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LOWER ORDOVICIAN CONODONT BIOSTRATIGRAPHY IN ARGENTINA [1]

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The purpose of this lecture is to give our preliminary conclusions about the Lower Ordovician conodont Biostratigraphy in Argentina.

We began with the conodont researches in the Argentine Precordillera in 1968 and our first works were published in 1970 and 1971. They gave "the first ilustration of Ordovician conodonts from South America", as **Serpagli** has pointed out in 1974 in his brilliant monograph about Argentine conodonts.

Besides the Ordovician conodonts, we have discovered these microfossils in the Silurian of Precordillera and in the Permian of the Puna and Bolivia.

According to our present knowledge the Ordovician System has, among all southamerican countries, the best representative in Argentina. There, the Ordovician beds have a complete development in marine facies that are very rich in megafossils, specially in Trilobites and Graptolites which have been reported and ilustrated by **Harrington** and **Leanza,** in 1957 and by **Turner** in 1960 respective-

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Contribution to IGCP Proyect 192, Cambro. Ordovician development in Latin - America.

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ly. They cover a strecht that goes from the Lowermost Tremadocian to the Ashgillian, completing an integrated column of more or less 10.000 meters and distributed along the West of Argentina from the Bolivian boundary in the North, to the Mendoza Province in the South, with an approximate length of 1400 kilometers (Fig. 1).

The Ordovician rocks are exposed in three main regions, which are:

I – Northwest of Argentina, Jujuy and Salta Provinces

In the Northwest of the country, there are several important outcropping sections of Lower Ordovician beds. The thickest and most complete Lower Ordovician section is among them, not far from the Bolivian boundary, along Santa Victoria River in Salta Province.

There, over the Cambrian rocks, we have a continuous sequence of about 4.000 (four thousand) meters' thickness, from the Lower Tremadocian to the Upper Arenigian, developed principally in dark grey to black shales with intercalations of dark grey marls and bluish-grey limestones and some greenish-grey shaly sandstones. The biozonation, based on the Triolobites faunas, was made in 1957 by **Harrington** and **Leanza.**

The Lowermost Tremadocian in represented by the **Parabolina argentina** Zone followed by the **Kainella meriodionalis** Zone. Both of them also gave the Graptolite **Dictyonema flabelliforme.** The Upper Tremadocian, as well as the Arenigian, is represented by two Trilobite Zones.

Upper Tremadocian	**Triarthrus tetragonalis - Shumardia minutula** **Notopeltis orthometopa** Zone
Areginian	**Kayseraspis asaphelloides** Zone **Ogygiocaris araiorhachis** Zone

Both arenigian Zones provided the Graptolite **Didymograptus vacilans deflexus.** The Tremadocian as well as the Arenigian of the Northwest of Argentina gave conodonts in several localities, but unfortunately they haven't been studied until today, with the exception of the Tremadocian conodonts of the Purmamarca, Jujuy Province (**Bultynck P.** and **F. Martin,** 1982) and the Lower Tremadocian conodonts of "Sierra de Cajas", Jujuy Province, the finding of which we make known at present. In that place we have a

Lower Tremadocian section of 278 m. with two formations; the Lower one is the shaly Lampazar Formation with the fauna of **Parabolina argentina** and the Upper one, with laminated sandstones, is the Cardonal Formation, with the Trilobite **Kainella meridionalis** (**Aceñolaza, F.G.** 1968).

The conodonts-bearing samples come from the thin greenish-dark grey limestone beds which are located at the top of the Lampazar Fm. They have abundant and very well preserved conodonts of the **Cordylodus** Fauna, with **Cordylodus proavus** and **C. oklahomensis** as dominant elements, with an average rate of 3 to 1. Among the associated simple conodont elements we have **Oneotodus** sp. and **Proconodontus** sp.

The same conodont assemblage reported by **Müller** in 1959, by **Miller** in 1969, and by other authors too, has been named Fauna "A" by **Ethington** and **Clark** in 1971. Consequently, we can correlate our **Cordylodus** levels of "Sierra de Cajas" with the earliest Tremadocian Fauna "A" of the United States of America, whose leading elements are **Cordylodus proavus** and **C. oklahomensis** according to **Lindstrom** (1976).

It is important to mention that the same **Cordylodus** Fauna associated with **Parabolina argentina** was reported for Oaxaca, México, by **Robinson** and **Pantoja-Alor** in 1968.

The Cardonal Formation and all the Upper Tremadocian sequences, with the **Ceratopyge** Fauna, remain to be investigated.

II – The Famatina Range and the "Cordillera de Narváez" in La Rioja and Catamarca Provinces respectively.

We haven't yet found conodonts in this region, with about 2.000 m. of Lower Ordovician sediments principally developed in shaly facies.

III – The Precordillera of La Rioja, San Juan and Mendoza Provinces.

The Ordovician beds are extensively exposed in the Argentine Precordillera for more than 500 Km, from La Rioja Province to Mendoza Province. (Fig. 1, numbers 2 to 9).

While the eastern exposures are mainly formed by limestones, distributed in several meridional belts, very few calcareous deposits are known along the western border.

Excellent outcropping sections of the well known carbonate

San Juan Formation, principally integrated by limestones, dolomites, and flint nodules and lenses are present along the eastern border, from North to South.

Owing to our ignorance of a structural profile, this Formation was assigned an approximate ninimum thickness of 500 meters and a maximum one of 3000 m. (**Furque**, 1972), and, on the weak basis of endemic Trilobites, **Harrington** and **Leanza** in 1957, refe rred it to the Llanvirnian age. A little more recently, in 1973, Cuerda referred the San Juan Formation to the Llanvirnian-Arenigian, based on the Graptolites of the overlying shaly Gualcamayo Formation.

One the basis of the rich conodont fauna of the San Juan Formation, outcropping at the right riverside of the San Juan River, **Serpagli** considered in 1974 that such formation must be referred to the Arenigian, al least in its upper 200 meters.

Along twelve years of investigations in several sections of Precordillera we have realized findings of conodont guide species and we have arrived to conclusions that are largely coincidental with what **Serpagli** has stated as for the Conodont Zones, but leading us to refuse the horizontality of the San Juan Formation in which we observe a marked diachronism.

I want to show some of the most important Lower Ordovician sections of precordillera that have yielded conodonts (Sec. Fig.2):

A - Guandacol River (La Rioja Province)

It is the most important sequence for us because it provides a complete succession of the Lower Ordovician. As a first task, it was necessary to understand the structural profile of the carbonate rocks, reducing the total thickness of 3000 m, estimated by other authors, to only 900 m. Besides, it has been possible to determine that the lower 650 m. (six hundred and fifty meters) correspond to a stromatolithic monotonous succesion of alternated limestones and dolomites, originated in an algal plain of little depth, with complete lack of macro and microfossils. This carbonate complex, named "Los Sapitos Formation" (**Hünicken** and **Pensa**, 1981), is present in the basal part of the calcareous deposits of Precordillera. This formation referred to the Upper Cambrian–Tremadocian, passes in transition to the San Juan Formation, which thickness is of 250 m. and where dolomite beds are absent.

It deals with a succesion of thinly bedded limestones and marls and with an important contents of macro and microfossils. It

has been possible to determine the occurrence of **Prioniodus elegans** and the associated conodont fauna of the respective zone in the middle part. Inmmediately above and up to the top of the Formation, abundant specimens of the multielement species **Oepikodus evae** and the associated conodont fauna have been found. It remains to be determined if **Paroistodus proteus** is present in the lower third section of the Formation. The occurrence of more than 80 m. of limestones which samples are under analysis at present, leads us to expect positive results. It has been possible to determine for the first time the bottom and the top of the San Juan Formation and also to define its thickness and Lower Arenigian age in this section. The overlying shaly Gualcamayo Formation, with an abundant Graptolites fauna and referred to the Llanvirnian at present must unquestionably correspond to the Upper Arenigian in the Guandacol section.

B - Sierra La Batea (San Juan Province)

From a lithological viewpoint, the Lower Ordovician deposits in "Sierra La Batea" are the same as in Guandacol section. Unfortunately we don't have a measured profile, but in the lower part there are stromatolithic deposits of the Los Sapitos Forma-

part there are stromatolithic deposits of the Los Sapitos Formation (Upper cambrian? Tremadocian) followed by the impure limestones of the San Juan Formation which upper part has yielded abundant conodont elements.

In this assemblage no good index fossils have been found until today, but, the very high frequency and abundance of **Periodon flabellum** Hadding, associated with **Paroistodus parallelus** (Pander) and **Protopanderodus elongatus** Serpagli, allows to admit that the top of the San Juan Formation can be correlated here with the **Baltoniodus navis** conodont zone of the Baltic area.

At present we are studying the Graptolite-bearing overlying shaly Gualcamayo Formation, with several intercalated thin layers of grey limestones, where we hope to find conodonts.

C - Huaco Section (San Juan Province)

There are two separate belts of Lower Ordovician carbonate rocks; the western one shows tectonic contacts and it cleary represents the stromatolithic Los Sapitos Formation assigned to the

Upper Cambrian-Tremadocian age in the Guandacol section. Only 150 meters of breached limestones and dolomites are visible.

The eastern belt represents the fossiliferous upper 200 meters (two hundred m.) of the San Juan Formation. The grey limestones with interbedded yelowish-green marly shales form here an asymmetrical anticline which is disconformably overlain by Carboniferous sedimentes.

The uppermost 25 meters of limestone beds yielded abundant conodont elements. The occurrence of all the **Baltoniodus navis** Lindström morphotypes in particular and also the occurrence of **Reutterodus andinus** Serpagli, **Drepanodus arcuatus** Pander, **Paroistodus parallelus** (Pander), **Drepanoistodus forceps** (Lindström), **Protopanderodus elongatus** Serpagli, **Juanognathus jaanussoni** Serpagli, etc **(Lemos Brasil, V. 1981)** doubtless indicate that the rocks which yielded these conodonts belong to the **Baltoniodus navis** zone.

At present we are analyzing many limestone samples of the San Juan Formation in this section, and we hope to find elements of the **Baltoniodus triangularis** and **Oepikodus evae** Zones.

Near the South of "Quebrada de Huaco", in Puesto Viejo, we have found, a few days ago, ambalodiform elements of **Eoplacognathus pseudoplanus** (Viira) (**Amorphognathus variabilis Zone**) in the uppermost limestone beds of the San Juan Fm., which indicates that the top of the San Juan Formation reaches the Llanvirnian age in Puesto Viejo. There, the Llanvirnian to Caradocian shales appear as a wedgelike between the limestones and the overlying Carboniferous.

D - Jachal Section (San Juan Province)

There are several Lower Ordovician limestone belts near Jachal town. The most important belt, located 5 km. towards the South, shows about 250 m of limestones and marly limestones of the San Juan Formation that overlie Upper Cambrian - Tremadocian stromatolites. Six samples of the outcropping uppermost 25 m yielded a great number of conodont elements. The index fossil **Oepikodus evae** (Lindström), that appears in all the samples, is associated with the same species that **Serpagli** pointed out in 1974 for the Fauna "B", at the Río San Juan section.

A very narrow belt with the uppermost San Juan Formation limestones located 10 km. Southwest of Jachal, is very poor in conodonts. No good index fossils have been recognized there, but

the ocurrence of **Reutterodus andinus** Serpagli, **Paroistodus parallelus** (Pander), **Drepanoistodus forceps** (Lindström), **Protopanderodus leonardi** Serpagli and **Protopanderodus elongatus** Serpagli, makes possible the correlation of this assemblage with the Fauna "C" of **Serpagli** (1974), tentatively referred to the **Baltoniodus triangularis** and **Baltoniodus navis** zones.

E - Talacasto Section (San Juan Province)

One of the most important sequences of the San Juan Formation is in the "Quebrada de Talacasto". There are more than 400 m of impure limestone beds, but unfortunately the basis is not visible and the top is disconformably overlain by Silurian deposits.

The first occurrence of conodonts is about 70 m above the outcropping basis of the Formation where there are abundant and well preserved elements of the index fossil **Oepikodus evae** (Lindström). (prioniodiform, oepikodiform and falodiform elements). This species marks the **Oepikodus evae** Zone in the Baltic Region. ⊏ Lower Arenigian Latorpian stage (B I) – Billingen substage (B I γ) ⊐

We hope to find elements of the other Arenigian-Llanvirnian conodont Zones, in several limestone samples that come from the upper 250 m. of the San Juan Formation.

F - San Juan River Section (San Juan Province)

The San Juan River has an important and thick limestone section, but unfortunately it is not complete, with the basis and top not well defined.

Here, our biostratigraphic knowledge is due to Dr. **Serpagli** (1974) who pointed out 5 tentative local assemblage Zones, on the basis of conodont collections of the upper 200 m of the San Juan Fm. limestones.

The lower zone, named Fauna "A", can be equivalent to the Baltoscandian **Prioniodus elegans** Zone. The Fauna "B" follows in order, with the important index species **Oepikodus evae** associated with other numerous conodont species. This fauna can be correlated with the Baltoscandian **Oepikodus evae** Zone, that represents the upper Lower Arenigian. The Fauna "C" is characterized by **Reutterodus andinus, Protopanderodus leonardi, Drepanodus arcuatus, Paroistodus parallelus,** etcetera, but no good

fossils have been recognized. **Serpagli** correlates this fauna with both, **Prioniodus triangularis** and **Prioniodus navis** Zones. The Fauna "D", with **Scandodus brevibasis** is correlated with **Paroistodus originalis** Zone of the Baltic Area. The last Fauna "E" is extremely poor in species.

REMARKS

Now, I want to comment some news about the Middle and Upper Ordovician of the Argentine Precordillera, as an additional information.

Above the San Juan Formation limestones ⊏ with elements of **Eoplacognathus pseudoplanus** (Viira) B III (Kundan) γ ⊐, in the Huaco Section, in Puesto Viejo, we found several moulds of **Pygodus serrus** associated with the Graptolite **Paraglossograptus etheridgei** into the graptolite-bearing black shales of Los Azules Formation.

The two morphotypes of the index species **Pygodus anserinus** were identified in the bluish-grey limestones of the Ponón Trehué Formation, at the far South of Mendoza Province (**Heredia**, 1981).

Finally, as a conclusion of the conodont researches in Precordillera, we must change the concept of synchronism of the San Juan Formation, first referred to the Llanvirnian and after to the Arenigian.

It deals with a typical diachronous formation (Fig. 3). Meanwhile in the Southern sections, (E and F), the limestones begin with the **Oepikodus evae** Zone, in the North (Section A, Guandacol River), the San Juan Formation finishes with the same conodont Zone.

At the same time of the San Juan limestones sedimentation in the Huaco Section, Graptolite-bearing black shales of the Gualcamayo Formation were being deposited in the Guandacol Section.

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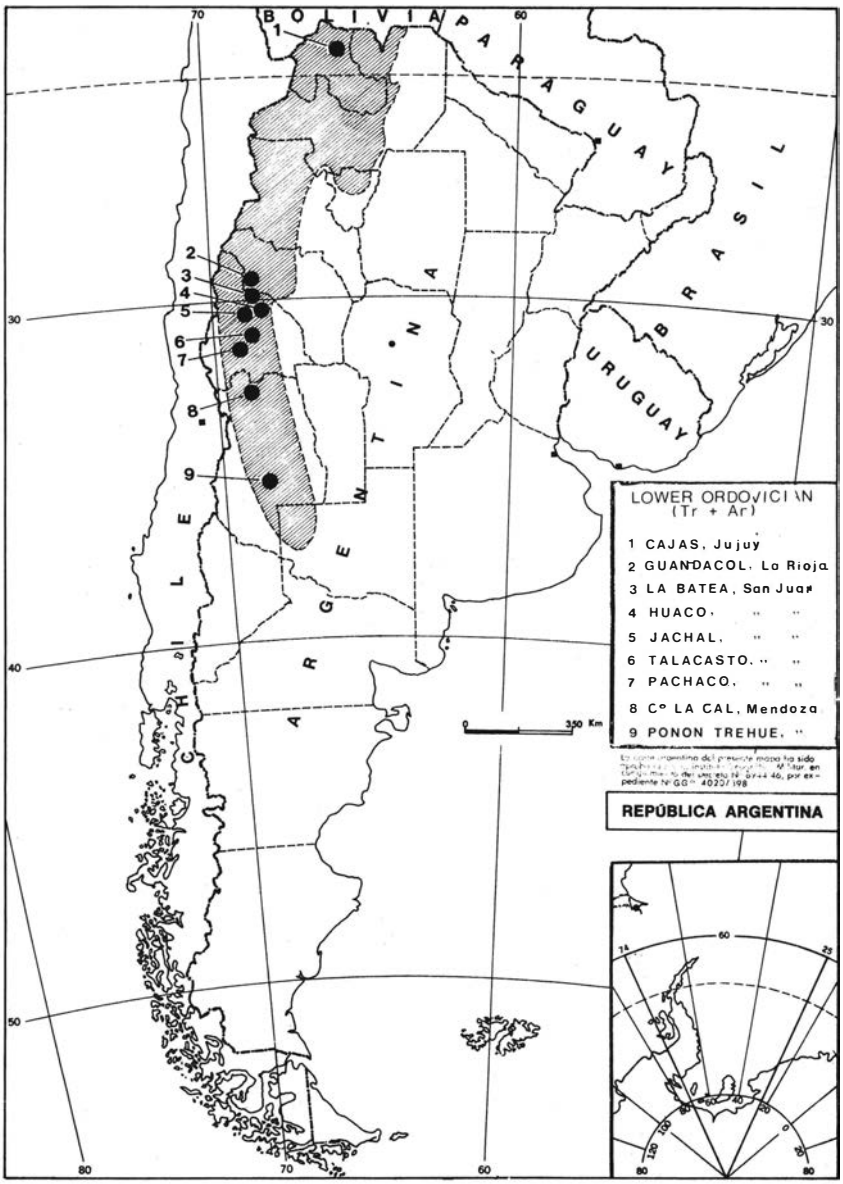
BOLIVIA
PARAGUAY
BRASIL
URUGUAY
ARGENTINA
CHILE
70
60
30
40
50
80
LOWER ORDOVICIAN
(Tr + Ar)
1 CAJAS, Jujuy
2 GUANDACOL, La Rioja
3 LA BATEA, San Juan
4 HUACO, " "
5 JACHAL, " "
6 TALACASTO, " "
7 PACHACO, " "
8 Cº LA CAL, Mendoza
9 PONON TREHUE, "
0 350 Km
REPÚBLICA ARGENTINA

Fig. 1

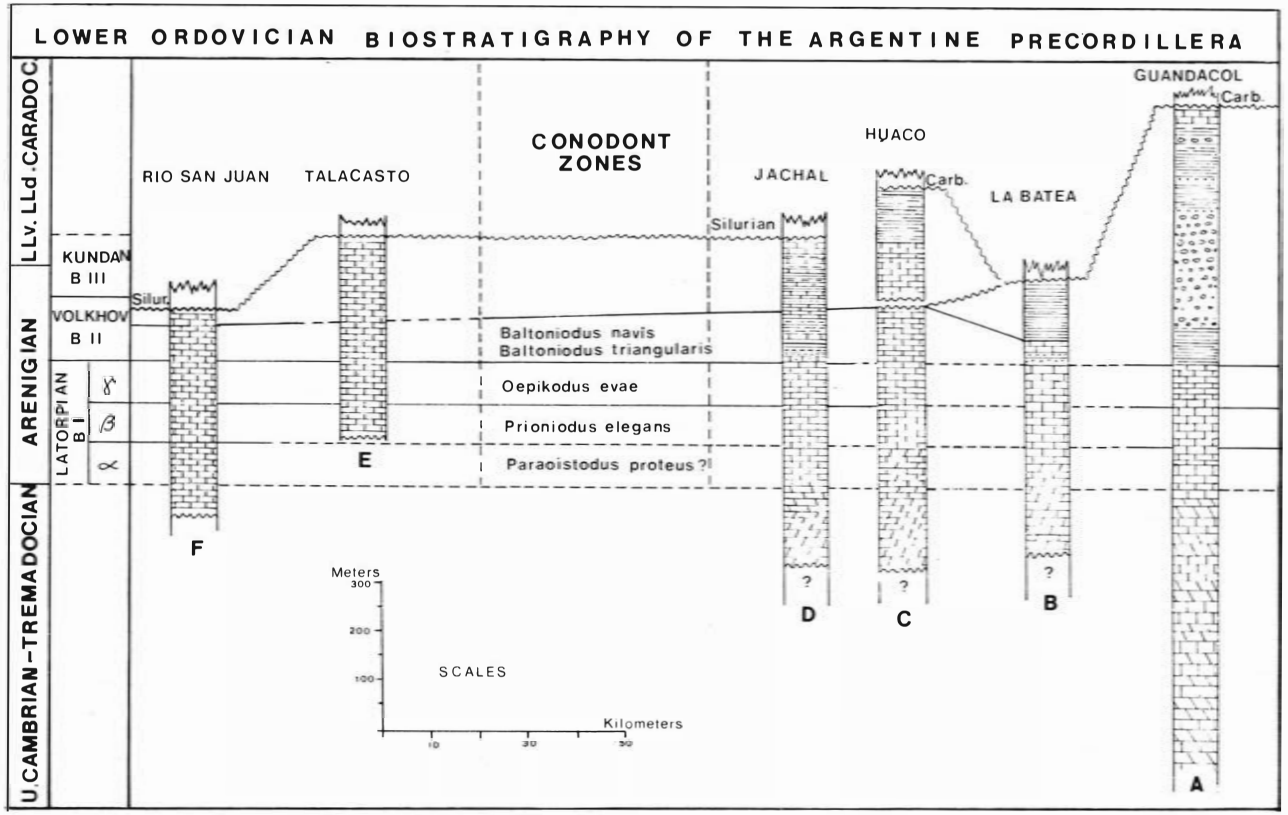
LOWER ORDOVICIAN BIOSTRATIGRAPHY OF THE ARGENTINE PRECORDILLERA
U.CAMBRIAN–TREMADOCIAN
ARENIGIAN
LLv. LLd. CARADOC
KUNDAN B III
VOLKHOV B II
LATORPIAN B I
γ
β
α
RIO SAN JUAN
TALACASTO
CONODONT ZONES
JACHAL
HUACO
LA BATEA
GUANDACOL
Silur.
Silurian
Carb.
Baltoniodus navis
Baltoniodus triangularis
Oepikodus evae
Prioniodus elegans
Paraoistodus proteus?
F
E
D
C
B
A
?
Meters
300
200
100
SCALES
Kilometers
10
30
50

Fig. 2

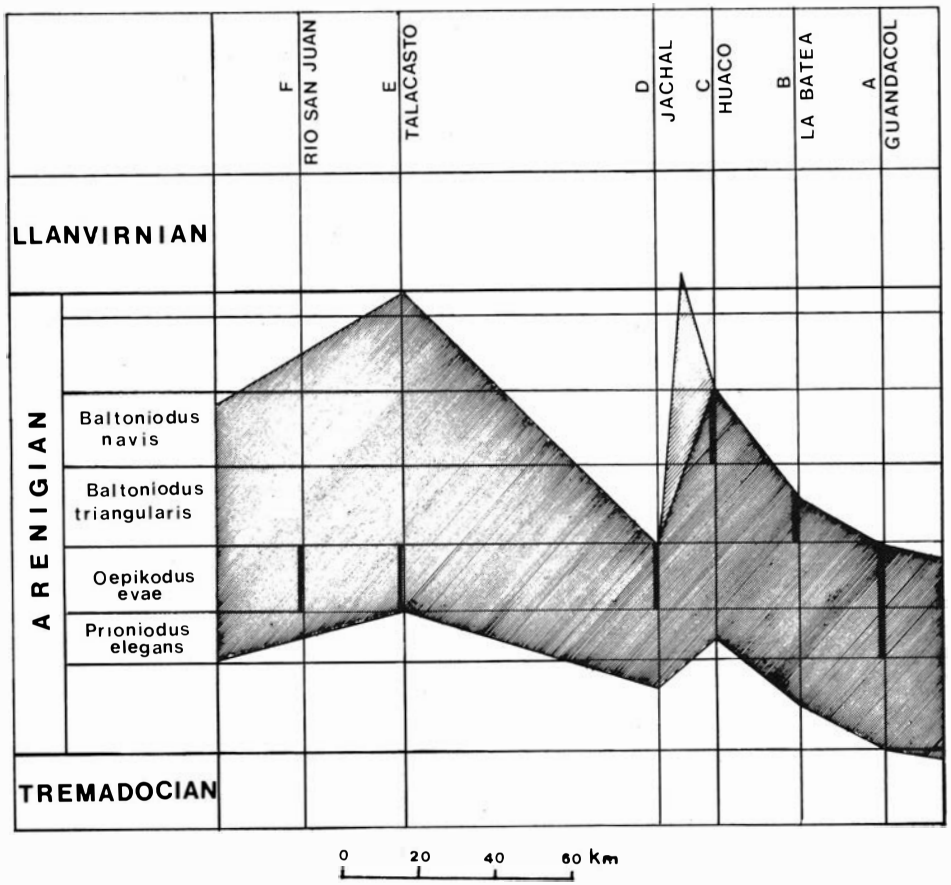

Fig. 3 Diachronism of the San Juan Formation

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LOWER ORDOVICIAN CONODONT BIOSTRATIGRAPHY IN ARGENTINA (1)

Dr. Mario A. Hünicken (2)

SYNOPSIS

A preliminary Ordovician Conodont sequence has been recognized in Argentina. The *Cordylodus proavus* fauna (Lower Tremadocian) is associated with *Parabolina argentina* (Trilobite) in the northwest of the country (Jujuy and Salta Provinces). In the Precordillera of La Rioja, San Juan and Mendoza, the following Conodont Zones are present in the San Juan Formation: *Prioniodus elegans*, *Oepikodus evae*, *Baltoniodus navis* and *Eoplacognathus pseudoplanus*, the last one was recognized at the top of the formation. The *Pygodus serrus* Zone is present in the Los Azules Formation, and finally *Pygodus anserinus* was reported in the south of Mendoza Province (Ponón Trehué).

SINOPSIS

Ha sido reconocida en la Argentina, en forma preliminar, una secuencia de Conodontes ordovícicos. La fauna de *Cordylodus proavus* (Tremadociano inferior) está asociada con *Parabolina argentina* (Trilobite) en el noroeste del país (Provincias de Jujuy y Salta). En la Precordillera de La Rioja, San Juan y Mendoza, en la Formación San Juan, están presentes las siguientes zonas de Conodontes: *Prioniodus elegans*, *Oepikodus evae* y *Baltoniodus navis* y la de *Eoplacognathus pseudoplanus* fue reconocida en el techo de la formación. La Zona de *Pygodus serrus* está presente en la Formación Los Azules (Provincia de San Juan) y para el sur de la Provincia de Mendoza (Ponón Trehué) fue mencionada la presencia de *Pygodus anserinus*.

(1) Presented at the IV International Symposium on the Ordovician System, held at OSLO, Norway, in August 1982.
Contribution to the IGCP Proyect 192, Cambro, Ordovician development in Latin-America.

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