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LATE CRETACEOUS AGE BASED ON K/Ar DATES OF GRANITIC ROCK FROM THE TAMBELAN AND BUNGURAN ISLANDS, SUNDA SHELF, INDONESIA

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SUMMARY

K/Ar determination on two adamellites from the Tambelan and Bunguran Islands, on the Sunda Shelf between the Malay Peninsula and Borneo, indicate that these are pre-Tertiary, probably Late Cretaceous. Rb-Sr determinations on the rock from Bunguran Island, and a third granitic rock from Tambelan Island, are not definitive, but are consistent with a Late Cretaceous age for the intrusion of the granitic rocks. These determinations, the first age indications from the Tambelan and Bunguran Islands, throw doubt on the supposed "pre-Upper Triassic" age of the acid batholiths in the Anambas Zone of the Sunda Shelf and its extension into West Borneo.

INTRODUCTION AND OUTLINE OF GEOLOGY

The Tambelan and Bunguran (Natuna) Islands lie on the Sunda Shelf north and northwest of Borneo. Before 1969 nothing was known of the geology of the Tambelan Islands, and knowledge of the geology of the Bunguran Islands was limited to papers by Bothé (1925; 1928a and b) which were based on observations made and specimens collected by mining engineers prospecting for useful minerals in 1916-18. During April 1969, the first of us was able to visit the Tambelan and Natuna Islands for a total of five days while directing a UNESCO/ECAFE Shipboard training course in Marine Geology and Geophysics, on board the Indonesian research vessel R/I JALANIDHI. During this short visit a reconnaissance of some of the islands was made, and samples collected for radiometric dating. The determinations were made by the second of us.

A summary of what is known of the geology of the Anambas and Bunguran Islands is shown on table 1, and a fuller account has been given by the first author (Haile, 1970). The Tambelan Islands are composed of intermediate and basic igneous rocks, intruded by granite, which is itself cut by dykes of basaltic and andesitic composition. The only evidence of the age of the rocks is the radiometric determinations on the granite described here.

The granitic rocks on the Tambelan Islands include normal fine to coarse biotite granite, which is exposed at the south end of Tambelan Island and on Benua Island, and alkali leucogranite, alkali microgranite, and granophyric granite porphyry.

Specimen UM6143, from the west side of Pulau Benua in the Tambelan Islands (Lat. 0° 56.60′N. Long. 107° 26.18′E.) is a normal fine-grained biotite adamellite, grain size about 1-2 mm, composed of microperthite, plagioclase (oligoclase-andesine, with oscillatory zoning), brown biotite (mainly fresh, some partly altered to chlorite), and a little apatite, monazite, and magnetite. A modal analysis (6000 points counted) indicated the following composition (volume percent):

Quartz	28	Biotite	3
Microperthite	31	Magnetite	<0.6
Plagioclase	37	Apatite, monazite	<0.5

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Specimen UM6125, from Kampong Melayu, Tambelan Bay, Tambelan Island (Lat. 0° 59.8′N., Long. 107° 34.65′E.) is a light brownish-gray alkali leucogranite, composed of predominant microperthite as turbid anhedral crystals, abundant quartz, and less common oligoclase with strong oscillatory zoning. Brownish-green biotite is rather sparse. Magnetite and/or ilmenite, zircon, and ? epidote are present as accessory minerals.

The Bunguran Islands (formerly known as the Natuna Islands) are composed of the intensely folded Mesozoic Bunguran beds comprising chert, tuff, and metasediments, associated with serpentinite, gabbro and dolerite, which on Bunguran Island are intruded by granite, the largest intrusion being that forming Mount Ranai (Ranai granite). The northern part of Bunguran Island is composed of Natuna sandstone, which comprises flat-lying thick bedded and cross-bedded sandstone and conglomerate, which unconformably overlies the Bunguran beds, and is most likely younger than the Ranai granite, and so probably of Tertiary age.

The specimen dated (UM6156) came from a 5-metre core boulder, one of many near the coast on the north side of Senubing Cape (Tanjong Senubing), the eastern end of Mount Ranai, at Lat. 3° 58.2′N., Long. 108° 23.8′E.

The rock is a medium to coarse biotite-muscovite adamellite. The texture is hypidiomorphic granular, with an average grain size of about 3 mm. Plagioclase (andesine or oligoclase-andesine with strong oscillatory zoning) is present as almost two-thirds of total feldspar, so the rock is on the borderline between an adamellite and a granodiorite. Quartz, orthoclase, biotite (partly altered to chlorite), primary muscovite, (less common than the biotite) occur with accessory apatite and some secondary white mica associated with patches of a pale yellowish mineral which might be halloysite.

GEOCHRONOLOGY

Isotope ratio determinations and K/Ar age determinations are shown in table 2. The K/Ar datings set a younger limit for the ages of the granites of Late Cretaceous, the Cretaceous being dated as about 135-65 m.y. (Harland et al., 1964). The Rb-Sr determinations are not definitive, but point both to a low initial $^{87}Sr/^{86}Sr$ ratio and to an intrusive age of about Middle to Late Cretaceous. Assuming the low initial $^{87}Sr/^{86}Sr$ ratio of 0.704 (usual range for this ratio in granites is 0.703-0.710) then the data would indicate apparent ages of 99 ± 30 m.y. for UM6125 and 114 ± 25 m.y. for UM6156 ($\lambda\beta^{87}Rb = 1.47 \times 10^{-11}\ yr^{-1}$). If the granite were Late Triassic in age (about 200 m.y.) then present day $^{87}Sr/^{86}Sr$ ratios of 0.716 for UM6125 and 0.722 for UM6156 would

TABLE 1

Summary of the geology of the Tambelan and Bunguran Islands

Tambelan Islands	Bunguran Islands
Basaltic and andesitic dykes (Cainozoic)	*Natuna sandstone* (Tertiary) Immature, sandstone and conglomerate; gently dipping. Probably continental. Thickness > 1000 m
Granite (Late Cretaceous; 84 m.y.)	*Ranai granite* (Late Cretaceous; 73 m.y.)
(No pre-granite sedimentary rocks known)	*Bunguran beds* (Mesozoic; probably Jurassic to Early Cretaceous) chert, tuff, metasediments; intensely folded.
Gabbro, diorite, dolerite, andesite, keratophyre; mostly metamorphosed (Mesozoic or older)	Serpentinite, gabbro and dolerite; may be an ophiolitic suite associated with the Bunguran beds.

TABLE 2

Isotope determinations on granitic rocks from the Tambelan and Bunguran Islands

Sample No.	Field No.	Locality	Material analysed	K percent	Radiogenic ^{40}Ar ppm	Age
UM 6143	JN 9.19	Pulau Benua, Tambelan Island	Biotite	4.01	·02447	84 ± 2 m.y.
UM 6156	JN 15.4	Tanjong Senubing Bunguran Island	Biotite	6.46	·03408	73 ± 2 m.y.

Sample No.	Field No.	Locality	Material analysed	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$ present
UM 6156	JN 15.4	Tanjong Senubing Bunguran Island	Whole rock	236	114	5.98	·714
UM 6125	JN 9.1	Kampong Melayu, Tambelan Island	Whole rock	157	111	4.09	·710

Constants for ^{40}K

$\lambda_\beta = 4.72 \times 10^{-10} yr^{-1}$ $\lambda_e = 0.584 \times 10^{-10} yr^{-1}$ $^{40}K/K = 0.0119$ at. percent

be required, assuming an initial ratio of 0.704. The Rb-Sr data may therefore be taken as tentatively supporting a Late Cretaceous date for the intrusion of both granites.

DISCUSSION

The Tambelan Islands fall within the so-called Anambas Zone of the Anambas Mountain System of van Bemmelen, which extends in an arc from north of the Anambas Islands southeast through Tambelan and east into his Schwaner Subzone of the Basement Complex, or Zone C_2 of West Kalimantan (van Bemmelen, 1949, figs. 126, 130). This zonation was made with only a very general knowledge of the geology of West Borneo and the Anambas Islands and none of the Tambelan Islands; and to this day there is not a single determinative fossil or radiometric age determination from either the Anambas Islands, or the adjacent part of West Kalimantan (Borneo). Van Bemmelen considered that post-Triassic intrusions were absent from the Anambas Zone (op. cit. p. 335, table 79). The determination recorded here disproves this view, and also casts doubt on the supposed "pre-Upper Triassic" age, postulated for acid batholiths of that part of west Borneo lying on the extension of the Anambas Zone. It seems probable that at least some of these granitic rocks are Mesozoic in age, and that Triassic and older rocks are of much smaller extent than presently supposed.

The Bunguran Islands show a fairly close resemblance in geology to extreme West Sarawak, particularly the Tanjong Datu area of the Lundu District (see Wolfenden and Haile, 1963). The radiolarian chert of the Bunguran beds finds its counterpart in similar chert in the Serabang Formation of West Sarawak, although the Serabang chert is only a minor component of a predominantly clastic, flysch, sequence. Both the Bunguran beds and the Serabang Formation contain interbedded volcanic rocks, and metamorphosed basic and ultrabasic igneous rocks. The Serabang Formation is pre-Campanian, probably Jurassic and/or Cretaceous.

Van Bemmelen (1949, p. 225, 303) correlates the Bunguran beds with the Danau Formation of Borneo, which was supposed by him to be of Carboniferous-Permian age; however, the attribution of a Carboniferous-Permian age to the Danau Formation was later questioned, and the formation shown to be at least in part Cretaceous (see Haile, 1957). There is thus no justification for attributing a Carboniferous-Permian age to the Bunguran beds; the most that can be said, on the evidence of the identified Radiolaria, and on regional grounds, is that they are probably Mesozoic, possibly Jurassic or

Early Cretaceous.

The granite (adamellite) forming Gunong Ranai at Bunguran resembles rather closely that intruded into the Serabang Formation in West Sarawak at Tanjong Datu, Gunong Pueh, and Gunong Gading, which has been dated radiometrically as Late Cretaceous (70-80 m.y.), i.e. of the same general age as is indicated here for the Ranai adamellite (see Wolfenden and Haile, 1963, p. 80-85). However, cassiterite, recorded on Bunguran, has not been found in Sarawak. The Natuna sandstone, in its general aspect of a sequence of coarse, thick-bedded, cross-bedded, gently to moderately folded probably continental sandstone with basal conglomerate, resembles sandstone in west Sarawak assigned to the Plateau Group, of Late Cretaceous to Early Tertiary age.

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