

## DIPLOGNATHODUS OCCURRENCE IN THE ITAITUBA FORMATION, AMAZONAS BASIN, BRAZIL

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**ABSTRACT** – The Itaituba Formation contains the most abundant and diverse fossiliferous deposits of the Tapajós Group Pennsylvanian of the Amazonas Basin with a rich fauna of normal marine organisms, including conodonts, fish remains, foraminifers, brachiopods, echinoids, gastropods, bryozoans, trilobites, corals, ostracodes, scolecodonts, sponges. Palynomorphs are also common. Conodonts are widely distributed. Genera like *Rhachistognathus*, *Neognathodus*, *Idiognathodus* and *Diplognathodus* are among the most important to calibrate the age and to correlate the studied deposits. The occurrence of *Diplognathodus coloradoensis*, *D. orphanus*, and the first appearance of *D. ellesmerensis* in the Itaituba Formation, Pennsylvanian of the Amazonas Basin are reported, which suggest an Atokan age to this interval.

**Key words:** Conodonts, *Diplognathodus*, Amazonas Basin, Pennsylvanian, Itaituba Formation.

**RESUMO** – A Formação Itaituba possui os estratos carbonáticos mais espessos do Grupo Tapajós. Esta formação contém os depósitos fossilíferos mais diversos e abundantes do Pensilvaniano da Bacia do Amazonas com organismos que representam uma fauna de ambiente marinho normal, incluindo conodontes, fragmentos de peixes, foraminíferos, braquiópodes, equinodermos, gastrópodes, briozoários, trilobitas, corais, ostracodes, escolecodontes, esponjas e flora caracterizada por palinórfos. Os conodontes tem sido amplamente encontrados. Gêneros como *Rhachistognathus*, *Neognathodus*, *Idiognathodus* e *Diplognathodus* estão entre os mais importantes para o refinamento das idades e a correlação dos estratos estudados. Este trabalho tem por objetivo reportar a presença de *Diplognathodus coloradoensis*, *D. orphanus*, e a primeira ocorrência de *D. ellesmerensis* na Formação Itaituba, Pensilvaniano da Bacia do Amazonas, as quais sugerem uma idade Atokana para o intervalo estudado.

**Palavras-chave:** Conodontes, *Diplognathodus*, Bacia do Amazonas, Pensilvaniano, Formação Itaituba.

### INTRODUCTION

Conodonts have shown to be useful for correlation and biozonation in the Pennsylvanian strata widely studied in North America and Europe. In Brazil, conodonts have been reported in Paleozoic basins with main attention to the Pennsylvanian strata of Amazonas Basin, which comprises the marine deposits of Tapajós Group - Monte Alegre, Itaituba and Nova Olinda formations. Among these formations the Itaituba Formation has the thick carbonate marine strata of the Tapajós Group been the focus of this study.

Some species of the genus *Diplognathodus* have been regarded as useful for stratigraphic correlation of Pennsylvanian strata because they have shown stratigraphically short ranges, like *Diplognathodus orphanus*, typical of Atokan age. Outside North America the distribution of this genus is still little known, whereas other genera like *Idiognathodus* and *Neognathodus* have been widely discussed and documented in the Carboniferous of North America and Europe.

*Diplognathodus* distribution has been analyzed in the Pennsylvanian of United States mainly by Merrill (1973), von Bitter & Merrill (1990) among others, in the Midcontinent region, Appalachian and Illinois basins, by Bender (1980) in the Canadian Arctic, by van den Boogaard (1983) in Western Europe and North Africa, by Wang Zhi-hao & Qi Yu-ping (2002) in China, among others.

In South America, *Diplognathodus* has been found in Brazil in Pennsylvanian strata of the Amazonas Basin. *Diplognathodus coloradoensis* and *D. orphanus* were studied by Lemos (1990) and Neis (1996) in wells collected by PETROBRAS. Later, studying an outcrop area of fossiliferous calcareous limestones in the southern part of the Amazonas Basin, Scomazzon (1999) report the presence of *D. orphanus* in the lower portion of the Itaituba Formation and Nascimento *et al.* (2005) registered the occurrence of *D. coloradoensis* in a quarry in this region, however in stratigraphically older marine deposits, suggesting an Atokan age to the studied interval.

This paper aim to record the Pa elements of *Diplognathodus*

occurrence in calcareous marine deposits of the Itaituba Formation, Pennsylvanian of the Amazonas Basin. We herein present the occurrence of Pa elements of *Diplognathodus coloradoensis*, *D. orphanus* and the first report of Pa elements of *D. ellesmerensis* in the Amazonas Basin.

#### MATERIAL AND METHODS

The material here studied comes from four wells made by the Brazilian oil company (PETROBRAS) in the Amazonas Basin (Figure 1). About 15 kg of carbonates from thirty-nine samples were collected from the wells. Processing techniques followed the usual methodology of Austin (1987). Around 400 g of each sample were used to process the material. From the processed material 125 Pa elements of the genus *Diplognathodus* were studied (Table 1). Other elements like M and S ones were also found in the sediment analyzed, but they were not herein considered because it is difficult to establish whether they belong or not to *Diplognathodus* apparatus. The conodonts studied herein are deposited in the collection of the Departamento de Paleontologia e Estratigrafia, UFRGS under acronym MP-M.

#### GEOLOGICAL SETTING

The Amazonas Basin is a large intracratonic sedimentary basin occupying 500 000 km<sup>2</sup> within the northern Brazilian states of Amazonas and Pará (Figure 1). Three sectors are distinguished trending generally east – west: the north platform, the south platform and the central basin area. The Paleozoic sedimentary succession is limited by two Precambrian Shields, the Guianas to the north and the Guaporé to the south of the Amazonian Craton (Tassinari & Macambira, 1999). To the east, it is separated from the Marajó Basin by the Gurupá Arch, and to the west it is separated from Solimões Basin by a subsurface basement-high, the N-S trending Purus Arch. The basin holds a Proterozoic through Recent sedimentary and sub-volcanic stratigraphic record up to 6,000 m thick, in the central area. The Carboniferous-Permian contribution accounts for more than half of the total deposition (Caputo, 1984, Milani & Zalán, 1998).

The Pennsylvanian-Permian deposits are represented by the Tapajós Group, which comprises the Monte Alegre, Itaituba, Nova Olinda and Andirá Formations. The Itaituba Formation, the focus of this paper, varies in thickness from 110 m in the southern outcrops area to 420 m in the central part of the basin. This formation represents the establishment of widespread marine conditions. It consists of diverse carbonate rocks including lime mudstones, wackestones, packstones, and oolitic and peloidal grainstones and includes a rich faunal association with brachiopods, crinoids, bryozoans, corals, foraminifers, trilobites, ostracodes, gastropods, bivalves, scolecodonts, and fish teeth. Although conodonts are low in numbers, they are more abundant and diverse in the Itaituba Formation than the other formations of the Tapajós Group, occurring in the three geographic areas of the Itaituba Formation.

#### SYSTEMATIC PALEONTOLOGY

##### *Diplognathodus* Kozur & Merrill in Kozur (1975)

**Type species.** *Spathognathodus coloradoensis* Murray & Chronic, 1965.

**Diagnosis.** A spathognathodid consisting anteriorly of a blade-like portion and posteriorly of an enlarged cup of subelliptical shape, both portions separated orally by a distinct notch. The blade-like portion is formed by laterally compressed denticles and extends anteriorly into a single row of more rounded denticles an undenticulated carina.

*Diplognathodus coloradoensis* (Murray & Chronic, 1965)  
(Figures 2A, B)

*Spathognathodus coloradoensis* Murray & Chronic, 1965: 606-607, pl. 72: 11-13; Webster, 1969: 44, pl. 7: 7; Merrill, 1973: 304, pl. 3: 20-42.

*Diplognathodus coloradoensis* (Murray & Chronic); Merrill, 1975: 48-50, figs. 16: 40, 17: 16; Landing & Wardlaw, 1981: 1257-1259, pl. 1: 4, 5, 8.

**Description.** In lateral view unit small, slightly arched. In oral view blade with four to six denticles more or less uniform in length, posterior part of the oral edge consisting of approximately one half of the total length composed of single spatula-like ridge (carina) which is separated from the denticulate blade by a prominent notch. The carina is distinctly lower than the denticulate blade. In aboral view a large and symmetrical basal cavity, deep beneath the carina and continuing as a groove along aboral surface of the blade.

**Remarks.** This species is distinguished from *D. orphanus* in having a nondenticulate carina, the blade with uniform denticles and not as high as in *D. orphanus*, and the prominent notch.

**Material.** 39 specimens.

*Diplognathodus orphanus* (Merrill, 1973)  
(Figures 2C, D)

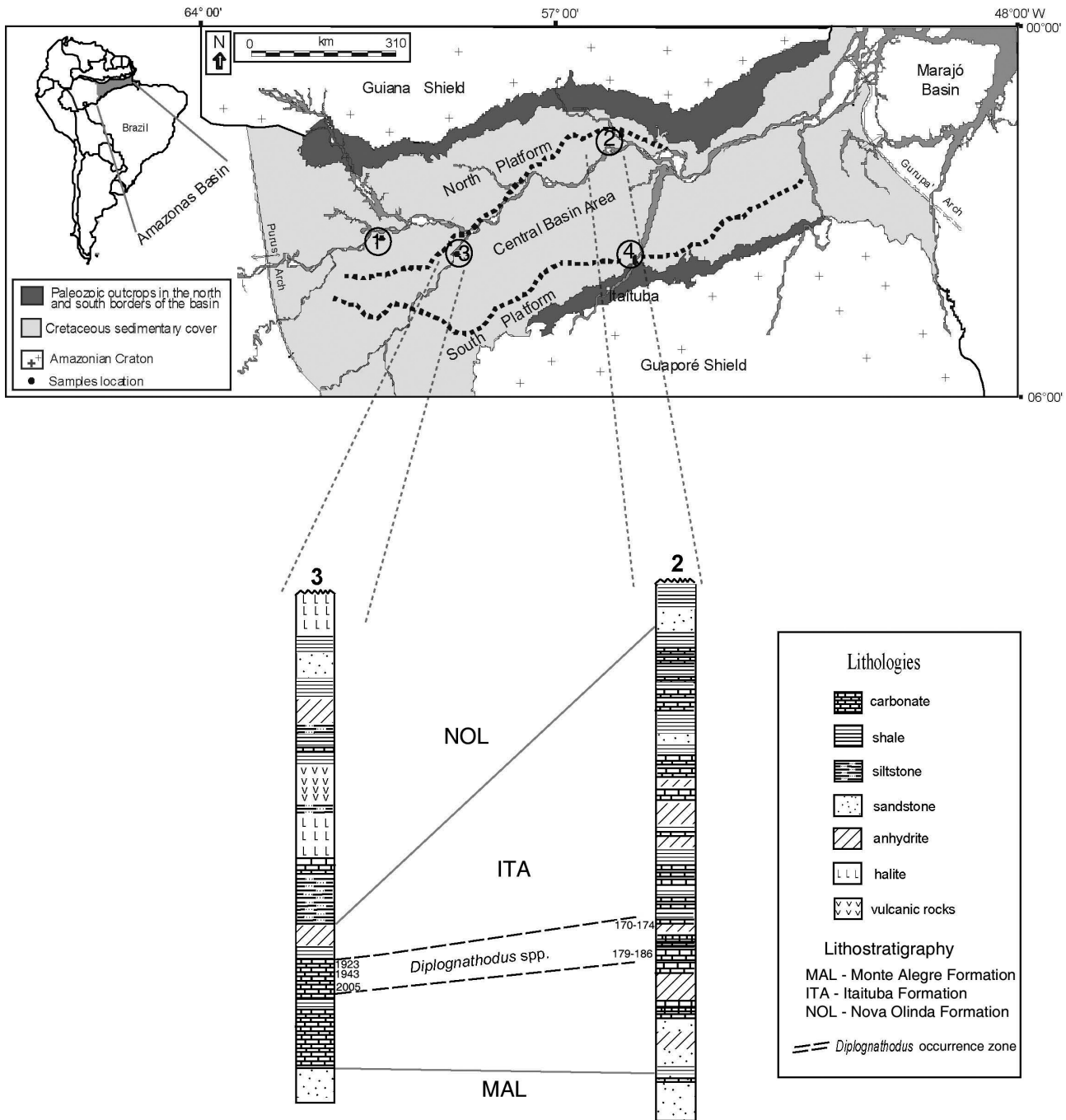
*Spathognathodus orphanus* Merrill, 1973: 309, pl. 3: 45-56.

*Diplognathodus coloradoensis* (Murray & Chronic); Landing & Wardlaw, 1981, pl. 1: 1, 6, 7, 9, 10.

*Diplognathodus orphanus* (Merrill, 1973); Grubbs, 1984: 69, pl. 1: 4.

*Diplognathodus coloradoensis* (Murray & Chronic); Savage & Berkeley, 1985: 1473, figs. 12: 9-16.

**Description.** In lateral view element slightly arched, anterior half of the unit up to twice as high as posterior half. The denticles of the blade are higher than those of the carina. They are fused about 2/3 of their length. The denticles of carina are short and fused over half their length resulting in a row of denticles of which the free tips are as high as their fused parts. Between the posteriormost denticle of the blade and the anterior most denticle of the carina occurs a



**Figure 1.** Location map of the studied wells (1- 4) in the Amazonas Basin. Stratigraphic profiles of the wells 2 and 3, showing the sampled levels (indicated by the numbers), constituting the *Diplognathodus* reference section (modified from Scomazzon, 1999).

suppressed denticle located in front of the apex of the basal cavity. This point is comparable to the notch of the *D. coloradoensis*. The denticles of the carina are almost uniform. They increase slightly in inclination toward the posterior end forming a right angle to the aboral side of the unit. In oral view the unit is almost straight. In aboral view the basal cavity is deep, wide and subsymmetrical.

**Remarks.** *Diplognathodus orphanus* is distinguished from *D. coloradoensis* by the latter having the prominent notch and by the carina; it is coarsely denticulate in the former and

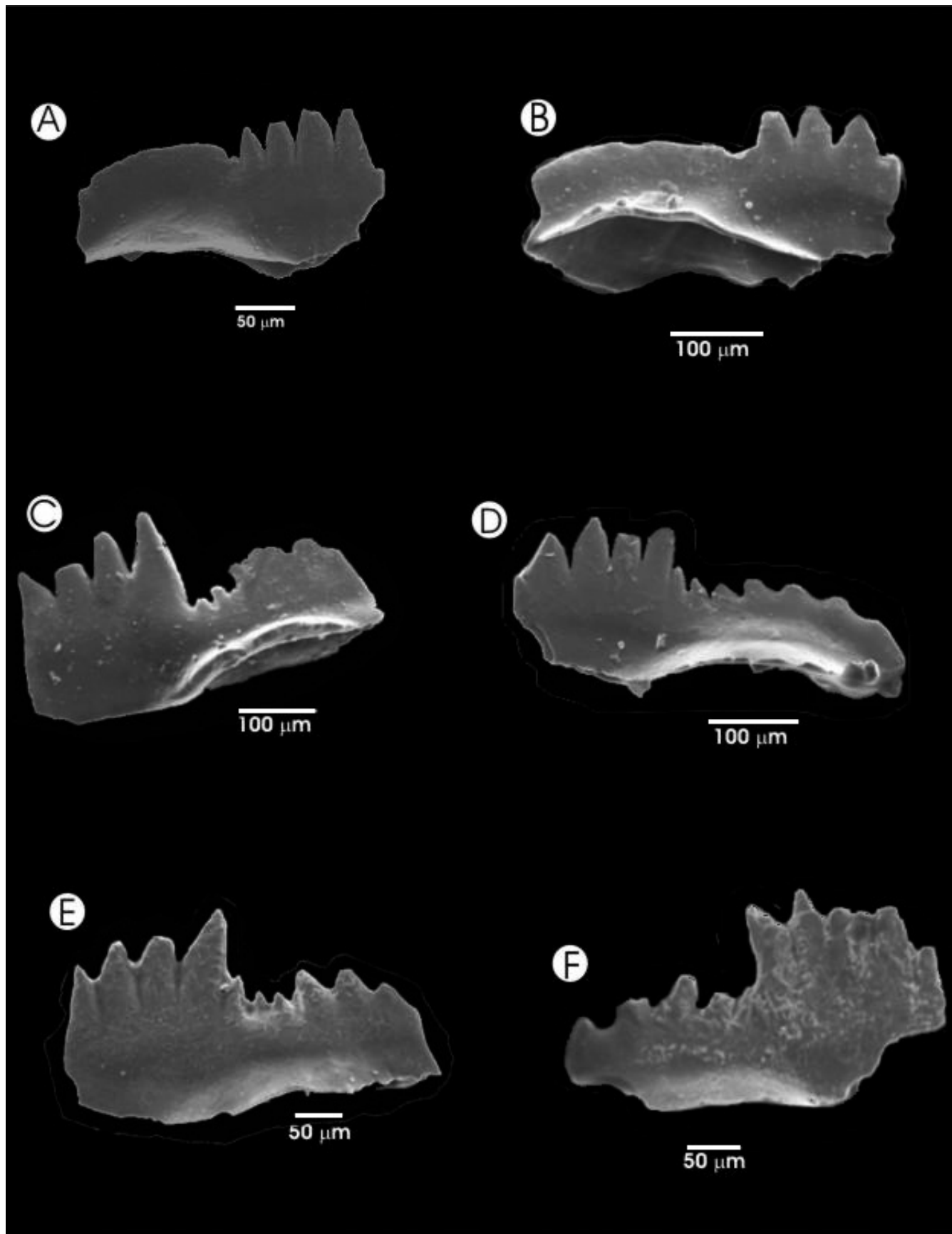
relatively to nondenticulate (spatula) in the latter.

**Material.** 42 specimens.

*Diplognathodus ellesmerensis* Bender, 1980  
(Figures 2E, F)

*Diplognathodus ellesmerensis* Bender, 1980: 9-10, pl. 4: 5-7, 11, 15-21, 23-25.

*Diplognathodus orphanus* (Merrill, 1973); Grubbs, 1984: 69, pl. 1: 3.



**Figure 2.** *Diplognathus* from Itaituba Formation, all hypotypes, in lateral view. **A-B**, *Diplognathodus coloradoensis*: **A**, MP-M-687; **B**, MP-M-705; **C-D**, *D. orphanus*: **C**, MP-M-706; **D**, MP-M-691; **E-F**, *D. ellesmerensis*: **E**, MP-M-696; **F**, MP-M-694.

**Table 1.** Conodont distribution along the four wells studied.

Taxa	Wells				Total
	1	2	3	4	
<i>D. coloradoensis</i>	—	3	13	23	
<i>D. ellesmerensis</i>	—	35	9	—	
<i>D. orphanus</i>	3	23	16	—	
N° of Pa elements recovered	3	61	38	23	125
N° of samples collected	3	11	11	14	39

**Description.** In lateral view the specimens are small. The blade consists of four to five denticles increasing in length toward the posterior end of the blade. The apex of the basal cavity is under the notch, which has in general one small denticle. The blade is twice as high as the posterior portion of the unit. In some specimens the long axes of the denticles of the blade slightly diverge giving a particular appearance to the blade. The denticles of the carina are low, the third or rarely the fourth denticle from the posterior end is the highest. In oral view the specimens are straight. In aboral view a broad and symmetrical basal cavity extends from the posterior end to about the aboral midpoint of the blade.

**Remarks.** *Diplognathodus ellesmerensis* is distinguished from *D. orphanus* by unfused denticles of the carina, the posterior end is sharp and the posteriormost blade denticle is prominent pointing toward the carina.

**Material.** 44 specimens.

## DISCUSSION

The conodont fauna of the studied material comprises *Diplognathodus coloradoensis*, *D. orphanus*, *D. ellesmerensis*, *Idiognathodus incurvus*, *Idiognathoides sinuatus*, *Neognathodus bassleri*, *N. atokaensis*, *N. medadulimus*, *N. roundyi* and *Adetognathus lautus*.

The three *Diplognathodus* species studied were recovered from the lower through the upper part of the Itaituba Formation. While *D. orphanus* and *D. ellesmerensis* are more abundant in the lower part, *D. coloradoensis* mainly occurs in the upper part of the formation. The latter species is characteristic of lower Desmoinesian, but its range is Morrowan to lower Desmoinesian (von Bitter & Merrill, 1990). *D. orphanus* is typical of Atokan age. This species has been used to characterize this interval in North America by Grubbs (1984), von Bitter & Merrill (1990), among others. *Diplognathodus ellesmerensis* was considered characteristic of Atokan by Bender (1980). However, van den Boogaard (1983) and von Bitter & Merrill (1990) suggest that this species may also range into the early Desmoinesian.

The occurrence of these species is extremely important to refine the Pennsylvanian of the Amazonas Basin. Scomazzon (1999), suggested that the Atokan-Desmoinesian boundary is somewhere between the Itaituba and Nova Olinda Formations. However, the present conodonts were all considered of Atokan-early Desmoinesian age. Therefore,

the occurrence of the Atokan guide-form *D. orphanus* and other short-ranging conodont species are important for the dating of the Pennsylvanian strata.

*Diplognathodus coloradoensis*, *D. orphanus* and *D. ellesmerensis* have been considered to be morphotypes of one species by Landing & Wardlaw (1981) and Savage & Barkeley (1985) and as separate species by van den Boogaard (1983), van den Boogaard & Bless (1985), and von Bitter & Merrill (1990) because of denticulate or undenticulated spatulas. Comparing and discussing the Pa elements of the specimens found in this study we suggest that they belong to different *Diplognathodus* species because they have distinct characteristics discussed in the systematic paleontology. For an extensive discussion related to inter- and intra-specific variation of *Diplognathodus* and its speciation see von Bitter & Merrill (1990).

## CONCLUSIONS

*Diplognathodus coloradoensis* was found in the lower, middle and upper part of the Itaituba Formation. According to the accepted range of this species would be possible to suggest a Morrowan to early Desmoinesian age to this interval; however this species is main characteristic of early Desmoinesian. Nevertheless, the occurrence of *Diplognathodus orphanus* and *Diplognathodus ellesmerensis* in the lower and upper part of the formation help to refine the suggested age pointing to an Atokan age to this interval.

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