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Conodonts of Mexico: a GIS database☆

Los conodontos de México: una base de datos en SIG

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Abstract

A geographic information system (GIS) database is herein presented to integrate all reports of conodont occurrences in Mexican localities. In addition to the database and the interactive map, we included detailed static maps of each locality, whenever the information was available. The analysis of data included in 62 scientific works revealed 45 localities in Mexico where conodonts have been reported. Conodont record in Mexico spans the entire stratigraphic range of the group, from the late Cambrian to the Late Triassic. Conodont biodiversity includes at least 611 species of 229 genera, although we have not carried out validation of taxonomic assignments nor taxon validity or synonymy. The results obtained contribute to a better understanding of paleobiodiversity and the evolution of marine ecosystems in Mexico and provide a valuable tool for future paleontological and geological studies.

Keywords: Conodonts, Biostratigraphy, Paleontology, Biodiversity, Database, Mexico.

Resumen

El presente trabajo consiste en una base de datos y Sistema de Información Geográfica (SIG) donde se integran todas las ocurrencias de conodontos reportadas en localidades mexicanas. Además de la base de datos y el mapa interactivo, se incluyen mapas estáticos de cada localidad, siempre que esta información esté disponible. El análisis de los datos incluidos en 62 publicaciones científicas reveló 45 localidades en México donde se han reportado conodontos. El registro de conodontos en México abarca el rango estratigráfico completo del grupo, desde el Cámbrico tardío hasta el Triásico Tardío. La biodiversidad de conodontos incluye al menos 611 especies de 229 géneros, aunque el presente trabajo no incluye validación de las clasificaciones taxonómicas ni validación del taxón o sinonimia. Estos resultados contribuyen a un mejor entendimiento de la paleobiodiversidad y la evolución de los ecosistemas marinos de México y proporcionan una herramienta valiosa para futuros estudios geológicos y paleontológicos.

Palabras clave: Conodontos, Bioestratigrafía, Paleontología, Biodiversidad, Base de datos, México.

1. Introduction

Conodonts are a group of extinct organisms, which inhabited the oceans from late Cambrian to earliest Jurassic times (Du et al., 2020; 2023). Their fossil record consists almost exclusively of discrete, microscopic, phosphatic elements known as conodont elements, which can be found in every Paleozoic or Triassic marine rock (Sweet, 1988). Despite their abundance, the phylogenetic affinities of conodonts are still debated (e.g., Donoghue and Keating, 2014). This is due to the discrete nature of their fossil record and the difficulty in understanding how conodont elements group together in each individual to form the conodont apparatus (Zhuravlev, 2007), in addition to the fact that there are no living representatives of the group. Since they were first described by Pander (1856), conodont supra-

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generic classification has been referred to almost every higher-rank taxon. Conodonts have been considered even as their own phylum (Sweet, 1988); however, they are currently grouped in the Class Conodonta (Donoghue et al., 2008), part of the Phylum Chordata, as jawless vertebrates (agnatha) and included in the stem-gnathostomes (Donoghue and Keating, 2014). Their vertebrate affinity is still under discussion (Turner et al., 2010) although most conodont workers agree with such vertebrate assignment.

Even though the paleobiology of conodonts is still poorly understood, their geological value as biostratigraphic markers for Paleozoic and Triassic rocks is widely known. Of the 56 stage/age boundaries of the Paleozoic Era and Triassic System included in the Geological Time Scale of the International Commission on Stratigraphy (the latest version published in Gradstein et al., 2020), 29 (51.8%) are defined by the first appearance datum (FAD hereafter) of a conodont species. Cambrian is officially subdivided through FAD of trilobite species; Ordovician and Silurian mostly with graptolites; however, the Cambrian/Ordovician Boundary, as well as the Dapingian/Darriwilian (Middle Ordovician) and Llandovery/Wenlock boundaries of the Silurian Period are defined by the FAD of conodont species. All but four boundaries from the Devonian to the end of the Triassic periods are formally defined based on conodont species distribution. This is because they thoroughly fulfill the requirements for being considered an index fossil: cosmopolitism, ubiquitous occurrence in the fossil record, and brief biostratigraphic range of the species distribution.

Conodont studies in Mexico have a history of more than 60 years. However, during those 60 years, most of the works published on conodonts have been made by researchers affiliated with foreign institutions. This fact poses two main problems. One is the low dispersion of literature, which in some cases made it impossible to get a copy of the work. The other one is the loss of the published specimens, which are not properly hosted in a Mexican paleontological collection. In some cases, there is no information regarding the location of such material. In this work, we made an exhaustive bibliographic review of the Paleozoic and Triassic paleontological literature of Mexico, trying to get all the studies with a reference to conodonts, including research papers, meeting abstracts, and theses. This database with paleontological information is also valuable when updating the systematics of reported fossil groups employing new taxonomic criteria or changes in the definition or organization of taxa.

2. Methods

In this work, we have conducted exhaustive research in the scientific literature looking for occurrences of conodonts in Mexico, either as a single report or as a detailed and systematic study. We have analyzed published data arranged and systematized them for uniformly compiling whenever possible. A total of 62 scientific publications are considered for this study (Tables 1, 2, 3 and 4), including 45 conodont localities. For this compilation, we have used QGIS software. The geological maps at the scale of 1:250,000 are available as shape files at the Servicio Geológico Mexicano (SGM) website. We edited the attribute table of the SGM geological map of Mexico by deleting all geological polygons younger than Triassic and simplifying exposures by age. The database herein included is presented in a Geographic Information System (GIS), with the attribute tables organized by locality, including, whenever available, the fields of State, Author, Year, Locality, Geographic coordinates, lithostratigraphic formation, faunistic associations, Period, Age, Biozone, Color Alteration Index (CAI) and Paleontological collection where the fossil material is hosted. Associated database and map will be periodically updated whenever new Mexican conodont papers are published.

3. Results

In Mexico, the study of conodonts dates back to the early 1960s, with the first conodont report described in the Mina Plomosas-Placer de Guadalupe area in the eastern part of the state of Chihuahua. This work corresponded to a PhD Thesis from the University of Texas (Bridges, 1962). Samuel P. Ellison, also from the University of Texas, made conodont taxonomic determinations. This complete study included conodont associations with different ages covering most of the Paleozoic Era (Ordovician, Silurian, Devonian, Late Mississippian, Pennsylvanian, and Permian). Despite the profound study (60 samples out of 215 yielded identifiable conodonts), with 38 genera listed, conodont data were not correctly published, and there are no illustrated specimens nor reference to where the material was deposited. Only a part of the results from that work were published in a formal but brief article (Bridges and De Ford, 1961). Benedetti (1976) studied the same locality in Placer de Guadalupe. He established Paleozoic lithostratigraphy with slightly different biostratigraphic ages. His work included extensive documentation of the conodont fauna, although it lacks detailed information about samples (location and weight of the processed sample). This thesis is currently unavailable in Mexican university libraries. The second conodont study published in Mexico was by Robison and Pantoja-Alor (1968), who included very few references to conodont occurrences in a paper on trilobites around Santiago Ixtaltepec, state of Oaxaca. It was not until almost 40 years later when Landing et al. (2007) properly studied the Cambrian—Ordovician conodont fauna of the Tiñú Formation.

During the decades of the 70s and 80s, Palmira Brunner published a number of papers about conodont biostratigraphy of Devonian and Carboniferous key localities in several states of Mexico, including Sonora, Puebla and Chiapas (Brunner, 1975, 1976, 1984, 1987). These contributions are also noteworthy because they were the first published by a Mexican institution, the Instituto Mexicano del Petróleo.

Since these pioneering studies, many changes have happened in the systematic paleontology of conodonts. In fact, one of the most significant improvements was the establishment of

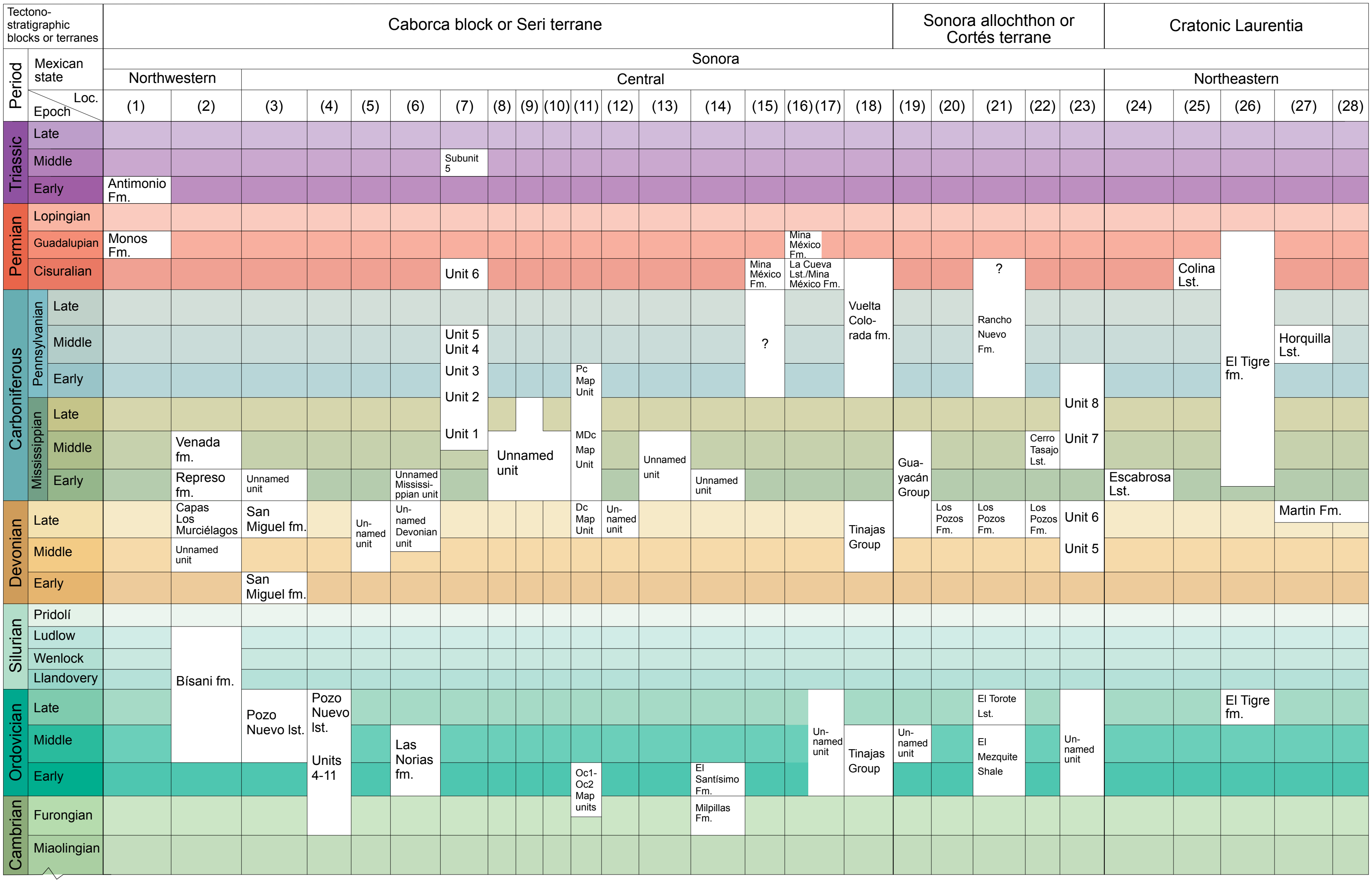

Table 1. Lithostratigraphic units with conodont occurrences in Sonora reviewed for the present conodont database. See Table 3 for locality names. / Tabla 1. Unidades litostratigráficas con presencia de conodontos en Sonora revisadas para la presente base de datos de conodontos. Véase la Tabla 3 para los nombres de las localidades.

Tectono-stratigraphic blocks or terranes		Caborca block or Seri terrane				Sonora Alloch. or Cortés terrane	Alisitos	Cratonic Laurentia		Oaxaquia				Coahuila Block	El Fuerte Block		Ciudad Victoria Block	Maya Block
Period	Mexican state	Baja California					BCS	Chihuahua		Puebla		Oaxaca		Coahuila	Sinaloa		Tamaulipas	Chiapas
	Epoch / Loc.	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)	(41)	(42)	(43)	(44)	(45)
Triassic	Late						San Hipólito Fm.											
	Middle																	
	Early			De Indio Fm.														
Permian	Lopingian													Las Delicias units				
	Guadalupian									Tecomate Fm.								
	Cisuralian								Pastor Fm.							San José de Gracia Fm.		Paso Hondo Fm. Grupera Fm.
Carboniferous – Pennsylvanian	Late										Patlanoaya Fm.							
	Middle							Mina Plomosas units						Las Uvas flysch beds			Del Monte Fm.	
	Early								Pastor Fm. / Monillas Fm.									
Carboniferous – Mississippian	Late				Cañón Calamajué unit			Mina Plomosas units										
	Middle											Ixtaltepec Fm.						
	Early					Arroyo Grande Group												
Devonian	Late		Canal de las Ballenas Group					Mina Plomosas units										
	Middle								Solís Fm. / Monillas Fm.									
	Early																	
Silurian	Pridolí																	
	Ludlow																	
	Wenlock																	
	Llandovery																	
Ordovician	Late								Sostenes Fm.						El Fuerte Fm.			
	Middle																	
	Early	Rancho San Marcos allochthon										Tiñú Fm.						
Cambrian	Furongian																	
	Miaolingian																	

Table 2. Lithostratigraphic units with conodont occurrences in Mexico (for Sonora see Table 1) reviewed for the present conodont database. See Table 3 for locality names. / Tabla 2. Unidades litostratigráficas con presencia de conodontos en México (para Sonora, véase la Tabla 1) revisadas para la presente base de datos de conodontos. Véase la Tabla 3 para los nombres de las localidades.

Tectono-stratigraphic blocks or terranes	Mexican State	(#)	**Locality**	References
Caborca block or Seri terrane	Sonora	**(1)**	El Antimonio	Lucas et al., 1997; Lara-Peña, 2019; Lara-Peña et al., 2021
		(2)	Rancho El Bízani	Brunner, 1976; Brunner 1984; Silva-Magaña, 2023
		(3)	Rancho Placeritos	Poole et al., 2003a; Poole et al., 2003b; Navas-Parejo et al., 2016; Page et al. 2012
		(4)	Sierra López	Stewart et al., 1990; Stewart and Poole, 2002; Page et al., 2012
		(5)	Rancho Las Barajitas	Stewart and Poole, 2002
		(6)	Sierra Santa Teresa	Stewart et al., 1997
		(7)	Rancho Las Norias	Page et al., 2003; Poole et al., 1995a; Page et al., 2012
		(8)	Puerto El Orégano	Casarrubias, 2015
		(9)	Sierra Los Leyva	Stewart and Poole, 2002
		(10)	Sierra de Mazatán	Stewart and Poole, 2002; Vega-Granillo 1996
		(11)	Sierra Agua Verde	Navas-Parejo et al., 2017; Repetski et al., 1985; Poole et al., 1995a; Page et al., 2012; Stewart et al., 1999a
		(12)	Cerro La Cueva	Ramos-Martínez, 2016, Navas-Parejo et al., 2019
		(13)	Rancho Sobechi	Stewart and Poole, 2002
		(14)	Arivechi	Almazán-Vázquez, 1989; Almazán-Vázquez and Fernández-Aguirre,1987 ; Reyes-Montoya, 2017
		(15)	Mina México	Stewart and Poole, 2002
		(16)	Cerro Las Rastras	Lara-Peña, 2019; Lara-Peña et al., 2020
		(17)	Sierra Martínez	Stewart and Poole, 2002; Lara-Peña, 2019; Lara-Peña et al., 2020; Poole et al., 1995a; Page et al., 2012
		(18)	Cerro Cobachi	Ketner and Noll, 1987; Poole et al., 1995a; Poole et al., 1995b
Sonora allochthon or Cortes terrane	Sonora	**(19)**	Cerro Guayacán	Noll et al., 1984; Borjas Realivázquez, 2014
		(20)	Arroyo Tesotitas	Navas-Parejo et al., 2016
		(21)	Barita de Sonora	Poole and Amaya-Martínez, 2000
		(22)	Cañón Máviro	Navas-Parejo et al., 2016; Navas-Parejo and Sandberg, 2018
		(23)	Sierra El Aliso	Bartolini, 1988; Bartolini et al., 1989; Bartolini et al., 1995; Poole et al., 1995b
Cratonic Laurentia	Sonora	**(24)**	Cerro La Cal	Stewart and Poole, 2002
		(25)	Rancho La Cueva	Blodgett et al., 2002
		(26)	Sierra Pilares de Teras	Holcomb, 1979
		(27)	Sierra Los Ajos	Page et al., 2010
		(28)	Sierra Las Mesteñas	Lara-Peña, 2017
Caborca block or Seri terrane	Baja California	**(29)**	Rancho San Marcos	Gastil and Miller, 1981; Lothringer 1983; Lothringer 1993
		(30)	Canal de las Ballenas	Campbell and Crocker, 1993
		(31)	El Volcán	Gastil and Miller, 1983; Buch and Delattre, 1993
		(32)	Sierra Calamajué	Hoobs, 1985; Griffith and Hoobs, 1993
Sonora allochthon or Cortes terrane	Baja California	**(33)**	Sierra Las Pintas	Leier-Engelhardt, 1986; Leier-Engelhardt, 1993
Alisitos	Baja California Sur	**(34)**	Punta San Hipólito	Orchard et al., 2007
Cratonic Laurentia	Chihuahua	**(35)**	Mina Plomosas	Bridges, 1962
		(36)	Mina Plomosas-Placer de Guadalupe	Benedetti, 1976
Mixteca block	Puebla	**(37)**	Tecomate	Keppie et al., 2004
		(38)	San Salvador Patlanoaya	Brunner, 1987; Caridroit et al., 2002
Oaxaquia	Oaxaca	**(39)**	Santiago Ixtaltepec	Landing et al., 2007; Robison and Pantoja, 1968; Navas-Parejo et al., 2023
		(40)	Arroyo Totoyac-Tiñú	Robison and Pantoja, 1968
Coahuila Block	Coahuila	**(41)**	Las Delicias	Mckee et al., 1988; Wardlaw et al., 2000
El Fuerte Block	Sinaloa	**(42)**	El Fuerte	Stewart et al., 1999a; Poole et al., 2010
		(43)	San José de Gracia	Gastil et al., 1991
Ciudad Victoria Block	Tamaulipas	**(44)**	Cañón de la Peregrina y Cañón de Caballeros	Casas-Peña et al., 2024; Stewart et al., 1999b
Maya Block	Chiapas	**(45)**	Chicomuselo	Brunner, 1984

⋮ (continued)

Table 3. Correlation of tectono-stratigraphic blocks and terranes with Mexican states, localities and references included in the database presented herein. Color refer to Mexican tectonostratigraphic block and terranes commonly used in the literature; see Table 4 for color key meaning. / Tabla 3. Correlación de bloques tectonoestratigráficos y terrenos con los estados mexicanos, localidades y referencias incluidas en la base de datos presentada en este trabajo. Los colores hacen referencia a bloques tectonoestratigráficos y terrenos mexicanos comúnmente utilizados en la literatura; véase la Tabla 4 para la clave de colores.

a multielement taxonomy, as opposed to form-taxonomy or monoelemental taxonomy, where each morphology is considered as a different taxon (Jeppsson and Merrill, 1982). According to Sweet (1988), Hinde (1879) was the first author who practiced a real multielement taxonomy when he defined *Polygnathus dubius*. However, it was not until 1962 that conodont researchers accepted the multielement methodology for studying conodonts, in which each species is composed of several paired elements with different morphologies occupying different positions within the feeding apparatus of the animal (Sweet, 1981). The acceptance of this multielement taxonomy implies a change in the understanding of the Paleobiology of conodonts as a group, whose consequences are still helping to define conodont apparatuses. This way of classification does not influence the biostratigraphic age of the strata and formations studied but it affects biodiversity values and evolutionary analysis, even affecting the inference of globally occurring biodiversity episodes or massive extinction events.

The lack of a paleontological methodology is systematically shown in most conodont papers published on Mexican samples. Inherently, this lack of systematics complicates a realistic evaluation of the biodiversity and abundance of Mexican conodonts reported until now. A first analysis is herein made, allowing us to evaluate conodont studies' usefulness and poten-

Mexican tectonostratigraphic block and terranes based on Campa & Coney (1987); Sánchez-Zavala et al (1999); Stewart & Poole (2002); Poole et al (2005); Ortega-Gutíerrez et al (2018).	Generalized facies based on Stewart & Poole (2002); Poole et al (2005).
Caborca block or Seri terrane	Continental-shelf rocks of Laurentia (miogeoclinal)
Sonora allochthon or Cortes terrane	Ocean-basin rocks in Sonora allochthon (eugeoclinal)
Cratonic Laurentia	Cratonic-platform rocks of Laurentia
El Fuerte block Coahuila block Oaxaquia Cd. Victoria Block Mixteca block Maya block	Fragments of Gondwana or interposed volcanic-arc terrane

Table 4. Correlation of Mexican tectono-stratigraphic blocks and terranes with Paleozoic general paleoenvironment terms commonly used in the literature. / Tabla 4. Correlación de los bloques tectono-estratigráficos y terrenos de México con términos generales de paleoambientes del Paleozoico comúnmente utilizados en la literatura.

tial. Mexican conodont records published until now cover the entire geochronologic range of the group, from the Furongian (late Cambrian) to the Rhaetian (Late Triassic) (Tables 1 and 2). Geographically, conodonts have been reported in 45 localities from ten Mexican states, including Sonora (Table 1), Baja California, Baja California Sur, Sinaloa, Chihuahua, Puebla, Oaxaca, Coahuila, Tamaulipas, and Chiapas (Table 2).

A further analysis of provincialism and paleogeographic distribution of Mexican conodonts is not the aim of this work. However, we used a tectonostratigraphic context to organize lithostratigraphy and conodont occurrences. Tectonostratigraphic terranes, as reviewed in Campa and Coney (1983), Sedlock et al. (1993), and Ortega-Gutiérrez et al. (2018), are herein followed.

3.1. Caborca block or Seri terrane

The vast majority of conodont reports in Mexico are located in the Caborca block (Campa and Coney, 1983), also called the Seri block (Sedlock et al., 1993). This terrane includes Paleozoic deposits formed in the continental passive margin of southern Laurentia, formerly known as "Miogeoclinal facies". Such a passive margin changed to an active margin by Pennsylvanian time (Poole et al., 2005), consequently involving a change in facies and paleoenvironment. As a result, this terrane also includes facies described as foredeep deposits, known as the Mina Mexico Formation (Poole et al., 2005). This unit was deposited in the foreland basin formed during the collision between Gondwana and Laurentia in the westernmost segment of the Ouachita-Marathon-Sonora orogen (Poole et al., 2005, Stevens et al., 2014). Conodont localities in the Caborca block are located in Baja California and Sonora (Tables 1 and 2). According to the Ouachita-Marathon-Sonora orogen hypothesis (Poole et al., 2005), however, localities of Baja California included in the Caborca Block would be part of the Cortés Terrane instead. This is consistent with the facies and paleoenvironment associated with the succession described in the Arroyo Grande locality (Navas-Parejo et al., 2018). Conodont biostratigraphic ages include Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, Permian and Triassic. An Upper Pennsylvanian stratigraphic gap, reported by Navas-Parejo (2018), is evident in the Sierra Santa Teresa locality, but not recorded by conodont biostratigraphy in other Sonoran exposures.

3.2. Sonora Allochthon or Cortés Terrane

This terrane includes the stratigraphic succession of the Sonora Allochthon, which is part of the Ouachita-Marathon belt in their westernmost segment. This allochthonous succession started deposition in the westernmost Rheic basin, southwest of Laurentia, and then migrated to the north during the late Paleozoic (Poole et al., 2005). The Cortés terrane also includes metamorphic-metasedimentary rocks in southern Sonora and northern Sinaloa, considered herein as the Internal Domain of the Oua-chita-Marathon-Sonora orogen. This deep-water succession was formerly known as "Eugeoclinal facies". Most of the conodonts reported in the Cortés Terrane come from the Sonora Allochthon (i.e., central Sonora). Only some occurrences are reported in the southern part of this terrane, in the state of Sinaloa. Conodont biostratigraphic ages include Ordovician, Devonian, Mississippian and Pennsylvanian. A significant stratigraphic gap is detected in this succession, spanning from the Upper Ordovician to the Middle-Late Devonian.

3.3. Cratonic Laurentia

The vestiges of the supercontinent Laurentia are located in Mexico in Chihuahua and northeastern Sonora. Commonly, lithostratigraphic units of this region are correlated with those cropping out in southwestern United States. During the Paleozoic, most of it was represented by an epicontinental sea, which covered much of the western and southern United States (Gutschick and Sandberg, 1983). Conodont biostratigraphic ages include (Cambrian?), Ordovician, Silurian (?), Devonian, Mississippian, Pennsylvanian and Permian.

3.4. Peninsular terranes

Paleozoic rocks from the state of Baja California are included in the Peninsular Terranes, except the succession in Arroyo Grande, which, according to the proposal by Ortega-Gutiérrez et al. (2018), would be part of the Caborca Block. The Peninsular Terranes also include Triassic marine rocks from Baja California Sur. The latest Precambrian to mid-Cretaceous successions of the Peninsular California are known as the Prebatholithic (Gastil and Miller, 1983).

Paleozoic rocks of Baja California are grouped in two different facies: shallow marine and deep water. Both have been traditionally correlated to equivalent successions cropping out in Sonora, that is, the continental shelf and the basin rocks of the Sonora Allochthon (Poole et al., 2005 and references therein). A palinspastic restoration of the Peninsula and southern California of 300-400 km to the SE needs to be repositioned as before the Neogene right-lateral plate boundary shifting.

3.5. Perigondwanan Mexican Terranes

Most of central and southern Mexico is composed of a mosaic of geologic terranes with different basement rocks. In this work, we choose to use the general term Perigondwanan Mexican Terranes to group the localities in the states of Coahuila, Puebla, Guerrero, Oaxaca, Tamaulipas, and Chiapas.

3.6. Oaxaquia

Paleozoic sedimentary rocks cropping out in the Oaxaca state are included in Oaxaquia and considered the sedimentary cover of the Oaxacan Complex (Pantoja-Alor and Robison, 1967, Ortega-Gutiérrez et al., 1995). This sedimentary cover appears as small outcrops that have been grouped into four lithostratigraphic formations: the Cambrian–Ordovician Tiñú Formation, the Mississippian Santiago Formation, the Serpukhovian-Pennsylvanian Ixtaltepec Formation, and the Permian clasts of the Yododeñe Formation. Conodonts have been reported from these formations, particularly Cambrian and Ordovician species from the Tiñú Formation and a Middle Mississippian association from the Ixtaltepec Formation. The Ixtaltepec Fm. has been traditionally considered of a younger age; this age is assigned by means of several invertebrate associations, mainly brachiopods (Torres-Martínez and Sour-Tovar, 2023).

Upper Paleozoic (meta)sedimentary rocks in the Puebla state are included in the Patlanoaya group and the Tecomate Formation (Caridroit et al., 2002, Keppie et al., 2004). Paleogeographic context and paleoenvironment understanding of these successions are still the subject of debate. Recent paleogeographic models for the late Paleozoic, including Mexican terranes (Guerrero-Moreno et al., 2023; Casas-Peña et al., 2024), locate these successions south of the Ouachita-Marathon-Sonora orogen, northwest of Colombia and South America. Conodonts found in the state of Puebla indicate Pennsylvanian and Permian biostratigraphic ages.

3.7. Coahuila block

Paleozoic sedimentary rocks are the oldest rocks described in the Coahuila Block (Mckee et al., 1988). These sedimentary rocks are late Paleozoic, mainly Pennsylvanian and Permian in age. The lithostratigraphy of these rocks is still not well established since the continuity of the outcrops is very limited. In fact, Mckee et al. (1999) recommended the use of lithosome units instead of lithostratigraphic units because of the sedimentologic nature of the succession. Conodont biostratigraphic ages include Pennsylvanian ages, corresponding to conodonts found in Cretaceous flysch units included in the Las Uvas beds, and Permian ages from several strata within the classic Las Delicias formation.

3.8. Ciudad Victoria Block

The Paleozoic sedimentary rocks included in the Tamatán Group, along with Precambrian and Paleozoic metamorphic and igneous complexes that widely crop out in the state of Tamaulipas and in Nuevo León, represent units that defined the Ciudad Victoria Block and where previously included in the Sierra Madre terrane, Guachichil terrane and/or Oaxaquia Superterrane. Recent works on the Aserradero Rhyolite indicate a correlation with other Mexican blocks, but with different affinity that allowed the definition of the Ciudad Victoria Block (Ramírez-Fernández et al., 2021; Casas-Peña et al., 2021). Conodont biostratigraphic ages reported in the Del Monte Formation from the Tamatán Group correspond to the Pennsylvanian.

3.9. Maya block

Paleozoic sedimentary rocks of Chiapas appear in the southern area of the Chiapas Massif Complex. Permian (Cisuralian) sedimentary rocks are included in the Grupera Formation and Paso Hondo Formation, which extensively crop out in the Chicomuselo area, close to the Guatemala International Border (Heredia-Jiménez et al., 2025 and references therein). The paleogeographic position of both formations during the late Paleozoic and before the opening of the Gulf of Mexico are inferred to be south of the Ouachita-Marathon-Sonora orogen, closer to Northern Gondwana (northern part of South America) than to the rest of Mexico. Conodonts reported from the Paleozoic successions of Chiapas indicate a Permian age, although these reports correspond with very preliminary studies, which eventually were not completed.

4. Conclusions

Paleozoic and Triassic exposures in Mexico are significant due to their location during Pangea's assembly and the beginning of its fragmentation. Geological studies needed to understand the dynamic that took place include petrological analyses, provenance analyses, and paleoenvironmental reconstructions. In addition, a suitable stratigraphic frame and biostratigraphic controls are essential, allowing us to accurately reconstruct the geological history. Conodonts, as indisputable marine index fossils for Paleozoic and Triassic studies, should be considered as one of the main tools for accomplishing this kind of paleogeographic reconstructions. However, detailed studies with Mexican conodonts, including illustrations, taxonomic descriptions, systematic discussions, and information regarding abundance, occurrences, and distribution, are scarce.

After analyzing the spatiotemporal distribution of the records published so far, it clearly appears that conodonts are ubiquitous and diverse in Mexico. Conodont biodiversity includes at least 611 species of 229 genera, although we have not carried out validation of taxonomic assignments nor taxon validity or synonymy.

From the analysis carried out in this work, we can conclude that the line of research on conodonts in Mexico has great potential. On the one hand, and despite not existing currently many detailed studies of conodonts, the record of conodonts in Mexico covers its entire geological history, almost 300 million years, since it includes faunistic associations that go from the late Cambrian (Furongian) to the Late Triassic (Rhaetian). On the other hand, there is a record of different localities where conodonts have been found, mainly studied from a biostratigraphic analysis point of view and which suggest the possibility of being studied in greater depth, including the development in Mexico of other lines within the Earth Sciences, such as Geochemistry, Paleoclimatology and/or Paleoceanography using conodonts.

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