non-rotated Paleocene rocks (Skerlec & Hargraves, 1980).

The age of 88.5 ± 0.8 Ma taken as the best approximation for the time of intrusion of the tonalitic/gabbroic batholith on Aruba is another argument for a pre-collision emplacement, as the collision is inferred to have taken place between approximately 88 Ma and 83–84 Ma ago. The calc-alkaline island-arc magmatism leading to the intrusion of the batholith followed thus shortly after the termination of the basaltic magmatism (with MORB-affinity, Beets et al., 1984) giving rise to the volcanic sequences of the Turonian Aruba Lava Formation.

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