

Paleontological and Stratigraphic Research in Paraguay

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Grant 2112: To make transects across Carboniferous–Permian exposures in Paraguay.

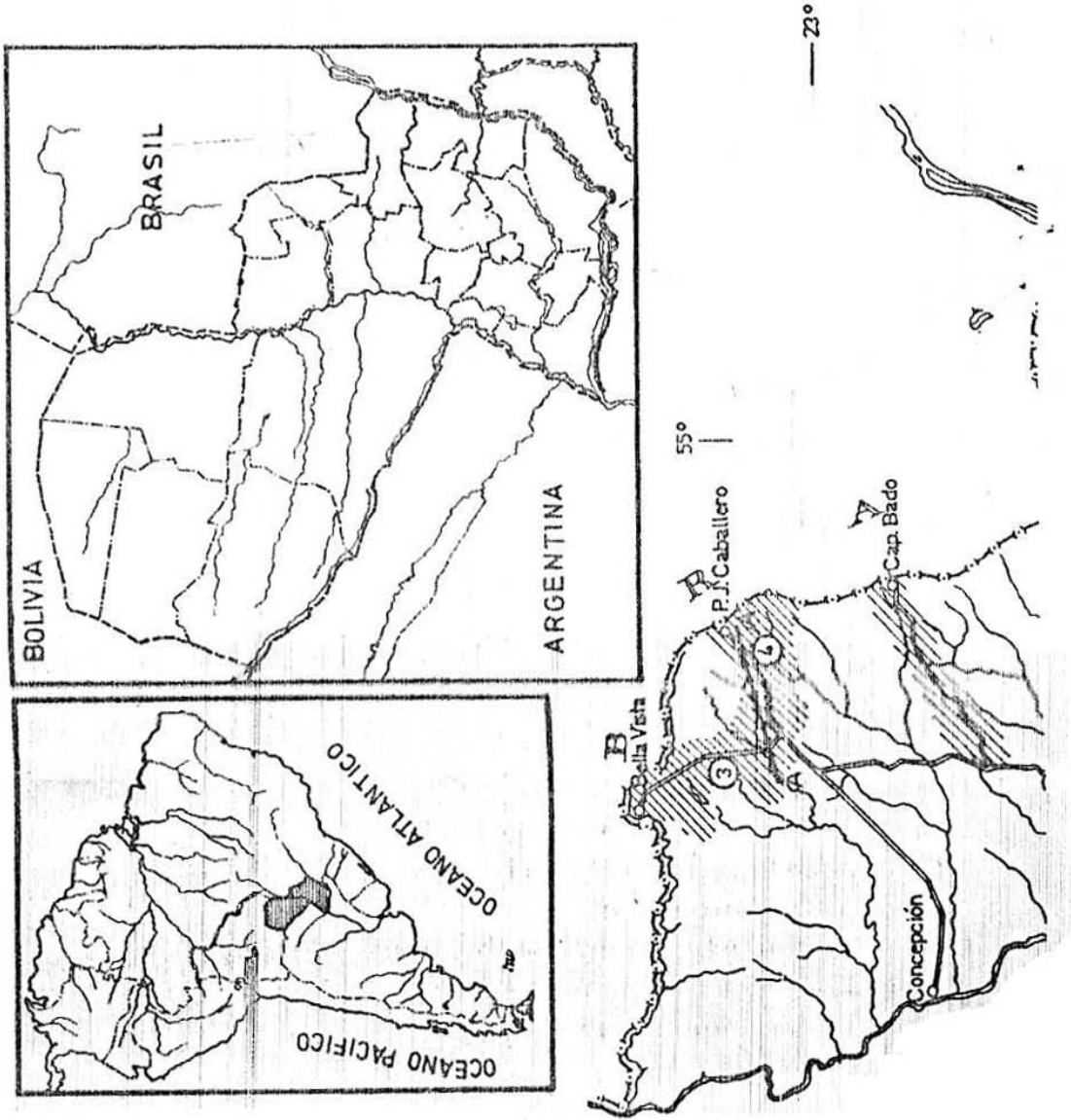
OBJECTIVES AND METHODS

Our research, conducted from March 1980 to November 1981, had several objectives. First, we wanted to establish a regional scheme of the stratigraphic column of the so-called Carboniferous–Permian sequence and, with the fossiliferous (and other) evidence at hand, to correlate this with the Brazilian sequence, since both form part of the Paraná Basin. We also wanted to increase our knowledge of the fossil contents of the sequence, searching for more and better localities and using our findings as tools for better correlations.

Not very much is known of the upper Paleozoic in Paraguay. Apart from a few papers of historical value, with scarce and confusing stratigraphic information, the most important paper on the topic is still Harrington's 1950 essay on the geology of eastern Paraguay (very little was known at that time on the subsurface of the Chaco region, west of the Paraguay River). Although some of Harrington's statements proved mistaken, his essential points are still valid. Later contributions were those of Eckel (1959) and Putzer (1962), the last providing interesting data on the subsurface of the Chaco region (where, since 1950, much drilling had been done). Even so, the general stratigraphic scheme, and even the nomenclature, remained basically unchanged.

During some fossil-collecting trips in the early 1970s, I discovered no Carboniferous but only Permian rocks. This fact seemed strange given the Carboniferous extension shown on the maps, but I attributed this at

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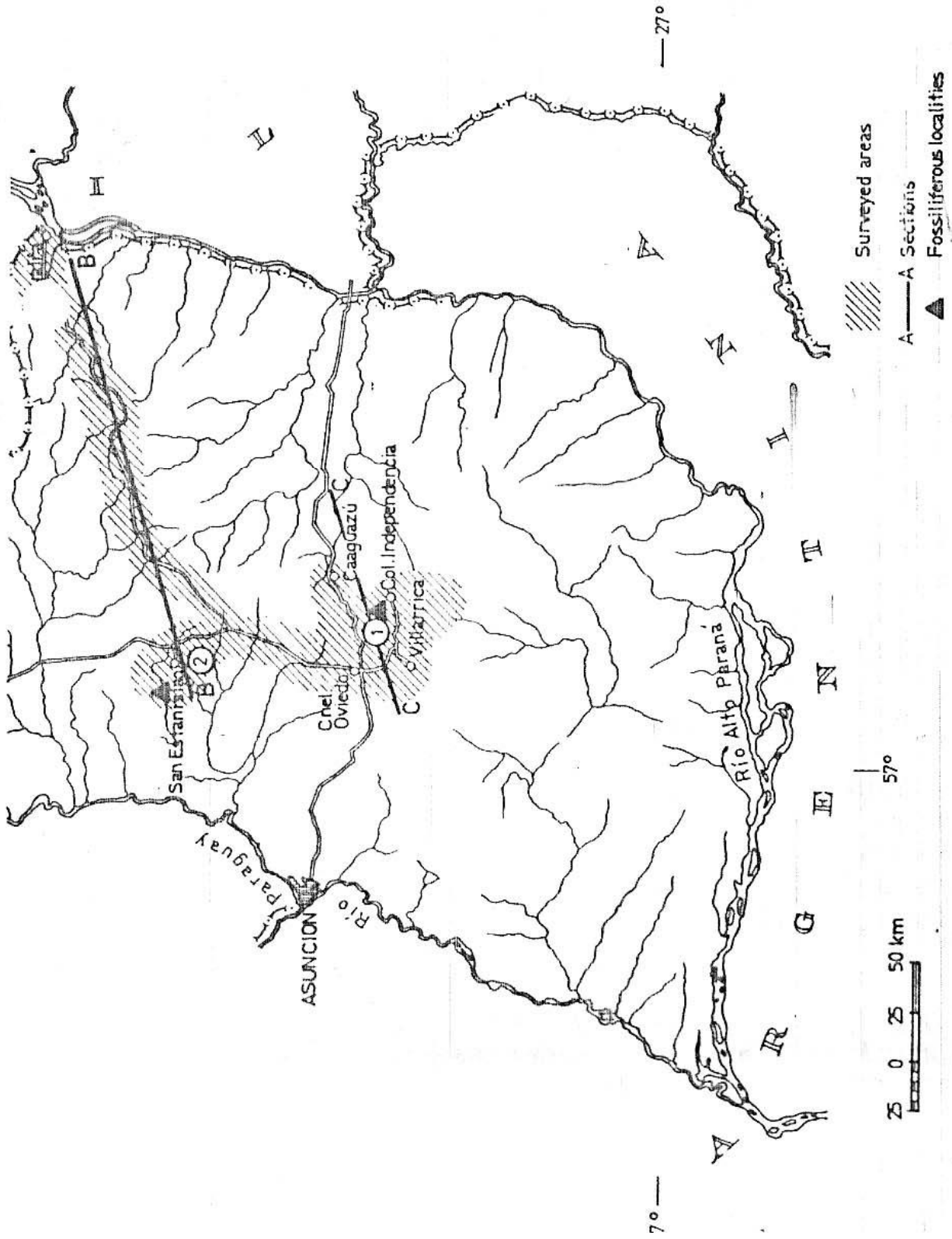


FIGURE 1. Areas surveyed in Paraguay.

the time partly to the scarcity of outcrops, and this scarcity, in turn, to the presumed (and described) characters of the rocks preventing their preservation. In any case, some paleontological and stratigraphic investigations were carried out during those years, and general interest in the subject increased.

The methods of study were determined by the particular geographic and geomorphologic conditions in eastern Paraguay, which is located in the subtropical zone of South America and is almost completely covered with dense forest. Study areas were selected partly on the basis of aerial photographs and partly on the basis of their transitability. These areas would be visited, the local stratigraphic sections surveyed, and fossils sought. The fossils would then be studied, identified, and correlated with better known parts of the Paraná Basin.

Three field trips were completed following the original proposal of the project, that is, trips on a west-east axis trying to find and follow the main sequence (see Sections A-A, B-B, and C-C in Figure 1). Several localities along these sections proved fruitful for fossil collecting. A few of these localities had been discussed in the literature.

Again, it should be noted that there are difficulties in traveling in Paraguay, mainly owing to the lack of roads. Only a few main roads are paved, while most roads are merely dirt roads, and very large areas lack roads completely. Traveling is done by trail (many times wagon trail) and then only during the dry season.

PALEONTOLOGICAL RESULTS

Some of the interesting findings of fossil plants have been reported in technical papers (Herbst, 1980, 1981a, 1981b); other materials are still being studied together with Brazilian specimens (which they resemble closely, and which have not yet been studied in Brazil). Findings are briefly summarized below.

PLANTS

Many plant petrifications were found. They can be divided into two groups, pteridophytes and gymnosperms, the most spectacular of which are the first. A beautifully preserved tree fern was described that required not only a new genus (*Guairea*) but also a new family (Guaireaceae) to be named among the osmundales (Figure 2). The discovery raises several interesting phylogenetic problems, mainly because of the lack of an adequate explanation for the presence of these anatomically advanced tree ferns in the southern hemisphere, while at the same time only primitive ones dwelt in the northern hemisphere. These findings contradict the postulated northern origin of the group.

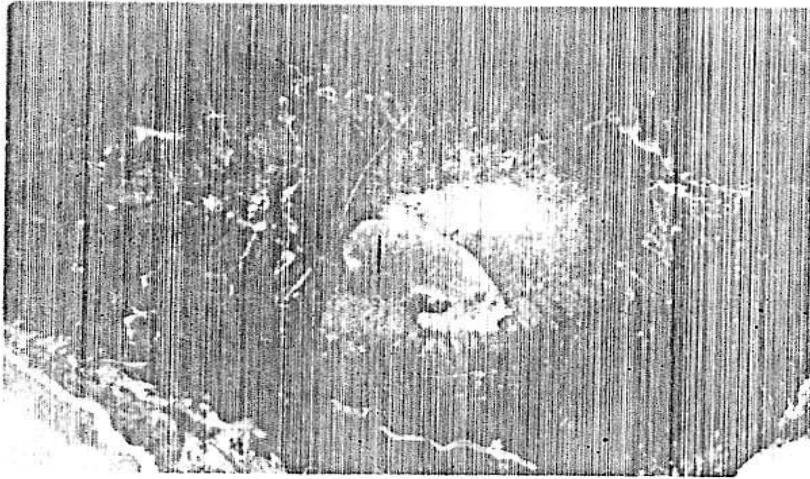


FIGURE 2. Transverse section of fossilized stem of *Guairea milleri* nov. gen. et sp.

A group of primitive ferns that seems very well represented in the upper Paleozoic of South America is the marattiales. Until now, only one species of the genus *Tietea*, with marattiaceous affinities, had been described. At least two different types of these ferns, of rather large size (one with a stele more than 35 cm in diameter), have been collected in Paraguay. One apparently belongs to *Tietea*, presumably a new species; the other, a large one, probably represents a new genus (Figure 3). The importance of these findings, apart from their great novelty, lies in the possibility of learning many things about this important group of ferns.

At least three different types of gymnospermous wood have been collected, including some large specimens, but they have not been studied yet. On cursory inspection they closely resemble some of the trees described in Brazil.

Plant impressions have been found at two localities. Lycopods had been described earlier (Herbst, 1972), and now megaspores and charophyte gyrogonites have been added to the flora (Herbst, 1981a). At the other newly studied locality lycopods, sphenopsids, and megaspores were found and described. Although the impressions are far from good, and the flora is rather poor, the general association is very interesting. It can be closely compared with Brazilian localities, and certain paleoecological conclusions can be drawn for great areas.

ANIMALS

Different animal remains have been found at several localities. The most abundantly distributed and best preserved are pelecypods, which have been classified. Pelecypod faunules of the upper Paleozoic have been described previously in Paraguay and Brazil by several authors, but

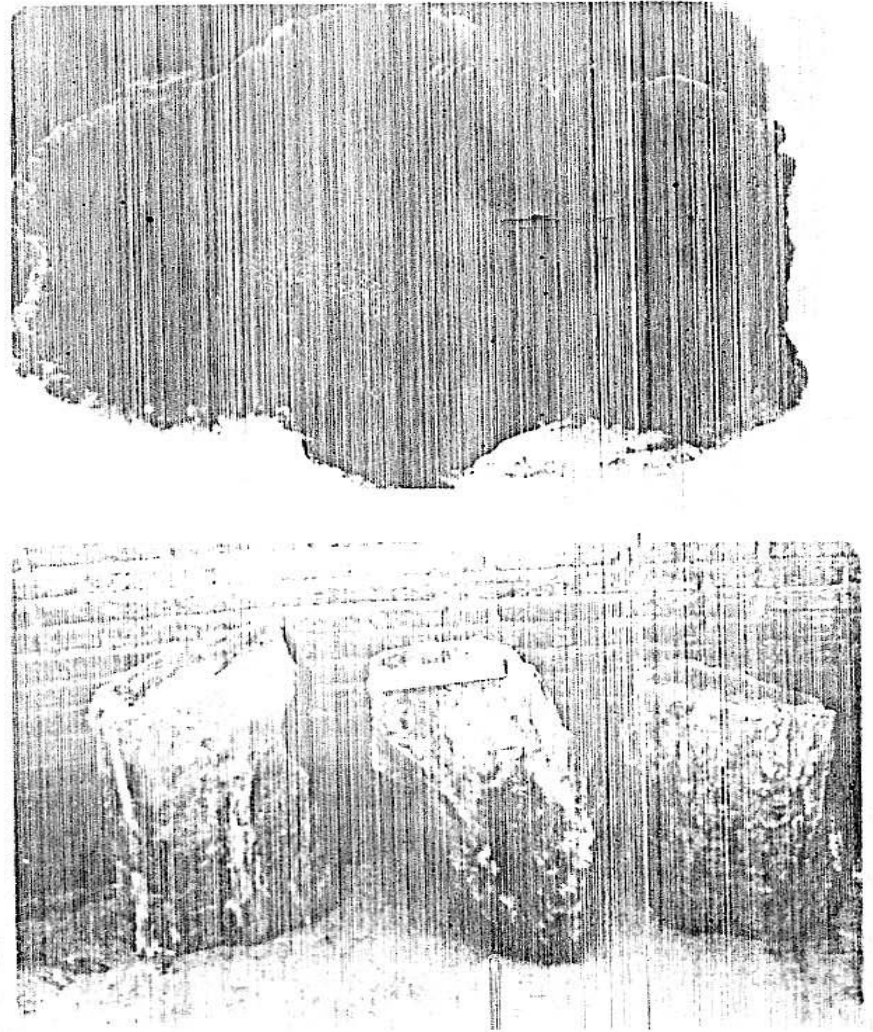


FIGURE 3. Fossils of a new genus of marattiaceous fern. *Top*: transverse section. *Bottom*: pieces of stem weighing, together, more than 500 kg. The white marker indicates 25 cm.

only recently Runnegar and Newell (1971) produced a comprehensive study of Brazil in which they define three associations. A considerable number of important paleoecological as well as stratigraphic facts were well established in that paper.

The Paraguayan faunules, found at various places, belong mostly to the *Pinzonella neotropica* association, which is placed in a very definite and strict horizon in the Permian.

At other localities, poorly preserved impressions of fish scales and dorsal fragments of Pygocephalomorpha (?) (a group of crustaceans) have been found and submitted to specialists for more information. Unfortunately the remains are too badly preserved and too fragmentary to be of any use for classification much less for any correlation. Although they are not classifiable, they are nevertheless interesting: They occur

more or less in the same beds as the pelecypods, just as in many localities in Brazil. Finally, a faunule of at least four distinct types of ostracods has been collected, closely associated with the megaspores and the charophytes. They occur as impressions (internal, rarely external), but present few morphological features, which so far has made classification impossible. The same type of faunule, with the same problems of classification, appears in Brazil; and again there is close similarity in paleoecological conditions over wide areas. More information ought to be gathered on this point.

GEOLOGICAL RESULTS

Several areas were investigated along the sections traversed (see Figure 1), and some new facts were definitely established.

In the first place, in none of the areas visited could any part of the stratigraphical sequence be attributed to the Carboniferous. All the fossils collected are of much younger age. The area crossed from north to south by the route between the city of Bella Vista (on the Apa River) and intersection with Route 5 (marked 3 on Figure 1) shows a lithology somewhat different from the rest, so it may be the "Carboniferous" various times reported in the literature (Harrington, 1950; Eckel, 1959; Putzer, 1962). However, there is no evidence at all supporting this claim for the time being. According to that literature, this area would constitute the southern outcrops of the Aquidauana Series. Yet no traces of glacial intercalations have been found in Paraguay (the literature mentions at least three of these horizons). Moreover, the few coarse sediments found may correspond to mud flows, not necessarily originating from glacial conditions, for which, again, there is no evidence.

The region of Cerro Corá (Department of Amambay, marked 4 on Figure 1), where the Carboniferous was identified and mapped, proved to be composed of Jurassic sediments equivalent to the Botucatú Formation of Brazil, or "Areniscas de Misiones," by the informal local name. The formation name should be rejected since it has been used for similar, not necessarily equivalent, sediments of the southern part of the country. The landscape of buttes, composed of red sandstones, mainly fluvial, was thought to constitute the Carboniferous, but it is clear that they are merely relicts of the Misiones sandstones, which can easily be seen to underlie the eastward, well-known Serra Geral basalts, of Jurassic-Cretaceous age.

Finally, the Sierra de Yvytyruzú (Department of Guairá, marked 1 on Figure 1) was classically believed composed of Permian sediments. We found it mostly composed of basic vulcanites (basalts), whose exact age is not known, but surely post-Permian (and pre-Jurassic). These sediments

form the hilly plains of Colonia Independencia north of the sierra, and the Numi-Fassardi area to the south. The Colonia Independencia can be considered our best fossiliferous area; most of the well-preserved fossils were found there.

Based on information summarized above, it appears that the rocks surveyed (except those from the Bella Vista area) are included in a single formation, the Independencia Formation, which, from the bottom, consists of the following:

- A. Approximately 50 to 60 m of fine- to medium-grained sediments, reddish, yellowish, and whitish, generally well stratified, not very hard in general, with fairly common and thin intercalations of siltstones of the same colors, not yet observed to contain fossils.
- B. A highly variable lithological sequence of 15 to 18 m, which includes, at different localities, an oolitic limestone containing silicified pelecypods; calcilutites with plant rests, calcareous sandstones, and fine quartzose sandstones; and siltstones with ostracods and charophytes. Colors represented are generally gray, blackish, yellowish, and green, rarely reddish. Hardness and other characters vary locally.
- C. More than 70 m (probably more than 100 m) of clear-colored, medium- to coarse-grained quartzose sandstones, with typical eolic cross-bedding, rather hard; bearing the petrifications mentioned above at their base. The total thickness of the formation is thus about 150 m.

Except for the base of Section C, which yields the fossil wood, the rest of the fossils here discussed come exclusively from Section B.

CONCLUSIONS

Our principal conclusions can be summarized as follows:

- Important advances have been made in the knowledge of Upper Permian fossil plants from Paraguay: A new genus and species (and a new family) have been described; plant impressions (lycops and sphenopsids) as well as megaspores and charophytes have also been newly described.
- At least two interesting tree ferns and three different types of gymnospermous wood, from the petrified material, remain to be described.
- Further knowledge of ostracods, fish, and crustacean remains will depend on finding better preserved material.

- The main stratigraphic sequence of the upper Paleozoic of Paraguay consists of sedimentary rocks and is included in the Independencia Formation as defined.
- In no place in eastern Paraguay could Carboniferous sediments be found; the dating at the northernmost area (close to Bella Vista) remains somewhat doubtful, however, and should be more thoroughly reviewed.
- Mainly the fossiliferous information (Herbst, 1972, 1981a; Runnegar and Newell, 1971), but also the close paleoecological similarities, and to a lesser degree the lithological data, allow a very close correlation of the Independencia Formation with the Teresina Formation (the upper part of the Estrada Nova Formation named by other authors) from the Rio Grande do Sul, Paraná, and São Paulo states of Brazil. Its age has been established as Upper (perhaps uppermost) Permian.

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