CONCLUSÕES Como as reservas do depósito, mesmo inferidas, mostram-se relativamente pequenas, gostaríamos de lembrar alguns outros pontos que sem dúvida merecerão uma atenção especial no esclarecimento real do potencial econômico da ocorrência:

1. a distância rodoviária, relativamente grande, dos centros consumidores mais próximos: São Paulo a 1 200 quilômetros e Belo Horizonte a 1 400 quilômetros;

2. o estudo comparativo dos resultados das análises disponíveis com as que estão sendo feitas;

3. a possibilidade de uma associação com os metais do grupo da Platina.

Quanto ao item 3, algumas análises preliminares, feitas nos laboratórios do U. S. G. S., revelaram, semiquantitativamente, a presença de metais do grupo da Platina. Com isso, é possível que, na dependência dos teores e da definição do modo de ocorrência dos metais nesta associação, possa haver, a partir do minério de cromo, uma recuperação econômica de um subproduto platinífero, caso aquêle seja utilizado para fins químicos.

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GEOCHRONOLOGY OF EASTERN PARAGUAY BY THE POTASSIUM-ARGON METHOD

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ABSTRACT This note presents the results of 22 K-Ar analyses on 17 rock samples from several magmatic and metamorphic units of Eastern Paraguay.

The Precambrian in the Rio Apa region is an extension of the Guaporé Craton, which was defined in the Brazilian side. Based on the available data, the Precambrian occurrences in the Southern part of Eastern Paraguay cannot be correlated to that tectonic unit.

The acid vulcanism of Caapucu apparently belongs to the Lower Paleozoic, with a possible time relation to similar Brazilian occurrences. The alkaline intrusions are of Eocretacic age, contemporaneous to the basaltic vulcanism, but there are exceptions: the Mbocayaty and Pão de Açúcar intrusions presented older results. The different ages obtained for the Sapucai Lavas may represent successive extrusions during a long time interval (J-K). Basalts of the Paraná Basin yielded ages comparable to those obtained in the Brazilian side (J-K). For the vulcanism of Asunción region a Cenozoic age was obtained.

RESUMO Esta nota apresenta os resultados de vinte e duas análises K-Ar de dezessete amostras provenientes de diversas unidades metamórficas e magmáticas do Paraguai Oriental.

O Pré-Cambriano da região do Rio Apa constitui um prolongamento do Craton do Guaporé, definido do lado brasileiro. Já as ocorrências pré-cambrianas do sul do Paraguai Oriental não puderam ser seguramente relacionadas com essa unidade tectônica, fazendo-se necessárias novas análises.

O vulcanismo ácido de Caapucu apresenta idade aparente paleozóica inferior, em concordância com diversas ocorrências similares brasileiras.

As intrusões alcalinas datadas forneceram resultados que permitem considerá-las contemporâneas às primeiras manifestações basálticas da Bacia do Paraná. Duas exceções foram observadas: o maciço de Mbocayaty e o do Pão de Açúcar. As lavas de Sapucaí apresentaram dois resultados discordantes, atribuíveis a manifestações sucessivas, sendo a última contemporânea ao magmatismo basáltico. Dêste obteve-se idades concordantes com aquelas do lado brasileiro (Cretáceo inferior).

Um vulcanismo cenozóico parece ter-se processado na região de Asunción, aparentemente relacionado com o diastrofismo germanótipo moderno daquela área.

INTRODUCTION Precambrian rocks are exposed in Eastern Paraguay, east of the Chaco Boreal and of the Paraguay River. These rocks are overlain by Ordovician and Cretaceous sedimentary formations with intrusions and lava flows of presumably Mesozoic age. The general outline of the geology of the region has been established by HARRINGTON (1950), ECKEL (1959), PUTZER (1962) and COMTE (1968).

The existence of many problems, specially of geochronologic order, is explained by the fact that Precambrian and its pre-Silurian cover have been studied progressively. To HARRINGTON and PUTZER, therefore, the Precambrian of the northern part of Eastern Paraguay constitutes an extension of the Cuiabá Series, wich is well exposed in the State of Mato Grosso (Brazil). Recently, however, ALMEIDA (1965) restricted the Cuiabá Series further to the east, and attributed the rocks exposed in the east and center of the Bodoquena Range to an older crystalline complex. This complex, wich would extend southward into Paraguay, was named Guaporé Craton.

Another problem consists in correlating the Precambrian of the southern part of Eastern Paraguay with that of the northern part with no conclusive proofs. In addition, younger ages are attributed to the granites and rhyolites of Caapucu by the Authors mentioned above.

Discordant and folded sedimentary formations have been described. An example is the case of the Itapucumi Series of BOETTNER (1947), wich has been considered to be Lower Paleozoic (HARRINGTON, *op. cit.*), Eocambrian (ECKEL, *op. cit.*) and "infra-Cambrian" (KARPOFF, 1965). ALMEIDA (*op. cit.*) correlated the Itapucumi Series with the Cerradinho Formation at the base of the Corumbá Group, which constitutes the pelitic-carbonated sequence of the Paraguai-Araguaia miogeosyncline in southern Mato Grosso. In the southern part of Eastern Paraguay, near Paraguari, the greenschists and red siltites of the Escobar Series have been thought to be components of the Tubarão Group by HARRINGTON and by ECKEL, and are attributed to the Precambrian by PUTZER.

The subhorizontal detrital series which pile up around the Precambrian areas of eastern Paraguay belong for the most part to the Paraná Sedimentary Basin, and are well dated, either by their fauna (Silurian) or by affinities with the type facies of the Gondwanic units of the Brazilian side. The São Bento Group, with the Botucatu Formation sandstones and the basalts of the Serra Geral Formation, was considered to be Liassic by correlation of the basalts with those of South Africa. Today they are considered Upper Jurassic to Lower Cretaceous, based on potassium-argon dates (AMARAL *et al.*, 1966). On the other hand, the sparse alkaline intrusions and certain basic bodies were considered Cretaceous by PUTZER, without tangible proof.

As it can be seen, many geochronologic problems exist. Regarding the Brazilian Platform and its pre-Silurian sedimentary covers, as well as the Mesozoic magmatism of the Paraná Basin, numerous studies are being published, and several hundred radiometric age dates exist for the region. In Paraguay similar studies have only lately been started.

In this note are presented the results of 22 K-Ar determinations on 17 samples from Eastern Paraguay. The focus is on the Precambrian and on the Mesozoic magmatism. An attempt is made to discuss the results in the light of the latest available geologic data.

EXPERIMENTAL METHODS The dating techniques by the K-Ar method used at the CENTRO DE PESQUISAS GEOCRONOLÓGICAS of the University of São Paulo, where the present analyses were made, have been described by AMARAL *et al.* (1966), who also discussed their validity, reproductibility and accuracy.

Essentially, a fraction of the material (0.2 to 5.0 grams of concentrated minerals, or whole-rock fragments) is fused by induction heating in ultra high vacuum systems. The gas is purified in Cu-CuO and Ti furnaces and mixed with aliquots of pure Ar^{38} (spikes), prepared in groups of 400, in order to analyse the Ar^{40} by isotopic dilution in a Reynolds type mass spectrometer by the static method.

The potassium is dosed out in fractions of 0.15 to 0.30 grams using a Baird Atomic research flame photometer with lithium internal standard. The chemical procedure for the preparation of the solution is essentially the same to that described by BRANNOCK and BERTHOLD (1949).

The constants used in the calculations were:

$$\lambda_{total} = 0.530 \times 10^{-9} \text{ year}^{-1}$$
$$\lambda_{k} = 0.586 \times 10^{-10} \text{ year}^{-1}$$
$$K^{40} \text{ in total K} = 0.0119 \text{ atom \%}$$

The accuracy of the method is around 5 for most analyses. The experimental error is larger in those cases where there is a very low potassium content, or a large correction for atmospheric Ar. This 5% accuracy is a little higher relative to the usual accuracy at the CENTRO DE PESQUISAS GEOCRONOLÓGICAS, and it is due to a larger error in the Ar^{38} concentration for the spike system which was used (E Series).

RESULTS Twenty-two analyses were made on 17 samples collected in various localities from different geologic units. The samples are described in the Appendix. Sample locations and their K-Ar ages are presented in the figure. Table I exhibits the analytical results.

DISCUSSION OF RESULTS The significance of the K-Ar dates for alkaline and basaltic rocks of Southern Brazil was discussed by AMARAL *et al.* (1966) and AMARAL *et al.* (1967). Their conclusions can be extended to similar rocks in Paraguay, as there is a similar geological situation.

For the post-Baikalian eruptives and acid intrusives of the Caapucu region, which did not undergo reheating or later metamorphism, it is assumed that the K-Ar dates approach the age of the volcanism, since there has been no occasion for appreciable argon loss.

There has been much discussion concerning the metamorphic rocks and granites related to orogenesis (v. g., MOORBATH, 1965 and 1967). The problem is found principally in the argon retention by the minerals and rocks, being a function mainly of the crystalline structure, grain size, and temperature. The influence of temperature has been shown by HART (1964). It is known that different minerals only retain argon when they are placed below specified isotherms, which can happen in time periods quite different from that of crystallization or recrystallization, and are related to the rising of the rock

Table I

N.	SPK-	ANALYSED MATERIAL	ROCK TYPE	LOCALITY	K	Ar^{40} rad 10^{-5} cc/g STP	% Ar^{40} atm.	K-Ar AGE · 10^6y
1	1 410	Whole rock	Amphibolite	Rio Apa	1.106	6.28	1.8	1 056 ± 55
2	1 411	Muscovite	Pegmatite	Rio Apa	8.45	59.7	4.6	1 250 ± 65
3	1 405	K-feldspar	Granodiorite	San Bernardino	5.43	17.0	8.9	786 ± 40
4	1 417	Plagioclase	Amphibolite	Villa Flórida	1.602	3.04	40.1	424 ± 25
4	1 414	Amphibole	Amphibolite	Villa Flórida	.396	1.21	59.1	539 ± 40
5	1 418	K-feldspar	Granodiorite	Villa Flórida	9.94	24.5	1.4	535 ± 30
6	1 473	K-feldspar	Granite	Caapucu	8.21	18.3	1.9	468 ± 25
7	1 400	Whole rock	Microdiorite	Mbocayaty	.544	2.22	17.8	820 ± 85
7	1 470	Whole rock	Microdiorite	Mbocayaty	.545	2.71	8.7	960 ± 100
8	1 408	Biotite	Microdiorite	Cêrro Corá	6.95	4.13	10.3	143 ± 8
8	1 412	Whole rock	Microdiorite	Cêrro Corá	7.11	3.99	13.7	135 ± 7
9	1 409	Biotite	Diorite	Cêrro Charará	7.25	3.86	45.8	129 ± 7
9	1 413	K-feldspar	Diorite	Cêrro Charará	5.23	3.24	10.9	149 ± 8
10	1 398	Whole rock	Diabase	Sapucaí	3.83	1.78	8.7	113 ± 6
11	1 399	Whole rock	Diabase	Sapucaí	3.41	2.39	27.0	178 ± 10
11	1 471	Whole rock	Diabase	Sapucaí	3.41	2.56	9.5	179 ± 10
12	1 401	Whole rock	Basalt	Sapucaí	3.90	1.75	39.7	109 ± 6
13	1 404	Whole rock	Andesite	Sapucaí	5.78	2.68	10.7	113 ± 6
14	1 406	Whole rock	Diabase	Ybytyruzu	.675	.353	20.7	127 ± 10
15	1 396	Whole rock	Diabase	Ybytyruzu	.535	.237	47.9	108 ± 10
16	1 407	Whole rock	Basalt	Asunción	1.043	.195	82.0	46 ± 7
17	1 475	Whole rock	Phonolite	Pão de Açúcar	4.72	4.17	7.0	209 ± 11

in the crust. In cases of polimetamorphism or re-heating, the K-Ar dates tend to reflect the last event. Regarding the structure of the minerals, it is accepted that amphiboles have great argon retention and furnish older dates than micas, while feldspars, specially the potassic ones, are not good retentors (CORDANI and BITTENCOURT, 1967). As a function of grain size, micas from pegmatites generally yield good results, and in general the more developed minerals furnish more consistent results than the fine grained ones.

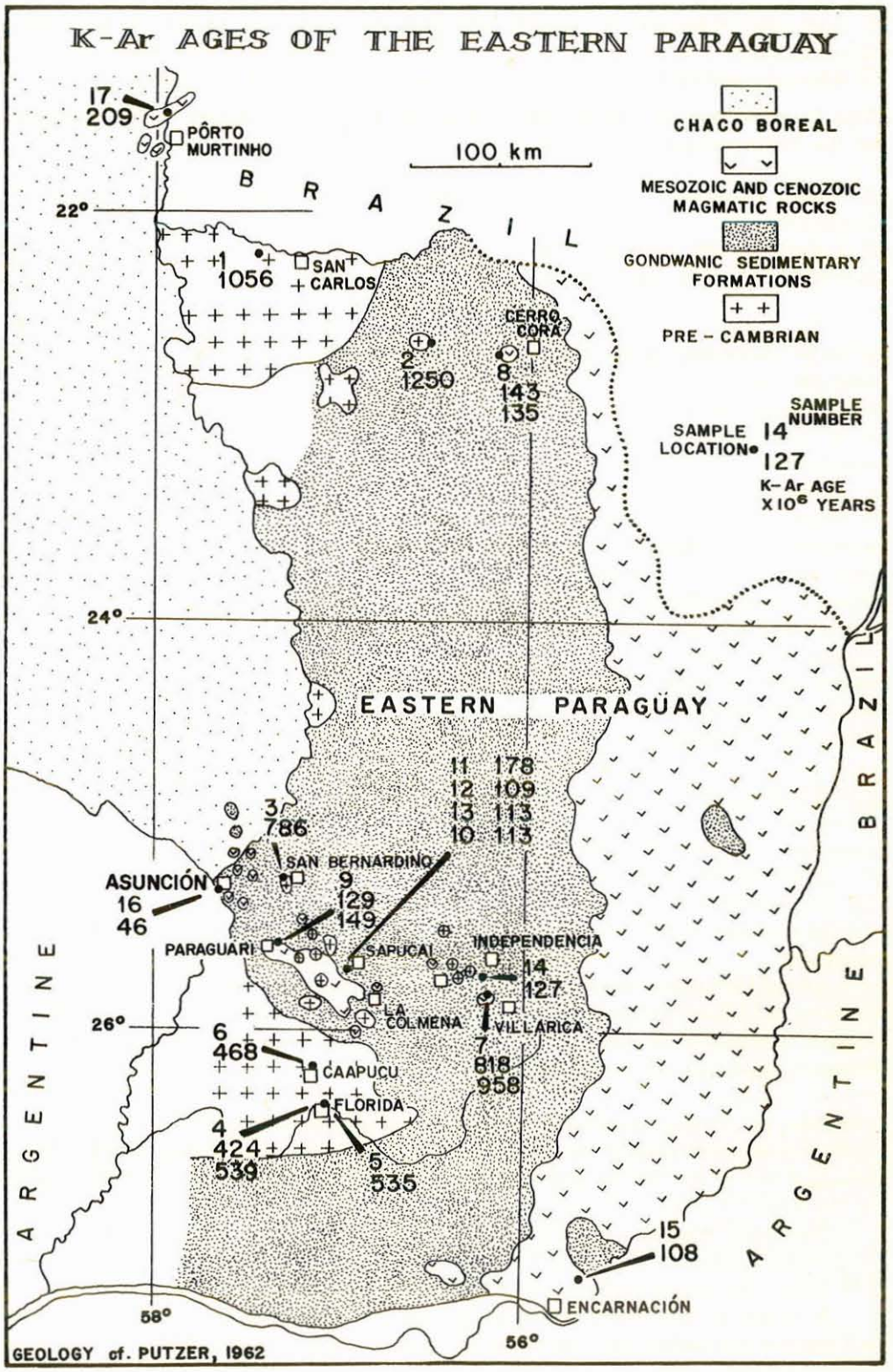
The Precambrian in the Northern part of Eastern Paraguay The Guaporé Craton is bounded by the Paraguay-Araguaia orogenic belt (Brazilian Cycle, 500-650 m. y.) on the east. The Paraná Basin overlies it in the southeast, the Amazon Basin overlies it in the north, and the Chaco Boreal overlies it in the west and southwest.

The Guaporé Craton is still very poorly known. Other than the ages determined by PRIEM *et al.* (1966) for the tin-bearing granites of Rondônia (960 m. y.), some analyses were made on rocks from Mato Grosso, Pará and Amazonas (HASUI and ALMEIDA, 1970; G. AMARAL, unpublished), but the data are not yet sufficient to elaborate a general outline. A very old basement, affected by the Trans-Amazonic event (2000 m. y.), seems to exist, as well as younger sequences of rocks, partly of magmatic origin (tin-bearing granites of Rondônia, Uatumã Series, and others).

The northern part of Eastern Paraguay is essentially made up of quartzites, quartz-schists, and amphibolites, cut by granitic intrusions, and aplite and pegmatite dikes.

The muscovite analysis of Sample 2 and the whole-rock analysis of Sample 1 yielded results of 1250 and 1056 m. y., which are enough to ascertain that the Precambrian of the Northern part of Eastern Paraguay is an extension of the Guaporé Craton to the south of the Apa River.

Although the existence of an orogenic belt of the Uruaçuano-Minas Cyde (900-1 300 m. y.) in the Guaporé Craton could be assumed to exist from the above data, at present


K-Ar AGES OF THE EASTERN PARAGUAY
CHACO BOREAL
MESOZOIC AND CENOZOIC MAGMATIC ROCKS
GONDWANIC SEDIMENTARY FORMATIONS
PRE - CAMBRIAN
SAMPLE NUMBER
SAMPLE LOCATION
K-Ar AGE X10⁶ YEARS
100 km
BRAZIL
ARGENTINE
EASTERN PARAGUAY
PÔRTO MURTINHO
SAN CARLOS
CERRO CORÁ
ASUNCIÓN
SAN BERNARDINO
PARAGUARI
SAPUCAI
INDEPENDENCIA
LA COLMENA
VILLARICA
CAAPUCU
FLORIDA
ENCARNACIÓN
17 209
1 1056
2 1250
8 143 135
11 178
12 109
13 113
10 113
3 786
9 129 149
16 46
14 127
6 468
7 818 958
4 424 539
5 535
15 108
22°
24°
26°
58°
56°
GEOLOGY cf. PUTZER, 1962

it seems more reasonable to consider them only minimum ages, keeping in mind the very sparse number of analyses, the deficiences of the K-Ar methods and, above all, the lack of adequate knowledge concerning the tectonic evolution of the craton.

The Precambrian of the Southern part of Eastern Paraguay The Precambrian in the Southern part of Eastern Paraguay is exposed:

1 – in a small area 50 km east of Asunción, where the San Bernardino granitic body is exposed,
2 – south of the Tebicuary River, as gneisses, micaschists, amphibolites, quartzites, and marbles, cut by small granitic or granodioritic apophyses, frequently cataclased.

The results obtained for samples 3, 4 and 5 refer to these areas. The potassium feldspar of the San Bernardino granodiorite yielded a relatively high result and suggests a correlation with the Guaporé Craton, but additional analyses are necessary. The granodiorite of Villa Flórida yields a younger age. The amphibolite, located near the granodiorite, seems to be concordant, perhaps reflecting thermal contact influence. The plagioclase of the amphibolite yielded a lower age apparently due to incipient alteration by weathering.

The ages presented, then, do not positively explain the relation of the Precambrian in the south to that of the north. The age values, on the other hand, could indicate an association of the granitic rocks with the Brazilian Cycle, to which the Cuiabá Group is associated. Nevertheless, important rejuvenations, as in the rest of the world, have been shown to exist in Precambrian areas of Brazil. Such is the case of Goiás State, where there is a range of ages explained by rejuvenation and remobilization (HASUI and ALMEIDA). Similar regions have been shown to exist by ALMEIDA *et al.* (1969) in the Brazilian Northeast, and by PFLUG (1967) in Minas Gerais State. It is possible, therefore, that the southern Paraguayan zone has undergone analogous rejuvenation, being located on the border of the Guaporé Craton.

The Caapucu granites and rhyolites Near Caapucu small granitic intrusions are found, surrounded by rhyolites. These acidic rocks were not affected by folding or metamorphism related to the Brazilian Cycle.

Acid volcanic rocks associated to molassic beds in Southern Brazil have been dated (K. KAWASHITA, unpublished) and results were obtained similar to that of Sample 6. As the analysed material from this samples was a feldspar, we cannot yet establish correlations.

ALMEIDA (1965) correlated the Caapucu granites and rhyolites with the Amoguijá (Southwest of Mato Grosso State) quartz-porphyries. They both have the same petrographic nature, absence of metamorphism, and pericratonic location. The quartz-porphyries, however, have not yet been dated.

The Pão de Açúcar alkaline massif Some isolated massifs of nepheline syenite and similar rocks occur close to the Paraguay River in southwestern Mato Grosso State. The principal one is the Pão de Açúcar, located north of Pôrto Murtinho, which stands out in the subdued relief of the Paraguay River valley.

The massif has been dated by AMARAL *et al.* (1967), who obtained an age of 239 m. y. from biotite and 207 m. y. from feldspar. An analysis made on Sample 17 yielded 209 m. y., concordant with the latter result.

It would seem, therefore, that the Pão de Açúcar massif had at least one phase of intrusions of the oldest type known on the margins of the Paraná Basin.

The Mesozoic alkaline intrusions Several stocks of essexite and similar rocks have penetrated the Escobar Series and the sandstones of the Caacupé Series in the Paraguari region.

For the Cêrro Charará stock (Sample 9) we obtained an age of 129 m. y. from biotite and 149 m. y. from feldspar. For the Cêrro Corá stock, which penetrated the Aquidauana Sandstone, the age obtained was 143 m. y. from biotite and 135 m. y. from whole rock (Sample 8). The occurrences are 400 km apart from each other and yield ages of the same order of magnitude. It seems possible, therefore, that at least some of the numerous intrusions of Eastern Paraguay were contemporaneous to the first basalt flows of the Paraná Basin. They are contained in what AMARAL *et al.* (1967) called the "oldest group" of Mesozoic alkaline intrusions of the Brazilian Platform, and are related to the Wealdean Reactivation (ALMEIDA, 1967).

Radiometric dates are still few in number, which makes it necessary to obtain additional analyses in order to verify the existence of younger intrusions, and different phases of magmatism. This has been done in Southern Brazil (AMARAL *et al.*, 1967; CORDANI and HASUI, 1968; HASUI and CORDANI, 1968).

For the small microdiorite and shonkinite massif of Mbocayaty, in a repeated analysis of Sample 7, we obtained very old ages. The discordance between the two results seems to be due to the lack of homogeneity of the analysed aliquots, since fragments of about 3 mm were used. It has been said that the massif is intrusive into the Tubarão Group (Upper Carboniferous). If this is true, there would be an excess of argon, the cause of which should be investigated.

The Sapucaí Lavas The intrusive complex of Sapucaí and neighboring regions is composed of various dikes and stocks related to an important expanse of volcanic rocks. These rocks are exposed between Sapucaí and Santa Isabel, and seem to be a complex laccolith 8-10 km long, 3 km wide and 200-250 m thick. This complex, now exposed by erosion, would have been formed between the Gondwanic peneplanation surface which affected the Caacupé Series sandstones, and the already eroded Gondwanic formations.

The variety of rock types (porphyritic basalts, nepheline basalts, phonolites, andesites, rhyolites) seems to result from successive injections of material of different compositions rather than from in situ differentiation. This would explain the irregular location of the different petrographic facies as well as the ages of 180 to 110 m. y. obtained on whole rock samples (Samples 10, 11, 12 and 13).

Although the basic magmatism of the Paraná Basin has a Lower Cretaceous to Upper Jurassic age, some analyses from Southern Brazil have yielded older results, as shown by AMARAL *et al.* (1966). The age of 179 m. y. of sample 11, therefore, is not strange.

The Basalts from the Paraná Basin The eastern portion of Eastern Paraguay is covered by basalts of the Paraná Basin. On the Brazilian side these basalts have been subjected to radiometric studies undertaken by AMARAL *et al.* (1966), MELFI (1967), CREER *et al.* (1965) and MC DOUGALL and RUEGG (1966).

Two analyses were made. One sample (14) comes from the base of the basalt flow which overlies the Botucatu Sandstone in the great erosion outlier of the Ybytyruzu Range. It yielded an age of 127 m. y., which is concordant with the values for Southern Brazil. Sample 15, from Capitán Miranda, slightly altered by weathering, yielded an age of 108 m. y.

The Olivine-Basalts from the neighborhood of Asunción Various olivine basalt necks with the appearance of irregular, isolated, covered domes appear in the neighborhood

of Asunción, aligned along the banks of the Paraguay River. They stand out in relief as elevations oriented NE-SW and NW-SE. The basalt flow of the Caanabé Arroyo valley, as well as the diabase dikes that cut through the red fluvio-lacustrine sandstones of probable Triassic age on the plateau east of Asunción, can probably be related to this volcanism. The intrusion would have been favored by fractures which parallel the faults that delimit the Ypacarai Depression.

One olivine basalt sample (16) yielded a mininum age of 46 m. y. Although other analyses are necessary, a Cenozoic age is suggested for the germanotype tectonism of the Asunción region, responsible for the fracturings to which is related the volcanism.

CONCLUSIONS The first results of the K-Ar analyses which are here presented permit the following general conclusions regarding the Paraguayan portion of the Brazilian Platform:

1 – The Precambrian in the northern part of Eastern Paraguay is an extension of the Guaporé Craton.
2 – The number of age dates available for the Southern part of Eastern Paraguay is not sufficient to enable correlations with the northern part. It is not possible to say, therefore, whether it is a region of Brazilian age or if it is the Guaporé Craton rejuvenated.
3 – The acid volcanism of Caapucu is post-Baikalian, having an apparent Lower Paleozoic age, and seeming to have a time relation with the volcanism of Castro, Camaquã, Amoguijá, etc, in Brazil.
4 – The alkaline intrusions which were dated presented different ages. The Mbocayaty massif yielded an anomalous age which can be explained by excess argon if we accept the stratigraphic relation which was pointed out. The Pão de Açúcar intrusion had its age confirmed, being older than the intrusions known in Brazil at the margins of the Paraná Basin. The other occurrences are of Eocretacic age, contemporaneous to the basaltic volcanism of the Serra Geral Formation.
5 – The lavas of Sapucaí yielded two different results, suggesting successive occurrences during a relatively long time interval. This should be ascertained with additional analyses.
6 – The Paraná Basin basalts in Paraguay yielded ages comparable to those obtained in the Brazilian side (J-K).
7 – A single analysis on an olivine basalt from the Asunción region suggests that the volcanism in that region is Cenozoic.

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APPENDIX A brief description of the samples analysed

SAMPLE 1 – Very fine grained amphibolite with nematoblastic texture, constitued of larger amphibole crystals in a groundmass of amphibole, plagioclase, biotite, titanite and quartz. Incipient chloritization of biotite and amphibole is observed.

Sample location – Estancia Arrecife, 30 km W of San Carlos and 1 km S of the Apa River.

Collector – D. Comte

SAMPLE 2 – Plate of muscovite from a granitic pegmatite.
Sample location – 70 km W of Cerro Corá.
Collector – A. Carrillo

SAMPLE 3 – Fine to medium grained rose granodiorite with allotriomorphic granular texture, composed of quartz, plagioclase, perthitic K-feldspar, chloritized biotite, some muscovite and opaque minerals. Drill core sample.
Sample location – 50 m from the Hotel du Lac, SW of San Bernardino.
Collector – D. Comte

SAMPLE 4 – Amphibolite from drill core, fine grained, composed of amphibole, plagioclase, apatite and opaque mineral. Amphiboles occur as slightly oriented prisms. Incipient plagioclase alteration observed.
Sample location – Villa Flórida, banks of Tebicuary River.
Collector – G. Vera Morinigo.

SAMPLE 5 – Porphyritic granodiorite from drill core, with poikilitic plagioclase phenocrysts up to 2.5 cm in a matrix of quartz, plagioclase, some microperthitic orthoclase, biotite, apatite, zircon and opaque minerals.
Sample location – Villa Flórida on the banks of the Tebicuary River, less than 200 m from Sample 4.
Collector – G. Vera Morinigo.

SAMPLE 6 – Medium to coarse grained rose granite with allotriomorphic granular texture, composed of perthitic (poikilitic) orthoclase, quartz and some plagioclase. Accessories are biotite, opaque minerals, zircon and rare apatite.
Sample location – Enterprise Hoschtieff, 2 km NNE of Caapucu.
Collector – D. Comte

SAMPLE 7 – Gray porphyritic leuco-microdiorite with porphyritic texture due to phenocrysts of amphibole, pyroxene and opaque minerals, up to 2 mm, in a trachytic groundmass of plagioclase, amphibole, opaque minerals, titanite, apatite and carbonate.
Sample locality – Ybytyruzu Range, 10 km from Villa Rica.
Collector – D. Comte

SAMPLE 8 – Light gray microdiorite with porphyritic texture due to clear and zoned feldspars up to 2,5 cm, and biotite and opaque minerals up to 2 mm, in a trachytic matrix composed of the same feldspars, plagioclase, biotite, opaque minerals, titanite, apatite and rare quartz.
Sample location – Arroyo Gasory, 15 km WSW of Cerro Corá.
Collector – D. Comte

SAMPLE 9 – Gray diorite, medium grained, with hypidiomorphic granular texture, composed of plagioclase, orthoclase, biotite, opaque minerals, clinopyroxene, some olivine and apatite.
Sample location – Enterprise Hoschtieff, Cerro Charará, 5 km from Paraguari.
Collector – D. Comte

SAMPLE 10 – Porphyritic holocrystalline diabase with phenocrysts of pyroxene, olivine, plagioclase and opaque minerals in a very fine grained groundmass of plagioclase, pyroxene, biotite, chlorite and opaque minerals.
Sample location – 4 km from Sapucaí towards Santa Isabel.
Collector – D. Comte

SAMPLE 11 – Porphyritic holocrystalline diabase, with phenocrysts of pyroxene, opaque minerals, amphibole, biotite and apatite in an aphanitic groundmass of plagioclase, opaque minerals and biotite.
Sample location – 2 km from Sapucaí towards Santa Isabel.
Collector – D. Comte

SAMPLE 12 – Alkali basalt with porphyritic texture, composed of phenocrysts of clinopyroxene, opaque minerals, pseudoleucite, apatite and olivine in a fine grained groundmass of plagioclase, chloritized pyroxene, opaque minerals, apatite and some devitrified glass.
Sample location – 2.5 km from Sapucaí towards Santa Isabel
Collector – D. Comte

SAMPLE 13 – Oriented gray andesite with porphyritic texture. Masses of perthitic orthoclase up to 1 cm, carbonate, amphibole, biotite, and opaque minerals, up to 3 mm, occur in a trachytic and feldspatic matrix with some carbonate, quartz, apatite, opaque minerals and titanite.
Sample location – 3 km from Sapucaí towards Santa Isabel.
Collector – D. Comte

SAMPLE 14 – Diabase with ophitic texture, composed of plagioclase, pyroxene, opaque minerals and some chloropheite.
Sample location – 7 km from Colonia Independencia, N of Ybytyruzu Range.
Collector – D. Comte

SAMPLE 15 – Very fine grained holocrystalline diabase, ophitic texture, composed of plagioclase, pyroxene, opaque minerals and some chloropheite. Slightly weathered.
Sample location – Capitán Miranda, 22 km NE of Encarnación.
Collector – D. Comte

SAMPLE 16 – Porphyritic basalt with phenocrysts of pyroxene, olivine, opaque minerals in a very fine grained matrix of plagioclase, opaque minerals, pyroxene and some glass. Olivine is partially serpentinized.
Sample location – Cerro Tacambu Highway, Asunción.
Collector – D. Comte

SAMPLE 17 – Dark gray very fine grained holocrystalline phonolite, with porphiritic texture due to nepheline phenocrysts up to 2 mm, perthitic feldspars, amphibole, opaque minerals and biotite in a non-oriented matrix of the same minerals, besides apatite and titanite.
Sample location – Pão de Açúcar, about 25 km N of Pôrto Murtinho, in the Paraguay River valley.
Collector – F. F. M. de Almeida (field number: MT-132).

OS ANFIBOLITOS DA REGIÃO MORRETES-ANTONINA (PR)

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ABSTRACT Two metamorphic zones have been established for rocks of the Morretes-Antonina area, State of Paraná, Brazil. The first one is composed chiefly of oligoclase-andesine gneisses interbedded with gondites, oligoclase-andesine amphibolites, and andesine-labradorite amphibolites. The second, which has been affected by retrograde metamorphism exhibits albite gneisses, albite amphibolites, magnesian schists, chlorite schists, and magnetite quartzites. The mineral assemblages for those zones are consistent respectively with the amphibolite facies and greenschist facies of metamorphism.

The andesine-labradorite amphibolites, showing no evidence of retrogressive metamorphism, are composed essentially of brown hornblende and plagioclase An_{40-54}. The oligoclase-andesine amphibolites exhibit plagioclase An_{25-35}, as well as brown and green hornblende.

Albite (An_{0-5}), epidote, and actinolite are major minerals on the albite amphibolite group. Mineralogical breakdowns from hornblende to actinolite, or to biotite plus chlorite, and from calcic plagioclase to sodic plagioclase plus epidote, are common features of these rocks.

No significant chemical variations have been registered for the low and high-grade amphibolites. The Niggli numbers *si*, *alk*, and *k* are only slightly greater for the albite amphibolites than for the andesine amphibolites, whereas the *mg* value is lower for the former. The chemical data for major elements indicate that the amphibolites are of igneous parentage.