

The Southern Precambrian in Paraguay - Geological Inventory and Age Relations

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With 3 figures and 1 table in the text

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Abstract: The Southern Precambrian in East Paraguay, a basement complex of 3000 km², may be divided from N to S in three units. The northern part comprises granites and rhyolites, which intruded not later than during Late-Precambrian/Cambrian. Bordering the fault zone in the South, low grade metamorphic (?), biotite and hornblende bearing rhyolites occur. The fault zone at the Tebicuary consists of metamorphic, magmatic and metasedimentary rocks as well as of tectonites in narrowly alternating sequences. Basic dikes of Jurassic to Cretaceous age are cutting these rocks. The southern part is mainly metamorphic. It forms a plain covered by Quaternary sediments under which as predominating rocks ortho- and paragneises, quartzites, amphibolites, metaaprites, talc lenses and younger rhyolitic dikes are exposed. Preliminary K-Ar dates on minerals indicate Middle Proterozoic age.

Zusammenfassung: Das Südliche Präkambrium von Ostparaguay, ca. 3000 km² groß, ist von N nach S in drei Einheiten gegliedert. Den Nordteil nehmen Granite und Rhyolithe ein, deren magmatische Abkühlung an der Wende Präkambrium/Kambrium erfolgte. Im Grenzbereich zur anschließenden Störungszone finden sich schwachmetamorphe (?) Rhyolithe, die Biotit und Hornblende führen. Die Störungszone entlang des Tebicuary umfaßt in engräumig wechselnder Folge magmatische, metamorphe, metasedimentäre Gesteine sowie Tektonite. Sie wurden von jurassischen/kretazischen basischen Gängen intrudiert. Die Südzone von Villa Florida bis San Juan Bautista ist überwiegend metamorph. In einer Ebene mit mächtiger Quartärbedeckung finden sich Ortho- und Paragneise, Quarzite, Amphibolite, Metaaprite, Talklinsen und jüngere Rhyolithgänge. Hier ergaben K-Ar-Daten von Mineralen erste Hinweise auf mittel-proterozoische Alter.

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Resumen: Durante un trabajo de campo de un año de duración, fueron se juntaron datos sobre la configuración del Precámbrico Sur, un complejo cristalino de 3000 km² de extensión en el sur del Paraguay oriental. Se presenta un mapa geológico detallado y los resultados de las primeras dataciones isotópicas (método Potasio-Argón). Geológicamente el terreno se clasifica, desde el norte hacia el sur, en tres unidades: La parte Norte está constituida de rocas ígneas ácidas (variedades de granitos y riolitas). De acuerdo a dataciones preliminares asumimos, con

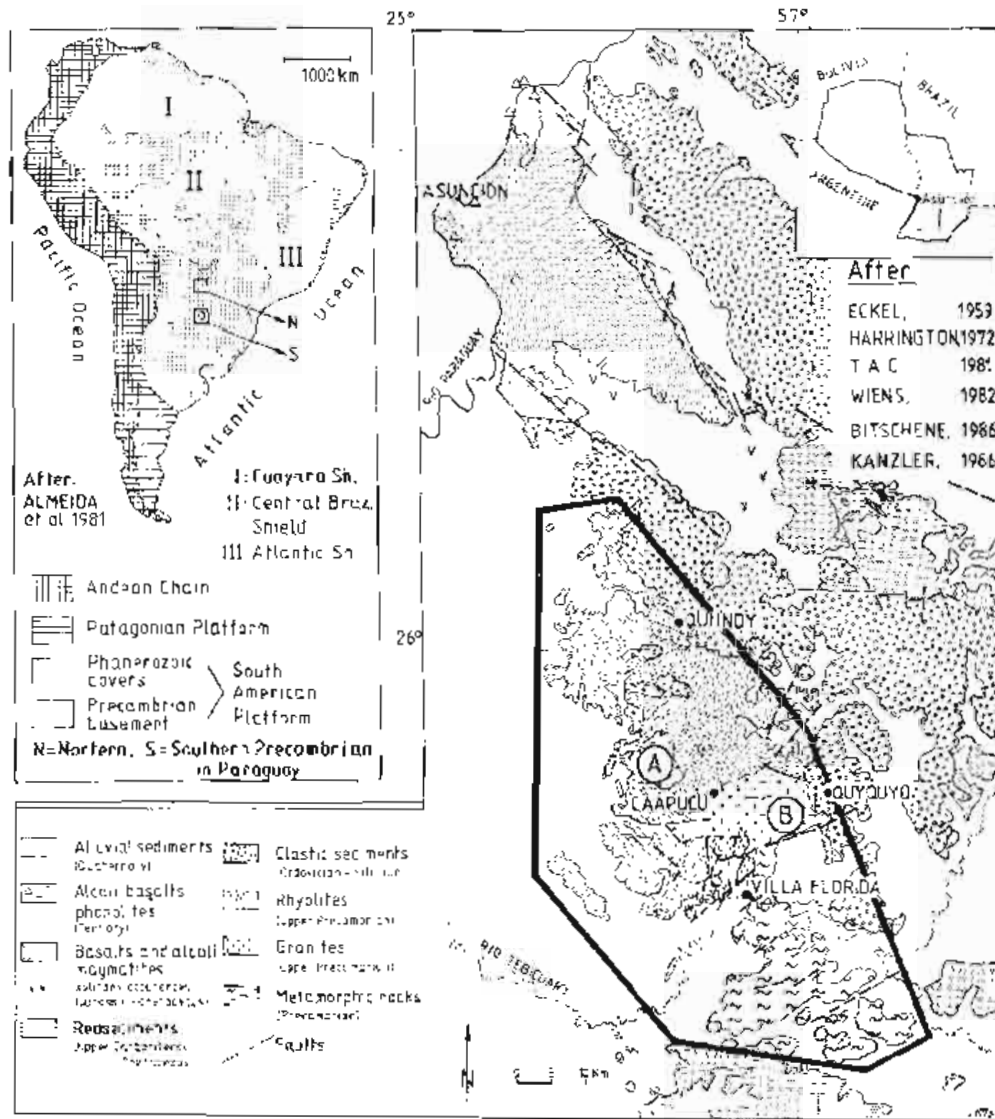


Fig. 1. A geological survey of the southern East Paraguay. The working area is enframed (A = Jhu-granite, B = Barrerito-granite). The inset map on the left shows the major geotectonic regions of South America.

reserva, que el enfriamiento de estas rocas se produjo entre el límite Precámbrico-Cámbrico. En el límite situado hacia la "zona de fractura" aparecen riolitas débilmente metamorfizadas (?) que contienen biotita y hornblenda.

Alrededor del Río Tebicuary se encuentra una zona de fractura compuesta de rocas ígneas, metamórficas, metasedimentarias y también de tectonitas, que cambian dentro de cortas distancias. Estas rocas están intruídas por diques básicos de rumbo NW cuya edad Potasio-Argón, corresponde al límite Jurásico-Cretácico.

La parte sur se extiende desde Villa Florida hasta San Juan Bautista y es un terreno metamórfico. En una llanura con una cubierta cuaternaria potente, afloran ortogneis y paragneis, cuarcitas, anfibolitas, meta-aplitas, lentes de talco y también diques de riolita más jóvenes. Investigaciones K-Ar en concentraciones de plagioclasa y hornblenda de dicha zona, indican una edad Proterozoica media. El significado geológico de estos indicios debe ser examinado.

Introduction

Apart from the big Precambrian shields the South American basement consists of a number of smaller complexes (ALMEIDA et al. 1976), among them those in East Paraguay (Fig. 1).

VOGEL (1893), MILCH (1895) and CARNIER (1911) were the first to make geological observations in Paraguay. HIBSCH (1891) and GOLDSCHLAG (1913) for the first time published petrographic descriptions of basement rocks in East Paraguay. Extensive steps towards a systematic geological investigation of this country were made by HARRINGTON (1950), ECKEL (1959) and PUTZER (1962). First K-Ar data on crystalline rocks were provided by COMTE & HASUI (1971). In the years 1978 - 1982 the North American "The Anschutz Cooperation" (T.A.C.) carried out a large scale geological inventory of East Paraguay, resulting in a geologic map in the scale of 1:500.000 (T.A.C., 1981). BITSCHENE & LIPPOLT (1986) have geochemically and geochronologically worked on single basement rock occurrences, especially in Central East Paraguay. The area of crystalline rocks in the north of East Paraguay (Rio Apa Highland) was analyzed petrographically and tectonically by WIENS (1986). ALMEIDA et al. (1976) within the scope of the "Paraguay-Araguaia Belt" first tried to connect the basement rock occurrences in Paraguay to the Amazonian Craton in southern Brazil.

This study presents the first results of a one year field work, carried out for the most part in the "Southern Precambrian" between Quiindy, Villa Florida and San Juan Bautista (Figs. 1 and 2). So far, this region has hardly been investigated geologically; neither the spectrum of the rock types nor their contacts had been known in detail. The aims of the field study were to work out a detailed geologic map of this region based upon field observation and further to collect appropriate samples for subsequent petrographic, geochemical and geochronological analyses. First results were presented by KANZLER & LIPPOLT (1986).

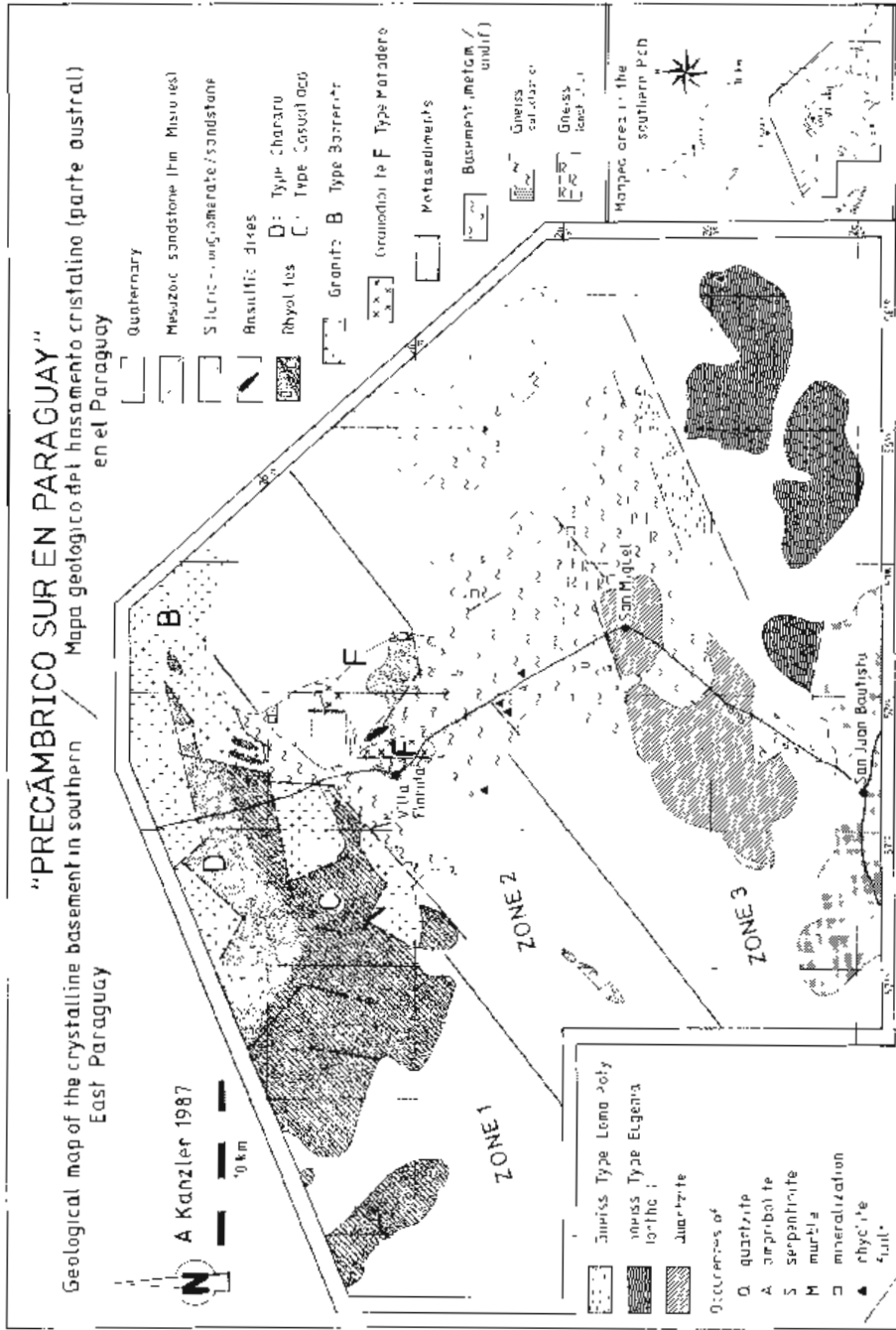


Fig. 2. Geological map of the southern part of the Southern Precambrian in Paraguay distinguishing three NE-trending genetic zones.

General geological settings

Paraguay's geological structure is characterized by two large basins - the Parana basin in the East and the Chaco basin in the West. Between these two basins in East Paraguay there are three basement rock occurrences. PUTZER (1962) combined them as "Zentralparaguayische Schwelle", a rise trending roughly north to south.

The northern part of this basement rock belt - the Rio Apa Highland - lies on the border to Brazil, comprising an area of about 5000 km². Analogy reasoning connects this area with the crystalline rocks of Mato Grosso in Brazil (ALMEIDA et al. 1976; RADAMBRASIL 1982; WIENS 1986).

In Central Eastern Paraguay, about 40 km to the east or southeast of Asunción in the village of San Bernadino single granitic as well as in the vicinity of Ypacaraí single rhyolitic occurrences are exposed. These are the acid magmatites investigated by BITSCHENE & LIPPOLT (1986).

The Southern Precambrian of East Paraguay

The present study concentrates on the southern basement occurrence in Paraguay, the "Southern Precambrian". HARRINGTON (1950), ECKEL (1959) and PUTZER (1962) also examined geological features of the Southern Precambrian when taking stock of the crystalline and sedimentary rocks in Paraguay. The granites and rhyolites in the north of the Tebicuary for the first time were distinguished on the geological map of the T.A.C. (1981). WIENS (1984) devised a geological sketch map and a first attempt to a stratigraphical subdivision of the rock groups in the Southern Precambrian (Tab. 1).

When starting this study the following conception of the geological structure of the Southern Precambrian existed:

The Southern Precambrian is a basement rock complex between the villages Quiindy and San Juan Bautista with an extension of about 3000 km², 100 km from north to south and 40 km from west to east at the most. The section in the north of Villa Florida is characterized by acid magmatites (granite, rhyolite; according to WIENS (1984): "Grupo Caapucú"). Remnants of Silurian sediments discordantly overlie these rocks. In the NE of Villa Florida, near Estancia Paso Pindo, metasedimentary rocks occur ("Paso Pindo" after ECKEL 1959).

The area reaching southward from Villa Florida to San Juan Bautista displays different metamorphic rocks ("Rio Tebicuary Complex", after WIENS 1984). The prevalent rocks to be found here are quartzites, talc schist, biotite schist, graphic granitic pegmatites and aplites, the preferred foliations are between 120° - 130° and 30° - 40°.

Morphology of the Southern Precambrian

Morphologically the Southern Precambrian is subdivided into two parts:

From the south of Quiindy to the Tebicuary a hilly area is extending, its maximum altitude coming up to 280 m (e. g. Cerro de la Virgen, N. W. Caapucú). The highest elevations are built up by rhyolites. The granitic

GEOLOGICAL TIME		LITHIC TYPE	GROUP OCCURRENCE
Ma	ERA		
0-18	CEANOZOIC	alluvial	Aluviones recientes
0-18		shale basalt volcanism	Basaltos de bloque de Asunción
0-65	MESOZOIC	granite-basalt magmatism	Granitos de Itaipu
0-65		sandstone	Fm. Misiones
0-70	PALLOZOIC	glacial sediments	Fm. Capatzen
0-70		sandstones shales conglomerates	Gr. Itaipu
0-450	PROTEROZOIC	extrusives	Gr. Capatzen
0-450		sediments calcareous organic	Gr. Itaipu
0-1000	ARCHEAN	granite gneiss schists	Gr. Itaipu, Gr. Capatzen, Gr. Itaipu
0-1000		basalt gneiss schists	Gr. Itaipu, Gr. Capatzen, Gr. Itaipu
0-1000	MIDDLE PROTEROZOIC	granite gneiss schists	Gr. Itaipu, Gr. Capatzen, Gr. Itaipu
0-1000		basalt gneiss schists	Gr. Itaipu, Gr. Capatzen, Gr. Itaipu
0-1000	EARLY PROTEROZOIC	granite gneiss schists	Gr. Itaipu, Gr. Capatzen, Gr. Itaipu
0-1000		basalt gneiss schists	Gr. Itaipu, Gr. Capatzen, Gr. Itaipu
0-1000	ARCHEAN	granite gneiss schists	Gr. Itaipu, Gr. Capatzen, Gr. Itaipu
0-1000		basalt gneiss schists	Gr. Itaipu, Gr. Capatzen, Gr. Itaipu

Tab. 1. Temporal classification of rocks from the Southern Precambrian in Paraguay after WIENS (1984 and 1986), according to lithological comparisons with occurrences in Brazil. The actual duration of the rock formation periods and of the groups is not well known. (Time scale modified after SALOP (1983)).

rocks form a slightly undulatory landscape, patched with some swampy plains. The geological outcrop conditions in this region are good.

Going southward from the river Tebicuary, a steppe like plain follows, in which there are no elevations but few quartzite hills nearby San Miguel and Itayuru, rising up to 60 m above the flat. Huge Quaternary coverings and deeply weathered rocks are typical. A swampy area covers more than 200 km² in the SE.

Geology of the Southern Precambrian based on the field work

The rock identifications, classifications and generalisations described in the following have been established merely on field observations and few microsection studies. After further laboratory studies revisions and/or refinements are to be envisaged. The coordinates of the type localities are based upon topographic maps published in the scale of 1:100.000 by the I.G.M. (Instituto Geografico Militar) in Paraguay.

The southern half of the working area was geologically mapped in the scale of 1:100.000 (Fig. 2). Relevant field observations in the northern sector are enclosed in the map of Fig. 1.

Based upon the observations a subdivision into three zones (from NW to SE) is obvious:

Zone 1: Magmatic rocks in the north of Villa Florida

Prevailing rocks of this region are: granites, aplites, granitic porphyres as well as rhyolites and rhyolitic dikes.

- Granites

Two main granite occurrences may be distinguished: The Jhu granite, 10 km NW of Caapucú and the Barrerito granite between Caapucú and Quayquyó (Fig. 1: A and B, Fig. 2: B).

The Jhu granite (called after a village in the NW of Caapucú) is a porphyric granite variety with quartz and feldspar phenocrysts in a medium-grained groundmass. The content of biotite is low. This granitic complex is surrounded by a rhyolitic hill chain on its western and southwestern margins (Fig. 1). Outcrops of this reddish rocks can be easily detected at (464000mE/7119000mN), about 12 km in the west of Valle Apua.

The Barrerito granite (called after a ranch NE from Villa Florida) is spread over a rather large terrain (Fig. 2: B). It is a pink coloured rock with quartz, alkali feldspar and plagioclas phenocrysts in a medium-grained groundmass. Parts of the plagioclasses are zonated, biotite often is intergrown with sometimes large idiomorphic hornblende. The granite shows evidence of weak tectonic strain. There are numerous aplite dikes, but only few quartz pegmatites. Well exposed, these granites are found in the SE of the Estancia Barrerito at (496500mE/7091300mN). Because of the porphyric fabric, the Jhu as well as the Barrerito granites are supposed to be the result of intrusions in high crustal level.

- Rhyolites

The main rocks of zone 1 in terms of their extension are various rhyolites. According to megascopical analyses revealing fabric differences of the groundmass, a subdivision into two groups seems to be appropriate: Casualidad rhyolite and Charara rhyolite (Fig. 2: C, D)

The rhyolite of the type Casualidad (name of a cattle-breeding company in the centre of the occurrence) is found on the border to zone 2 (fault zone) in a tract with a maximum latitude of 11 km (Fig. 2: C). Its character is uniform on the whole. Special features, clearly differing from those of the Charara rhyolite, are its fine-grained groundmass as well as the biotite and hornblende contents.

Considering the nature of the fabric and the simultaneous occurrence of prehnite and chlorite, the type of formation of the Casualidad rhyolite may be attributed to a consolidation under thin covering and/or to a low-grade metamorphosis.

Among the few inclusions are metasedimentary fragments. Typical outcrops are situated nearby the Estancia Casualidad (477000mE/7085000mN) and in the region adjoining in the west.

Under the term Rhyolite of Charara (Fig. 2: D, name of a settlement 12 km WNW from Caapucú), different varieties with a dense groundmass are comprised. Only very few of them display biotite crystals. The rhyolite has good outcrops at (466000mE/7101800mN) in the west from Caapucú. The overwhelming majority of rhyolites in the Southern Precambrian are rocks of this type. At present time a further subdividing of the Charara rhyolite seems to be premature.

Generally contacts between granite and rhyolite appear distinct, but in many cases they are marked by zones with altered material. In some cases, under bad outcrop conditions, megascopical distinction between certain varieties of the Barrerito granite and the Casualidad rhyolite clearly cannot be made.

Zone 2: Fracture zone around Villa Florida

In a 10 km wide NE trending fracture zone near Villa Florida, magmatic, metamorphic and metasedimentary rock units are lying side by side. The majority of rocks found here are acid magmatites (granite, granodiorite and rhyolite) as well as metamorphites (quartzite, gneiss, amphibolite). In the NE sector of the fracture zone, a metasedimentary rock series extending to about 12 km² is found (ECKEL 1959: "Paso Pindo" group). There are further small occurrences of marble and serpentinite and several basaltic dikes. On the eastern village boundary of Villa Florida (489300mE/7080000mN), a nearly 1 km long and more than 100 m wide basaltic dike is found trending NW. The few granitic deposits of this area are taken to belong to the Barrerito type. In the southern part of zone 2 sporadic occurrences of dark, mylonitic rocks were observed.

At present different granodiorite outcrops (Fig. 2: F) are summarized under the term Matadero granodiorite (name of a slaughter house in the south of Villa Florida). They occupy the east and south of Villa Florida, and mainly to be seen in artificial outcrops (fountain shafts). The only outcrops above ground lie in the NE of the Matadero (489000mE/7078999mN) and in the river-bed of the Tebicuary at (487750mE/7080000mN).

Further deposits are found in the vicinities of two countryside resorts (Parador Centu Cué, 8 km E and Parador Las Mercedes 5 km NE of Villa Florida).

Contrasting to the Barrerito granite, the granodiorite Matadero is a black-white colored rock partially with spots of cm-large alkali-feldspar megacrysts. The amounts of biotite and hornblende are high; in some cases only hornblende as mafic mineral frequently is found. The rocks have been subject to tectonic activity, especially in Villa Florida. In the north of Villa Florida, at the shore of the river, a NE trending amphibolitic lens of some 100 m is conspicuous. It is cut through by crossing swarms of small granitic dikes.

The metasedimentary rock complex in the NE of this zone was found to consist of weakly metamorphic conglomerates, sandstone, siltstones

striking about 130°/30° to 40° NE, and further of conspicuous clay schist/conglomerate or clay schist/arcose-sandstone interbeddings, which were already mentioned by ECKEL (1959).

In few cases, these layers are concordantly interlain by mm-thick hematite strata. The whole metasedimentary block discordantly superposes Precambrian basement rocks. Thin iron ore and copper ore deposits are connected with fault zones on the periphery of this complex. This rock complex possibly may be correlated with the metasediments of the Escobar series near the village Paraguairí (KARPOFF 1965), with the "San Luis series" in the "Rio Apa Highland" described by PUTZER (1962) or with the Urucum formation in Mato Grosso do Sul in Brazil (RADAM-BRASIL 1982). The ages of these rocks are still controversial. The question is to be investigated whether isotopic dating on the metasedimentary material will be possible.

The two units distinguished by WIENS (1984/86) in this area, shown in Tab. 1 as "Grupo Ramos" (limestones) and "Grupo Villa Florida" (basic meta-volcanites, probably represented by the amphibolitic complex in Villa Florida) in our opinion cannot be considered as units of their own. Occurrences of limestone have not been observed. A marble lens on the area of the former Estancia Ramos and the amphibolites of Villa Florida are rather to be associated with zone 3 unless further geochronological analyses will disprove this.

Zone 3: Metamorphic rocks in the south of Villa Florida

The rocks of zone 3 adjoining the fracture zone (zone 2) still display features of tectonic activity. In zone 3 ortho- and paragneisses, quartzites, metaaprites, metatexites, amphibolites, epidote gneisses, talc, iron-ore impregnated gneisses as well as non-metamorphic rhyolite dikes are prevailing.

The main rocks in the northern part of this zone are light, fine-grained quartz-feldspar paragneisses, quartzite lenses, epidote gneisses and amphibolite lenses. Characteristics of the paragneisses are elongated cm-long highly flattened quartzes. Mafic minerals like biotite and hornblende megascopically are not detectable. Tectonically superimposed dike granites (also without mafic minerals) are cutting the gneisses. Younger rhyolitic dikes run NW and are intensely jointed.

More to the centre of the metamorphic complex light metatectic gneisses are observed more frequently. In the neighbourhood of the quartzite hills, epidotebearing and amphibolitic gneisses are found. Seldom talc lenses, hematite and magnetite mineralizations are observed.

About 7 km in the E of San Miguel, an independent homogeneous looking gneiss complex has been mapped, which in the following will be referred to as Loma Poty gneiss (Fig. 2). It is a tectonically overprinted hard, reddish and fine-grained biotite gneiss, the minerals of which are partly recrystallized. Good exposures of these rocks are at (503000mE/7060800mN) on the brook San Roque. Field investigations and thin-section observations lead to the assumption that the Loma Poty gneiss is of paragne nature.

At its SE margin, the Loma Poty gneiss is separated from the adjacent Eugenia gneiss by a fault. The Eugenia gneiss is a 200 km²-sized orthogneiss complex on the SE border of zone 3. The gneisses are grey to white coloured, rarely reddish, bearing hornblende and/or biotite. The fresh looking rocks are medium- to coarse-grained and in some zones bear almost cm-thick alkali feldspar megacrysts. As lenses quartz-pegmatites and pegmatoids occur. In the eastern part (close to Estancia Graciella), the orthogneisses are intruded by rhyolites. On the terrain of the Estancia Eugenia at (502000mE/7054000mN) a typical outcrop of the Eugenia gneiss is exposed.

Tectonics

The lineations in the area of the Southern Precambrian, mainly revealed by aerial and satellite photo interpretations, are running NE and NW (Fig. 3). These tectonic directions were appearing in the adjoining northern basement of East Paraguay (WIENS 1986) as well as in the crystalline units in Brazil (ALMEIDA & HASUI 1984) are considered to have existed already in Proterozoic times. Subsequently they have been reactivated during the thermotectonic cycle between 1000-450 Ma ("Brasiliano") and again during Mesozoic times close to the Jurassic/Cretaceous transition. These directions are also found in studies carried out by DRUECKER (1985) and DEGRAFF (1985) who examined mafic dikes and the associated crustal extension in East Paraguay during the Mesozoic period.

All the basaltic dikes, which have been discovered during the field work in the fracture zone of the Southern Precambrian, are striking NW. The main direction of the faults in the acid magmatic rocks of the northern working area (zone 1) is in the range of 140°-150°, a secondary maximum is at 30°.

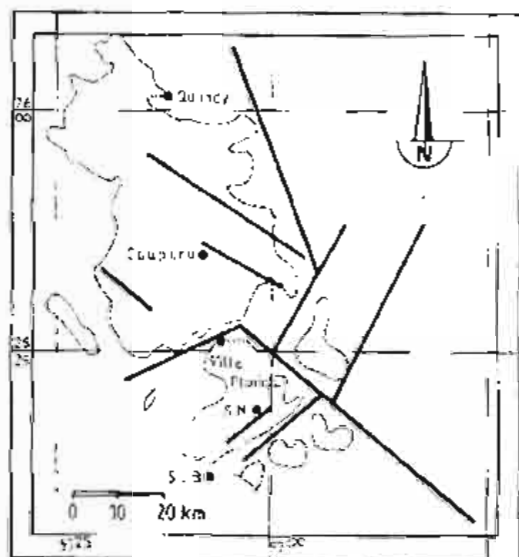


Fig. 3. Main courses of photolineations in the area of the Southern Precambrian in Paraguay (Interpretation of orbital photography).

The main strike of the s-planes of the gneisses in the central part of metamorphic zone 3 around San Miguel is NE with inclination to the NW. The same trend is observed for the rhyolitic dikes.

Geochronological Results

The K-Ar dates of COMTE & HASUI (1971) suggested that the acid plutonites of the Southern Precambrian at Caapucú and Villa Florida are associated with the youngest stage of the Brasiliano epoch. A similar age was found for an amphibolite near Villa Florida. This result, however, may be due to thermal resetting. Age estimates for the stratigraphic sequence of the rocks of the Southern Precambrian introduced by WIENS (1984) are based on lithological comparison to rocks of the Precambrian in Brazil and to their age sequences (Tab. 1) and are preliminary.

BITSCHENE & LIPPOLT (1986), applying the $^{40}\text{Ar}/^{39}\text{Ar}$ -technique, confirmed the Late-Brasiliano age of the granite at Caapucú in zone 1 (544 \pm 11 Ma).

In order to promote the field work, some first age determinations using the conventional K-Ar method have been carried out (LIPPOLT et al., in preparation). Total rock samples from two basalts in the fracture zone (zone 2) yielded ages on the turn Jurassic-Cretaceous. Plagioclase and hornblende enrichments of metamorphically superimposed magmatic rocks of the same zone yielded age values at the turn between Precambrian and Cambrian. The question has yet to be clarified whether these results are due to resetting older values by thermal action of the acid magmatism in the northern zone 1.

In the metamorphic zone 3 of the Southern Precambrian discordant Middle-Proterozoic K-Ar data on plagioclase and hornblende concentrations were measured. The reasons for the discordance are not yet understood. Two unpublished Rb-Sr dates from Brazil (CORDANI, pers. comm. 1986) suggest that in this zone rock ages ranging from 2,5 to 1,8 Ga may occur.

Conclusion and Perspectives

Based upon field observation, the Southern Precambrian in Paraguay is subdivided into three zones. In zone 1 with acid magmatites in the north of Villa Florida according to mineral contents and the character of their groundmass two granitic (Jhu and Barretito granite) as well as two rhyolite units (Casualidad and Charara rhyolites) have been distinguished.

In the fracture zone 2 on the Tebicuary river magmatic, metamorphic and metasedimentary units are lying side by side in alternating sequences. The majority of these rocks has been subject to intense tectonic activity. Zone 2 also comprises granodiorites of the Matadero type and several basaltic dikes. K-Ar total rock analyses on the basalts yielded ages on the turn Jurassic - Cretaceous. Dates of plutonic rocks from this zone indicated ages on the turn between Precambrian and Cambrian times. Zone 3 is characterized by metamorphic rocks (S from Villa Florida) of varying metamorphic grade. Independent lithologic units are fine-grained paragneisses (type Loma Poty) and a orthogneiss complex (type Eugenia)

extending over more than 200 km². K-Ar determinations on mineral concentrates of metamorphic rocks in this zone yielded Middle Proterozoic ages. Further investigations, in particular by the ⁴⁰Ar/³⁹Ar method, the zircon-lead method and by Rb-Sr analyses, will have to reveal the time span documented by these rocks.

There is clear evidence of a number of differing plutonic stages in the Southern Precambrian which are characterized by the original rocks of the orthogneisses, by the granodiorites of the fracture zone and by the granites in the northern sector of the working area.

These studies, being primarily based upon field observations, will be followed up by petrographic and analytical laboratory investigation. Furthermore crystalline and metasedimentary samples from Central East-Paraguay and from the Río Apa Highland as well as from the Brazilian Urucum area in the north will render possible comparisons of these areas and their rocks. The samples taken from the Paraguayan Southern Precambrian seem to be suitable to reveal the genesis of this complex by petrographic, geochemical and geochronological means. Thus conclusions about their possible association with the old shields of South America may be drawn after further investigations. On the basis of the forthcoming results on the rocks in the Southern Precambrian, in particular the meaning of the temporal term "Brasiliano event" will be defined more precisely.

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References

- ALMEIDA, F. F. M. de, HASUI, Y. & BRITO NEVES, B. B. de (1976): The upper Precambrian of South America. - Bol. IG, USP, 7: 45-80; São Paulo.
- ALMEIDA, F. F. M. de, HASUI, Y., BRITO NEVES, B. B. de & FUCK, R. A. (1981): Brazilian Structural Provinces: An Introduction. - Earth Sci. Rev., 17: 1-29; Amsterdam.
- ALMEIDA, F. F. M. de & HASUI, Y. (1984): O precambriano do Brasil. - 378 p.; São Paulo.
- BITSCHENE, P. R. & LIPPOLT, H. J. (1986): Acid Magmatites of the Brasiliano Cycle in East Paraguay. - Zbl. Geol. Paläont. Teil I, 1985 (9/10): 1457-1468; Stuttgart.

- CARNIER, K. (1911): Reisen in Mato Grosso und Paraguay. - Mitt. Geogr. Ges., **61**: 18-44; München.
- COMTE, D. & HASUI, Y. (1971): Geochronology of Eastern Paraguay by the Potassium-Argon Method. - Rev. Bras. Geoc., **1**: 33-43; Rio de Janeiro.
- DEGRAFF, J. M. (1985): Late Mesozoic crustal extension and rifting on the western edge of the Parana Basin, Paraguay. - Geol. Soc. Amer., Abstr., 1 p.; Washington.
- DRUECKER, M. D. & GAY, S. P. (1985): Mafic dike swarms associated with Mesozoic rifting in Eastern Paraguay. - Geol. Ass. Can., Abstr., 1 p.; Waterloo, Ontario.
- ECKEL, E. B. (1959): Geology and Mineral resources of Paraguay - A Reconnaissance. - U. S. Geol. Surv. Prof. Pap., **327**: 110 p.; Washington.
- GOLDSCHLAG, M. (1913): Zur Petrographie Paraguays und Mato Grossos. - Mitt. Geogr. Ges., **3**: 293-301; München.
- HARRINGTON, H. J. (1950): Geología del Paraguay Oriental. - Contr. Cient., Ser. E, Geol., Univ. Buenos Aires, **1**: 82 p.; Buenos Aires.
- (1972): Silurian of Paraguay. - In: BERRY, W. B. N. & BOUCOT, A. J. (ed.): Correlation of the South American Silurian rocks. - Geol. Soc. Am., Spec. Pap., **133**: 41-50; Boulder/Col.
- HIBSCH, J. E. (1891): Einige Gesteine aus Paraguay. - Tscherm. Min. Petr. Mitt., **12**: 253-255; Wien.
- KANZLER, A. & LIPPOLT, H. J. (1986): Das prä-ordovizische Grundgebirge im südlichen Ost-Paraguay nach neuen Feldstudien und ersten Altersbestimmungen. - Berliner geowiss. Abh. (A), Sonderbd., **10**. Geowiss. Lateinamer. Koll.: 153-154; Berlin.
- KARPOFF, M. R. (1965): Observations géologiques au SE d'Asuncion. - C. R. Acad. Sci., **261** (25): 5558-5560; Paris.
- MILCH, L. (1895): Über Gesteine aus Paraguay. - Tscherm. Min. Petr. Mitt., **14**: 383-394; Wien.
- PUTZER, H. (1962): Die Geologie von Paraguay. - Beitr. reg. Geol. Erde, **2**: 182 p.; Berlin (Gebr. Borntraeger).
- T. A. C. (The Anschutz Corporation) (1981): Geologic Map of Eastern Paraguay, 1:500.000 (compiled by F. WIENS), 1 map; Asuncion.
- Radambrazil-Projeto (1982): Folha SF. 21 Campo Grande. - Levant. Rec. at., **28**: 412 p.; Rio de Janeiro.
- SALOP, L. J. (1983): Geological Evolution of the Earth During the Precambrian. - 459 p.; Berlin/Heidelberg/New York (Springer).
- VOGEL, P. (1893): Reisen in Mato Grosso 1887/88. - Z. Ges. Erdk., Ber.; Berlin.
- WIENS, F. (1982): Mapa geológico de la región oriental, República del Paraguay, esc. 1:500.000. - I. Simp. Rec. Natur. Paraguay, 8 p. + 1 map; Asunción. [Ms.]
- (1984): El precámbrico paraguayo. - I. Simp. Nac. Geol., 7 - 2 p. + 2 maps; Asuncion. [Ms.]
- (1986): Zur lithostratigraphischen, petrographischen und strukturellen Entwicklung des Rio-Apa-Hochlandes, Nordost-Paraguay. - Clausth. geowiss. Diss., **19**: 280 p.; Clausthal-Zellerfeld.

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