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Carmen Rosales Domínguez and Federico Olóriz

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10th International Congress on the Jurassic System

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Carmen Rosales-Domínguez and Federico Olóriz

2018

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EDITORS LETTER

All over the world, the Jurassic System represents an extraordinary time period.

More than 50 million years of sedimentation, tectonics, preservation of organic remains (fossils), and many other geologic processes have left traces of relevance for both science and economy. For these reasons, we have to recognize the extraordinary work done every four years by the International Subcommission on Jurassic Stratigraphy (ISJS) to promote the organization of a congress devoted, exclusively, to the Jurassic. On this occasion, it is an honor for the Mexican institutions involved in the organization of the 10th International Congress on the Jurassic System, to have the opportunity of contributing to the efforts of the ISJS, as the result from the selection of Mexico as the country to go ahead with this responsibility.

In Mexico, the Jurassic is one of the most important periods since their rocks have economic oil importance. Moreover, from north to south, many Mexican formations contain abundant and well preserved macro- and microfossils that have permitted to progress with the establishment of a detailed stratigraphy.

Local and foreign scientist from many countries who participate in the 10th International Congress will contribute to improve our knowledge on the Jurassic around the world: lithostratigraphy; sedimentology and microfacies analysis; biostratigraphy and correlation; taphonomy, paleontology and paleobotany; paleoecology; evolution; geochemistry; paleoclimatology; structural geology and geodynamics; geologic history; mineralogy; volcanology; and petroleum geology, among other topics with special relevance from multidisciplinar to transdisciplinar approaches.

We thank the integrated efforts of the Organizing Committee, the Organizing Institutions, and the Sponsors, as well as to all participants their enthusiasm to make of this event a great experience. Thank you all. And welcome to San Luis Potosi, Mexico!

Carmen Rosales-Domínguez and Federico Olóriz

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Abstracts

Sedimentological and biostratigraphic study of the Upper Jurassic Pimienta Formation in Mazatepec, Puebla, Mexico

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A detailed sedimentological and biostratigraphic study was carried out in the Upper Jurassic Pimienta Formation in Mazatepec, Puebla, Mexico, using a 250 m continuous core drills from outcrops. These comprise from the base of Tamaulipas Inferior Formation (Lower Cretaceous Berriasian) till the upper part of San Andres Formation (Upper Jurassic Kimmeridgian). In the studied outcrop core the total thickness of Pimienta Formation is 64.20 m; the lower contact is lithological abrupt and contains abundant chemical dissolution, whereas towards the upper contact gradually changes to facies of Tamaulipas Inferior Formation.

Ten sedimentary facies were identified in the Pimienta Formation: wackestone of Saccocoma, wackestone-packstone of *Saccocoma*, wackestone of radiolarians, wackestone-packstone of radiolarians, wackestone of calcispheres, recrystallized wackestone-packstone, wackestone of mollusc fragments, argillaceous lime mudstone, argillaceous lime mudstone-wackestone and argillaceous wackestone of bioclasts. Laminae and thin beds of light green bentonite (of pyroclastic origin) are present along the entire Pimienta Formation and also two thin sills at the lower and middle part of this formation.

A thorough biostratigraphic analysis based on peaks of abundance, and first and last faunistic appearances of dasycladacean algae, sponges, benthic foraminifera, stomiosphaerids, saccocomids and calpionellids allowed the biozonation of the Pimienta Formation, identifying three biozones from bottom to top: 1) *Parastomiosphaera malmica*, 2) *Saccocoma arachnoidea*, and 3) *Crassicollaria intermedia*. Furthermore, there were also recognized the *Acicularia elongata elongata biozone* indicating the top of the San Andres Formation and *Calpionella alpina* biozone showing the base of the Tamaulipas Inferior Formation.

The analysis of sedimentary facies, biostratigraphic content and gamma ray log, acquired throughout the total outcrop core, allowed to define three stratigraphic packages in the Pimienta Formation. The lower part (19.50 m thick), deposited during the Early Tithonian consists mainly of wackestone of calcispheres, wackestone of Saccocoma and wackestone-packstone of *Saccocoma* in thin stratification, with scarce horizons of bentonite. This interval shows abundant calcispheres, Saccocoma, radiolarians and fish fragments. The vertical distribution of the facies and gamma ray log show an increase in the

content of the organic matter and clay towards the top of this interval, suggesting an outer platform to basin depositional environment.

The middle part of the Pimienta Formation (32.70 m thick) was deposited in the Middle Tithonian, is formed by argillaceous lime mudstone, wackestone of radiolarians and wackestone-packstone of radiolarians of thin to medium stratification and abundant horizons of light green bentonite. The facies stacking pattern and their response to gamma rays show that this interval contains the richest organic matter facies and the highest clay content inferring that these sediments were deposited in a basinal environment.

The upper part of the Pimienta Formation (12.0 m thick), deposited during Late Tithonian is represented by wackestone of radiolarians, wackestone-packstone of radiolarians, argillaceous wackestone of bioclasts, wackestone of mollusc fragments and recrystallized wackestone-packstone of thin to medium stratification with sporadic light green bentonite horizons. The vertical arrangement of facies and the gamma rays logs indicate a decrease in the content of organic matter towards the top of the formation deducing an outer platform depositional environment.

The sedimentological and biostratigraphic analysis of the Pimienta Formation in Mazatepec, Puebla, Mexico indicates that was deposited during Early Tithonian to Late Tithonian in an environment that varies from outer platform to basin.

Keywords: Pimienta Formation; sedimentary facies; biostatigraphy; Tithonian.

Ecological change within assemblages of brachiopods and molluscs across the Early Toarcian (Early Jurassic) extinction event in the Lusitanian Basin, Portugal

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Global warming and temperature-related stresses, in particular deoxygenation and acidification of seawater, have raised concerns over the degradation and transformation of modern marine ecosystems. The geological and fossil record conserves ancient episodes of severe environmental perturbations and their effects on the taxonomic composition, ecological characteristics and evolutionary dynamics of the marine biota, thus providing the opportunity to develop better predictive frameworks for long-term biotic response to climate change. We assessed the ecological changes across the Early Toarcian warming/extinction event through a detailed bed-by-bed study of assemblages of brachiopods, bivalves and gastropods at the stratigraphically complete Fonte Coberta/Rabaçal section in the Lusitanian Basin, Portugal. The marlstones and micritic carbonates of the ca. 28 m thick succession from the Pliensbachian–Toarcian boundary to the middle of the Levisoni Zone represent a fairly continuous middle to distal ramp depositional environment below storm wave base.

The pre-extinction assemblages are dominated by brachiopods whereas bivalves are more abundant in the post-extinction assemblages. Yet these bivalves are small-sized compared to the brachiopods so that in terms of biomass brachiopods are still more prominent. The dominance of brachiopods suggests generally low levels of food supply because articulate brachiopods are capable of utilizing dissolved organic matter in addition to particulate organic matter and because they have a generally lower metabolism than bivalves. Standardized sample-level diversity (species richness) indicates moderately high diversity throughout the 7.3 m thick pre-extinction interval without any significant declines prior to the abrupt onset of a ca. 6.4 m thick interval with virtually no shelly fossils which we regard as the lower part of the crisis interval. The follwing 8.5 m thick upper part of the crisis interval shows the sporadic occurrence of survivors and occurrences of potential disaster taxa such as the rhynchonellid *Soaresirhynchia* and the bivalve *Parvamussium*. The post-extinction interval starts with the first new taxa in low-diversity assemblages that extend over ca. 4.3 m before species richness recovers to pre-extinction values in the uppermost 1.8 m of the studied section.

Comparison of the taxonomic composition of pre- and post-extinction assemblages reveals a large-scale faunal turnover that is almost complete in brachiopods and somewhat less severe in bivalves, suggesting that brachiopods were much more affected by environmental perturbations than the molluscs. Finally, we analyzed whether benthic marine assemblages exhibit distinct shifts in ecological attributes across the Early Toarcian extinction event. We characterized the constituent species of pre-extinction and post-extinction assemblages and those sporadically occurring in the crisis interval in terms of their mobility, feeding mechanisms, and tiering and analyzed changes in the abundance of the various modes

of life across these three intervals by performing nonmetric multidimensional scaling on the Bray-Curtis distances among samples. Figure 1 illustrates that the faunal samples from the three time intervals constitute fundamentally different assemblies of functional groups, indicating a major reorganisation of the ecological composition of the local communities.

Key words: Portugal, Early Toarcian, temperature-related stresses, ecological change, bivalves, brachiopods.

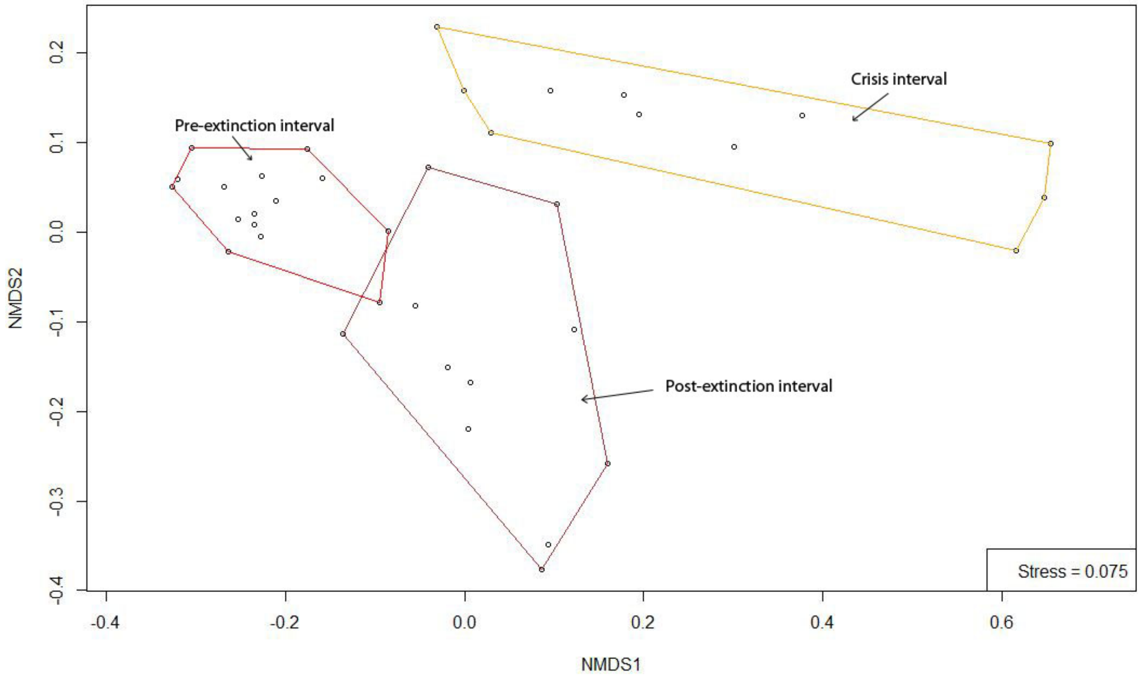

Figure 1. Nonmetric multidimensional scaling (NMDS) ordinations of the Bray-Curtis distance among samples before, during, and after the Early Toarcian extinction event at Fonte Coberta/Rabaçal. Analyses are based on the proportional abundances of modes of life. Convex hull surfaces of samples form discrete, virtually non-overlapping groups. Differences among the three groups are significant at p = 0.001.

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The Tithonian chrono-biostratigraphy of the Neuquén Basin, Argentine Andes: a review and update

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The Tithonian of the Neuquén Basin of western Argentina is mostly represented by the marine rocks of the Vaca Muerta Formation, deposited after a period dominated by the accumulation of non-marine clastics (Tordillo Formation and equivalents). In the initial stages of this widespread transgression from the Paleo-Pacific across an active volcanic arc, the waters remained shallow and slightly hypersaline and the Neuquén embayment was covered by a thin stromatolitic zone. Upwards the common rocks are dark bituminous shales and marls reaching several hundred meters thick. Meanwhile the eastern and south-eastern sides of the Neuquén Embayment record mixed carbonate siliciclastics assemblages represented by the Picún Leufú and other time-equivalent formations (Legarreta and Uliana, 1991, 1996). As Vaca Muerta is today one of the biggest non-conventional reservoirs in the world, its knowledge is based not only in studies on its extensive outcrops but also as result of wells exploration and development activity performed by oil companies.

U–Pb detrital zircon ages have been presented for the underlying continental clastics of the Tordillo Formation. The source region of sediment supply was the Andean arc and the maximum deposition age for the Tordillo Formation is around 144 Ma (Naipauer *et al.*, 2015). It is worth noting here that this age has a discrepancy of at least 7-8 Ma from the absolute age of the Kimmeridgian-Tithonian boundary (152.1± 0.9, in the International Commission Stratigraphy chart v. 2017/2) which should be in the upper part of the Tordillo Formation.

The timing of the depositional sequence of the Vaca Muerta Formation was traditionally based on age-diagnostic fossils and for nearly a century ammonoids allowed the most consistent local zonation (Riccardi, 2008, 2015; Vennari, 2016). This biostratigrahic dating has recently been supported by studies on other groups as nannofossils, radiolarians and calpionellids (Ballent *et al.*, 2011; Vennari *et al.* 2014; Vennari and Pujana, 2017; López-Martínez *et al.*, 2017). This integrated biostratigraphy allowed the fine-tuning of the age of the Vaca Muerta Formation and also consolidated the established correlation with the Mediterranean Province of the Tethys for the Tithonian.

The ammonite biozones of *Virgatosphinctes andesensis*, *Pseudolissoceras zitteli* and *Aulacosphinctes proximus* which correspond to the early Tithonian have been recognized on many surface sections as well as in cores. The *Virgatosphinctes andesensis* zone (formerly *V. mendozanus* zone) has been tentatively subdivided into two interval subzones: *Pseudinvoluticeras primordialis* subzone to the base, and *Indansites malarguensis* subzone to the top (Vennari, 2016). Four bioevents of calcareous nannofossils allowed to characterize the early Tithonian in cores. The first occurrences (FOs) of *Polycostella beckmanni*, *P. senaria*, *Helicolithus noeliae* and *Eiffellithus primus* allowed us to correlate these levels with the biozones NJ20A, NJ20B, NJKA (Bralower *et al*., 1989; Bornemann *et al*., 2003) and NJT 16 (Casellato, 2010) defined for the Tethyan region. Recently, a radiolarian fauna dominated by nasellarian genera has been described from beds of the *Virgatosphinctes andesensis* zone and represents the first lower Tithonian described from the Neuquén Basin. This fauna can be partially correlated with the base of radiolarian Zone 4 of Pessagno *et al.* (2009), interpreted as upper lower Tithonian in Mexico (Vennari and Pujana, 2017).

The ammonite biozones of *Windhauseniceras internispinosum*, *Corongoceras alternans* and *Substeueroceras koeneni* are widely recognized across the basin, both with surface and subsurface records. They span from the lower upper Tithonian, and the youngest reaches the lower Berriasian. Regarding the nannofossils, several bioevents were identified even including the J/K boundary. The FOs of *Umbria granulosa, Rhagodiscus asper* and *Nannoconus wintereri* were recorded allowing the definition of subzones NJKB and NJKC of the late Tithonian (Aguirre-Urreta *et al*., 2014). All of them have been correlated with the *S. koeneni* zone.

Regarding the radiolarians, a fauna linked to the *Substeueroceras koeneni* zone yielded abundant representatives of the Family Pantanellidae. The presence of *Complexapora kozuri* (Kiessling and Zeiss) and *Loopus primitivus* (Matsuoka and Yao), two important radiolarian primary markers of the Late Jurassic in North America, supports a late Tithonian age for at least part of the *S. koeneni* zone (Vennari and Pujana, 2017).

Recently, Ivanova and Kietzmann (2017) described several species of calcareous dinoflagellate cysts in the Vaca Muerta Formation, some of which have biostratigraphic value in the Tethyan region. Kietzmann (2017) recognized the Chitinoidella and Crassicollaria standard zones and claimed that, unlike in the Tethys where the chitinoidellids abound during the late early Tithonian until the late Tithonian, in the Neuquén Basin they persist in the Berriasian *Argentiniceras noduliferum* ammonite zone. López-Martínez *et al.* (2017) studied the distribution of hyaline calpionellids in the well-documented Las Loicas section that enabled them to correlate their record with ammonites and nannofossils. They recognized the upper part of the Crassicollaria zone and the lower part of Calpionella zone across the Jurassic/Cretaceous boundary in the basin and were able to expand the calpionellid paleogeographic distribution to the southern Hemisphere, far from their typical Tethyan occurrence.

Besides all these recent advances in the biostratigraphy, ash-fall tuffs interbedded within the sediments of the Vaca Muerta Formation have been dated with high-precision U-Pb zircons techniques which have given, for the first time, a trustworthy absolute age constraint (Vennari *et al*., 2014; Lena *et al*., 2017). The CA-ID TIMS U-Pb dates are two from the Berriasian and the other one with an age of 140.1 Ma is late Tithonian, located 3 meters below the J/K boundary based on the first occurrences (FOs) of the nannofossils *Nannoconus kamptneri minor* and *N. steinmanni minor* which correlate with the NJK-D subzone (Bralower *et al*., 1989) and NKT (Casellato, 2010) (Vennari *et al*., 2014; López Martínez *et al*., 2017).

Key words: Vaca Muerta Formation, Neuquén Basin, Biostratigraphy, Geochronology, Andes

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Low-latitudinal seawater temperatures during the Jurassic: the stable isotope record of northern Gondwana

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Traditionally, the Jurassic climate has been described as equable, warmer than today, with weak latitudinal temperature gradients, and no polar glaciations. Over the last few decades, this view has changed with studies pointing to distinct climate fluctuations and the occasional presence of polar ice caps (e.g., Price, 1999; Dromart et al., 2003; Dera et al., 2011; Korte et al., 2015). However, most temperature reconstructions are based on stable isotope analyses of fossil shells from Europe, while additional data from other parts of the world are only slowly completing the picture.

Rhynchonellid brachiopods and oysters were collected from the Middle to Upper Jurassic succession of Gebel Maghara in the northern Sinai Peninsula of Egypt (see Alberti et al., 2017). The area was situated at a palaeolatitude of ca. 3°N, and after a phase of terrestrial sedimentation in the Early Jurassic, marine conditions dominated since the end of the Aalenian. Before analysis, the collected specimens were screened for diagenetic alteration using cathodoluminescence and scanning electron microscopy. Well preserved shells were then sampled using either a hand-held dental drill or a computer-controlled micromill. High-resolution sampling of two oysters was conducted for seasonality reconstructions. The carbonate samples were then analysed with a mass spectrometer and palaeotemperatures were calculated using the equation of Anderson and Arthur (1983).

Based on a generally used δ^{18}O ratio of the seawater during shell formation of -1‰ VSMOW, the temperatures varied only a little around an average of 25.7°C from the Bajocian to the Kimmeridgian (see Alberti et al., 2017). Slightly warmer conditions existed in the Early Bathonian (~27.0°C), while the Kimmeridgian shows the lowest temperatures (~24.3°C). Unfortunately, no material is so far available from the Oxfordian time interval. The seasonality, reconstructed with the help of two oyster shells, was found to be very low (<2°C) as expected for a tropical palaeolatitude. A comparison of the results from Egypt with literature data allowed the calculation of latitudinal temperature gradients. Apparently, this gradient was much steeper than previously expected for the Middle Jurassic and comparable to today. During the Kimmeridgian, temperatures in Europe were generally warmer leading to weaker latitudinal gradients.

Interestingly, the reconstructed Jurassic water temperatures in Egypt and Europe from settings above the thermocline are mostly lower than Recent sea-surface temperatures. These results seem to contradict earlier perceptions of the Jurassic world. For example, Martin-Garin

et al. (2012) noted an absence of coral reefs in a belt along the equator during the Middle Oxfordian and proposed high water temperatures as the reason. However, the calculation of absolute water temperatures based on stable isotope analyses is dependent on the $\delta^{18}O$ ratio of the seawater during shell formation which is not well known. Most studies on Jurassic fossils use a $\delta^{18}O$ value of -1‰ VSMOW for an ice-free Jurassic world (Shackleton & Kennett, 1975). Nevertheless, it might be considered unlikely that this value was the same throughout Tethyan waters. Roche et al. (2006), for example, proposed prominent latitudinal gradients in the $\delta^{18}O$ values of sea-surface waters in the past. If applied to the present dataset, this would lead to reconstructions with much warmer temperatures at low latitudes, but at the same time still steeper latitudinal temperature gradients. Thus it becomes evident that further results, including temperature data from additional localities and independent reconstructions of low-latitudinal $\delta^{18}O$ ratios of the seawater, are highly desirable.

Key words: Jurassic; Gondwana; palaeoclimate; stable isotope analyses; seasonality; latitudinal temperature gradients

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Early Jurassic volcanic arc successions in western San Luis Potosí, Mexico

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Introduction: Volcanic successions outcropping in western San Luis Potosí (Fig.1) rest on Triassic turbidites and are overlain by Oxfordian limestones. According to their stratigraphic position, such volcanic rocks are considered part of the Early Jurassic Nazas arc (Bartolini et al., 2003; Lawton and Molina-Garza, 2014), known from northern Durango and Coahuila. Intermediate to felsic lava flows and ash-flow tuffs with interlayered epiclastic materials are termed Nazas Formation (Pantoja-Alor, 1972), also comparable to volcanic rocks contained in La Boca Formation, a Lower Jurassic red bed succession exposed in Tamaulipas. At the top of the succession, a fining upward sequence composed of breccia and red sandstone is known as La Joya Formation (Mixon et al., 1959) and represents deposition related to an erosional unconformity in the region.

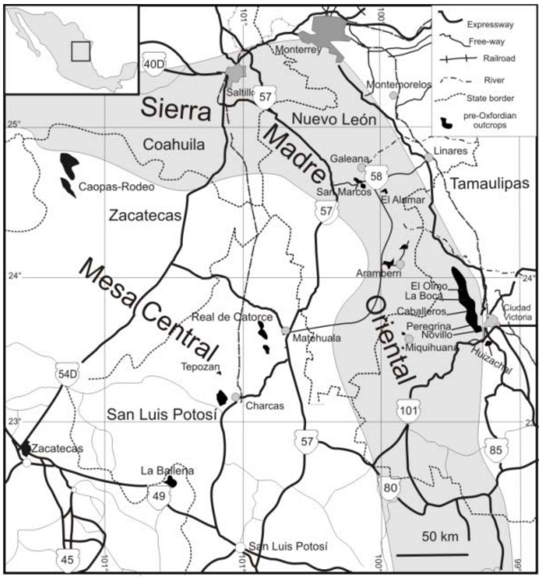

Figure 1. Location of Study areas and physiographic-morphotectonic provinces

Objective: The goal of our research was to confirm ages and geochemistry of volcanic rocks exposed in some localities of western San Luis Potosí, whose absolute age and geochemical character remained until the present unknown or improperly determined.

Methodology: Geochronological studies (U-Pb, zircon) allowed determining new ages; in addition, new geochemical data were performed as well as the petrography and descriptions of exposed successions in Sierra de Catorce, Charcas, Tepozan and La Ballena areas.

Results: We confirmed for all localities the presence of Lower to Middle Jurassic rocks (194-166 Ma) as well as calcalkaline suites related to a marginal volcanic arc. Due to the lack of zircons in mafic rocks, the more frequently dated volcanic rocks are of felsic to intermediate composition; therefore, the age of some mafic rocks that occupied mostly the lower part of the succession remains unknown but considered as Lower Jurassic according to their stratigraphic position. The Nazas arc, according to distribution of the several outcrops, builds a northwest-trending up to 200 km wide volcanic belt. In the Sierra de Catorce, the Nazas Formation consists of andesitic-basaltic lava flows at the base, rhyodacitic flows and pyroclastic breccia in the middle and upper parts as well as porphyritic rhyolitic dikes and domes that intrude the Lower Jurassic succession, the last yielded an Early Jurassic age (U-Pb, zircon) of 174.7 ± 1.3 Ma (Barboza-Gudiño et al., 2004). We dated (U-Pb, zircon) a rhyodacitic volcanic breccia of the middle part of the succession, exposed in Cañón General, near Socavón de Purisima, at 180.7 ± 2 Ma. In the Sierra de Charcas, a rhyodacitic ignimbrite yielded an age of 179 ± 1 Ma (U-Pb, zircon) (Zavala-Monsivais et al., 2012). In the area, this pyroclastic rock overlies older andesitic lava flows. North of Charcas, in El Tepozan area, pyroclastic rocks of rhyodacitic composition also yielded an U-Pb age (zircon) of 165 ±2 Ma. In this locality, the base of the succession is not exposed. Instead, limestones and calcarenites of the Zuloaga Formation rest directly on the volcanic rocks and La Joya Formation is absent. Finally, a new absolute age of 168.8 ± 0.8 Ma was determined for a rhyolite flow (U-Pb, zircon) found in the Sierra de Salinas close to the boundary of San Luis Potosí and Zacatecas states. The Nazas Formation in this locality consists of more than 200 m of andesitic lavas, intermediate volcanic breccia, interlayered epiclastic materials and subordinate strongly deformed rhyolitic flows and dikes. In all analyzed intermediate to felsic volcanic rocks the major and trace element contents are typical of calc-alkaline rocks, as found in volcanic arcs, and the abundance of silica-rich magmas, partly K-rich, is also typical for continental arcs. Moreover, the patterns observed in normalized multi-element diagrams are characteristic of subduction-related rocks. Several discrimination diagrams support in the same way an origin of these rocks in a continental volcanic arc, but at the same time reflect variations in the processes of magma generation, with high Th/Nb ratios as well as La/Sm(n) and low Ba/Th, especially at the bottom of the succession, indicating a possible increase in the involvement of subducted sediments. Some values of initial $^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$ and εNd are consistent in all the cases with mantle-derived magmas in a magmatic arc emplaced within continental crust. Nd model ages range from latest Mesoproterozoic to Neoproterozoic, indicating also the influence of an old continental crust.

Conclusions: 1) An Early to Middle Jurassic age for pre-Oxfordian volcanic successions exposed in western San Luis Potosí was confirmed, 2) The geochemistry of the analyzed rocks shows the influence of subduction with some amounts of crust assimilation and subduction sediments involvement, 3) The Jurassic volcanic remnants in San Luis Potosí can be considered part of the Nazas Arc exposed in northern Durango and Coahuila, which is also comparable to Early Jurassic calc-alkaline granitoids exposed in Sonora, Baja California, Marías Islands and in southern Mexico State. Such a distribution of Lower–Middle Jurassic calc-alkaline igneous rocks suggests influence of subduction processes in a broad area or very distant isolated zones of Mexico during the Early Jurassic time remains as a discussion (Martini and Ortega-Gutierrez, 2015), 4) There are through our results new data available in addition to several previously published geochronology and geochemical studies, as well as petrographic and field observations that confirm a subduction influence and an arc setting for the Jurassic volcanic rocks exposed in north-central to northeastern Mexico, in a way that a new tectonic model is needed to explain the coeval extension at the east, during the opening of the Gulf of Mexico basin. We propose in addition to the subduction process in western Mexico, an immature and fragmented nature of the crust in the area as the condition that led to development of an extensive area of influence of subduction magmatism. The subduction process may have also influenced the extension in the area of the Gulf of Mexico as an atypical back arc, whereas the classical model of continental arc and back arc developed near and parallel to the trench can be only exclusive of continental margins of major cratons or thick and well consolidated continental masses.

Key words: Jurassic; volcanic arc, San Luis Potosí

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The Jurassic marine vertebrates of Mexico: new discoveries

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Mexico has a large surface of marine Jurassic sediments, including fossiliferous units ranging between the Callovian and Tithonian ages. They belong to the La Casita and La Caja formations in the central-northern area of the country (along the States of Coahuila, Nuevo Léon, Puebla and San Luis Potosi); the Mapache, Rancho Solano, and Sabinal formations deposited within the Tlaxiaco Basin, and also in southern Mexico (in the States of Guerrero, Puebla, and Oaxaca).

Although different marine reptiles from Mexico are known since decades ago, mainly in its north area, recently, new discoveries in the southern part of this country provide additional paleontological data and increase our knowledge on the biodiversity of marine vertebrates along the Jurassic. Together, these fossils display new clues to understand the marine biotic change throughout the Hispanic Corridor, between Eastern Tethys Sea Domains (ETSD) represented by numerous fossils collected in Europe, and Middle East and the Western Tethys Sea Domains (WTSD) recorded in a smaller number of localities in Cuba, Mexico and Colombia. Such Mexican fossils consist of isolated, fragmented, and semi-complete specimens that correspond to the four major groups of marine reptiles.

The Mexican Jurassic fossil assemblage includes the following fishes and reptiles. Sharks are represented by few remains of the hybodontid *Planohybodus*. Actinopterygian fishes found in this site are the pycnodontiforms *Gyrodus macropththalmus* and *Gyrodus* sp., abundant lepisosteiforms scales of at least three different morphotypes including *Scheenstia*, the basal teleostean *Peuropholis cisnerosorum,* as well as complete or partial skeleton body parts that still need to be studied in detail representing indeterminate lepisosteiforms, aspidorhynchiforms, and small lepisosteid-like fishes.

Talattosuchian crocodyliforms are well represented in this country, and include metriorhynchid species, as *Cricosaurus saltillensis*, *Torvoneustes mexicanus,* and specimens attributable to *Dakosaurus*, *Maledictosuchus*, and *Geosaurus*, as well as an indeterminated species that represents the first teleosaurid found in America.

Abundant remains of icthyosaurs of the Family Ophtalmosauridae are also present in México, as *Ophtalmosaurus* cf. *icenicus, Ophtalmosaurus* sp.*,* a specimen that probably

represents the genus *Arthropterygius,* and numerous isolated bones of indeterminate ictiosaurs.

The pliosaurids are well represented by specimens of *Liopleurodon* and abundant indeterminate isolated bones. Recently, a new species of the Jurassic turtle *Notoemys* from the Sabinal Formation (Tlaxiaco Basin, Puebla) was described as *N. tlaxiacoensis*. The taxonomical groups represented in this Mexican fossil association of marine vertebrates show strong affinities with the faunas from the ETSD and a weak relationship with those American similar fossiliferous sites in Cuba and Colombia.

Key words: Jurassic; marine, vertebrate; Mexico

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Importance of the calcareous dinoflagellate cysts and the pelagic biomicrofacies to date the Upper Jurassic-lowermost Berriasian deposits in the Tethyan realm

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The study of several hundred thin sections from dozen outcrops of three western Tethyan basins: External Rif Belt (northern Morocco), Vocontian Basin (SE France) and northern Tunisia, has confirmed the importance of the main pelagic microfossil groups to date the Upper Jurassic deposits. Among these: crinoid saccocomids which appear in the middle Oxfordian (Verniory, 1955; Borza, 1969; Dromart & Atrops, 1988) are abundant in the three studied basins from the base of the lower Tithonian (Hybonotum zone) up to the disappearance of the group in the upper part of the Crassicollaria calpionellid zone, at the boundary between A2-A3 subzones (Dromart & Atrops, 1988 ; Benzaggagh, 2000). On the basis of the stratigraphic distibution of saccocomid skeletal element sections, seven biozones, called Sac. 1 to Sac. 7 (Fig. 1 and Benzaggagh et al., 2015a) were defined for the upper Oxfordien-upper Tithonian interval time. Calcareous dinoflagellate cysts (incertae sedis, fibrospheres, microproblematics, calcispheres, calcareous dinocysts,….) led to characterize ten biozones (Fig. 1 and Benzaggagh & Atrops, 1996; Benzaggagh et al., 2015b). Comparing our results to data from other regions, especially from western Carpathians (Nagy, 1966; Nowak, 1968; Borza, 1984; Borza & Michalik, 1986; Cecca, & Rehanek, 1991; Rehakova, 2000; Petrova et al., 2012), at least seven of the defined biozones are common to the Tethyan realm. Protoglobigerines were abundant from the upper Oxfordian to basal Kimmeridgian (Platynota zone), and become rare or absent in younger stratigraphic layers. In the External Rif and northern Tunisia, microfilaments show two acme levels (M-F1 and M-F3, Fig. 1) in the Divisum and Beckeri zones respectively, and then disappear at the top of the Beckeri zone. Chitinoidellids, which define the Chitinoidellid zone, with two subzones: Dobeni and Boneti (Borza, 1969, 1984; Borza & Michalik, 1986), characterize the lower-upper Tithonian boundary (Enay & Geyssant, 1975; Benzaggagh & Atrops, 1995a). The Dobeni subzone corresponds to the Ponti ammonite zone and the Boneti to the Microcanthum *pro parte* zone (Benzaggagh & Atrops, 1995a). Calpionellids appear at the upper part of the Microcanthum zone (Moravisphinctes subzone, Benzaggagh & Atrops, 1997). They are abundant within the Durangites and Euxinus zones and characterize two biozones for the upper Tithonian-lower Berriasian interval: Crassicollaria (Moravisphinctes to basal Jacobi subzones) and Alpina (Euxinus *pro parte*). The first one is divided into three subzones: A1, A2, A3 (Remane, 1963, 1971) and dominated by the genus *Crassicollaria*. The second is widely dominated by

Calpionella alpina of small lorica. Its lower boundary coresponds to the Tithonian-Berriasian boundary in agreement with the recommandation of the Berriasian Working Group. This boundary is situated within the Jacobi subzone according to Frau et al. (2016a-b) and Wimbledon et al. (2011, 2013). *Globochaete* specimens are often abundant during the Tithonian interval. Radiolarians show an irregular stratigraphic distribution. Using all of these various fossil groups and their abundance, we define thirteen Assemblage Biozones (As. 1 to As. 13; Fig. 1 and Benzaggagh et al., 2015b), which are well-correlated with ammonite zones. This work is a contribution towards a potential and more practical biostratigraphic zonation for the Upper Jurassic-lowermost Berriasian in the Tethyan realm.

Keywords: Pelagic microfauna; Biozonation; Upper Jurassic-lowermost Berriasian; Western Tethys

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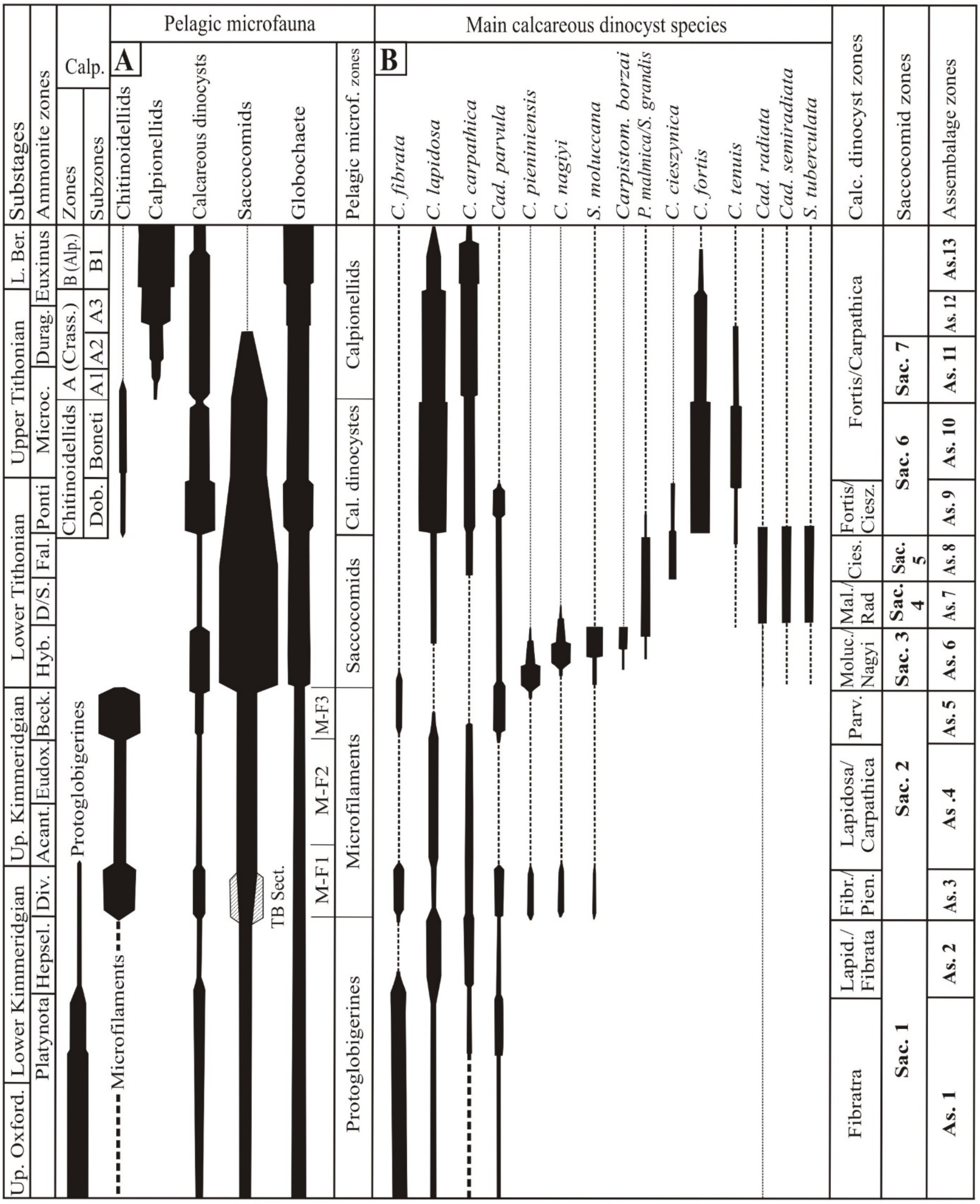

Fig. 1. Synthetic table showing: A, the stratigraphic range of the major pelagic microfossil groups (in: Benzaggagh, 2000, slightly modified); B, the main species of the calcareous dinoflagellate cysts from the Upper Jurassic-lowermost Berriasian (In: Benzaggagh & Atrops, 1996, slightly modified, and Benzaggagh et al., 2015b), and C, defined biozones and correlations with the ammonite zones (in: Benzaggagh et al., 2015a-b).

Saccocomid crinoid sections and biozones of the Upper Jurassic in the western Tethyan realm

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The saccocomids, a group of stemless pelagic crinoids, are frequently reported in the Upper Jurassic deposits of the Tethyan realm. Their calcitic skeleton, up to 5 cm wide (Fig. 1a), is made of a large number of articulated skeletal pieces ranging from a few hundred microns to a few millimetres in size. These skeletal pieces dissociated soon after death and were discarded burrying in sediments. Due to their high-magnesium calcitic nature, it is often difficult to isolate them from the fine-grained carbonate matrix in which they are lying. Despite the abundance of these saccocomid remains in the carbonate microfacies, few works were dedicated to their thin section analysis. The high complexity and great geometrical diversity of section shapes put field geologists and micro-bio-stratigraphers off their study. Most investigations on this fossil group focused on isolated plates (Brodacki, 2006; Ferré & Berthou, 1994; Ferré & Dias-Brito, 1999; Ferré et al., 1999, 2005; Hess, 1972, 2002; Kroh & Lukeneder, 2009; Manni & Nicosia, 1984; Manni et al., 1992). Lombard (1937) was the first to illustrate some saccocomid sections that were first considered as originating from an organism *incertae sedis*, then as sections of algal thalli of *Eothrix alpina* (Lombard, 1945). Brönnimann (1955) erected the genus *Lombardia* for some similar sections from the middle Tithonian of Cuba. Verniory (1954, 1956) showed that the sections assigned by both former authors to *Eothrix alpina*, then *Lombardia* are genuine skeletal plate sections of crinoid genus *Saccocoma* Agassiz. Verniory (1954, 1956, 1960) thoroughly illustrated several plate sections of *Saccocoma* with their three-dimensional reconstruction. Amidst this glut of morphologies, he reckoned sections of ramule (tertibrachial), axillary, lateral-winged, secundibrachial and rare primibrachial plates. With the exceptions of the seminal works mentioned above, saccocomid sections in microfacies are only mentioned to stress out their frequency variations and stratigraphic range. Most researchers agree for a stratigraphic distribution ranging from the middle Oxfordian to the late Tithonian (Benzaggagh, 2000; Benzaggagh & Atrops 1995; Benzaggagh et al., 2010, 2015b; Borza, 1969; Dromart & Atrops, 1988; Nicosia & Parisi, 1979 ; Savary et al., 2003; Verniory, 1955), with an acme during the Tithonian. Analysis of several hundreds of thin sections from a dozen outcrops belonging to three different basins of western Tethyan realm (Rif Belt of northern Morocco, Vocontian basin of south-eastern France, and northern Tunisia) made it possible to compile a preliminary inventory of these saccocomid sections, to propose a morphological classification and to state properly both their geographic and stratigraphic distributions. The most inventoried sections are showing typical geometric shapes and occurring in coeval stratigraphic levels from very distant sections. Based on the most frequent and characteristic sections, at least forty-seven standard sections are recognized for the upper Oxfordian-upper Tithonian interval time (Benzaggagh et al., 2015a). They are named and coded from their geometric shapes, and divided into six clusters, which are: Biaxial sections (2Ax); Triaxial sections (3Ax); Sections with one or two branches (Br/2Br); Sections in tooth shape (Tt); Wing-shaped sections (Wg) and Head-shaped sections (Hd). Actually most of these sections, previously considered without any stratigraphical value, are indeed characteristic of several stratigraphic intervals, either due to their geometric shape or to their assemblage. Subsequently they can play an important role in dating the Upper Jurassic pelagic deposits when ammonites are lacking. In the three studied basins we notice a major occurrence of these saccocomid sections from the base of the early Tithonian (*Hybonotum* Zone), then the group dominates the pelagic microfaunal assemblages until its disappearance at the boundary between A2 and A3 calpionellid subzones (upper part of *Crassicollaria* Zone). Seven association biozones, well correlated with the standard ammonite zones, are defined for the studied interval time. Each zone is characterized by a particular association of sections. They are (Fig. 1b): Sac. 1 Biozone, Upper Oxfordian-Lower Kimmeridgian (*Hypselocyclum* Zone); Sac. 2 Biozone, *Divisum-Beckeri* zones; Sac. 3 Biozone, *Hybonotum* Zone; Sac. 4 Biozone, *Darwini-Semiforme* zones; Sac. 5 Biozone, *Fallauxi* Zone; Sac. 6 Biozone, *Ponti-Microcanthum* pro-parte zones; Sac. 7 Biozone, uppermost *Microcanthum*-lower *Durangites* zones).

Key words: Saccocomids; Skeletal plate sections; Biozones; Upper Jurassic; Tethyan realm

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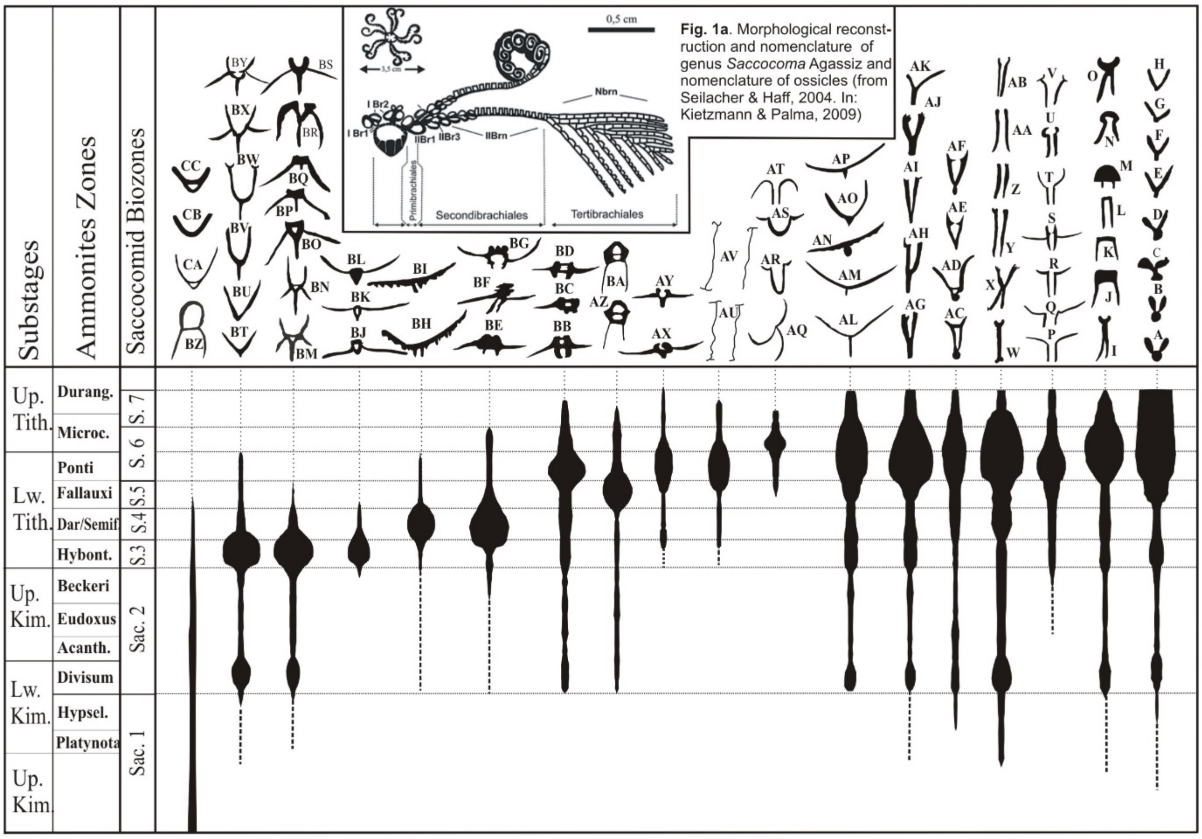
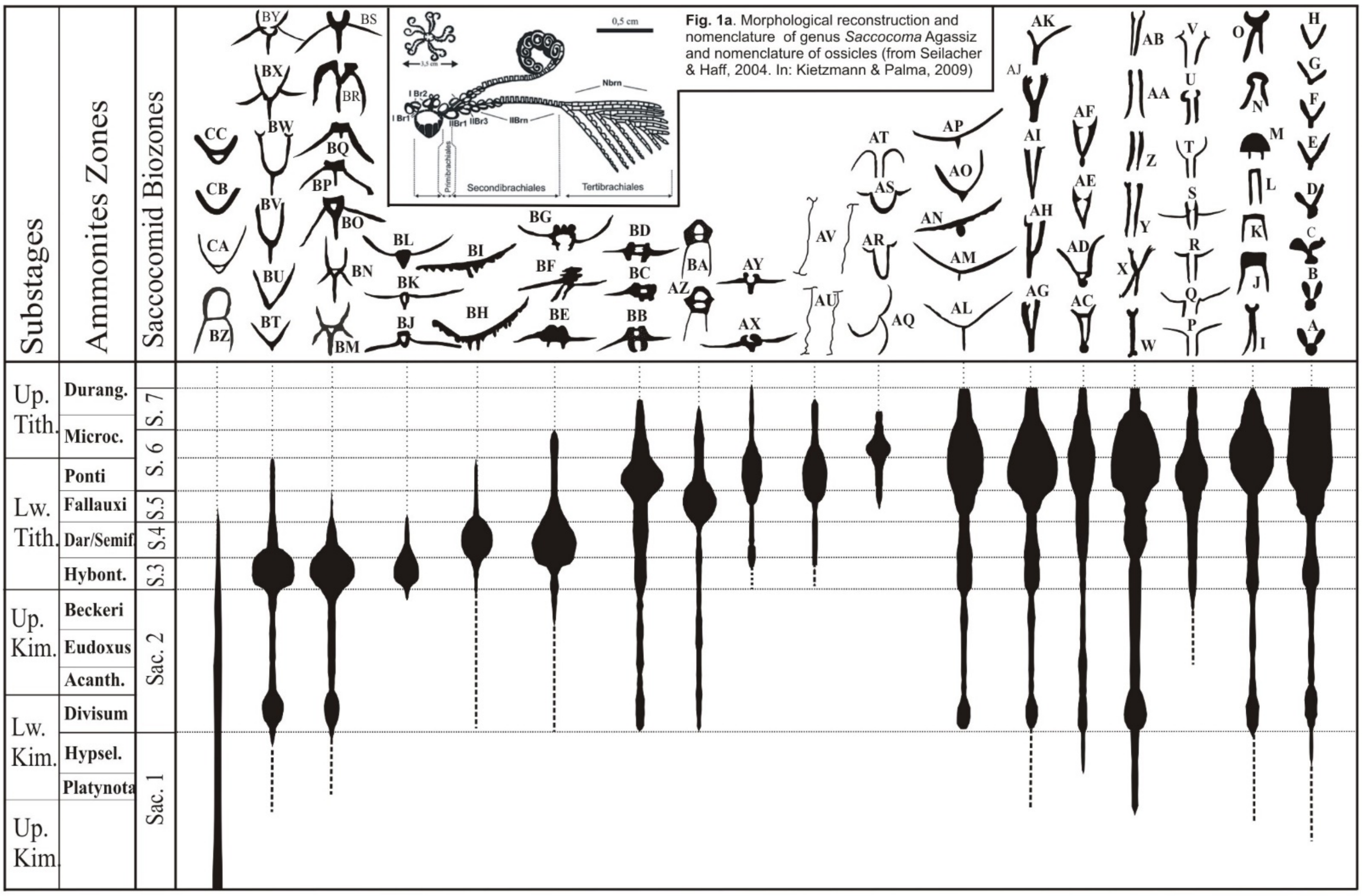


Fig. 1a. Morphological reconstruction and nomenclature of genus *Saccocoma* Agassiz and nomenclature of ossicles (from Seilacher & Haff, 2004. In: Kietzmann & Palma, 2009)

Fig. 1b. **Synthetic table showing the stratigraphic range of the main saccocomid skeletal sections defined in this work and biozones:** **A-B**. *2Ax.brd.br/rd.ax.tp*; **C-D**; *2Ax.brd.br/psd-rtg.ax.tp*; **E-F**. *2Ax.brd.br/elg.ax.tp*; **G-H**. *2Ax.brd.br/shr.ax.tp*; **I**. *elg.Tt*; **J**. *brd.ml.Tt/brd.flt.crw*; **K**. *brd.ml.Tt/ tn.flt.crw*; **L**. *elg.ml.Tt/tn.flt.crw*; **M**. *cvx.ml.Tt/brd.crw*; **N**. c*vx.ml.Tt/tn.crw/int.cvt*; **O**. *cnc.ml.Tt*; **P-R**. *2prl.Br/elg.tp*. **S.** *2prl.Br/2lat.apd*; **T-V**. *2prl.Br/cnc.tp*; **W**. *elg.Br*. **X**. 2*Br.X*; **Y-AB**. *2prl.Br/ smpl.tp*; **AC-AD**. *2Ax.brd.br/trg.cvt/ax.tp*; **AE-AF**. *2Ax.ac*t.V; **AG-AK**. *3Ax.brd.br*; **AL**. tn.Wg/ elg.ax.tp; **AM**. tn.Wg/ shr.ax.tp; AN. tn.Wg/ovl.ax.tp; **AO-AP**. *tn.Wg/trg.ax.tp*; **AQ**. *prp.Wg*; **AR-AS**. *2Ax.U*; **AT**. *2prl.Br/cvx.tp*; **AU-AV**. *2tn.prl.Br*; **AX-AY**. *op.tg.Hd/shr.ft/2lat.apd*; **AZ-BA**. *elg.psd-hxg.Hd/2lat.apd*; **BB-BD**. *flt.psd-hxg.Hd/2lat.apd*; **BE-BG**. *irg.Hd*; **BH-BI**. *srd.Wg/tk.ts*; **BJ-BL**. *cls.trg.Hd/lrg.trg.cvt/2lat.apd*; **BM-BN**. *cls.trg.Hd/ft/4lat.apd*; **BO-BP**. cls.trg.Hd/lng.ft/2lat.apd; **BQ**. *cls.trg.Hd/shr.ft/2lat.apd*; **BR-BS**. *op.trg.Hd/lng.ft/2lat.apd*; **BT-BU.** *2Ax.act.br/ptd.b*s; **BV-BW**. *3Ax.act.b;* **BX**. *3Ax.act.br/2lat.apd*; **BY**. *3Ax.act.br/2lat.apd*; **BZ**. *Cph.Hd*; **CA**. *elg.2Ax/tn.br/trg.cvt*; **CB**. *bw.2Ax*. **CC**. *2Ax.brd.br/trg.cvt*.

Abbreviations used for the names of the saccocomid sections: 2Ax: *Biaxis*; **3Ax**: *triaxis*; **act**: *acute*; **apd**: *appendix*; **bw**: *bowed*; **ax**: *axial*; **Br**, **br**: *branche*; **brd**: *broad*; **bs**: *basis*; **cls**: *closed*; **cnc**: *concave*; **cph**: *cephalon*; **crw**: *crown*; **cvt**: *cavity*; **cvx**: *convex*; **elg**: *elongated*; **flt**: *flattened*; **ft**: *foot*; **Hd**: *head*; **hxg**: *hexagonal*; **int**: *internal*; **irg**: *irregular*; **lat**: *lateral*; **lng**: *long*; **lrg**: *large*; **ml**: *molar*; **op**: *open;* **ovl**: *oval*; **prl**: *parallel*; **prp**: *propeller*; **psd**: *pseudo*; **ptd**: *pointed*; **rd**: *rounded*; **rtg**: *rectangular*; **shr**: *short*; **smpl**: *simple*; **srd**: *serrated*; **tip**: *point*; **tk**: *thick*; **tn**: *thin*; **tp**: *tips*; **trg**: *triangular*; **ts**: *test*; **Tt**: *tooth*; **Wg**: *wing.*



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Tectonic and structural control for the development of sedimentary sequences during the Mesozoic in one portion of the Tampico-Misantla Basin, Eastern Mexico

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We use well and seismic information to interpret geometry, thickness variation and fault association of Jurassic sequences in the study area. Based on well tops we correlated key seismic horizon corresponding to Basement, Mid-Jurassic, Oxfordian, Kimmeridgian and Tithonian stratigraphic units.

All horizons, but the Basement, were easy to follow due to their continuity and relatively constant seismic character. The basement surface is cut by numerous normal faults that separate three major lows and highs. Lows are as deep as 6,500 mbsl, but highs, cut by some wells, are found up to 3,000 mbsl. Orientation of major faults systems varies, one is oriented NE-SW, the other trends NW-SE, they are perpendicular to each other. Their fault planes are very steep and their typical throws reach 1000 m. The Mid-Jurassic (Cahuasas) surface shows the same lows and highs, and similar trends of fault systems as those of the Basement. As expected, the largest thickness (up to 3,000 m) of the Mid-Jurassic rocks is found in three major depocenters associated with basement lows.

The Mid-Jurassic (Tepexic) surface inherited part of the Cahuasas trends, but a predominance of concave NW/SE trending systems of faults is observed at this level. A subscircular broad structural high dominates the eastern part of the study area, and NW-SE elongated synclines its western part. Normal faults cut the flanks of these structures, they have considerable reduced throws. Thickness map between these two surfaces shows variations from zero, in the southeast corner of the study area, to 1,000 m in localized small depocenters at the toe of major normal faults.

The Oxfordian (Santiago) surface exhibits similar structural features as the Mid-Jurassic (Tepexic) surface but with significant lower relief. Thickness map between these units indicates the presence of three well defined depocenters limited by curve normal faults with significant throw reduction. One of these depocenters was developed in a previously high region.

The Kimmeridgian (Taman) surface shows similar structural trends and systems of faults as the Oxfordian surface with still less structural relief as previous surfaces. The isopach map between these surfaces shows a major depocenter trending, first NE-SW, and then N-S along the western part of the study area.

The Tithonian (Pimienta) surface shows low relief, elongated highs and lows oriented NW-SE, cut by numerous normal faults of relatively much reduced throws. The corresponding thickness map between Thitonian and Kimmeridgian surfaces shows a large depocenter whose axis is slightly displaced with respect to that formed between Oxfordian and Kimmeridgian surfaces.

Most of the faults identified in this study are normal faults formed during a period of extensional deformation in Mid Jurassic that extended into the Upper Jurassic and Cretaceous units. Some of them were re-deformed by the contractional deformation associated with the Laramide Orogeny in late Cretaceous-early Tertiary.

This work allowed us to infer how several process such as subsidence, sedimentation and deformation interacted to produce structural styles, major depocenters and their evolution along the Jurassic in the study area.

A 3D model was also constructed to shows configuration of the interpreted stratigraphic units. This model is important not only to understand the tectonic and sedimentary history of the region, but also as a reference for hydrocarbon exploration in the area.

Lithostratigraphy study of the Tecocoyunca Group (Middle Jurassic) in the Numi River area (close of Tlaxiaco), Oaxaca, and considerations about the regional distribution of the biota.

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Middle Jurassic rocks of the Mixteca region are relatively well known, however the system on which is based includes poor descriptions of their formations. [e.g. vagueness, characterization by fossil content, insufficient cartographic discrimination]. In order to contribute to correct such deficiency, we undertook a detailed study of the Río Ñumí Area [vicinity of Tlaxiaco], where the Middle Jurassic units that make up the Tecocoyunca Group, clearly display their attributes, thus allowing to supplement the formational descriptions. It was found that locally there, the Tecocoyunca Group includes in the lower part the associated Formations Zorrillo/Taberna [Early to Late Bajocian, consisting of ~287m of carbonaceous siltstone, mudstone and subarkosic very fine-grained sandstone and siltstone; this composite unit bears pelecypods and continental plants, as well as two carbon zones; it was part of a delta complex]. These associated formations conformably underlie the Simón Formation [Middle-Late Bathonian, it consists of ~270m of subarkoses and siltstone set in thin to thick strata; it is interpreted as a transitional deposit]. This unit concordantly underlies the Otatera Formation [Late Bathonian, consisting of ~170m of pelecypod coquina with intercalations of intraspatite limestone strata; it is regarded as shallow neritic with a subordinate beach component. This unit concordantly underlies the Yucuñuti Formation [Middle Callovian, constituted by ~118m of fine-grained sandstone, coquina and biomicrite that bear pelecypods and gasteropods; it is interpreted as transitional to shallow neritic deposit. The Yucuñuti Formation is unconformably overlain by the Oxfordian Limestone with "*Cidaris,*" which does not belong to the Tecocoyunca Group. The Tecocoyunca Group Biota includes a typical Middle Jurassic flora, whose taxa are widely distributed in central and southern Mexico, as well as in northern Central America; the paleofauna consists of Middle Jurassic mollusks common throughout the Mixteca region. The biota as a whole discloses a warm and humid climate regime. Finally, it is thought that the detailed descriptions of the formations making up the Tecocoyunca Group, are in fact an advance in the redefinition of the Mixteca region's Middle Jurassic units.

Jurassic Dinosaurs of Thailand

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Dinosaur remains discovered from Mesozoic non-marine fluvial deposits of Thailand range from Late Triassic to Early Cretaceous in age. According to the studies of those remains since the first discovery of dinosaur bone in Thailand in 1976 to the present, 9 new dinosaur species were described from Late Triassic and Early Cretaceous rock formations. This work will overview the Jurassic dinosaur fossil records distributed in the North, the South and the Northeast of Thailand and introduce the recent work on the recent Jurassic dinosaur site where the dinosaur diversity is very notable.

Some articulated cervical and dorsal vertebrae and several bone fragments of a sauropodomorph were unearthed in 2002 from the uppermost of Lower Jurassic to Middle Jurassic Ms-3 Formation in Chiang Muan locality, Payao Province in the North region. In southern peninsula of Thailand, a large dorsal vertebra of mamemchisaurid, an Asian endemic dinosaur group, was reported in 2005 from the middle Jurassic Khlong Min Formation in Krabi Province. Although dinosaur remains of these two localities from Shan-Thai Block give inadequate taxonomic information, their occurrences are significant in supporting the idea of a collision of the Shan–Thai Block with the Indochina Block before Jurassic period. In Northeastern part of the country, called “Khorat Plateau”, which is in the Indo-China Block has revealed remarkably dinosaur diversity discovered from several sites particularly from the Phu Kradung Formation ranged from Late Jurassic-Early Cretaceous. A dorsal vertebra of a stegosaur was found from Kalasin Province. A tibia of a sinraptorid theropod and a femur of a hypsilophodon were reported from Mukdaharn Province and also many theropod teeth were discovered from Udonthani Province.

The recent dinosaur excavation in the Phu Kradung Formation has been proceeded since 2008 to now at Phu Noi locality, Kham Muang District, Kalasin Province. This site has yielded more than 2,500 vertebrate fossil specimens including fish, fresh water sharks, amphibians, turtles, crocodiles, pterosaur and dinosaurs. Phu Noi becomes the largest and most diverse fossil excavation site in Thailand and is now protected by the Fossil Protection Act for particular purpose of the exploration and research about the site or fossils. The preliminary studies of the majority of dinosaur remains comprising of teeth, cranial and postcranial skeletons suggest that dinosaur assemblage of Phu Noi is comprised of Mamenchisauridae which is the most abundant, Sinraptoridae, unknown small theropods and Hypsilophodontidae. The osteological studies of those dinosaurs are in progress whose results will possibly provide new Thai dinosaur species. This dinosaur assemblage of Phu Noi can be comparable to the dinosaur assemblage dominated by Mamenchisauridae from the upper member of the Middle Jurassic Shaximiao Formation and Chuanjie Formation in the Sichuan-Yunnan Basin, in the Upper Jurassic Suining Formation and Penglaizhen Formation of Sichuan Basin in southwestern China and in the Upper Jurassic Shishugou Formation of the Junggar Basin in northwestern China. The discovery of Mamenchisauridae and Sinraptoridae from Phu Noi consistent the distribution of these families is endemically in Asia. The distribution of Mamenchisauridae that constrict to the Late Jurassic in China probably suggests that Phu Noi at the Phu Kradung Formation is Late Jurassic in age. In addition there is no fossil record of either mamenchisaurid or sinraptorid dinosaurs from the Early Cretaceous of China and other continent so far. However, more precise dating of Phu Noi Site should be resolve to affirm the hypothesis of the relative age of Phu Kradung Formation and better understand the range and distribution of these Asian endemic dinosaur assemblages.

To conclude, the Jurassic dinosaur remains of Thailand have been exposed from many parts of Thailand. The recent discoveries show the diversity of Jurassic ecosystem and the relation of eastern Asian dinosaurs though the further studies are compulsory. Moreover, Jurassic dinosaur of Thailand can fulfill and affirm our knowledge in biogeography and paleontology of Asia.

Keywords: Dinosaur, Jurassic, diversity, Thailand, Asia

Late Jurassic epicontinental platform dynamics revealed by geochemical patterns of extended deposits (Betic Cordillera, SE Spain)

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In ancient carbonates, elemental abundances record an intricate combination of environmental, biological and diagenetic variables. The interpretation of geochemical proxies therefore benefits from an integrated overview of their significance, focusing on separating paleoenvironmental signals from diagenetic noise.

During the Late Jurassic, the South Iberian margin was placed close ca. 30ºN in a tectonically unstable area affected by relative movements between the Iberian and African plates. The wide epicontinental shelf system surrounding Iberia was represented by the Prebetic Zone and northeast equivalents, offshore of which oceanic waters connected the westernmost Tethys and the Hispanic Corridor. Under monsoonal climate, recorded regional marine mean water temperature was within the range of 16-23ºC (Coimbra et al., 2014; Holz, 2015; and references therein).

The Puerto Lorente section comprises mid-shelf shallow-marine carbonates. Condensed, hiatal deposition during Oxfordian times is interrupted by an Early Kimmeridgian three metres thick siliciclastic intercalation, followed by a thick (over 100 metres), homogeneous succession comprising a marly and silty limestone rhythmite.

From 109 hand-samples collected, 275 powder samples were drilled in order to cover a wide range of carbonate materials. Stable C and O-isotopes and elemental content (Ca, Mg, Sr, Fe and Mn) revealed well differentiated stratigraphic intervals along the Puerto Lorente section. Interestingly, these are clearly delimited by sharp Mn concentration peaks from 100 up to 600ppm. These are interpreted as geochemical evidence for hydrothermal contamination during tectonic pulses of regional to (at least) Tethyan scale.

The lowermost portion of the section (ca. 5 metres) shows both negative C and O-isotope values (-1 and -4.5‰, respectively), along with increasing trends of Mg, Sr, Fe and sustained high Mn values (ca. 300pm). This combined signal suggests that these are shallow-platform deposits, only interrupted by a single bed showing strong dolomitization as evidenced by the sharp increase of Mg concentration (up to 50.000ppm).

Interval 2 (ca. 10 metres) is characterized by a sudden rise in C-isotope values from -1 to 2.5‰, a range consistent with known Late Jurassic C-isotope records for northern Tethyan margins. This shift is accompanied by less negative O-isotope values, evidencing a fair diagenetic preservation of this interval showing an overall more "pseudonodular" character. Elemental values for Mg, Sr, and Fe show an increasing trend throughout this interval, contrary to Mn showing a decreasing trend. The geochemical signature of this interval indicates the establishment of marine conditions along this setting, which is consistent with the onset of the mid-Oxfordian transgression recorded along the Tethyan margins.

A third, larger stratigraphic interval is recognized throughout the remaining 75 metres of the section. In contrast to the underlying intervals, interval 3 shows a very stable geochemical record. Carbon isotope values are maintained within a marine value of 2.5‰, whilst $\delta^{18}O$ shows rather lowered values of ca. -4.5‰ indicate a stronger diagenetic imprint throughout this interval. The Mn record is also constant at low ca. 100ppm. These and the remaining geochemical indicators show only minor variations, at time even with a recurrent fluctuation pattern. This may be the result of paleoenvironmental conditions leading to the intercalated deposition of marly/limestone rhythmite or/and to a differential diagenetic imprint acting on these mixed carbonate fine siliciclastic deposits.

Key words: Jurassic; epicontinental; paleoenvironment; chemostratigraphy.

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Approaching the stratigraphic meaning of changes in the morphospace realized by the genus *Idoceras* Burckhardt, 1906.

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The genus *Idoceras* was proposed by Carl Burckhardt in 1906 based on Mexican specimens collected from Mazapil, in northern Zacatecas, Mexico. Burckhardt described 17 species characterizing the so-called "*Couches à Idoceras*" belonging of Kimmeridgian age, however he did not provide precise biostratigraphic control of the specimens studied. Up today, no morphological patterns have been described explaining the distribution of morphological types in the stratigraphic interval corresponding to the *Idoceras* record.

The phenotypic spectrum of the *Idoceras* genus offers sufficient preserved traits for realization of studies of theoretical morphology, whose exploration is beginning. The research carried out has been directed to describing patterns of morphological change in the genus *Idoceras* by means of morphospace characterization –Raup's morphospace– and Principal Component Analysis (PCA). The material used corresponds to the Burckhardt types (1906) existing in the "Colección Nacional de Paleontología", UNAM, as well as new material collected with precise stratigraphic control from the MZ-3 section at San Matías Canyon, Mazapil, Zacatecas (Villaseñor, 1991, Lara-Morales, 1994 and later field surveys). The sample size analyzed is 72 specimens distributed in two stratigraphic intervals corresponding to the faunal assamblages proposed by Villaseñor et al. (2000, 2012): Lower *Idoceras* Assemblage and Upper *Idoceras* Assemblage. As a previous step to "species" revision, morphotypes' grouping was chosen. Four morphotypes were established based on the degree of coiling (subinvolute, subevolute or evolute), the type of ribbing (simple or complex), and the shape of the whorl section (comparatively low and high equidimensionality) as additional variable.

The ontogenetic analysis of morphospace using the parameters W (whorl expansion rate), D (distance of the axis of winding to the opening) and S (shape of the generating curve) of Raup (1967) revealed:
(1) Ontogenetic trend towards lower expansion rate and coiling degree. (2) Ontogenetic trend to less equidimensional (oval) whorl sections. (3) Distinct morphospace for each of the proposed morphotypes.

The stratigraphic analysis of the obtained morphospaces indicates that *Idoceras* phenotypes of the upper stratigraphic interval are restricted to morphs with lower degree of coiling (higher values of D) and with more equidimensional sections compared to morphs gathered from the lower stratigraphic interval.

Principal components analysis (PCA) was performed twice. The original variables were D, W and S, the number of external ribs per-quarter-whorl and the occurrence of simple or complex ribbing (PCA-1); and the umbilicus vs. diameter ratio, the whorl-width vs. whorl-height ratio, the number of external ribs per-quarter-whorl, and the occurrence of simple or complex ribbing (PCA-2). The variance explained was 73.01% and 79.55%, respectively, revealing a clear separation of two morphologically distinct groups, which are related to their respective stratigraphic interval:

(1) Lower stratigraphic interval: dominance of morphs with complex ribbing and more oval whorl sections.

(2) Upper stratigraphic interval: dominance of morphs with more equidimensional whorl sections and less complex ribbing.

The interpretation of the stratigraphic dominance of *Idoceras* phenotypes with higher or lower hydrodynamic designs is approached in terms of higher or lower adaptation to water column energy. Morphological diversity in Mexican *Idoceras* reveals the well-known co-variation between shell type and sculpture as constructional trade-offs within the particular evolutionary line of ammonites analyzed.

Triassic/Jurassic bivalve extinction and recovery in the Neuquén Basin, Argentina

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The extinction event at the end of the Triassic is one of the "big five" global crisis in the history of life in the marine realm. Nevertheless, that extinction and the subsequent biotic recovery are not so well known as others, and most of the published analyses were based on data from the Northern Hemisphere. Bivalves are one of the best studied groups in relation to the recovery after the end-Triassic extinction event. We analyze the Late Triassic extinction and Early Jurassic recovery of bivalve faunas within marine environments in the Atuel river area of the Neuquén Basin, Argentina (Riccardi et al., 1988; Lanés, 2005). The nearly continuous presence of marine stenohaline major taxa such as cnidarians, rhynchonelliform brachiopods, echinoderms and cephalopods indicate normal salinity (Damborenea & Mancenido, 2005). Data were collected from a thick and exceptionally well-exposed latest Triassic-earliest Jurassic section of the Andes, which allows a high-resolution reconstruction of the local diversity dynamics.

Four phases can be clearly distinguished on the basis of the analysis of bivalve diversity through time from Rhaetian to Early Sinemurian (Fig. 1), each characterized by the relative relationships between regression lines of cumulative first and last appearance data (FADs and LADs respectively) for the recorded species against section thickness: a) Triassic equilibrium phase (Rhaetian), b) extinction phase (late Rhaetian?), followed by a long interval with no recorded benthonic fauna (Early Hettangian), c) recovery phase (Middle to early Late Hettangian) and d) Jurassic equilibrium phase (from latest Hettangian). The recovery of the bivalve fauna was relatively rapid, within the Middle and lowermost Late Hettangian.

The taxonomic composition analysis through time at generic level suggests that the recovery was mainly triggered by immigration into the basin of widely distributed genera, and the origination of new taxa was restricted. Bivalve palaeoecologic diversity seems to have been fairly homogeneous along the section, being dominated most of the time (after extinction) by attached epifaunal bivalves. Strikingly, since the abrupt mid-Hettangian diversification, relative diversity of the different main life habits shows little variation, though some minor trends could be identified. One main difference between Triassic and Jurassic faunas is the abundance (both relative and absolute) of shallow burrowers, being more frequent during the Rhaetian than on subsequent stages. This new set of local data can be compared with information from other latitudes and contribute to future global analyses.

Key words: Triassic/Jurassic extinction; biotic recovery; Bivalvia; Argentina

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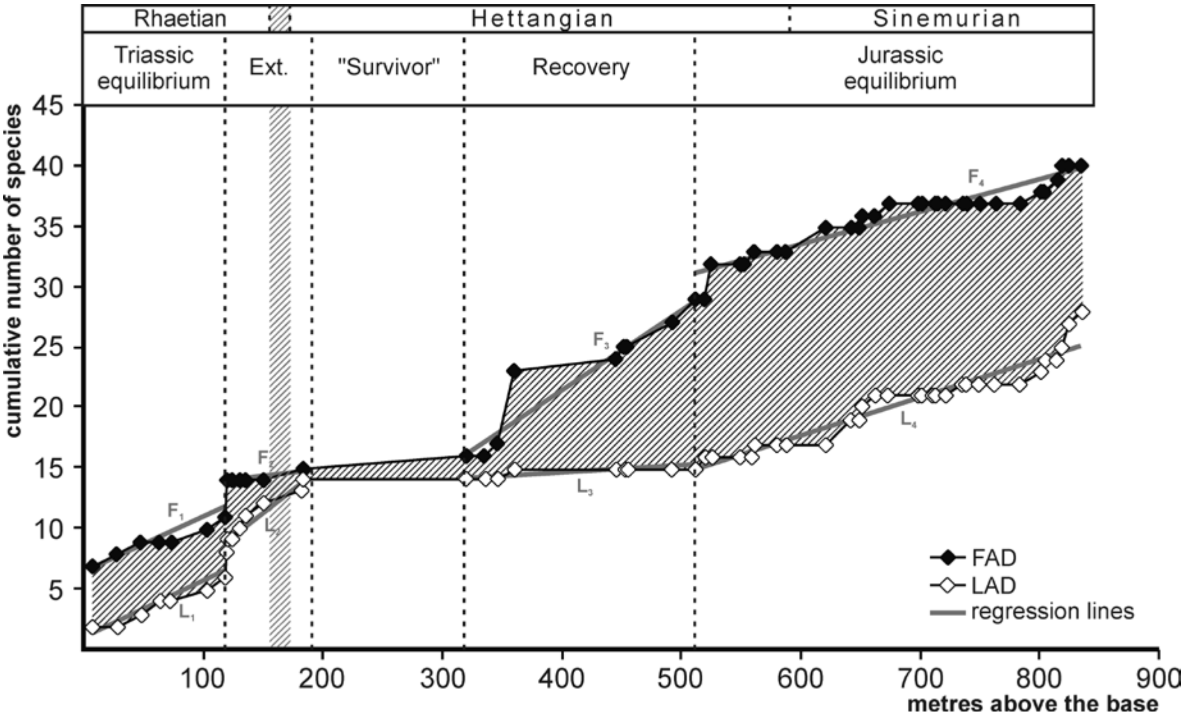

Fig. 1 . Cumulative FADs and LADs against section thickness and their regression lines (F_1 to F_4 and L_1 to L_4 respectively), characterizing four extinction/recovery phases across the Triassic/Jurassic boundary. Shaded area represents changes in diversity through time.

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An ammonite fauna of the "Goldschneckenton" (Lower Callovian, Middle Jurassic) from Uetzing (Franconia, Germany)

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In 1818, the director of the Gymnasio in Coburg, J.C.M. Reinecke, published a short monograph describing for the first time forty Jurassic ammonites (Reinecke 1818). Some of these became been index species of zones or subzones, for example *Opalinus*, *Anceps*, *Jason* or *Platynotus*. These and others are also types of a genus or a subgenus, for example (*Phlycticeras*) *Pustulatus* or (*Rasenia*) *Striolaris*. One of us (E.M.) has rediscovered the lost collection in 1992. Since then it has been possible to reconstruct the stratum typicum of most species. For the so-called "Goldschnecken" (gold snails), this was achieved already in 1966, when G. D. found numerous topotypes by means of an excavation at the Staffelberg near Uetzing (Franconia, Southern Germany).

The term "gold snail" refers to ammonites whose pyritic internal casts are coated with a golden, iridescent oxide skin. In Franconia, the Celts collected these ammonites for ritual purposes already in ancient times. After Reinecke, it was Coburg's geologist Otto Greif, who described some species systematically and compiled a detailed profile of the Lower Callovian of Uetzing. Since he did not publish his dissertation, his new species names are not available. In the years 1908-1910 Greif ran at the Staffelberg a kind of mining, so that thousands of gold snails came into numerous museums.

Although the gold snails of the Staffelberg were mentioned in countless publications, it was not clear for a long time of which layers they came from. Reuter (1908) gave a good profiling of the Uetzing sections, but as a finding point he only mentioned the 10 to 18 m thick Ornatenton (Lower Callovian). In the borehole sections of Schmidtill (1953) one can see that there are several different horizons, which can be differently thick at the particular locations. During the excavation of G.D. in Uetzing the typical gold snail fauna with most of the species described by Reinecke was found in a 2.5 m thick layer in the upper part of the Ornatenton, above a concrete layer 4 m below the White Jurassic (Oxfordian). In the ammonite fauna, *Choffatia*, *Hecticoceras* and *Oxycerites* are the most common species (together 70-80%), followed by *Macrocephalites* and *Sigaloceras*/*Kosmoceras*. *Reineckia*, *Parapatoceras*, *Subgrossouvria* and *Anaplanulites* occur only sporadic. The fauna mainly consist of microconchs.

The assemblage is described as a *parallelum* horizon and placed in the middle of the Enodatum Subzone of the Lower Callovium (Dietl & Mönnig 2016). Typical species are: *Sigaloceras enodatum* Nikitin [M], *Kosmoceras jason* (Reinecke) [m] *Hecticococeras parallelum* (Reinecke) [m], *Hecticoceras*? *laevigatum* (Reinecke) [m], *Macrocephalites tumidus* (Reinecke) [m], *M. platystomus* (Reinecke), *Oxycerites complanatus* (Reinecke), *Choffatia (Elatmites) annularis* (Reinecke) [m], *Choffatia (Choffatia) prosocostata* (Siemiradzki) [M] *Anaplanulites dificilis* Buckman [m] and *Reineckeia subanceps* Kuhn.

For each of Reinecke's species we could provide a long synonym list. However, only a few types can be discussed. *Nautilus Hylas* Reinecke is a thick variant of *Jason* or an inner whorl of *Sigaloceras enodatum*. *K. jason*, the index fossil of the Jason Zone and Subzone, is based on *K. (Zugokosmoceras) jason* sensu d'Orbigny (non Reinecke). In the Jason Subzone sensu Callomon *Reineckeia anceps* (Reinecke) probably occurs. The type was found in the east of Uetzing in a creek, where this subzone is relatively thick (3 m). In any case, the type of *Jason* definitely comes from the Lower Callovian and does not occur in the zone named after it. One solution of the problem would be to rename the type of d'Orbigny and to affiliate the Jason Zone sensu Callomon (1955) to the submediterranean Anceps Zone. *Macrocephalites tumidus* and *M. platystomus* may be varieties or two different species, but this has to be investigated in the future. *Hecticoceras hecticum* (Reinecke) possibly comes not from the *parallelum* horizon, while *H. lunula* is a smooth variety of *H. parallelum*.

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Review of stratigraphic study of Doi Phu Nang National Park Protection Unit (Dinosaur) and U/Pb Age Dating of Kangluang Rhyolite, Chiang Muan District, Phayao Province, Northern Thailand.

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Doi Phu Nang National Park Protection Unit (Dinosaur) situated in Chiang Muan District, Phayao Province is the only one dinosaur locality in Northern Thailand. In 2002, dinosaur bones belonging to a sauropodomorph were discovered from a non-marine reddish brown sandstone. This work is aim to finding age and studying stratigraphy of this locality in order to correlate it to the Mesozoic terrestrial Khorat Group in northeastern Thailand where the dinosaurs are very common. The Mesozoic continental red bed in Northern Thailand is subdivided into 5 formations including ms1-ms5 (Hahn, 1976). It overlies unconformably, locally conformably, on marine Triassic rock. Ms1, ms3 and ms5 Formations are dominated by reddish siltstone, sandstone and conglomerate while ms4 is dominated by thick bedded white quartzitic sandstone. Ms2 Formation is pyroclastic and volcanic rocks, which overlie on ms1 and covered by ms3 Formation. Ms2 is well exposed and continuity, traceable on geological map, in western part of Northern Thailand including Prae, Nan, Phayao and Chiangrai provinces.

The study of dating is focused on Kangluang rhyolite (ms2) in Doi Phu Nang National Park Protection Unit (Dinosaur) area. Kangluang rhyolite is very well exposed and it is overlain by reddish silici-clastic sedimentary rock (ms3) where sauropod bones were found.

Two samples of rhyolite have been collected from 2 locations of Kangluang, along Yom River. Results from zircon U/Pb age dating indicated 186.8±0.6 Ma and 194.7±0.9 Ma, suggesting Sinemurian-Toarcian age (Lower Jurassic). From results, we suggest that ms2 is Lower Jurassic and ms3 which yields sauropod bones is probably the uppermost of Lower Jurassic or in younger age. Consequently, we presume that this dinosaur locality of northern Thailand can hypothetically older than Phu Kradung Formation of Khorat Group.

Key words: zircon U/Pb age dating, continental red bed, Northern Thailand, Sinemurian-Toarcian age, Early Jurassic

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Provenance and age of the continental Jurassic deposits from Galeana-San Marcos, Aramberri and Huizachal valleys, NE Mexico

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This study focuses on a provenance study of the continental Jurassic deposits in the Galeana-San Marcos, Aramberri and Huizachal valleys in the NE Mexican states of Tamaulipas and Nuevo León. These valleys contain well-exposed continental red beds and volcanogenic strata included in the Huizachal Group, which consists of La Boca and La Joya formations, located below Late Jurassic-Cretaceous carbonate strata of the Sierra Madre Oriental. Although some recent studies have focused their attention on these continental deposits (e.g., Rubio-Cisneros and Lawton, 2011; Barboza-Gudiño et al. 2014), questions remain about the depositional ages and sediment source areas of these formations. Nearly 25 thin sections of sandstone samples were examined under polarizing microscope. 15 representative samples were selected for a detailed quantitative study based on point counting analysis in order to establish detrital modes and six were selected for U-Pb detrital zircon dating in order to establish the evolution of source areas in time and space and determine maximum depositional ages. La Boca Formation can be subdivided into three subunits based on their petrography. The lower subunit is characterized by dominant volcanic clasts whereas the middle unit contains mainly individual alkali feldspar clasts as well as alkali feldspar-bearing plutonic rock fragments. In the upper subunit, metamorphic grains are more dominant stratigraphically upwards with upward disappearance of the alkali feldspar. This change in clast types may be linked to the erosion of the Paleozoic Granjeno schist and Precambrian Novillo gneiss. This upper part of the sequence, dominated by metamorphic grains with no alkali feldspar, can only be found in the northern part of the Huizachal area and in the Aramberri and Galeana sectors. This spatial pattern suggests a progressive change in the source area from south to north, with no supply of these clast types (or alternatively no subsidence) to the southern basins. Detrital zircon U/Pb isotopic ages indicate maximum Early-Middle Jurassic depositional ages for the La Boca Formation. The U/Pb isotopic ages of the youngest detrital zircon grains in each sample are progressively older with increasing stratigraphic height, suggesting the progressive unroofing of Proterozoic-Paleozoic rocks. The overlying La Joya Formation kept the same source areas, with the presence of La Boca clasts in the. basal conglomerate and the erosional unconformity between the formations. These data, together with the large thickness changes of both formations over a horizontal distance of only a few kilometers, suggest that these basins opened as part of a rift, linked to opening of the Gulf of Mexico, and not in a magmatic arc context linked to the Nazas arc.

Key words: Jurassic, provenance, sandstone

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Belemnites from the Lower Bajocian of the Cook Inlet region and the Talkeetna Mountains, Southcentral Alaska

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Information on belemnites from Alaska is scant, and this group of cephalopods has never been thoroughly studied. Herein, we report Early Bajocian belemnites from the Tuxedni Group of Southcentral Alaska. Belemnite rostra examined come from the Red Glacier and Fitz Creek formations of the Cook Inlet region, and from the undivided Tuxedni Group of the Talkeetna Mountains. In biostratigraphic aspect, the studied interval includes the *Parabigotites crassicostatus* to *Sphaeroceras oblatum* ammonite Zones (Propinquans to Humphriesianum Chronozones) of the uppermost Lower Bajocian. The investigation of both the external (general shape, cross section, grooves) and internal (ontogeny, position of the apical line and the alveolus, the alveolar angle) characters were applied to these rostra.

The study of these belemnite collections has revealed representatives of the families Megateuthididae (Belemnitina) and Belemnopseidae (Belemnopseina). Among Megateuthididae, we introduce the first records of *Brevibelus* from Alaska, and the first records of *Brevibelus gingensis* and *Eocylindroteuthis* from outside Europe. Furthermore, two new species of *Eocylindroteuthis* and a new megateuthidid genus and species have been established in Southcentral Alaska. We conclude from our morphological analysis that a new megateuthidid genus represents a transitional form between the Megateuthididae and Cylindroteuthididae or may even have been ancestral to the latter. Based on external features, this new genus appeared to be member of the family Cylindroteuthididae due to the clearly apical position of the ventral groove, and only by examining the ontogeny were we able to recognize it as a member of the Megateuthididae. The new belemnite genus shows the conical to cylindriconical shape of juveniles, whereas juveniles of Cylindroteuthididae are cylindrical to slightly subhastate (spindle-like). The recognition of these new data suggests the possible need for revisions in the classification of some specimens reported previously from southern Alaska and western Canada as early *Cylindroteuthis* and *Pachyteuthis* (Cylindroteuthididae), based on external morphology only.

In our opinion, the presence of *Megateuthis* (Megateuthididae) in the Red Glacier and Fitz Creek formations (Stevens 1965) requires confirmation by new reliable data, while the record of *Gastrobelus* (Passaloteuthididae) from the Fitz Creek Siltstone (Stevens 1965) can be considered as most likely erroneous, because this genus disappeared by the end of the Early Jurassic (e.g., Doyle 1994).

The single rostrum of Belemnopseidae identified by us as *Hibolithes*? sp. juv. is the earliest record of the family from Alaska, while the enigmatic ?Belemnopseidae gen. et sp. nov. ind. (Jeletzky

1980) from the pre-Bajocian deposits of northwestern British Columbia is the first illustrated record of the early representatives of the family from the northeast Pacific region.

Belemnites developed marked provinciality during the Early and Middle Jurassic. During these times, the Tethyan and Boreal Realms, both including several provinces, became apparent. Examined belemnites in our study represent pan-Tethyan (genera *Brevibelus* and *Hibolithes*?), typically west Tethyan (*Brevibelus gingensis*, *Brevibelus* cf. *breviformis,* genus *Eocylindroteuthis*) and endemic northeast Pacific (new species of *Eocylindroteuthis* and new megateuthidid genus and species) elements. The late Early Bajocian belemnite fauna of the Boreal Realm differs considerably from the northeast Pacific association. In the Arctic province, belemnites were mainly represented by the Pseudodicoelitidae, and the first Cylindroteuthididae and *Paramegateuthis* (Megateuthididae). In the Boreal-Pacific province (northwestern Pacific), the last *Megateuthis* and the first *Paramegateuthis* were mainly developed.

Thus, Southcentral Alaska's belemnite fauna is contributing significant new data to the study of belemnite evolution and is highlighting the importance of evaluating both external features and internal structural details. Our new data suggest a location of the Peninsular terrane in the Early Bajocian south of the present location. The appearance of *Brevibelus*, *Eocylindroteuthis* and possibly *Hibolithes* near the northwestern shores of North America in the late Early Bajocian is most likely explained by their westward migration via the Hispanic Corridor, the migratory seaway between the western Tethys and the eastern Pacific.

Key words: belemnites; Bajocian; Alaska; Peninsular terrane; taxonomy; biogeography

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Early Jurassic trigoniides from southern South America: their recovery after extinction and its bearing on the evolution of the group

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After a major reduction due to the end-Triassic extinction event (only three surviving genera according to Ros-Franch et al., 2014), the order Trigoniida (Mollusca, Bivalvia) experienced a strong diversification during the Early Jurassic. In southern basins from South America at least eleven genera were recognized between the Hettangian and the Toarcian (Leanza 1993, Pérez et al. 2008). Three of them (*Trigonia*, *Prosogyrotrigonia* and *Frenguelliella*) were Triassic survivors, while the other eight genera evolved during the Jurassic, with the respective oldest records for many of them occurring within these basins. The genera *Groeberella*, *Neuquenitrigonia* and *Quadratojaworskiella* are exclusive from South America. The possibility that *Groeberella* evolved from myophorid ancestors as suggested by Pérez et al. (1995) implies a fourth surviving lineage from the Triassic. *Neuquenitrigonia* is clearly related to the *Trigonia* lineage (Pérez et al. 2008). The genus *Quadratojaworskiella* contains only two species; certain differences between them, nevertheless, suggest relationships to different genera for each. The genus *Jaworskiella* includes a few species from South and North America (Poulton 1979, Leanza 1993, Pérez et al. 2008), though they might represent different offshoots from *Frenguelliella*, perhaps providing an example of parallel evolution. *Myophorella*, a widespread and conspicuous Jurassic genus, most likely evolved from some species of *Jaworskiella* within southern South America during the Pliensbachian. *Scaphorella* seems to be closely related to *Myophorella*. *Psilotrigonia* is a genus of uncertain affinities; its oldest record (the Late Sinemurian or Early Pliensbachian species *P. vegaensis*) is from northern Chile (Pérez et al. 2008) being found later on in North America (Poulton 1979). The list of genera is completed with *Vaugonia*, most likely originating in Japan during the Hettangian and subsequently arriving to South America in the late Sinemurian via North America (Poulton 1979), though a wide variety of species have been included within the genus, which deserves detailed phylogenetic revision.

The lineage *Frenguelliella*-*Jaworskiella*-*Myophorella* shows one of the most important transitions within the group: the change of flank ornamentation pattern from sub-commarginal to oblique and tuberculate costae. This new combination of characters is typical of the Myophorelloidea, the most diverse clade of trigoniides during the Jurassic-Cretaceous. The probably parallel evolution among the species of *Jaworskiella* and *Quadratojaworskiella* might be showing a general evolutionary trend in such direction. Even the genus *Prosogyrotrigonia* may be part of this trend, supporting the suggestion by Poulton (1979) of a close phylogenetic relationship between this genus and *Frenguelliella*.

The high degree of variation of these taxa, reflected in, but not limited to, the number of nominal species described, suggests a complex and mosaic evolutionary history. Besides the systematic characterization of the group for the Early Jurassic, a detailed stratigraphic analysis of species and character states within the Myophorelloidea is attempted here in order to understand the early evolution of this major clade.

Key words: Myophorelloidea; mosaic evolution; Argentina; Chile

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Considerations on geochemical parameters and biostratigraphic elements, with respect to biogeographic changes of the Huayacocotla Formation (Lower Jurassic, Sinemurian).

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The lower marine Jurassic rocks were uplifted in east central Mexico, because the Laramide orogeny results here in the Sierra Madre Oriental range and constitutes the structural nucleus of the former. Lithologically it is recognized by fossiliferous sandy limolite that represents the complete range of *Bucklandi* to *Raricostatum* zones.

This biostratigraphic interpretation is supported by the works of Burckhardt (1930), Erben (1956), Schmidt-Effing (1984), Blau et al. (2000, 2003, 2008), Meister *et al*. (2000; 2005), Contreras and Núñez (1984); Esquivel *et al*. (2005, 2012, 2014), among others. Additionally, Flores *et al*. (2006, 2007) reinforced the idea of a fully developed homogeneus paleoenvironmental/sedimentary sequence (*sensu* Craig *et al*., 2013), so this sequence represents the complete Sinemurian stage; however, the most recent observations on the sequence are contradictory on this issue because there are not any faunal element from *Turneri-Obtusum zones*. Consequently the objective is to discuss the sedimentary uniformity in relation to the biostratigraphic discontinuity.

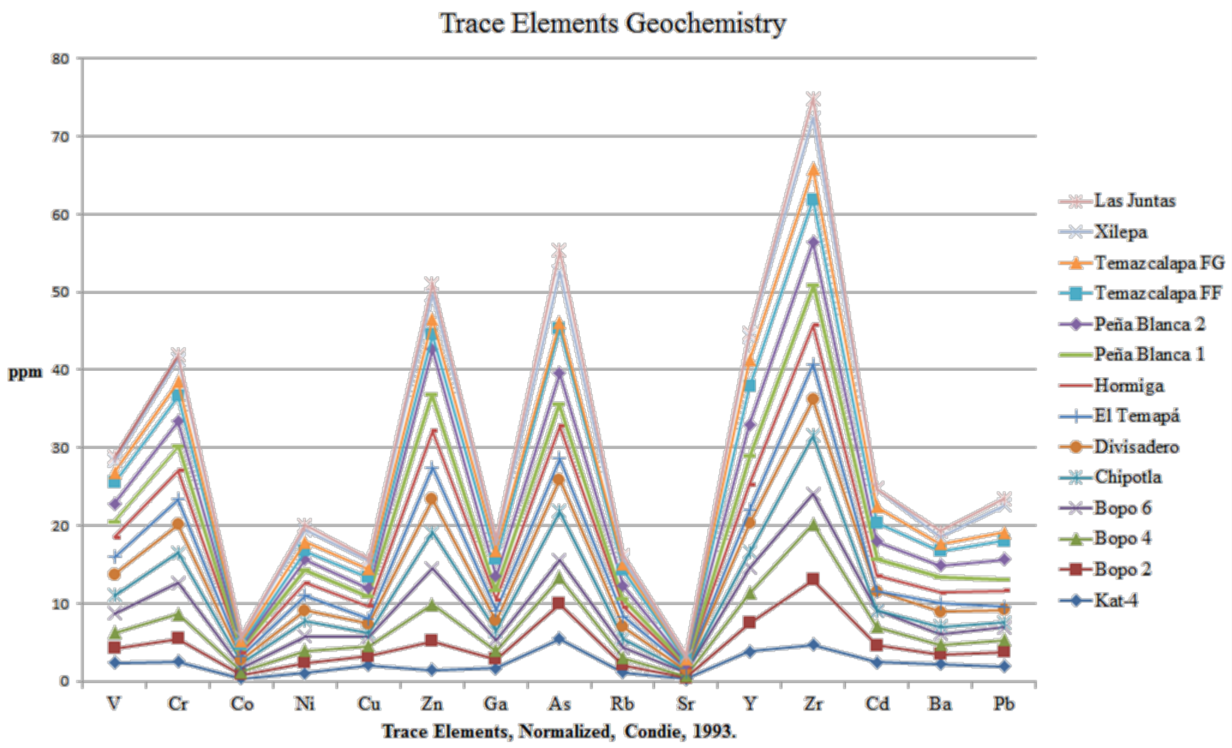
Thirteen outcrops were investigated taking geochemical samples at sites previously defined by fossils and lithology as belonging to the Huayacocotla formation. The major and trace elements were analyzed by mean of X ray fluorescence, Neutronic activation and Mass Spectroscopy. The organic carbon was extracted by means of reflux in organic solvents and analyzed by means of mass spectrometry. Sampling included thickness measurement and free collection of fossil specimens. The taxonomic work was made under principles of Arkell *et al.* (1957).

The upper Sinemurian outcrops related to Despí lithological unit such as: Temapá, Bopo, Hormiga, Chipotla, Divisadero y Kat, contain: *Paltechioceras rothpletzi*, *P. tardecrecens*, *P. hardbledownense*, *P. mexicanum*, *Ortechioceras jamesdanae*, *O. incaguasiense* and *O. pauper* are in *Oxynotum* y *Raricostatum zones.* While the Las Juntas outcrop represents *Bucklandi* and *Semicostatum* zones with: *A. aff. oppeli, Arnioceras* sp*., A. ceratitoides, A. miserabile, Juraphyllites nardii, Metophioceras conybeari, M.. molineroi, Calliphyllocers* sp*., Partschieras* sp.

The geochemical data from thirteen outcrops show remarkable uniformity in the presence and concentration of major elements (SiO, TiO_2, Al_2O_3, Fe_2O_3 MnO, MgO, CaO, Na_2O, K_2O, P_2O_5); great similarity in the presence of trace elements (V, Cr, Co, Ni, Cu, Zn, Ga, As, Rb, Sr, Y, Zr, Ba, Pb) (Angeles-Cruz, 2006), and in the presence of carotenoid derivatives of bacterial origin (Chlorobiacea y Chromatiacea) (Angeles-Cruz, 2006; Flores-Castro *et al.*, 2007) which are indicatives of euxinic conditions at the paleobasin during variable intervals and that reached the photic zone and explain the disappearance of cephalopods when closing the basin.

This appreciation reinforces that all fossils lack carbonates, which could be due to intense organic degradation as a consequence of oxidative diagenesis derived from euxinic. Organic decomposition could also generate high concentrations of sulfur (SO_4) under disoxic and / or anoxic conditions, and H_2S under anoxic conditions, which act as donors of electrons conferring a reducing character to the Huayacocotla sediment and that are revealed in the pyrite´s nodules and fossils.

The enrichment of Fe, Ga, As, Pb and Cd in most samples is due to their precipitation as sulfides under these conditions. The low concentration of MnO exhibited in all samples also indicates stagnant conditions consistent with a closed basin without marine circulation. There is a Ce anomaly in Las Juntas sample (*Bucklandi- Semicostatum*) suggesting an early regressive phase of the upper Sinemurian area of *Turneri-Obtusum* (Flores-Castro *et al.*, 2006) that points to the isolation of the basin and explains the consequent absence of marine fauna in the area.



This biostratigraphic gap was difficult to recognize because there is topographical and stratigraphic order with respect to the Cretaceous and Tertiary that are manifested in the area, coupled with the developed nature of the formation that does not allow to think about the interruption of the sedimentation process that filled the epicontinental back-arc paleobasin. In addition, in previous paleontological collections, the precise stratigraphic control was lacking due to the non-condensation of the sequence.

Since it is possible that this region is part of the hispanic paleocorridor (*sensu* Damborenea, 2000) it could have interrupted its faunal exchange with Europe, South America and North America during the *Turneri-Obtusum.* This phenomenon could represent the temporary closure of the back-arc basin where the Huayacocotla paleobasin (Flores Castro, 2007) developed euxinic conditions, subsequently giving rise to rocks without fossils during *Turneri-Obtusum* apparently present in the region, and recovering the ammonoids fauna in *Oxynotum-Raricostatum* zones. Epeiric uplifting is discarded to explain this pattern because there is not disruption of sedimentation. In other words, the hispanic paleocorridor was intermittent or was multiple, but at least in this segment was interrupted by a kind of barrier during *Turneri-Obtusum* zone.

Key words: Sinemurian, Biostratigraphy; Geochemistry; Ammonoids; Mexico.

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Source to sink relations between the Tian Shan and Junggar-Turpan Basins, Central Asia, in the Jurassic: Evidence from detrital zircon geochronology and depositional environments

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The Tian Shan, located in the southwest of the Central Asian Orogenic Belt (CAOB) and the middle of the Asian continent, can be divided into the West and East Tian Shan roughly along longitude 88°E. The West Tian Shan is divided into three tectonic units by two Paleozoic sutures, from south to north, the South Tian Shan, the Central Tian Shan and the North Tian Shan. While, the East Tian Shan consists of the South Tian Shan, the Central Tian Shan, the North Tian Shan and the Bogda Shan, from south to north. The Junggar Basin is located in the northern West Tian Shan and Bogda Shan, while, the Turpan-Hami Basin is an intermountain basin located between the North Tian Shan and the Bogda Shan. Both of them are important Jurassic coal- and oil-bearing basins. However, source to sink relationships between the Tian Shan and Junggar-Turpan basins are still controversial and lack of systematic analysis. In this paper, the Tian Shan-Junggar-Turpan basin system was divided into four sections, northern Western Northern Tian Shan (WNTS), northern Bogda Shan, southern Bogda Shan, and central Turpan. Then, a combined detrital zircon U-Pb chronology and depositional environment study of the Jurassic strata in each section was presented.

The Lower to Middle Jurassic strata in each sections all contain rich coal and oil source rocks, which can be divided into the Badaowan, Sangonghe and Xishanyao Formations from bottom to top. Shallow-water deltas were well developed under a humid climate during that time. However, the Upper Jurassic Toutunhe and Qigu Formations are characterized by red beds with few organic matter, indicating a prevailing dry climate. The uppermost Kalazha Formation, composed of thick conglomerates deposited in alluvial fan environments, covers directly on the Qigu fine-grained red beds.

Distribution characteristics of the detrital zircon ages in the Jurassic in the WNTS can be divided into two distinctive stages: 1) Lower to Middle Jurassic, showing multimodal ages. Except for the late Carboniferous peak age (301-329 Ma), there are many Precambrian and early Devonian Peak ages (416-988 Ma) from the Central Tian Shan, and the proportion of the Central Tian Shan ages peaks in the Middle Jurassic Xishanyao Formation (74%), indication gradual exhumation of the Tian Shan. 2) Upper Jurassic, characterized by abundant Late Jurassic (151-161 Ma) and Carborniferous to Permian (256-357 Ma) ages, indication uplift of the Tian Shan with relatively large scale volcanic eruption. In the northern Bogda Shan, distribution characteristics of the detrital zircon ages in the Jurassic can also be divided into two stages: 1) Lower to Middle Jurassic, all characterized by a unimodal age (300-315 Ma). The Lower Jurassic strata contain relatively rich Precambrian to Devonian ages from the Central Tian Shan. 2) Upper Jurassic, bimodal ages of 159-162 Ma and 293-331 Ma. The detrital zircon ages of the Jurassic strata in the southern Bogda Shan are dominated by Carboniferous to Permian ages, while, the detrital zircons of the Upper Jurassic in the Central Tian Shan are all characterized by a unimodal ages of 438-441 Ma.

Finally, we concluded that source to sink relations between the Tian Shan and Junggar-Turpan Basins in the Jurassic can be divided into three obvious stages: 1) During Early Jurassic, the Junggar Basin and the Turpan Basin developed into a united continental sag basin. The Tian Shan was eroded gradually with parts of drainages reaching the Central Tian Shan. 2) In the Middle Jurassic, a peneplaining occurred in the Tian Shan area and the Central Tian Shan became the main provenance. At the same time, the Bogda Shan began to uplift and transport detrital materials to surrounding basins. 3) During the Late Jurassic, the West Tian Shan uplifted again with large scale of volcanic eruption along the North Tian Shan fault. The Bogda Shan continued to uplift. However, the East Tian Shan inherited the Middle Jurassic peneplanation. The rudiment of the Tian Shan-Junggar-Turpan basin system began to form until now.

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New marine reptile assemblage from the Jurassic-Cretaceous boundary beds of the High Andes, Argentina

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Jurassic marine reptiles from the southern margin of the Eastern Pacific have been documented since the XIX century. Most of them have been recorded at the Neuquén Basin (west-central Argentina) in sedimentary rocks of the Vaca Muerta Formation (lower Tithonian-lower Valanginian). Outcrops of this lithographic unit in the southern sector of the basin have proven to be highly fosiliferous in marine reptiles (*e.g.* Cerro Lotena, Los Catutos and Pampa Tril, in the Neuquén Province; Gasparini and Dellapé, 1976; Pol and Gasparini, 2009; Gasparini and Fernández, 2011; Herrera *et al*., 2013). By contrast, exposures of the Vaca Muerta Formation in the northern sector of the Neuquén basin (Mendoza Province), though widely distributed, had not been prospected for marine reptiles since the middle of the XX century (*e.g.* Rusconi, 1938, 1948a, b, 1967).

During the last two years, a new field survey for marine reptiles was carried out in the southern Mendoza sector of the Neuquén Basin. Two cross-sections, 14 km apart, of the Vaca Muerta Formation were performed over the eastern flank of a NW-SE syncline: Arroyo Durazno (*c.* 260 m), located over the left margin of the El Durazno Creek, to the south, and Arroyo Paulino (*c.* 220 m), outcropping on the right margin of the Paulino Creek, to the north. At both localities the Vaca Muerta Formation consists of an intercalation of organic-rich laminated marls and nodular to massive limestones. Over the basis of bed-by-bed ammonoid sampling, an early to middle early Tithonian-early to middle Berriasian age span was determined for the succession studied at Arroyo Durazno (*Virgatosphinctes andesensis* to *Argentiniceras noduliferum* Andean Assemblage Zones; *Darwini*/ *Semiforme* to *Occitanica* Zones). While a late Tithonian-early to middle Berriasian age span was proposed for the interval analyzed at Arroyo Paulino (*Windhauseniceras internispinosum* to *A. noduliferum* Andean Assemblage Zones; *Microcanthum* to *Occitanica* Zones). In consequence, marine reptiles were sampled in connection with an accurate ammonoid based biostratigraphic control at both sections.

At Arroyo Durazno, 18 *in situ* marine reptiles were identified (14 ichthyosaurs, four metriorhynchid crocodylomorphs, and one eucryptodira turtle) and also four *ex situ* ichthyosaurs and five *ex situ* metriorhynchids coming from the same unit. Whilst at Arroyo Paulino, four *in* *situ* ichthyosaurus and five metriorhynchids have been found, plus one *ex situ* metriorhynchid. At both sections, marine reptile findings are concentrated in beds assigned to the *Corongoceras alternans* Zone, late Tithonian; *Microcanthum* to *Durangites* Zones).

Preliminary results depict ichthyosaurs as the main component of fossil assemblages (N= 22). Most of them are represented by articulated vertebrae. However, at least three specimens, based on forefin and pelvic morphologies, can be certainly identified as ophthalmosaurids. Metriorhynchids are also abundant (N= 15) and, contrary to ichthyosaur materials, most of them are diagnostic to a subfamily level. Six of them are provisionally referred to Metriorhynchinae indet. and four to Geosaurinae indet. Although both subfamilies have been previously identified at different localities of the Neuquén Province (*e.g.* Gasparini and Dellapé, 1976; Pol and Gasparini, 2009; Herrera *et al*., 2013; Herrera and Vennari, 2015), this is the first report of geosaurines and metriorhynchines recorded together at the same locality and within the same ammonite zone (*Corongoceras alternans* Zone). Of particular interest is one specimen of metriorhynchine, recovered from beds assigned to the *Argentiniceras noduliferum* Zone at Arroyo Paulino and identified as cf. *Cricosaurus*. This finding represents the first unquestionable record of an early cretaceous Metriorhynchinae from the Neuquén Basin. In addition, the only other tetrapod recorded at the studied sections, consists of a single eucryptodiran turtle identified as cf. *Neusticemys neuquina* (de la Fuente *et al*., 2016) from a bed included in the upper Tithonian-lower Berriasian *Substeueroceras koeneni* Zone (*Durangites* to *Jacobi* Zones) at Arroyo Durazno.

In the last years the knowledge of marine biotas of the Jurassic-Cretaceous transition has improved, triggered mainly by new paleontological surveys on the Arctic territories (Kear *et al*., 2016). In the case of marine tetrapods, the most significant findings correspond to those of the Agardhfjellet Formation (Svalbard archipelago, Norway) (*e.g.* Hurum *et al*., 2012; Delsett *et al*., 2016). Nevertheless, the structure of marine tetrapod assemblages from the J-K boundary of high northern latitudes differs significantly from that of middle southern latitude assemblages like the one presented herein. Norway assemblages are characterized by abundant ichthyosaurs and plesiosaurus and, as far as we know, no metriorhynchids or turtles have been recorded. On the contrary, Mendoza sections are characterized by abundant ophthalmosaurid ichthyosaurs and metriorhynchinae and geosaurinae metriorhynchids. The interpretation of these differences requires further scrutiny. New findings and comparisons with other localities from different paleolatitudes will undoubtedly help to understand the dynamic of marine tetrapods communities during the Jurassic-Cretaceous boundary interval.

Key words: Vaca Muerta Formation, Neuquén Basin, ichthyosaurs, metriorhynchids, ammonoid biostratigraphy.

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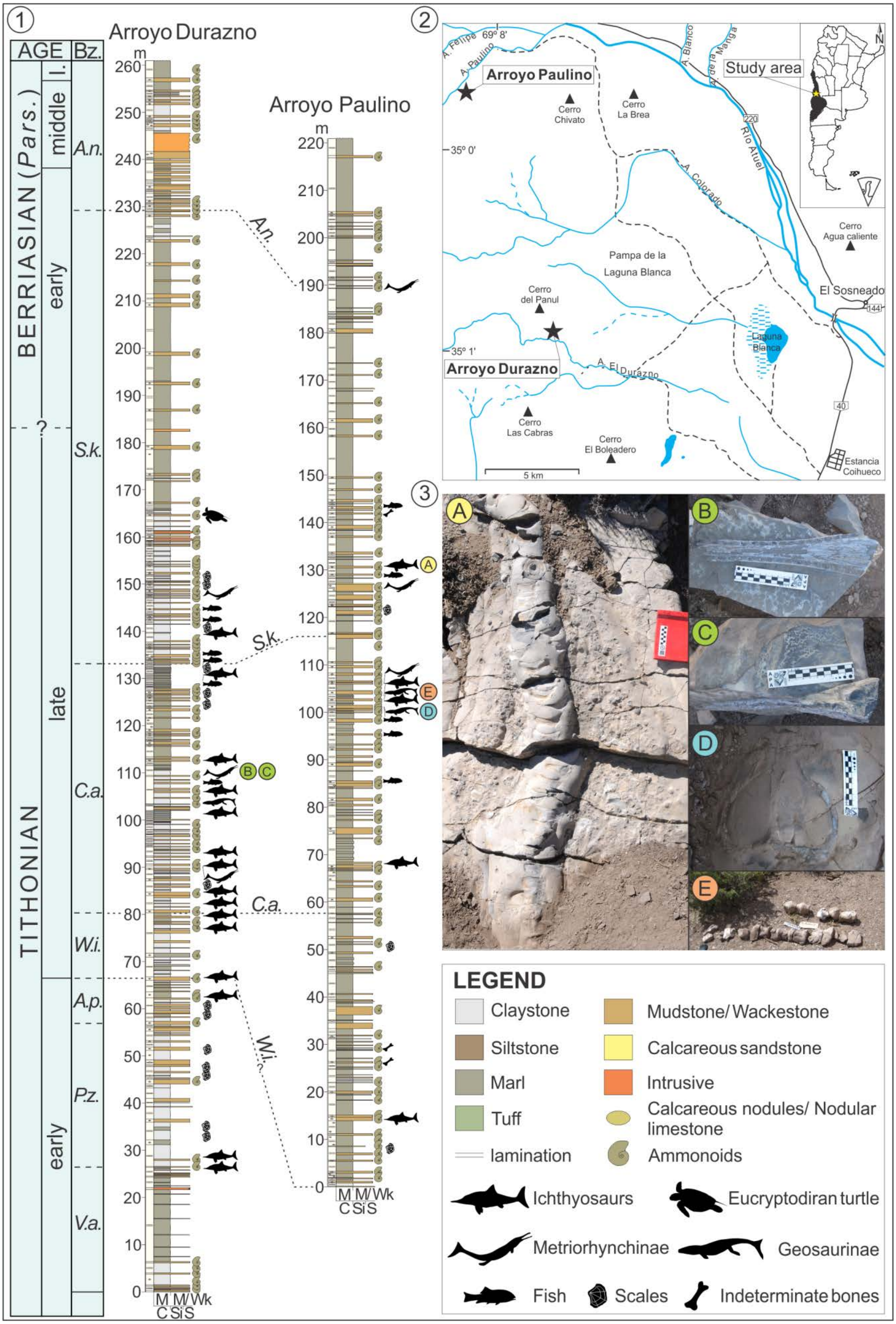
Figure caption:

1. Arroyo Durazno and Arroyo Paulino sections. Bz, Andean ammonoid Assemblages Zones, *V.a.*, *Virgatosphinctes andesensis*, *P.z*, *Pseudolissoceras zitteli*, *W.i.*, *Windhauseniceras internispinosum*, *C.a.*, *Corongoceras alternans*, *S.k.*, *Substeueroceras koeneni*, *A.n.*, *Argentiniceras noduliferum*; 2. Study area in the southern Mendoza sector of the Neuquén Basin. Stars show studied localities; 3. Selected outcrop pictures of marine reptiles: A, Ophthalmosauridae (Py 1), partial articulated vertebral column and hindfin; B, Metriorhynchidae (DU 16-10), partially preserved skull in ventral view; C, Metriorhynchidae (DU 16-10), partially preserved skull in left lateral view; D, Geosaurinae (Py 3), skull in dorsal view; E, Geosaurinae (Py 5), dorsal and sacral vertebrae; A, C and E at Arroyo Paulino, B at Arroyo Durazno.


①
Arroyo Durazno
AGE
Bz.
BERRIASIAN (Pars.)
TITHONIAN
early
middle
l.
late
early
?
A.n.
S.k.
C.a.
W.i.
A.p.
P.z.
V.a.
m
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M/ SiS
Wk
Arroyo Paulino
A.n.
S.k.
C.a.
W.i.
②
A. Felipe
69° 8'
A. Paulino
Arroyo Paulino
Cerro Chivato
Cerro La Brea
A. Blanco
A. de la Manga
Study area
220
Río Atuel
35° 0'
A. Colorado
Cerro Agua caliente
Pampa de la Laguna Blanca
Cerro del Panul
El Sosneado
144
35° 1'
Laguna Blanca
Arroyo Durazno
A. El Durazno
40
Cerro Las Cabras
Cerro El Boleadero
Estancia Coihueco
5 km
N
③
A
B
C
D
E
LEGEND
Claystone
Siltstone
Marl
Tuff
lamination
Mudstone/ Wackestone
Calcareous sandstone
Intrusive
Calcareous nodules/ Nodular limestone
Ammonoids
Ichthyosaurs
Eucryptodiran turtle
Metriorhynchinae
Geosaurinae
Fish
Scales
Indeterminate bones

Traces of epizoans, and evidences of commensalism on Jurassic cephalopod shells. Pelagic hitch-hikers or sessile islanders?

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Late Jurassic ammonites of the Transdanubian Central Range (Hungary) are generally preserved as internal moulds, but some carbonates, deposited on elevated highs, occasionally contain ammonites with permineralised shell preserved (Főzy et al. 2013). These shells may contain rare epizoans, such as calcareous polycheta worms, occasionally pennular corals, and crinoids, and different type of trace fossils. Among the traces the following types can be distinguished: (1) microborings of algae and/or bryozoans; (2) grazing traces of molluscan radula (*Radulichnus*); (3) home scars left behind possibly by patellid gastropods (limpets); (4) regular echinoid grazing traces (*Gnathichnus*); (5) elongated pits of possibly acrothoracia balanids.

Some of the listed animals settled down on the already empty shells, while others where attaching during the lifetime of the cephalopod. Traces of encrustation and bioerosion can be found mainly on the body chamber of larger ammonite specimens.

Patellid home scars are specific – only aspidoceratid ammonites possess these types of traces. Some of these traces suggest that the epizoans punctured the ammonite shell, which was subsequently healed by the cephalopod animal.

The oval, elongated and oriented pits were found only on the specimens of a single ammonite species, namely on the Kimmeridgian "*Aspidoceras*" *acanthicum* from Páskom Hill (Bakony Mountains). These traces may represent acrothoracica (burrowing barnacles) borings, which have never been documented on ammonites before. The evidence suggests, that the minute balanids were living together with the cephalopods; therefore these traces represent a new type of commensalism between the ammonites and the boring balanids.

The study of these epizoans and traces on ammonite shells give a new insight into complexity of the Late Jurassic Mediterranean sea-life, which can be characterized by previously unknown interactions, and also reveals the bioerosional significance of certain animals. Understanding the traces may contribute towards the better understanding of the palaeoenvironment, since different groups of animals require specific environmental conditions, which we have to take into account. The identification of trace makers shed light on the unknown aspects of the poorly known permanent Mesozoic evolution.

Key words: Jurassic, ammonite, Hungary, epizoans bioerosion, acrothoracia, grazing traces, limpet, commensalism

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Mexico

Late Jurassic rifting in Chihuahua, México

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Petrographic, stratigraphic, structural and geologic mapping-based studies of key areas in the northern Mexican state of Chihuahua are part of a research project to examine the Precambrian, Paleozoic, Mesozoic and Cenozoic stratigraphy and tectonics. This under way research is endeavoring to account for geologic explanations that are consistent with field observations.

The Chihuahua trough is considered as *"a right-lateral pull-apart basin that began to form ~159 to ~156 Ma (Oxfordian) during a period of relative counterclockwise rotation of the North American plate. Jurassic seas were well established by latest Oxfordian time and there was little change in basin configuration throughout the remainder of Late Jurassic, Neocomian and Aptian time"* (Haenggi, 2002). New data suggest that opening of the Chihuahua, Alamitos, Sabinas and Mexican-Sea sedimentary basins involve a rift tectonic process similar to that of the Gulf of California (Umhoefer, 2011) and Red Sea (Corti, 2012) opening. Evaporite diapir in La Popa region contain basaltic blocks which are interpreted belong to the Jurassic oceanic crust with 145-146 Ma (Garrison and McMillan, 1999). Oceanic accretion spreads the Sabinas Basin, which extends to the Alamitos and the Chihuahua basins along their eastern side and connecting the northern Tularosa? Basin. Formerly known as the Mexican Geosyncline (Humphrey and Diaz, 1956), the Mexican-Sea Basin extends south of the Coahuila Peninsula. This intracontinental rifted basin continues from Torreón-Mayrán region to the Olivina Lineament, a southern boundary for the Alamitos Basin in Chihuahua. Transgresivelly, this late Jurassic rift continues through middle Chihuahua. It crosses along western side of the Alamitos and the Chihuahua basins, to connect the Bisbee Basin. (Franco-Rubio et al., 2014). According to Lawton & Harrigan (1998), a basaltic basement of late Jurassic age characterizes this latter basin.

Closure of Mesozoic sedimentary basins by the subducting Farallon Plate at west, develops a foreland and hinterland tectonic elements in Chihuahua (Figure 1). Western-, Central- and Eastern-Foreland elements contain stratigraphic units, deposited on continental crust during late Jurassic and all Cretaceous times. They are characterized by relatively thin thicknesses, secondary deformation predominantly thrust fault and detachment-surface structures, partial or total absence of folds and frequent intrusive igneous masses. Contrastingly, Western- and Eastern-Hinterland elements are considered to have an oceanic crustal basement. They contain thick stratigraphic units, exhibiting anticlinal and synclinal folds that, at the edge between tectonic elements (hinterland-foreland), become to recumbent folds with opposing vergence. This concept is closely related with mineral deposits origin in Chihuahua.

Key words: Late Jurassic; rift opening; hinterland-foreland; opposing vergence; Chihuahua

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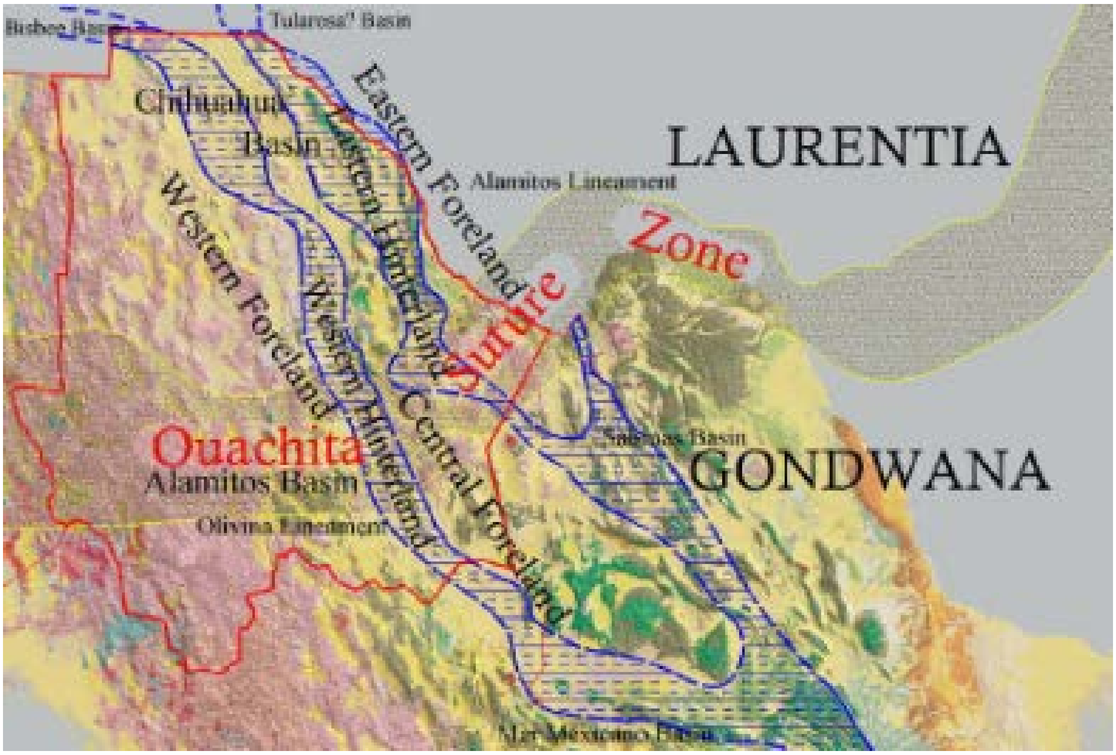

Figure 1.- Late Jurassic rift system as a tectonic model for the sedimentary basins from Chihuahua, México (Geologic base map from S.G.M., 2000)

Pore pressure prediction in well planning and design with final Upper Jurassic Kimmeridgian target

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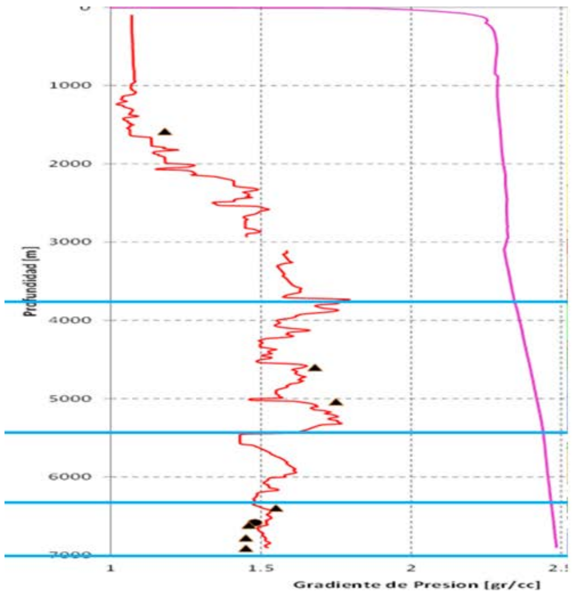
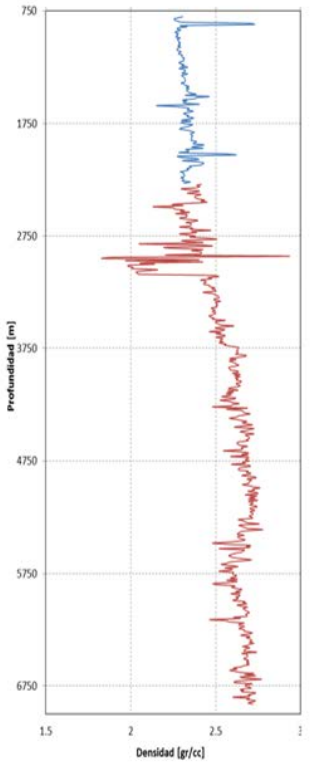
In well planning and drilling design is very important the knowledge about pore pressure (drilling mud weight and casing program design). The final target in this work was to drill to Upper Jurassic rocks, whereas the geologic objective was to find light oil production in Upper Jurassic limestones. The well has a depth of 6911 meters. The drilling had problems such as creep, stuck pipe, lost of mud weight drilling, blowouts and wellbore stability. In this study, pore pressure prediction helped to minimize the problems above mentioned. Pore pressure prediction in limestones is a new challenge in carbonate rocks. Finally, a comparison between the original well design and the operational window (real data of drilling) will help to improve the new design of well planning and design.

Keywords: mud weight, Mesozoic, Upper Jurassic, creep, stuck pipe



Predicción de la prección de poro

Derrumbes de la formación.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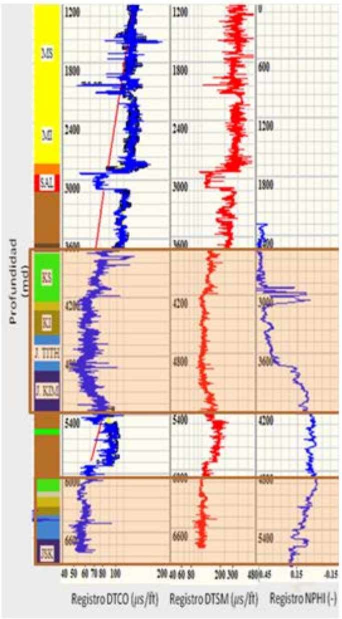
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Registro NPHI (-)

Oxygen and carbon isotopes, geochemistry and magnetic susceptibility around the *Prososphinctes* Acme Horizon – implications for Early Oxfordian paleogeographic diversification of ammonite faunas in the Submediterranean sea of southern Poland.

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Lower Oxfordian ammonite succession has been studied in several carbonate sections of Polish Jura Chain and the Mesozoic margin of *Góry Świętokrzyskie* in southern Poland. Stratigraphical interval under consideration ranges from the Mariae Zone (2.5 % of the total number of studied ammonite specimens) up to the middle Cordatum Zone in the Lower Oxfordian. The *Prososphinctes* Acme Horizon (abbreviated further to *PAH*) discovered in the Costicardia Subzone (Middle Cordatum Zone) (Głowniak, 2012) distinguishes by a short-term proliferation of a (Sub)Mediterranean ammonite species of *Prososphinctes claromontanus* (microconchs) - *consociatus* (macroconchs) group (subfamily Prososphinctinae). Our contribution aims in examination of plausible physical and geochemical causes which could trigger this phenomenon. The research is focused on the Wrzosowa section. Stratigraphy and a correlation with ammonite palaeobiogeographic events rely on the study of Głowniak (2000, 2006, 2012) and is based on 1.289 ammonite specimens (Coll. ZI.37 and Coll. IGPUW.A.36, Museum of the Faculty of Geology, University of Warsaw). The isotope studies are based on 35 belemnite rostra (7 archival ones published by Wierzbowski 2002; Wierzbowski et al., 2009; and 28 newly collected ones). In addition, more than 30 rock samples were studied for geochemistry, magnetic susceptibility (MS), TOC and $CaCO_3$ content. All fossils and rock samples were collected from 30 numbered and stratigraphically well documented Lower Oxfordian layers.

δ^{18}O values of well-preserved belemnite rostra from the Wrzosowa section vary between -0.4 and 0.9‰ and show a scatter (occasionally up to 0.9‰) in single horizons. The running mean δ^{18}O values trendline shows diminishing values throughout lower part of the Costicardia Subzone; then rises up through a middle part of this subzone and shows maximum values slightly above the *Prososphinctes* Acme Horizon; higher up δ^{18}O values trendline again decreases up to the top of the Costicardia Subzone. Belemnite δ^{18}O values point to the temperature variations of ca. 1-2.5ºC in Bukowskii and Costicardia time (although δ^{18}O values may also be related to variations in water salinity); the lowest temperatures occur approximately with the *PAH* (c. 10 ºC). Belemnite running mean δ^{13}C values trendline shifts towards higher values from the upper Bukowskii Subzone up to the middle Costicardia Subzone. There, slightly above the *PAH*, δ^{13}C values are the highest; then they again decline towards the top of the Costicardia Subzone. The δ^{13}C values fluctuations point to changes in seawater bioproductivity.

$CaCO_3$ content of rock samples is of high reverse relationship with magnetic susceptibility (MS) in the studied section. MS shows a high linear correlation with Al, Mg Mg, K, Zr; moderately high with Ti and with most of other lithophile elements. MS well reflects rhythm of terrigenous material supply. Al highly correlates e.g. with Mg, Fe, Ti, K, Ba, Bi, Ti, V, Zr, Th indicating detritic origin of these elements; and moderately highly with Fe, Na, P, U indicating mostly detritic origin of these elements.

P/Al ratio fluctuates from the bottom to the top of the Wrzosowa section following rhythm of calcareous and marly alternation. P/Al ratio polynomial trendline shows a valley in the middle Costicardia Subzone; there the lowermost P/Al ratio values correlate approximately with *PAH*. Approximately from this horizon up to the top of the Costicardia Subzone the P/Al ratio values trendline rises up. Similar increasing trend is visible in TOC content, which increases up from the *PAH* upward. Th/U ratio (palaeoredox proxy) shifts towards lower values in the uppermost Costicardia Subzone.

The above data reveal that the *Prososphinctes* Acme Horizon in the middle Costicardia Subzone correlates with the temporal cooling phase (low $\delta^{18}O$ values) and oligotrophication (low P/Al ratio values). This adverse conditions could have had impact on ammonite faunas, and cause the short-term proliferation of the ammonite group *Prososphinctes*; and the temporal decline of other ammonite groups. From middle to late Costicardia time occurred a transition from oligotrophic (in *Prososphinctes* Acme Horizon) to eutrophic conditions (high P/Al ratio values in upper Costicardia Subzone); associated with water warming (shift to low $\delta^{18}O$ values); increasing content of light ^{12}C isotope (shift to negative $\delta^{13}C$ values); certain deterioration of oxygen bottom water conditions (shift to low Th/U values); and increasing retention of burial carbon (shift to higher TOC content).

Correlation of the ammonite assemblages with paleoceanographic data confirm the previous assumption (Głowniak, 2012) that genus *Prososphinctes* encompasses generalist species which could prosper under conditions of short-time environmental stress. Shortage of other ammonites groups in the *PAH* suggests that cooling and oligotrophication created unfovarable life conditions. Re-establishing of eutrophic conditions in the late Costicardia time correlates with a decline and eventually total disappearance of *Prososphinctes* taxa from the study area, in exchange to other ammonite faunas whose number increase in late Costicardia time.

Reasons of paleoceanographic changes in Early Oxfordian sea will be a matter of further studies (cf. Wierzbowski et al., 2013).

Key words: Lower Oxfordian; ammonite bioevents, paleobiogeography, paleoceanography, Poland.

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The history of the Middle Jurassic belemnite faunas on the Russian platform, with special stress on the paleobiogeography

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The Middle Jurassic belemnites of the Middle Russian sea, occupying most part of East European (or Russian) platform, have long traditions of study, but this relates mainly to the Callovian assemblages. The belemnite assemblages pre-Callovian marine sediments of the region, despite widely spread in the southern half of the area, remained scarcely known until now. The new data collected mainly during 2016-2017 enables to draw relatively full picture of the belemnite fauna development in this area across the whole Middle Jurassic.

Aalenian belemnites are known from a single historical locality in the Donbass area (Ukraine), currently not existing, and connected with a relatively small gulf from Tethys at this time. This assemblage is represented by the characteristic megateuthidids referred as '*Dactyloteuthis*' in literature (Nikitin, 1975, 1981). Our study of similar forms collected in the Aalenian-Bajocian boundary interval of the Eastern Caucasus shows that these forms should possibly be treated under the genus Parabrachybelus.

The first confident record of Lower Bajocian marine strata on the Russian platform outside Donbass area was made only recently in the peri-Caspian area – Volgograd region (Ippolitov, 2017a). The belemnite assemblage from a single locality, tentatively assigned to top Discites-Laeviscula Zones, is characterized by the highly diversified complex representing predominantly genera Hastites, Homaloteuthis and Eocylindroteuthis. On generic level this assemblage is a typical subboreal (or 'euroboreal') association, known only from the Northern part of Central Europe, but looking somewhat heterochronous: the listed taxa were previously known in Europe from different levels – Upper Toarcian-Lower Aalenian, Middle-Upper Aalenian and Lower Bajocian, respectively. This indicates that the Subboreal belemnite biota in its two main areas – South of European Russia and North of Central Europe – developed in part independently and the migrational exchange between them was restricted. As it follows from the general paleobiogeographical situation for this time, the migrational pathway along the northern Tethyan margin implemented low latitudes and probably passed through the segment of the Mediterranean province with predominant Holcobelidae. The Early Bajocian marine transgression did not penetrate far north on the Russian platform, as it follows from the finds of the Late Bajocian cephalopods at the base of marine Jurassic succession in the localities ~200 km to the north.

Late Bajocian belemnite associations are known from several localities, historical ones from the Donbass area (Garantiana zone) and newly discovered ones in the Lower Volga area (Michalskii Zone ≈ equivalent of Parkinsoni Zone; Ippolitov, 2017b). The restudy of historical section in Donbass has revealed that besides Megateuthis-Belemnopsis-Hibolithes-Brevibelus assemblage elements, usual for Europe, this complex contains clear members of Hastitidae (considered to die out during Aalenian-Lower Bajocian) and also redeposited Homaloteuthis, which probably derives from the underlying sediments of Niortense Zone. Higher interval, Michalskii Zone of Volga area is characterized by oligotaxonic assemblage consisting of few specialized forms of ‘Parabrachybelus’. All the foresaid means that across the Late Bajocian, epicontinental sea at the northern Tethyan margin which covered southern part of Russian platform, served as a refugium for the archaic belemnite taxa with Toarcian-Aalenian roots.

Near the Bajocian-Bathonian boundary interval, the important paleogeographic event took place: the meridional marine strait, connecting northern Tethyan margin with Arctic through Russian platform, was opened. This event, previously fixed in its early stage by the appearance of Arctic foraminifera in the succession and in later stage by the wide immigration of Arcto-boreal mollusk taxa (Mitta et al., 2014), is also reflected in the drastic turnover of the belemnite biota. First was the short-spanned invasion episode of the Arctic genus Paramegateuthis, which completely replaced Late Bajocian ‘Parabrachybelus’ and formed a quickly evolving lineage in the Middle Russian sea, previously mentioned as ‘Nannobelus’ and now treated as a separate genus (Ippolitov, 2018). The marine pathway from the Arctic seem to close after this initial invasion episode, as the derivates of Paramegateuthis evolving in the Middle Russian sea do not have any counterparts in the Arctic, and this means that their endemism must be supported by the breakdown of gene flow between the regions. This frame is particularly important, as total situation represents the first isolated episode of establishment of Boreal-Atlantic belemnite province (characterized by a set of endemic taxa with initially Arctic roots, which replaced peri-Tethyan late ‘subboreal’ endemics of the Latest Bajocian), fully developping from the Callovian time only. The second phase of meridional marine strait opening, connected with the maximum of transgression in the Late Bathonian, is characterized by the wide immigration of Arctic mollusks and is described in literature in details (Mitta et al., 2014). In belemnites, this maximum transgression level is fixed by the immigration of Pachyteuthis (family Cylindroteuthididae) from the Arctic. Remarkably, at the same time endemic derivates of Paramegateuthis appear in European basins, represented only by isolated finds and this may indicate short-termed opening of meridional Pripyat strait connecting the Middle Russian sea with Polish basin.

Middle Bathonian time is an epoch of regression, and no marine strata are currently known from the territory. Overlying Late Bathonian strata are characterized only by the immigrants of the family Cylindroteuthididae, which started the extensive diversification across the Callovian, producing a number of endemic taxa in the Middle Russian sea. Additionally, members of Tethyan family Belemnopseidae are fixed at several levels indicating invasion eposides and are persistently present across the Middle-Late Callovian.

To conclude, belemnites can be used as a sensitive indicator for reconstruction of marine biota migrations. In our certain case, invasion of Arctic belemnites in the Bajocian/Bathonian boundary interval preceeds much the invasion of other marine mollusks (ammonites, bivalves), probably indicating the tolerance of small megateuthidid belemnites to extra-shallow and marginal environments, still serving as geographic barrier for other cephalopods.

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Foraminiferal biostratigraphy of the Middle and Upper Jurassic of the Polish Lowlands in relation to orthostratigraphy

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Middle and Late Jurassic foraminifers from the Polish Lowland have been studied for years, starting from 1954 by Pazdro. Numerous publications have been devoted to biostratigraphy resulted from the exploration of the deep geological structure of the Polish Lowlands by boreholes. Authors such as Kopik (1956, 1969); Bielecka and Styk (1969a, b, 1981a, b) established the first stratigraphic zonation for the Upper Jurassic of Central Poland, based on microfossils. The first synthesis on the basis of foraminifera stratigraphy was published in the " Atlas of guide and characteristic fossils " (Malinowska, **1988**), but in the above mentioned papers, as well as in many earlier micropalaeontological works, the stratigraphic position and the ranges of the most important foraminifera taxa have been presented against the background of biostratigraphic divisions, which in many cases deviate from the European standard zonation.

The following work is a presentation of stratigraphically important foraminifer taxa occurring in the Middle and Upper Jurassic of the Polish Lowlands, with references to the standard ammonite divisions. Based on the vertical succession of foraminiferal species from Upper Aalenian to Lower Kimmeridgian characteristic assemblages were described.

Additionally in Oxfordian and Lower Kimmeridgian deposits of the Peribaltic Syneclise, foraminiferal zones such as: *Ophthalmidium sagitum, Epistomina volgensis, Ophthalmidium strumosum-Lenticulina brestica*, and *Lenticulina russiensis-Epistomina uhligi* and *Epistomina praetatarensis-Lenticulina kuznetzovae* have been distinguished (Wierzbowski et al., 2015).

Based on the detail study of the foraminifers in the Oxfordian and Lower Kimmeridgian deposits, different foraminiferal assemblages were distinguished against the background of the nature of the deposits in the individual parts of the Polish Basin and varying influences of the palaeogeographical provinces (characteristic for the carbonates, so-called Sponge Megafacies and clastic deposits of the Łyna Formation).

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Jurassic Stratigraphy and Tectonics of the Mexico-USA Border Region

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Strata spanning the entire Jurassic Period were deposited in a long-lived extensional tectonic environment in northern Sonora, Chihuahua, Coahuila, northern Zacatecas, northern Durango and Nuevo León in Mexico, and southern Arizona and southern New Mexico in the southwestern United States. Jurassic strata can be broadly divided into two petrotectonic successions, an older succession of Early to Middle Jurassic age and a younger succession deposited during the Late Jurassic. The Lower-Middle Jurassic succession consists of dominant siliciclastic and subordinate carbonate deposits and commonly contains a bimodal magmatic association of silicic ignimbrites and volcanic flow breccias. Marine deposits are present in western parts of the succession, but give way primarily to redbeds eastward across northern Mexico. Eolian sandstones and siltstones interpreted as loessites are present in this succession in southern Arizona, northern Sonora and central Chihuahua, indicating a connection with widespread eolian deposits of the southwestern United States. Calderas present in this succession in southern Arizona are interpreted as a record of the Cordilleran continental-margin magmatic arc, but the trend of the arc is difficult southward to trace into Mexico. In Chihuahua and Sonora, rapid facies changes from conglomeratic facies to shallow-marine deposits suggest development of substantial topography and possible presence of normal faults at the margins of individual depocenters within sedimentary basins. Marine connections were toward the west and southwest, with the Pacific Ocean, and appear to have penetrated through the magmatic arc. Formations of the older Jurassic succession include: The lower part of the Glance Formation and Canelo Hills Volcanics in southern Arizona; the upper parts of the Antimonio and Barranca Groups and the Rancho Basomari and Rancho San Martin formations in northern Sonora; the upper three members--Cerro de Enmedio, Cerro Nevada Ignimbrite and La Sofía members--of the Plomosas Formation in central Chihuahua; and the Nazas Formation of northernmost Durango and Zacatecas.

Upper Jurassic strata unconformably overlie the older succession. In some localities, such as in central Chihuahua, the angular discordance at the unconformity is pronounced, resulting in major thickness changes in the underlying section due to erosional truncation. Facies transitions from alluvial-fan conglomerate to shoreface sandstone successions and deep-marine shales take place over distances of kilometers, indicating marked changes in water depth and the likelihood of syndepositional normal faults. Some successions in southeastern Arizona, southwestern New Mexico and northern Sonora contain mafic lavas and submarine basalts, including pillow lavas. Geochemical characteristics of the mafic rocks indicate an origin by partial melting of the asthenosphere beneath thinned continental crust. Kimmeridgian and Tithonian ammonites are common in most successions and Oxfordian ammonites are known from northern Sonora. The ammonites have Tethyan affinities and indicate a connection with the Gulf of Mexico, which became marine in

Oxfordian time. In some northern localities, including southeastern Arizona and southwestern New Mexico, Lower-Middle Jurassic strata are absent and the Upper Jurassic succession directly overlies Paleozoic strata. The Upper Jurassic strata have been associated with the Border Rift system of basins and include the following units: Cucurpe Formation and part of the Glance Formation in northern Sonora; the Crystal Cave Formation in southeastern Arizona; the Broken Jug Formation in southeastern New Mexico; and "La Casita" Formation, a very broadly distributed assemblage of diverse marine strata in Chihuahua, northern Durango, Coahuila and Nuevo León, extending almost to the Gulf of Mexico.

The regional tectonics of the Jurassic of northern Mexico and the border region remain debated because the mechanisms of extensional basin formation are difficult to discriminate. During much of the Jurassic, the subduction zone of an east-dipping subducted slab beneath Mexico migrated westward, likely creating extension in the upper plate due to slab rollback. At the same time, North and South America separated as a result of northward latitudinal drift of North America, which created synchronous transtensional basin formation in northern Mexico. On the basis of arc-like chemistry of magmatic rocks in the older succession, that subduction-related magmatism was superimposed on transcurrent faulting created by transcurrent faulting. The onset of mantle melting in the Late Jurassic suggests that passive rifting and crustal thinning became the dominant process of extension late in the Jurassic.

The Jurassic History of Mexico

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The Jurassic geologic history of Mexico was a time of profound changes in depositional style. It was a history recorded by varying patterns of sedimentary basin formation and crustal deformation created by competing tectonic mechanisms. Climatic shifts caused by latitudinal drift of North America also imposed changing characteristics on Jurassic strata. The Jurassic can broadly be divided into two phases, which are linked closely to stages of development of the Gulf of Mexico. The first phase, which spanned the Early and Middle Jurassic, was a period of crustal extension and local rift basin development that acccompanied separation of North and South America and rifting in the Gulf of Mexico. The second phase, which took place during the Late Jurassic, was marked by more connected rift basins and marine inundation that accompanied opening of the Gulf of Mexico during rotation of the Yucatan block. Subduction of a paleo-Farallon or pre-Farallon plate beneath western Mexico took place continuously throughout the Jurassic and complicates our assessment of the dominant tectonic mechanism that contributed to Mexico's Jurassic stratigraphic framework. It appears that rollback of this subducted slab likewise created extension of Mexican continental crust during separation of North and South America.

Early and Middle Jurassic phase one consisted of the development of separate extensional basins, most likely formed by transcurrent or pull-apart mechanisms. These basins filled with strata of diverse depositional origins, including alluvial-fan and braided-fluvial deposits. In northern Mexico, mainly Sonora and Chihuahua, Lower Jurassic deposits had both continental and shallow-marine origins and show some influence of nearby magmatism, which seems to have increased in importance with time. Fluvial deposition dominated successions in southern Mexico, such as the Tecocoyunca Group and Todos Santos Formation. Volcanic influence decreased with time in the Todos Santos Formation. Successions in northern Mexico, such as the Plomosas Formation, include fan-delta successions containing alluvial-fan and fluvial deposits that grade laterally in short distances to shallow-marine, tidally influenced deposits. The facies architecture suggests influence by pronounced local topography typical of rift basins. Because the Gulf of Mexico basin was not yet developed, marine connections were with the paleo-Pacific Ocean.

During phase two, separate basins became connected to form a continuous system of marine rift basins. Depositional systems were dominated by deltaic, shelfal and deep-marine facies characterized by a Tethyan, or Gulfian, ammonite fauna, indicating a connection with the Gulf of Mexico. In the Late Jurassic, the Border rift system extended from the northwestern Gulf of Mexico to southern Arizona in the U.S.

and northern Sonora in Mexico. Early deposits of the Border rift system in northeastern Mexico consisted of evaporites of the Minas Viejas Formation. Late Jurassic basins of eastern Mexico lay peripheral to the Gulf of Mexico, and were evidently strongly anoxic. Clastic deposits were derived from local block uplifts and commonly consist of basement-derived arkosic material.

Opening of the Gulf of Mexico continued into the early part of Early Cretaceous time, but carbonate platforms and basins developed on highstanding and down-dropped blocks, respectively, formed during the Jurassic. Extension of Mexican crust due to retreat of a subducted oceanic slab beneath western Mexico also continued into the Early Cretaceous. As a result, Lower Cretaceous basins of western Mexico contain abundant volcanogenic detritus that in general distinguishes them from strata of Late Jurassic basins.

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Paleoecological reconstruction and geometric morphometrics of benthic macrofauna of the Callovian of Israel

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The Jurassic sequence of the Levant holds some of the world's largest petroleum reservoirs and was rigorously researched due to its high economic potential. Two fundamental outcrops of the Middle Jurassic in (sub) tropical Israel preserve a unique picture of the geological history of this period. The Jurassic outcrops in Israel are rich in fossils of well-preserved benthic macrofauna, especially bivalves, gastropods, corals and stromatoporoids (Hirsch, 2005). Macrobenthic invertebrates are a dominant component of sedimentary rocks and have a rich and extensively sampled fossil record and are also particularly abundant in shallow shelf sediments. Molluscs are known to be sensitive indicators of seafloor conditions and serve as a useful tool for reconstructing environmental conditions of various time intervals. The taxonomic composition of molluscan assemblages and the degree of fossil preservation is used as a proxy for climate, sediment transport, oxygen availability, substrate type and the duration of sedimentary hiatuses (Kidwell and Bosence, 1991). Although the biostratigraphy of some of the fossil groups of the Jurassic in Israel has been well defined, few studies discuss their utility as means for paleoecological reconstructions and no study has quantitative information regarding any of the faunal data. Thus, the detailed environment of deposition of the shallow-marine Middle Jurassic of Israel still remains largely unknown.

Research objectives

1. Reconstruct the paleoecology of the Callovian in Israel and adjacent countries using quantitative data from benthic assemblages to follow facies changes.
2. Conduct geometric morphometrics of the body shape and size of bivalves and gastropods (especially Nerineoidea gastropods) to follow temporal and lateral changes in the Callovian.

Methodology

Detailed sampling of the Jurassic sequence concentrated on the abundant bivalves, gastropods, corals, sponges and stromatoporoids fossils within the Callovian. Target intervals included shale and marl layers of the lower Zohar Formation, and the patchy reefs and fossilifeous layers of the Be'er Sheba Formation in the Negev (southern Israel). The southern units were compared to their counterpart layers in the northern Hermon Formation (J4). Sampling was carried out using 50x50 cm^2 quadrats to quantitatively assess the diversity of fossil assemblages with a minimum of ca. 100 specimens counted for each fossiliferous layer. Taxonomic identification and description was based on the Jurassic collections of the Geological Survey, the National Natural History Collections of the Hebrew University of Jerusalem and the Fossil mollusc collection of the Natural History Museum, London. The feeding habits and life styles of the identified taxa were based on available family-level information deduced from modern settings. Variation in biodiversity was evaluated by a number of ecological indices such as species richness, evenness and dominance. Micro CT scanning was used to evaluate variation in the body shape and size of molluscan species (especially Nerineoidea gastropods) across the section based on geometric morphometrics. Maximum body length (apex to aperture for gastropods, anterior to posterior for bivalves) was measured in high resolution photography, with a minimum of ca. 20 individuals for each species. Multivariate analysis of assemblages was based on the Bray-Curtis similarity coefficient to examine compositional and structural differences between and within assemblages.

Initial results and conclusions

The targeted fossilifeous layers showed rich molluscan assemblages of bivalves and gastropods; the gastropod fossil assemblages are composed primarily of specimens of Nerineoidea. Analysis of the percent cover of reef components showed a shift from patchy reefs of corals earlier in the Callovian to branching sponges that dominated the upper part of the section. The size-frequency distribution of Nerineoidea specimens shows a significant increase in average size over time ($t_{71}=-6.87$, p-value $<<0.05$), suggesting a change in the depositional environment. The study of faunal response to changing environmental conditions, especially of paleo-warm periods, can improve our understanding of the consequences of future climate change to shelf ecosystems. Such information is important not only for modeling future biotic responses, but also for understanding the processes underlying global diversity patterns.

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Notoemys tlaxiacoensis, the oldest turtle from Mexico, Late Jurassic (Kimmeridgian)

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Until now, fossil record of turtles in Mexico has been restricted to the Cretaceous (Albian). However, recent discoveries have extended the fossil record in Mexico to the Late Jurassic (Kimmeridgian). The genus *Notoemys* are known from North and South America, and their fossil record spans from the Late Jurassic to the Early Cretaceous. *Notoemys tlaxiacoensis* consists of an partially preserved shell, including both the partial carapace and plastron and was collected in Sabinal Formation (Llano Yosobé, Oaxaca), and has increased the registration of this taxa, which was previously composed by *Notoemys oxfordiensis* (Oxfordian of Cuba), *Notoemys laticentralis* (Tithonian of Argentina) and *Notoemys zapatocaensis* (Valanginian of Colombia). The unique combination of characters shown by the specimen allows us to recognize it as a new species of *Notoemys*, named *Notoemys tlaxiacoensis* by: presence of a crest in the anteromedial part of vertebral scutes 3 and 4 (absent in *N laticentralis* and *N. zapatocaensis*); neural 3 hexagonal (being slightly octagonal in *N. laticentralis* and *N. zapatocaensis* and rectangular in *N. oxfordiensis*); neural 4 hexagonal (being rectangular in *N. laticentralis*, *N. zapatocaensis* and *N. oxfordiensis*); neural 6 hexagonal (being rectangular in *N. laticentralis* and irregular in *N. oxfordiensis* and *N. zapatocaensis*); suprapygal 1 contacting posterolaterally the corner of peripheral 11 and also laterally the costal 8 (in the others representatives of *Notoemys* it only contacts the costal 8); peripheral 10 contacts only costal 7 (in the others representatives of *Notoemys* it also contacts costal 8); sulcus between pleural 4 and vertebral 5 is located on peripheral 11 (in the others representatives of *Notoemys* it is on the costal 8); mesoplastron much wider than long. Recently the material of *Notoemys tlaxiacoensis* has been increased, which consist in fragments of the carapace and plastron and axial elements (ulna, tibia and fibula), these new axial elements add to those already observed in the first specimen. The fossil record of *Notoemys* during Late Jurassic and Early Cretaceous reinforces the proposed connection between the Tethys and the Palaeopacific through the Hispanic Corridor.

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Data for Lower to Middle Jurassic paleoclimatic reconstruction in the *Mesa Central* province, Mexico

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Objective: Interpretation of Lower to Middle Jurassic paleoclimatic conditions by means of palynological and stable isotope analysis in red beds from central to northeastern Mexico.

Methodology: Eleven samples were collected from five different localities in central to northeastern Mexico and were prepared for palynological analysis. Part of preparation and descriptions of the samples were performed in the Palynology laboratory of Institute of Geology, UNAM (Universidad Nacional Autónoma de México) and part in a new implemented laboratory in the Geology Institute of the UASLP (Universidad Autónoma de San Luis Potosí). For palynology the type of preparation for the samples were S = Schultz, A = acetólisis, C = Warmth, F = flotation, HCl = hydrochloric acid, HF = fluorhydric acid (Loyola-Martinez., 2015). The six samples prepared for isotope geochemistry correspond to carbonate concretions contained in different units trying to cover the range of ages of the latest Triassic to the top of the Jurassic. Analysis of O^{18} and C^{13} were performed on a MA-T253 Thermo mass spectrometer at the "Geo-Forschungs Zentrum" Research Center in Potsdam, Germany.

Results: By palynological studies in the red beds of The Lower Jurassic La Boca Formation and the Middle Jurassic La Joya Formation were determined the palinomorpha: *Selaginella* sp., *Clasopolis* sp., *Pityosporites* sp., *Asteropollis* sp., *Ephedripites* sp., *Asteropollis* sp. As well as Algae incertae sedis, trillete spores and dinophlagellates (Fig. 1).

The $\delta^{18}O$ values decrease at the end of the Triassic until the Middle Jurassic and subsequent show an increase from the Middle Jurassic up to the Upper Jurassic, in the same way, the $\delta^{13}C$ values show a continuous increase from the Upper Triassic to the Upper Jurassic, always with negative values.

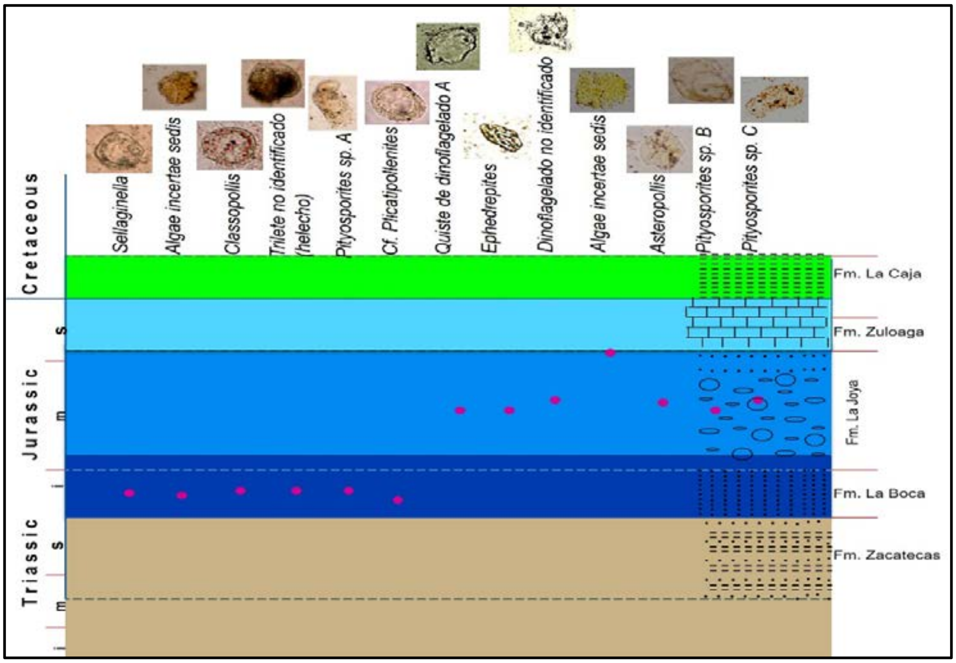

Figure 1. Palinomorpha identified in the Lower to Middle Jurassic red beds of central to northeastern Mexico.

Conclusions: *Asteropollis* sp, is characteristic of a subtropical climate. *Ephedripites* sp., belongs to arid climates and are abundant in the Mesozoic, *Sellaginella* sp. is indicative of humid, possibly marshy coastal environments of a tropical climate. On the other hand *Pytiosporites* sp. *Plicatipollenites* sp. and *Classopollis* sp, represents pollen of conifers, indicative of a cold climate, probably in the mountains, transported from the source areas of the same rivers. That allow to conclude that all described palinomorpha correspond to very different areas from the same continent or from very distant parts of the same basin, and can be transported and mixed in sediments in a fluvial or alluvial plain, proximal to a delta or even in a marine marginal environment, in tidal or near-shore environments, in turn with a distal contribution of sediments from dry areas.

The interpreted environments are compatible with models of phanerozoic climate changes and global seawater temperature conditions based in δ18O and δ13C values, that model warmer periods for the end of the Triassic and lower Jurassic time, and gradually decresse of the global temperature towards the Jurassic-Cretaceous-boundary (Veizer,1999), and finally an important increase in the Late Cretaceous (Berner, 2001).

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Preliminar study of a new lithostratigraphic unit from the Jurassic in Tlapa de Comonfort, Guerrero, México

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During the last century in Mexico, there have been a lot of descriptions and proposals of lithostratigraphic formations; the State of Guerrero with all its outcroppings was not the exception. One of these units is the Tecocoyunca Group, considered to outcrop out on a broad region of the Sierra Madre del Sur (SMS), from Olinalá, Guerrero to Tlaxiaco, Oaxaca. The range of age of the group is from the Bajocian to Callovian. Nowadays, it contains 5 formations with two subgroups. The lower one, that includes the formations: Simón, Taberna and Zorrillo; this subgroup is composed by layers of sandstone, shale, coal and some calcareous horizons (Erben, 1956). Four years ago, a sampling in the SMS in the municipality of Tlapa de Comonfort, Guerrero, was started in the locality named Tres Caminos (TC). It has a paleofloristic record extremely rich and diverse (Martínez-Martínez, 2015; Martínez-Paniagua, 2015). Due to its palinologic content a Middle Jurassic age was infered (Couper, 1958). Nevertheless, the lithology of this locality does not match with the one from the Tecocoyunca group in the region. As a result, in this paper we support the idea of a new unit based on the lithology and paleontology. A stratigraphic sequence of 407 meters was measured, paleontological material from three zones of the base towards the top of the column was collected (Z1 216 m; Z2 246 m and Z3 266.8 m). 587 prints of leaves and fronds were collected, in addition to 16 samples of rocks for palynology research among the localities mentioned before obtaining four positive samples (580 sporomorphs).

The new lithostratigraphic sequence is named Tres Caminos and it is characterized by having a lower limit with schist and phyllite; followed by a quartz conglomerate alternated with sandstone with a thickness of 180 m, intruded by a granitoid body; afterwards a sequence of sandstone and coal shale was deposited on it with a thickness of 75 m (Z1-Z2 fossilíferous). A lithologic hiatus of 2 m. was registered, subsequently the deposit continued with sandstone and coal shale for 33 m more (Z3). 90 m upwards, the sequence shows layers of sandstone and conglomeratic sandstone. The sequence ends with 27 m of thin layers of sandstone and coal shale. The sedimentary structures are: from the granitoid body to the lithologyc hiatus crossed and wavy lamination, iron nodes and normal gradation. Between the hiatus and the fine stratification there is crossed and wavy lamination, and load cast. In the conglomerate sandstone there is a lack of sedimentary structures. Last, in the final part inversed gradation was found. The paleontology content of flora and palinomorphs is integrated by Cycadophytas, Bennettitales, Pteridophytas

(Filicales), Ginkgoales, Gnetales, Coníferales and the genera *Mexiglossa* y *Perezlaria* (*Insertae sedis*), mushrooms and bryophythes. Revision of the outcrop from Tres Caminos shows a lithologic and paleontologic association different to that of the Tecocoyunca group. For the latter, sequences of layers of fine grained sandstone and shale are highlighted, with plane parallel and wavy lamination and intraclasts; the lack of flora records where the only genera existent is *Brachyphyllum*. Regarding the palinologic record, a new groups is introduced, the lycopsids. It is necessary to complete the analysis with sedimentological data, regional mapping and radiometric dating.

Key words: Palinology; *Dictyophyllidites*; Mixteco Terrane; Tecocoyunca Group

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Paleoenvironmental conditions across the Jurassic-Cretaceous boundary in central-eastern Mexico

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The Pimienta Formation is the major hydrocarbon source rock in Mexico and is ranked first in the list of targets for exploration and development like an unconventional resource of Shale Gas. Furthermore, the deposition of this unit occurred during an episode of accelerated global change across the Tithonian–Berriasian boundary that resulted in the accumulation of laminated, organic-rich mud rock in several marine basins worldwide (Klemme and Ulmishek, 1991; Föllmi, 2012). In this research we study one of the most continuous and expanded records of the Pimienta Formation (Tithonian–Berriasian), outcropping at the Padni section located in the southeastern part of the Sierra Madre Oriental. It provides an excellent opportunity to study the depositional evolution of pelagic sediments situated on the western edge of the central proto-North Atlantic Ocean. The section was described bed-by-bed and 38 rock samples were taken at selected intervals. Outcrop gamma-ray logging was performed at 50 cm intervals. Thin sections of the collected samples were obtained for microfacies analysis and pyrite framboid size analysis. Furthermore, mineralogical composition and total organic carbon determinations were carried out on selected samples.

As a result, we construct a stratigraphic column with a thickness of 154 m of which, from bottom to top, ~5.5 m corresponds the Taman Formation, ~135 m to the Pimienta Formation and ~13.5 m to the Lower Tamaulipas Formation. According to calpionellid biostratigraphy, the chronostratigraphic range of the Padni sections spans from the upper Tithonian Crassicollaria Zone to the upper Berriasian Calpionellopsis Zone (Oblonga Subzone). It is characterized by pelagic, organic-rich carbonates and shales and can be divided into four microfacies: 1-thin-laminated packstone to wackestone rich in calcified radiolarians, 2-thin-laminated wackestone with abundant calcified radiolarians and common calpionellids, 3- packstone to grainstone with highly disarticulated saccocomids and, 4-poor to moderately bioturbated mudstone to wackestone with abundant calpionellids. The calculated Spectral Gamma-Ray curve shows values varying between 16 and 145.6 API units and is remarkably similar to others from the subsurface of the Tampico-Misantla Basin. Mean size of pyrite framboids varies between 5 and 7.5 µm, while standard deviation varies between 1.5 and 3.5 µm. The mineralogy consists mainly of calcite (2-97%), quartz (0-85%), phyllosilicates (0-63%), dolomite (0-65%,) and pyrite (0-5%). Otherwise, total organic carbon content shows fluctuating values between 0.13% and 1.25% (mean 0.80%).

Our result indicates that the studied section was deposited in an outer ramp to basin with environmental conditions controlled by the tectonic events associated to the breakup and opening of the proto-Gulf of Mexico. The appearance of calpionellids in the lower part of the Pimienta Formation reflects the early incursions of Tethyan oceanic waters into the proto-Gulf of Mexico during late Tithonian. The occurrence of short and intermittent accumulations of saccocomids during early Berriasian times supports periodic connections between these basins and the Pacific during sea-level rise events. However, a full and stable connection between the Tethys and proto-Gulf of Mexico, with the establishment of an extensive circulation of water and oxygen exchange, occurred until the late Berriasian. This event is attested by the open marine and bioturbated facies of the Lower Tamaulipas Formation, rich in calpionellids and poor in organic matter. Their occurrence support a younger age for the finalization of the Yucatan Block rotation. Anoxic bottom-water conditions prevailed during late Tithonian-early Berriasian associated to high marine productivity in a semi-restricted basin. Deposition of the studied sediments took place mostly during arid climate conditions coinciding with a Tithonian-Berriasian arid phase reported in other Tethyan and Atlantic regions.

Keywords: Calpionellid, Tethys, Proto-Gulf of Mexico, Anoxia, Pyrite framboids.

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Provenance analysis of Jurassic sandstones from the Otlaltepec Basin, southern Mexico: Implications for the reconstruction of Pangea break-up

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The structural evolution that accompanied the break-up of Pangea during Jurassic time has been constrained in Mexico only at the regional scale on the basis of global plate tectonics and geometric considerations. According to available regional-scale reconstructions, the Jurassic tectonic evolution of Mexico was characterized by: 1) anticlockwise rotation of the Yucatán block along NNW-trending dextral faults and 2) sinistral block motions along W- to WNW-trending faults, which are geometrically needed to restore southern and central Mexico to the north-west of its present position during early Mesozoic time and avoid the overlap between North and South America in the reconstruction of Pangea. Reports of W- to WNW-trending sinistral faults that were active in Mexico during Jurassic time are presently few, and the existence, extension, and age of some of these structures have been questioned by many authors.

In this work, we present the provenance analysis from a Jurassic clastic succession deposited within the Otlaltepec Basin in southern Mexico. Whole-rock sandstone petrography integrated with chemical analysis of detrital garnet and U–Pb detrital zircon geochronology points out that the analyzed stratigraphic record was deposited during rapid exhumation of the Totoltepec pluton along the Matanza fault, which is a W-trending sinistral normal fault that extends along the southern boundary of the Otlaltepec Basin. U–Pb zircon ages and biostratigraphic data bracket the age of the Matanza fault between 163.5±1 and 167.5±4 Ma. This indicates that the Matanza fault was involved in the crustal attenuation that accompanied the break-up of Pangea and that sinistral motion of continental blocks along W-trending structures was taking place in southern Mexico as predicted by global plate tectonic reconstructions.

Stratigraphic potential of radiolarians for defining the Jurassic/Cretaceous boundary: phylitic analysis in the western Pacific and eastern Tethys

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The Global Boundary Stratotype Section and Point (GSSP) of the Jurassic/ Cretaceous (J/K) boundary is the last among the GSSPs in the Phanerozoic. It is defined as the base of the Berriasian Stage. The formal definition was made in 2016 to use the base of the *Calpionella alpina* Subzone as the primary marker by the Berriasian Working Group in the International Subcommission on Cretaceous Stratigraphy. The definition is satisfactorily applicable for shallow marine deposits within the western Tethys and north Atlantic. Unfortunately, the primary marker taxon cannot be found in the Pacific and circum-Pacific regions since the distribution of *Calpionella* is limited to the western Tethys and north Atlantic. To determine the base of the Berriasian outside of these regions, alternative markers are needed.

Radiolarians are good candidates for defining the J/K boundary because they are wide spread and can be found both in shallow and deep sedimentary facies. Pelagic sequences across the J/K boundary have been reported in ODP/IODP sites in the western Pacific and land sections in Japan, the Philippines, southern Tibet, Iran and others. Evolutionary series of several radiolarian lineages across the J/K boundary are reviewed and suitable bioevents, which are approximate to the J/K boundary, are presented. These lineages include the radiolarian genera *Archaeodictyomitra, Cinguloturris, Eucyrtidiellum, Hemicryptocapsa, Hsuum, Loopus, Mirifusus, Neorelumbra, Ristola, Podocapsa, Pseudodictyomitra, Tethysetta, Thanarla*, and *Vallupus*.

Matsuoka (1995) proposed a radiolarian zonal scheme for the entire Jurassic and lower Cretaceous. In defining zones evolutionary first appearance biohorizons (EFABs) are selected as much as possible. The J/K boundary is located within the *Pseudodictyomitra carpatica* Zone, whose base is defined by the EFAB of *Pseudodictyomitra carpatica* and its top is defined the EFAB of *Cecrops septemporatus*. Our current research revealed that important lineages for defining the J/K boundary are *Cinguloturris, Eucyrtidiellum, Podocapsa,* and *Vallupus*.

Key words: Jurassic/Cretaceous boundary, GSSP, Radiolarians, evolutionary lineage, Pacific, Tethys

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Petroleum Significance of Mexico´s Jurassic System

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The purpose of this work is to account three issues that are instrumental in assessing the significance of the contributions made by the petroleum industry to the progress of the geological knowledge of this System: the historical perspective; present knowledge; and the new landscape. The understanding of the historical dimension and factors that contributed to success will be crucial to design and execute future petroleum exploration's research programs and strategies in Mexico's Jurassic System.

The Historical Perspective

A first approach about the evolution of the understanding of Mexico's Jurassic System from the view of a petroleum geologist can be accomplished in the light of four circumstances: 1- Mexico's scientific tradition and its national history; 2- by attempting to identify research programs that have formulated explicitly its purpose in the mid or long term; and in which, individuals, scientific societies, and institutions have been involved to achieve those purposes; 3- the axiom that Petroleum Exploration demands geological maps displaying the sedimentary basins, with information about the distribution, age, and description of all aspects of the their sedimentary rocks that make up the petroleum systems; 4- Mexico's politics of oil.

Under this approach, in the lapse 1868-1983, the four factors allow to define three periods. From 1984 onwards -fourth period- it is difficult to identify a clear research program as those that were clearly established in the past three periods, because of the radical and endless institutional reorganizations led by a divergent Mexico's politics of oil.

The first period started in 1868 after Mexicans reinstated the Republic with Benito Juarez as Mexico's President. It was led by Antonio del Castillo and had the following milestones: the foundation of the Mexican Society of Natural History in 1868; the disclose of *Data for the Study of Mexico's Mesozoic Rocks* (Mariano Barcena,1875); the creation of the Mexican Geological Institute in 1888; the presentation of the first edition of Mexico's Geologic Map in 1889; the publication of *Data for the Geology of Mexico* by Aguilera and Ordoñez in 1893; the formal description of Mexico's Jurassic System by Del Castillo and Aguilera (1895); the endorsement of the presence of Jurassic rocks in the States of Durango, Zacatecas, San Luis Potosi, Queretaro, Puebla, Oaxaca, and Nuevo Leon by Aguilera, Ordonez and Buelna (1896); the assemblage of one the most prolific stratigraphic

research groups in North America in the lapse 1894- 1914; and the disclose of the *Etude Synthetique sur le Mesozoique Mexicain* by Burckhardt in 1930.
At the turn of the century, Del Castillo research program began to be parallel with the geological efforts of a legion of American and European geologists, paleontologists and drillers who came about because the firsts Mexico's oil boom. Hence, by 1926, the petroleum potential of the Jurassic System was tested with wells drilled in the Ebano-Panuco Province- the San Manuel wells- (Baker, 1928). In the second decade of this century, research programs at the Institute and exploration works in oil industry were harmful by the bleeding episodes came about by the overthrow and assassination of President Madero in 1913, and by the outbreak of the First World War in 1914.

The second period starts in 1930, and lasted until 1938. In this period Mexico's oil output declined drastically. Under these circumstances, documents reveal that the refinement of the regional tectonics and sedimentary analysis of Mexico's producing basins became instrumental to revitalize them. Hence, L.B. Kellum, a petroleum geologist, who had been working in Mexico's oil industry, discloses a new research program at the University of Michigan (1930, 1936, and 1944) that he will carry out with three main associates: Imlay, Kelly and Kane. The inception of this program is almost contemporaneous with two fundamental publications released by the oil industry. J.L. Tatum disclosed a paper untitled "Geology of Northeast Mexico" and John M. Muir (1936) published "Geology of the Tampico Region" in which he made a synopsis of what he named the "Tampico Embayment". These studies led to refine Burckhardt's first paleographic map of the Late Jurassic. Regional studies encompassed southeast Mexico as well, where outstanding geologists of the El Aguila Company studied the salt deposits, the structure of the Sierra de Chiapas foothills, and describe the Upper Jurassic Chinameca Formation.

The third period starts in 1939, with the assemblage of no more than ten specialists in geology and geophysics recruited by PEMEX (Rodríguez Aguilar, 1950). These men headed by Manuel Rodríguez Aguilar and with total support and confidence of President Lazaro Cardenas and his government, designed an exploratory plan in order to achieve three main objectives: finding new petroleum provinces in order to ensure Mexico's economic development; discovering new fields in the existing producing basins, in order to increase production; and giving general guidelines to the newcomers. This Research Program transcend into 1983 and could be divided in at least three main stages. In the first stage, PEMEX systematically began to investigate oil possibilities in Mexico's Jurassic System, as it is demonstrated by many papers published in AMGP and AMGE's bulletins, founded in 1949 and 1958, respectively. The turning point between the first stage and the second one, is the 20th International Congress, in which PEMEX discloses its achievements though several publications and forty five field trips across the country. Hence the second stage, starts with a commercial milestone in 1956: Mexico's first's commercial discoveries in the Jurassic System in the fields Tamaulipas- Constituciones and the San Andres located on pre-Jurassic basement highs of the Tampico-Misantla basin. From 1956 until 1972 PEMEX pursues systematically the assessment of the petroleum potential of the Mesozoic rocks, especially beyond the Tampico-Misantla basin. Hence, this period includes the most prolific era in terms of Exploration outputs for PEMEX. It started with an extensive exploratory program in the whole country, with renew geological concepts and technologies, in order to fulfill Mexico's domestic demand for fuels. The starting point of this campaign was the foundation of the IMP in 1965, where influential lines of research were established in areas like micropaleontology, ammonite biostratigraphy, geochronology, geochemistry, petrography, hard rocks, and regional tectonics that included pioneers works in suspect terranes. By 1968 the Arenque field was discovered in Kimmeridgian oolitic limestones offshore Tampico; and at the beginning of the seventies PEMEX geologists visualize and drill wildcats to test two new plays: the subsalt and the pre-salt plays in southeast Mexico. The great reward to these exploratory efforts came out with the discoveries of the Mesozoic Reforma –Akal trend between 1972 and 1976, and the commercial discoveries made in the Lower Cretaceous Formations in the Sabinas basin in 1975.

In the Reforma area, oil and gas production began to be discovered in Kimmeridgian dolomitized oolitic limestones in 1978 with the Paredon field; while in the Akal area, the discovered well, Chac -1 appraised the potential of the Oxfordian and Kimmeridgian rocks in 1976. This potential was confirmed with several discoveries made in the eighties and nineties. In the Sabinas basin, the Upper Jurassic Formations La Gloria and La Casita became key gas reservoirs in the Lampazos field discovered in 1976.

The fourth period- The new politics of oil undoubtedly impact the exploration's scientific approach. Investments in Exploitation were privileged upon Exploration of the country. Restricted areas of "investment projects' became the unit for exploration plans, strategies, and assessments, instead of geological provinces. By mid- nineties, this politics of oil led PEMEX to concentrate its exploration efforts and investments in selected and confined areas of the Gulf coast, mainly in southeast Mexico and in the deep-waters of the Gulf of Mexico basin. Explorers focused on detailed reservoir studies, geochemistry research, and integration studies with new concepts and leading -end technologies, in order to search for new prospects in the "investment projects" located in the previously discovered petroleum provinces and in deep-waters. With respect to the Jurassic System, significant fields were discovered in the Reforma-Akal trend, where salt movements during the Late Jurassic were the main geological control for the oolitic limestones distribution.

Present Knowledge and the New Landscape

PEMEX'S positive economic results in the Jurassic System have contributed meaningfully to the knowledge of the Gulf of Mexico basin in terms of classic stratigraphic and sedimentological concepts, geosynclinal theory, plate tectonics and sequence stratigraphy approaches as it is witnessed in several international publications. These achievements will be crucial in the future of Mexico's oil industry, because they have opened up economic expectations in both frontier and "mature basins". Subsalt and pre-salt plays in deep-waters of the Gulf and in the continental platform and onshore southeast Mexico; the northward extension of the Kimmeridgian plays along the western continental slope of the Yucatan platform; unconventional resources in the Tithonian rocks; and last but not least, in "mature basins", "already evaluated basins or areas", or even in "already evaluated fields and structures" that wait for new geological ideas for the reassessment of the Jurassic System. This reassessment could change in the short and mid- terms the present Mexico's resources a reserves base.

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Contributions of Petroleum Geology to the understanding of Tlaxiaco Basin´s Jurassic System

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The Tlaxiaco basin, located in southern Mexico, encompasses 30,000 square kilometers that are distributed in southern part of Puebla State, western part of Oaxaca State, and eastern part of Guerrero State. It lies southward of *Eje Neovolcanico Mexicano* and it is part of the physiographic province known as *Sierra Madre del Sur*.

Our purpose is to present the main scientific contributions provided by the geologic surveys conducted first, by geologists from *Instituto Geologico de Mexico* and afterwards by geoscientists from PEMEX, the *Instituto Mexicano del Petroleo (IMP)*, the *Instituto de Geologia-UNAM* and others studies published on *Revista de la Sociedad Geologica Mexicana*, on the understanding of the Jurassic System in a key area of southern Mexico as the Tlaxiaco basin.

The Mesozoic Tlaxiaco basin began to subside during Early Jurassic having as backbone Precambrian and Paleozoic igneous and metamorphic terranes, that include in some areas Upper Paleozoic sedimentary rocks (Flores de Dios and Buitron, 1982; Corona, 1983); and also, some locations with exposure of ignimbrites and andesitic-basaltic tuffs (Corona, 1981, 1994) of probable Triassic age.

Two regional tectonic features frame Tlaxiaco basin during Jurassic times. The trench of Nazas arc westward; and a shear zone eastward, along which, Yucatan block moved toward its present position as the Gulf of Mexico opens. In this singular tectonic framework, during Early Jurassic, subsidence was accompanied by deposition of continental-paralic (Rosario and Cualac formations) sediments that, during Middle Jurassic, gradually changed into marine environments as transgression encroached upon the area (Tecocoyunca Group changing northward to Tecomazuchil Group). At first, marine waters approached from the Pacific realm, but as the Gulf of Mexico opened, they advanced from this domain. By Late Jurassic as transgression and subsidence proceeded, shallow-water carbonate sediments (Chimeco Formation) were covered by deep-water bituminous thin bedded- shaly limestones (Sabinal Formation changing northeastward to Mapache Formation).

The sedimentary section displays a disconformity between Upper Jurassic and Lower Cretaceous, thus Lower Cretaceous is made up of continental and shallow sediments (Tlaxiaco Group, San Isidro Formation and Alacran Formation) that gradually change upward into Middle Cretaceous that is represented by a well-developed carbonate platform (Teposcolula Formation) that encompassed the most part of the basin, to the degree, that it extended into the Guerrero-Morelos basin, located toward the west. Deposition included thick bedded dolomitized limestones and evaporites (Yesos Tlaltepexi Formation). By Late Cretaceous, the carbonate platform drowned due to the effects of initial pulses of Laramide orogeny that produced a deep-water basin in which shaly carbonates and clastic terrigenous (Yucunama Formation) accumulated.

Uplift and folding of the Mesozoic sedimentary infill of about 6,000 meters thick, took place in Paleocene- Eocene, as result of Laramide Orogeny (Meneses et al, 1994).

The first geological surveys in Tlaxiaco basin started at the end of the ninety century with reconnaissance works made under the guide and direction of the *Instituto Geologico de Mexico*, and as a part of the project to elaborate the first Mexico's Geological Map that would be the basis of the evaluation of Mexico's mineral potential (Del Castillo, 1868; Hijar, 1904; Flores, 1909). In some of these works, geologists report a thick section of Mesozoic fossiliferous strata with coal deposits. With this background, Flores (1909) carried out extensive geological traverses and described in a general way, the lithology of these Mesozoic beds. He concludes that they represent the Triassic, Jurassic, and Cretaceous Systems. Regarding the Jurassic System, Flores reports Jurassic beds at three localities. At the environs of Chalcatongo on the basis of the presence of *Stephanoceras* of the group Humphesianum Sow (Dogger); at the surroundings of Amoltepec, where he describes thin-bedded limestones alternating with shales that contain traces of coal and *Idoceras* that allow him to assigned them a Kimmeridgian age; and at the environs of Tezoatlan where he reports a Triassic-Jurassic section composed of bituminous and coal- bearing shales and sandstones, in which he found *Parkinsonia* that led him to established a Middle Jurassic age. In this paper Flores (1909) points out that, Jurassic beds were also reported by Felix and Lenk (1889-1899), and states the economic importance of Tlaxiaco basin due to its diverse mineral wealth.

Two years after Flores, Birkinbine (1911) reports a more detailed study about Tezoatlan coal deposits based on laboratory tests; and in 1914 Wieland publishes the classic paper *La Flora Liasica de la Mixteca Alta* in which he mentions that his field work began in 1908 by invitation and support of Jose Guadalupe Aguilera, Director of the *Instituto Geologico de Mexico*. During the first oil Mexico's boom (1904-1921) Tlaxiaco basin was not a target for oil companies; however, because 1938 Mexico's oil production had decreased substantially, while national demand increased, PEMEX considered to explore all Mexico's sedimentary basins with oil-bearing characteristics. Hence by 1943, PEMEX geologists Salas and Guzman were assigned to map and to update stratigraphic and structural features of the Tlaxiaco basin (Salas, 1949; Guzman, 1950). Accordingly, at the beginning of the fifties PEMEX had more reliable geological maps of the Tlaxiaco basin to plan the petroleum exploration campaign. There are a good number of geological studies mainly of stratigraphic and structural type in internal reports of PEMEX, some of them, and others from other educational and scientific institutions, were published as those of Lopez Ticha (1988), Ortega (1978), Flores and Buitron (1982), Grajales and Lopez (1981), Corona (1981, 1994), Lopez Ramos (1984), Rueda Gaxiola (1997) y Meneses et al (1994) among others.

At broad strokes, Pemex exploratory campaign can be divided into four exploratory stages: geological recognition; stratigraphic and structural semi-detailed surveys; stratigraphic and structural detailed surveys; and regional synthesis and petroleum assessment. In each of these stages, surface geology and gravity and magnetometric surveys were the main exploratory methods; 2D seismic was deployed as well, but as recognition surveys. Paleontological studies were fundamental in the second stage; while the outstanding collaboration of the IMP, was instrumental in geochemical analysis and the study of hard rocks carried out in the fourth stage.

Two wildcats, Yucudaa-1(1972) and Teposcolula-1 (1974), were drilled during the third exploratory stage. That yielded information about the eastern limit of the basin and the composition and extent about the carbonate-evaporitic Cretaceous section. During the fourth exploratory stages, regional integration studies, as well as more detailed field work allowed to determine and rank the main Mesozoic trends and plays.

The lithological and geochemical characteristics of the Upper Jurassic in Tlaxiaco basin indicate that these rocks are excellent source rocks in a conventional petroleum system in which the main reservoir and seal rocks are within the Cretaceous System.

The area that seems most promising for oil exploration and less geological risk seems to be located in the area of Huamuxtitlan-Alpoyeca, in the west of the Tlaxiaco Basin, that have well-defined structures, an excellent seal constituted by Yesos Tlatepexi Formation and several hydrocarbons seeps. The assessment of the Upper Jurassic in an Unconventional Petroleum System awaits further studies.

In conclusion, the understanding of the Jurassic System in the Tlaxiaco Basin is the result of numerous studies carried out, over almost 150 years, by professional explorers from different geological disciplines and from several scientific institutions. Those explorers have contributed in a very important way to understand the geological history of this basin, where Pemex geoscientists have made a sustantive contribution. The knowledge thus far obtained shows that this basin has an interesting potential of conventional and possibly non-conventional oil resources waiting to be tested; in addition to other mineral resources of economic importance.

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On the Upper Bajocian Peri-Tethyan ammonite genus *Djanaliparkinsonia* Kutuzova (Stephanoceratidae, Garantianinae)

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The genus *Djanaliparkinsonia* Kutuzova was originally established as an endemic subgenus of the genus *Parkinsonia* (family Parkinsoniidae, superfamily Perisphinctoidea) from the Upper Bajocian (middle member of the Degibadam Fm) on the southwestern chains of the Gissar Range (Uzbekistan). Kutuzova (1975) described two new species, *Parkinsonia* (*Djanaliparkinsonia*) *lutshnikovi* Kutuzova (type species), and *P.* (*D.*) *tuadaensis* Kutuzova, and figured only the holotypes. One more species she described in open nomenclature as *Parkinsonia* (*Djanaliparkinsonia*) sp. nov. Later, the rank of *Djanaliparkinsonia* was raised to genus and another specimen identified as *Djanaliparkinsonia* sp. nov. (Besnosov & Kutuzova, 1982). Subsequently Besnosov and Mitta (1993) published an emended description of *Djanaliparkinsonia*.

Ammonites of the genus *Djanaliparkinsonia* were discovered during the study of the Middle Jurassic ammonites and biostratigraphy of the Upper Bajocian (upper member of the Djangura Fm) from the basin of the Kuban River (Northern Caucasus, Karachay-Cherkessia, Russia). The ammonites came from two localities. One is on the Kuban River near the village of Krasnogorskaya, a well-known locality for diverse ammonites of the Upper Bajocian Strenoceras Niortense Zone (Zatwornitzky, 1914; etc.). The second locality is ~30 km southwest, on the Kyafar River. The study of the Upper Bajocian ammonites from this region has very recently begun (Mitta & Sherstyukov, 2014; etc.). Beds with *Djanaliparkinsonia*, based on the co-occurrences of other ammonites (*Garantiana* spp., *Pseudogarantiana* sp., *Vermisphinctes* cf. *martiusii* (d'Orbigny)), belong to the standard Garantiana garantiana Zone. In addition, these beds yielded transit taxa of Phylloceratina and Lytoceratina, and rarely found nautilids, belemnites, and bivalves. On the Kyafar River, the age of the Beds with *Djanaliparkinsonia* is confirmed by their position between Baculatum Subzone of the Niortense Zone and Subarietis Subzone of the Parkinsoni Zone. In the Kuban River locality, the Garantiana Zone overlies the Lower Jurassic with angular disconformity. The finds of members of *Djanaliparkinsonia* in the Northern Caucasus allow the recognition of a new species, including macroconchs and microconchs. In addition, a specimen of *Djanaliparkinsonia* was identified from the lower subzone of the *Parkinsoni* Zone on the Kyafar River.

The re-examination of the original collection of V.V. Kutuzova from the Gissar Range and the study of newly collected material from the basin of the Kuban River showed that *Djanaliparkinsonia* should be assigned to the subfamily Garantianinae of the family Stephanoceratidae (superfamily Stephanoceratoidea). In *Djanaliparkinsonia,* the branches of the ribs approximate the mid-venter, as in Garantianinae, rather than alternate as in Parkinsoniidae.

The endemism of the *Djanaliparkinsonia* was shown to be far more limited than previously thought. W. Wetzel (1954) had described two fragments of a body chamber as *Garantiana* (*Subgarantiana*) *bentzi*, from the "Bigotiten-Schichten" of

Bielefeld (North Germany). This taxon has a large shell, with whorls rounded in cross-section and widely spaced, thick ribs is considerably different from other Garantianinae found in this interval, presently interpreted as the upper part of the Garantiana Zone – lower part of the Parkinsoni Zone. The comparison with the type material from Kutuzova's collection and our North Caucasus ammonites allowed Wetzel's species to be reassigned, and more so, the similarity of the North Caucasus ammonites clearly suggests that Wetzel's taxon belongs to *Djanaliparkinsonia*.

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Key words: Ammonoidea; *Djanaliparkinsonia*; Stephanoceratidae; Garantianinae; biostratigraphy; Peri-Tethys

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J.C.M. Reinecke (1818) – 200 years after his publication and the status of his collection with its type-material

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In 1818, the director of the Gymnasio in Coburg, J.C.M. Reinecke, published a short monograph describing for the first time 37 Jurassic ammonites (Reinecke 1818). Some became index species of zones or subzones, for example **Opalinus, Anceps, Jason** or **Platynotus**. These and others are also types of a genus or a subgenus, for example *(Peltoceras)* **Annularis**, (*Phlycticeras*) **Pustulatus** or (*Rasenia*) **Striolaris**. One of us (E.M.) has rediscovered the lost collection in 1992 in the Naturkunde-Museum Coburg. Since then it has been possible to reconstruct the stratum typicum of most species. For the so-called "Goldschnecken" (gold snails), this was already achieved in 1966, when G. D. found numerous topotypes by means of an excavation SE of the Staffelberg near Uetzing (Franconia, Southern Germany). The following list gives a brief overview of the status of the Reinecke collection and its type material.

Opalinus	1 specimen = HT of *Leioceras opalinum* (Reinecke 1818, figs. 1, 2). Opalinuston Fm, basal Aalenium. Editing: Schulbert 2001.
Meandrus	1 specimen, nomen dubium = *Leioceras opalinum* (R. 1818, figs. 3, 4). Opalinuston Fm, basal Aalenium.
Comptus	5 different specimens and species of *Pleydellia*, specimen to figs. 5, 6 = LT to *Pleydellia comptus*, Opalinuston Fm, upper Torarcium, Aalensis Zone. Editing: Chandler & Callomon 2009.
Complanatus	1 specimen of *Oxycerites complanutus* (R. 1818, figs. 8, 9). Sengental Fm, "Goldschneckenton", Lower Callovian, Enodatum Subzone. Editing: Dietl & Mönnig 2016.
Rotula	7 syntypes of *Amaltheus rotula* (R. 1818, figs. 9, 10). Amaltheenton Fm, Upper Pliensbachian, Margaritatus Zone.
Discus	9 syntypes of *Tarameliceras (Metahaploceras) discus* (R. 1818, figs. 11, 12). Arzberg Fm, Lower Kimmeridgian.
Polyplocus	7 syntypes of *Ataxioceras polyplocus* (R. 1818, figs. 13, 14) Arzberg Fm, Lower Kimmeridgian.
Jason	8 syntypes of *Kosmoceras (Gulielmiceras) jason* (R. 1818, figs. 15-17)

	Sengental Fm, ”Goldschneckenton“, Lower Callovian, Enodatum Subzone. Editing: Dietl & Mönnig 2016.
Castor	1 spec. = HT of *Kosmoceras (Spinikosmoceras) castor* (R. 1818, figs. 18-20). Sengental Fm, ”Goldschneckenton“, Middle Callovian, Coronatum Zone.
Pollux	2 syntypes of *Kosmoceras (Spinikosmoceras) pollux* (R. 1818, figs. 21-23). Sengental Fm, ”Goldschneckenton“, Middle Callovian, Coronatum Zone.
Hylas	umpteen sytypes, *Sigaloceras or Kosmoceras* (R. 1818, figs. 24-26). Sengental Fm, ”Goldschneckenton“, Lower Callovian, Enodatum Subzone. Editing: Dietl & Mönnig 2016.
Refractus	1 paratype, 1 lectotype to *Oecotpychius refractus* (R. 1818 fig. 27-30). Sengental Fm, ”Goldschneckenton“, Middle Callovian, Coronatum Zone. Editing: Schweigert & Dietze 1998.
Parallelus	umpteen syntypes of *Hecticoceras parallelus* (R. 1818, fig. 33, 34). Sengental Fm, ”Goldschneckenton“, Lower Callovian, Enodatum Subzone. Editing: Dietl & Mönnig 2016.
Costula	1 specimen = HT of *Dumortieria costula* (R. 1818, fig. 33, 34). Opalinuston Fm, Upper Toarcian, Levesquei Subzone. Editing: Schulbert 2001, p. 66, pl. 6/2, 10, 11.
Lunula	1 specimen, umpteen topotypes of *Hecticoceras lunula* (R. 1818, fig. 35, 36). Sengental Fm, ”Goldschneckenton“, Lower Callovian, Enodatum Subzone. Editing: Dietl & Mönnig 2016.
Hecticus	type lost, *Hecticoceras hecticus* (R. 1818, fig. 37, 38). Sengental Fm, ”Goldschneckenton“, Lower Callovian, Enodatum Subzone. Editing: Dietl & Mönnig 2016
Radians	2 paratypes, 1 lectotype of *Dumortieria radians* (R. 1818, figs. 39, 40). Opalinuston Fm, Upper Toarcian, Levesquei Subzone. Editing: Schulbert 2001.
Platynotus	umpteen syntypes of *Sutneria platynota* (R. 1818, figs. 41, 44). Arzberg Fm, Lower Kimmeridgian, Platynota Zone.
Dendatus	1 specimen = HT of *Creniceras dendatum* (R. 1818, figs. 43, 44). Arzberg Fm, lower Kimmeridgian, Hypselocylum Zone.
Polygyratus	1 specimen = HT of *O. (Ardescia) polygyratus* (R. 1818, figs. 45, 46). Arzberg Fm, lower Kimmeridgian, Platynota Zone.
Tumidus	2 syntypes of *Macrocphalites tumidus* (R. 1818, fig. 47, 48). Sengental Fm, ”Goldschneckenton“, Lower Callovian, Enodatum Subzone.
Trifurcatus	1 specimen = HT of *Rasenia (Eurasenia) trifurcata* (R. 1818, fig. 49, 50). Arzberg Fm, lower Kimmeridgian, Platynota Zone.

Inflatus	1 specimen = HT of *Aspidoceras inflatum* (R. 1818, fig. 51). Arzberg Fm, Kimmeridgian, Platynota Zone.
Striolaris	4 specimens = HT *Rasenia (Rasenoides) striolaris* (R. 1818, fig. 52, 53). Arzberg Fm, Lower Kimmeridgian, Platynota Zone.
Laevigatus	umpteen syntypes of *Hecticoceras laevigatus* (R. 1818, fig. 54, 55). Sengental Fm, ”Goldschneckenton“, Lower Callovian, Enodatum Subzone. Editing: Dietl & Mönnig 2016
Annularis	umpteen syntypes of *Choffatia (Elatmites) annularis* (R. 1818, fig. 56, 57). Sengental Fm, ”Goldschneckenton“, Lower Callovian, Enodatum Subzone. Problem: Type spescies of *Peltoceras*. Editing: Dietl & Mönnig 2016
Crenatus	1 specimen = HT *Rasenia crenata* (R. 1818, fig. 58, 59). Arzberg Fm, lower Kimmeridgian, Platynota Zone.
Platystomus	4 syntypes of *Macrocphalites platystomus* (R. 1818, fig. 60). Sengental Fm, ”Goldschneckenton“, Lower Callovian, Enodatum Subzone. Editing: Dietl & Mönnig 2016
Anceps	type lost, *Reineckeia (Reineckeia) anceps* (R. 1818, fig. 61). Sengental Fm, ”Goldschneckenton“, Middle Callovian, Anceps Zone. Editing: Dietl & Mönnig 2016
Elipticus	1 specimen, crushed = *Reineckeia (Reineckeia) anceps* (R. 1818, fig. 62.). Sengental Fm, ”Goldschneckenton“, Middle Callovian, Anceps Zone. Nomen dubium.
Pustulatus	1 specimen = HT of *Phlycticeras pustulatus* (R. 1818, figs. 63, 64). Sengental Fm, ”Goldschneckenton“, Middle Callovian, Coronatum Zone Editing: Schweigert & Dietze 1998.
Striatus	2 syntypes of *Liparoceras striatus* (R. 1818, figs. 65, 66). Numismalismergel Fm, Lower Pliensbachian.
Undatus	umpteen syntypes of *Ceratites (Ceratites) undatus* (R. 1818, fig. 67). Hauptmuschelkalk, Triassic, Upper Ladinian.
Costatus	23 syntypes to *Pleuroceras costatus* (R. 1818, figs. 68, 69). Amaltheenton Fm (nodule layer at top), Upper Pliensbachian.
Arietis	4 syntypes of *Germanonautilus arietis* (R. 1818, figs. 71, 70). Hauptmuschelkalk, Triassic, Upper Ladinian.
Colubrinus	6 syntypes of *Orthosphinctes colubrinus* (R. 1818, fig. 72). Diethfurth Fm, Lower Kimmeridian.
Anguinus	1 specimen = HT of *Dactylioceras anguinum* (R. 1818, fig. 73). Posidonienschiefer Fm, Lower Toarcian, Falciferum Zone.
Serpentinus	3 syntypes of *Harpoceras (Hildaites) serpentinum* (R. 1818, fig. 74, 75).

Posidonienschiefer Fm, Lower Toarcian, Falciferum Zone.

Caecilia 1 specimen = inner whorl of *H. (H.) serpentinum* (R. 1818, fig. 76, 77).
Posidonienschiefer Fm, Lower Toarcian, Falciferum Zone.

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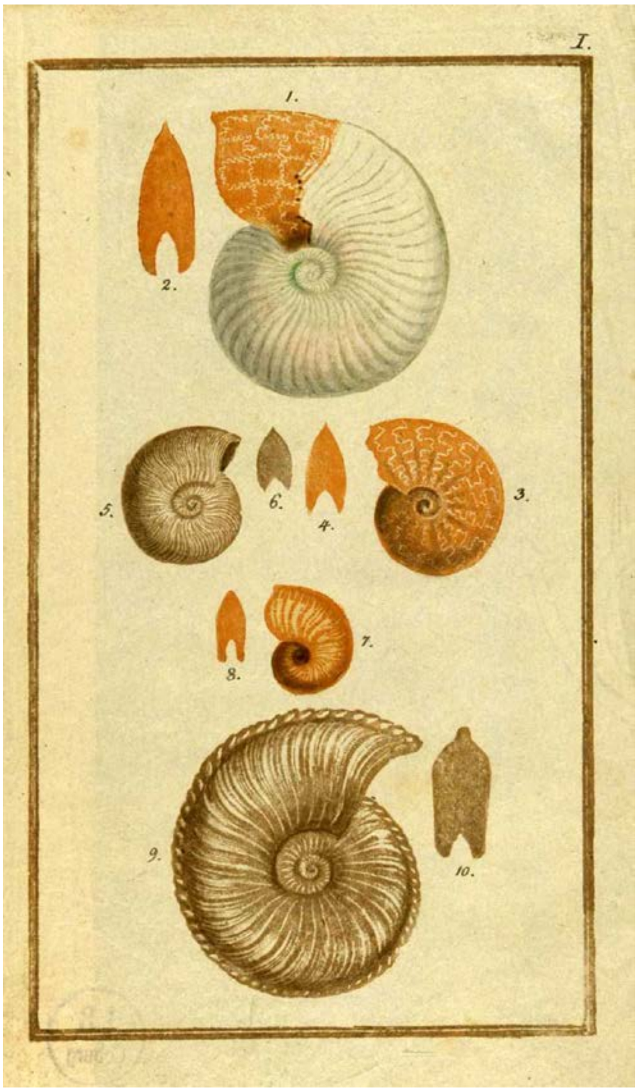

Fig. 1-10 (of 77) of Reinecke (1818). **1-2.** *Nautilus opalinus.* **3-4.** *Nautilus meandrus.* **5-6.** *Nautilus comptus.* **7-8.** *Nautilus complanatus.* **9-10.** *Nautilus rotula.*

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On the systematics, stratigraphy and palaeobiograhy of the ammonite genus *Kepplerites* (Bathonian and basal Callovian, Middle Jurassic)

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In the Upper Bathonian and Lower Callovian (Middle Jurassic), the ammonite genus *Kepplerites* is an important guide fossil. With its help, Jurassic rocks can be correlated from North America, Greenland, Russia to Central Europe. The basis of the Callovian Stage is described by the *keppleri* horizon, which occurs in more than 20 locations in Southern Germany and Switzerland, as well as in England, the Caucasus and the Russian platform. The genus *Kepplerites* s. str. occurs in the Upper Bathonian and basal Callovian of Southern Germany in five biohorizons with five or six species: *K. aigii* → (*K.* aff. *traillensis*) → *K. traillensis* → *K.* cf. *radiatus* → *K. radiatus* → *K. keppleri* (I+II), and in the *keppleri* horizon also *K. (Tychoites* n. sub. gen.*) herscheli* n. sp.. In the lower three horizons the genus is relatively rare (1-3%), it becomes more frequent at the Bathonian/Callovian boundary (15%).

The *Keppleritinae* have their origin in Western Canada and the Western Interior, where they derive from a very variable population of *Cadomites* (CALLOMON 1993). IMLAY (1953a) determined these ammonites as *Gowericeras* and created numerous species: *costihians, subitum, costicrassum, costimedium, spinosum, multus, costidensum* and *snugharborense*. For the transition to *Kepplerites*, the last two species are of interest. *Cadomites costidensum* (IMLAY) gave the *costidensum* beds of the Riedon Fm of Montana its name and occurs here with larger-sized cardioceratids of the genus *Paracephalites*. *Cadomites snugharborense* (IMLAY) comes from the lowest part of the Chinitna Fm of Alaska Peninsula. In comparison with the European morphotypes, *Cadomites rectolobatus* from the lower part of the Upper Bathonian (boundary of Bremeri and Retrocostatum zones) is the most similar. CALLOMON (1984, 1993) correlated the *Cadomites costidensum* and *C. snugharborense* with horizon f18 of Greenland (*Arcticoceras cranocephaloide*), for which he also assumes an age of the early Late Bathonium.

The species *Cadomites/Kepplerites stephanoides*, which occurs in this horizon, already leads to *Kepplerites*, but there are still morphotypes, which are very similar to *C. costidensum*. Starting from this very variable fauna, the Keppleritinae split into several evolutionary lineages, which can clearly be separated in the horizons f19 and f20 of Greenland. On the one hand the finely ribbed new sub-genus *Tychoites*, represented by *K. tychonis* RAVN (non SPATH, non CALLOMON), and the other by the coarse-ribbed subgenus *Kepplerites* with *K. inflatus* CALLOMON, including *K. tychonis* sensu CALLOMON (1993).

During the late Bathonian, the way of evolution was quite different in the various basins. In the Western Interior evolved a peculiar fauna with very large and evolute Keppleritinae, which look more like *Stephanoceras* than *Kepplerites* (*K. landuskiensis-mclearni-rockymontanus* IMLAY). In Greenland there are large-sized Keppleritinae too (*K. rosenkrantzi* SPATH, *K. peramplus* SPATH), probably at the same level. At that time, the Keppleritinae migrated to Svalbard, the northern North Sea, and the Russian Platform. Little is known about the development in Arctic Canda and Alaska. POULTON (1987) decribed a fauna with *K.* cf. *rosenkrantzi* and *K.* cf. *svalbardensis* from northern Yukon. The species figured by IMLAY (1953b) are all from the highest Bathonian (Apertum Zone to lowermost Callovian).

The first Keppleritinae on the Russian platform are *K.* aff. *inflatus* MITTA , *K.* cf. *rosenkrantzi* sensu GULYAEV & KISELEV and *K. svalbardensis* SOKOLOV & BODYLEVSKY. According to the boreal standard sensu CALLOMON (1993) this would correspond to the upper Variabile Zone, which is in accordance with the first Russian cardioceratids like *Paracadoceras barnstormi* (MEEK) and *Cadoceras infimum* (GULYAEV & KISELEV).

It was unclear for a long time how the first Keppleritinae came to Central Europe. An immigration from Greenland across the early Atlantic via South England and NW France seems obvious. Aspects in disfavor are the absence of any Boreal faunas in the Upper Bathonian of Western Europe and the blocking of the route over the present North Sea (CALLOMON 1979). A direct passage from the Russian Platform via Poland is also out of question, because the sea road via Belarus and Ukraine opened only after the transgression in the late Early Callovian. There remains only the way from the Russian Platform across the territory of today's Caucasus or Turkmenistan and from here along the northern edge of the Tethys west to Southern Germany. At first, *K. aigii* reached Southern Germany, nearly at the same time as *Macrocephalites*, which came from the Indo-East African Province on the other side of the Tethys. Both genera are, however, still relatively rare and are in competition with the Subboreal genera *Homoeoplanulites* and *Oxycerites*. It is only at the end of the Discus Chron that *Kepplerites* became more frequent, and with *K. radiatus*, the genus developed to a conspicuous faunal element in Swabia. A single specimen of Buffevent in France is an advance for the distribution to the west. *K. keppleri* then advanced even further to England. There is no evidence for Poland and Northern Germany.

Soon after *Kepplerites* had established in the Subboreal Realm, the species died out, not only in Europe, but also in wide parts of the Boreal Province. Only in Alaska and in western Canada some species survived. In the upper Herveyi Chron, their descendants with the new subgenus *Gowericeras* migrated to Europe again, according to above-described pattern via Greenland, Russia, Georgia, Central Europe and England. The sudden extinction of *Kepplerites keppleri* is difficult to explain, also because as the likewise Boreal genus *Cadoceras* continued to spread. However, after the extinction of *Kepplerites* all species of *Cadoceras* became endemic, which indicates isolation in separated sea basins. The reason for this was a rapid sea level fall, and possibly a cause for the extinction of *Kepplerites*, but climate change also could have played a role.

Key words: Jurassic, biostratigraphy, ammonites, *Kepplerites*

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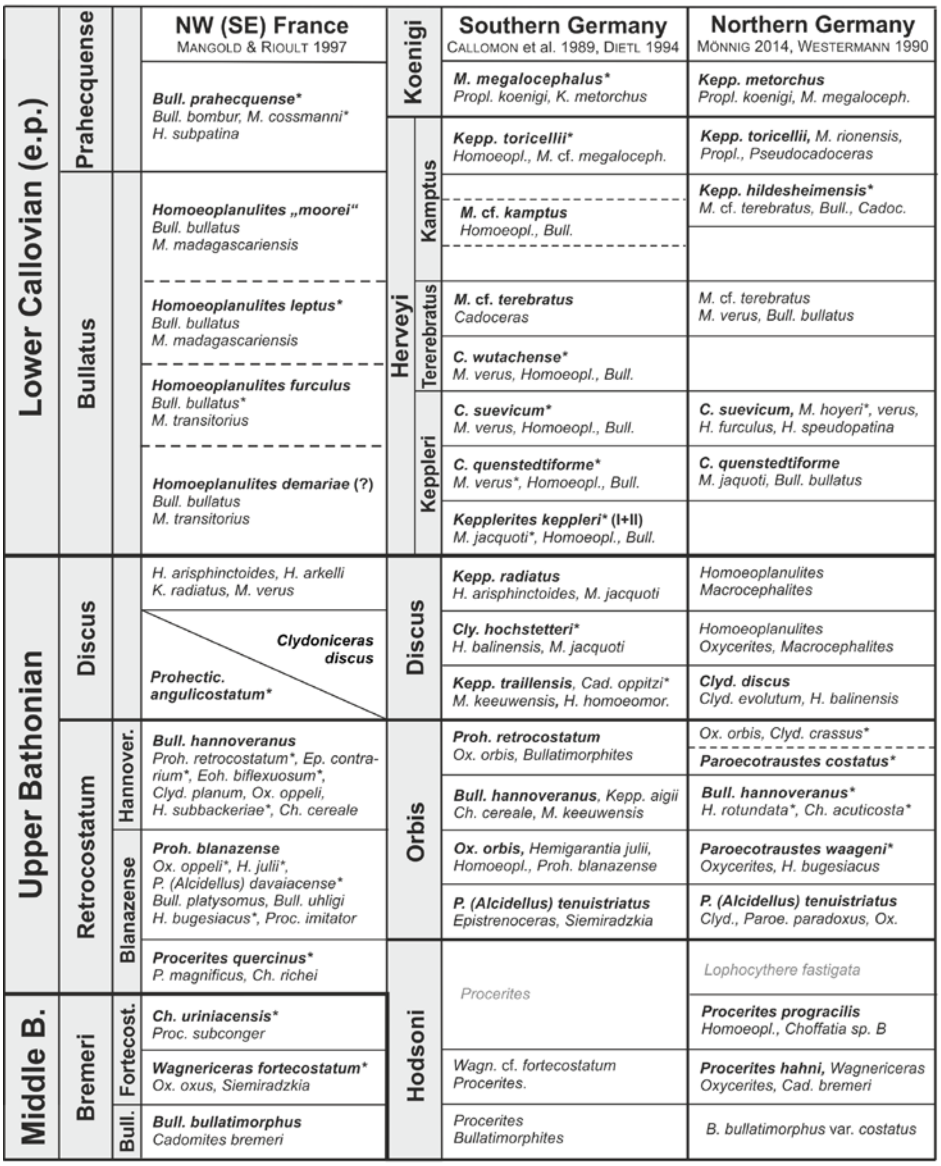

			NW (SE) France MANGOLD & RIOULT 1997
Lower Callovian (e.p.)	Prahecquense		***Bull. prahecquense**** *Bull. bombur, M. cossmanni** *H. subpatina*
	Bullatus		***Homoeoplanulites „moorei“*** *Bull. bullatus* *M. madagascariensis*
			Homoeoplanulites leptus* *Bull. bullatus* *M. madagascariensis*
			Homoeoplanulites furculus *Bull. bullatus** *M. transitorius*
			***Homoeoplanulites demariae* (?)** *Bull. bullatus* *M. transitorius*
Upper Bathonian	Discus		*H. arisphinctoides, H. arkelli* *K. radiatus, M. verus*
			Clydoniceras discus ***Prohectic. angulicostatum****
	Retrocostatum	Hannover.	***Bull. hannoveranus*** *Proh. retrocostatum*, Ep. contrarium*, Eoh. biflexuosum*,* *Clyd. planum, Ox. oppeli,* *H. subbackeriae*, Ch. cereale*
		Blanazense	***Proh. blanazense*** *Ox. oppeli*, H. julii*,* *P. (Alcidellus) davaiacense** *Bull. platysomus, Bull. uhligi* *H. bugesiacus*, Proc. imitator*
			Procerites quercinus* *P. magnificus, Ch. richei*
Middle B.	Bremeri	Fortecost.	***Ch. uriniacensis**** *Proc. subconger*
			Wagnericeras fortecostatum* *Ox. oxus, Siemiradzkia*
		Bull.	***Bull. bullatimorphus*** *Cadomites bremeri*

		Southern Germany CALLOMON et al. 1989, DIETL 1994	Northern Germany MÖNNIG 2014, WESTERMANN 1990
Koenigi		***M. megalocephalus**** *Propl. koenigi, K. metorchus*	***Kepp. metorchus*** *Propl. koenigi, M. megaloceph.*
Herveyi	Kamptus	***Kepp. toricellii**** *Homoeopl., M. cf. megaloceph.*	***Kepp. toricellii,*** *M. rionensis,* *Propl., Pseudocadoceras*
		M. cf. kamptus *Homoeopl., Bull.*	***Kepp. hildesheimensis**** *M. cf. terebratus, Bull., Cadoc.*
	Terebratus	***M. cf. terebratus*** *Cadoceras*	*M. cf. terebratus* *M. verus, Bull. bullatus*
		C. wutachense* *M. verus, Homoeopl., Bull.*	
	Keppleri	***C. suevicum**** *M. verus, Homoeopl., Bull.*	***C. suevicum,*** *M. hoyeri*, verus,* *H. furculus, H. speudopatina*
		C. quenstedtiforme* *M. verus*, Homoeopl., Bull.*	***C. quenstedtiforme*** *M. jaquoti, Bull. bullatus*
		***Kepplerites keppleri** (I+II)** *M. jacquoti*, Homoeopl., Bull.*	
Discus		***Kepp. radiatus*** *H. arisphinctoides, M. jacquoti*	*Homoeoplanulites* *Macrocephalites*
		Cly. hochstetteri* *H. balinensis, M. jacquoti*	*Homoeoplanulites* *Oxycerites, Macrocephalites*
		Kepp. traillensis*, Cad. oppitzi** *M. keeuwensis, H. homoeomor.*	***Clyd. discus*** *Clyd. evolutum, H. balinensis*
Orbis		***Proh. retrocostatum*** *Ox. orbis, Bullatimorphites*	*Ox. orbis, Clyd. crassus** ***Paroecotraustes costatus****
		Bull. hannoveranus*, Kepp. aigii* *Ch. cereale, M. keeuwensis*	***Bull. hannoveranus**** *H. rotundata*, Ch. acuticosta**
		Ox. orbis, *Hemigarantia julii,* *Homoeopl., Proh. blanazense*	***Paroecotraustes waageni**** *Oxycerites, H. bugesiacus*
		P. (Alcidellus) tenuistriatus *Epistrenoceras, Siemiradzkia*	***P. (Alcidellus) tenuistriatus*** *Clyd., Paroe. paradoxus, Ox.*
Hodsoni		*Procerites*	*Lophocythere fastigata*
			Procerites progracilis *Homoeopl., Choffatia sp. B*
		Wagn. cf. fortecostatum *Procerites.*	***Procerites hahni,*** *Wagnericeras* *Oxycerites, Cad. bremeri*
		Procerites *Bullatimorphites*	*B. bullatimorphus var. costatus*

Fig. 1. Standard zones and subzones of the Upper Bathonian and Lower Callovian and their ammonite faunal horizons. Modified after MÖNNIG (2014), Callovian France after THIERRY et al. (1997); bold: index species of this horizon; asterisk: the type of the species comes from this area and horizon. Abbreviations: ***Bull, B***: *Bullatimorphites;* ***Cad***: *Cadomites;* ***C*: *Cadoceras;*** ***Ch***: *Choffatia,* Subgenus *Subgrossouvria;* ***Cly***: *Clydoniceras;* ***Ep***: *Epistrenoceras;* ***H***: *Homoeoplanulites;* ***Kepp***: *Kepplerites;* ***M***: *Macrocephalites;* ***Ox***: *Oxycerites;* ***P***: *Procerites;* ***Paroe***: *Paroecotraustes;* ***Proh***: *Prohecticoceras;* ***Propl***: *Proplanulites.*

Overview of the geological evolution of Mexico

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Mexican geology is characterized by a high diversity in stratigraphic and tectonic features. The geological diversity in the continental domain is expressed by an intricated distribution of units and by the contrasting relief dominated by relatively young mountain chains and plains. The oceanic domain is also characterized by a diversity of tectonic and volcanic features that resulted from an active reconfiguration of oceanic plate boundaries. Several Geological provinces have been defined using major contrasts in Mesozoic-Cenozoic stratigraphic successions, tectonic discontinuities and sometimes contrasts in the geochronology and petrotectonic assemblages of metamorphic basements.

Most prominent geologic provinces include the active Trans-Mexican Volcanic Belt, the Paleogene volcanic province of the Sierra Madre Occidental, and the Sierra Madre Oriental which represents the front of the Cretaceous-Paleogene Mexican fold and thrust belt constituted by an impressive Mesozoic continental to marine succession. Other significant provinces are the fold and trust belt of the Sierra Madre de Chiapas, the craton of the Yucatan peninsula and the geologically diverse Baja California and Sierra Madre del Sur provinces. The present-day tectonic scenario is characterized by the concurrence in the Mexican territory of five different plate boundaries that produce well defined seismic and volcanic active zones.

Most of the Mesozoic to Cenozoic evolution of the Mexican continental crust occurred in the frame of two contrasting tectonic environments: an eastern passive margin developed as the result of the opening of the Gulf of Mexico since the Middle Jurassic and a western zone with convergent plate boundaries, characterized by a long-lived arc magmatism in a complex scenario including the development of back arc basins and the accretion of oceanic assemblages. A large segment of the juvenile continental crust of western Mexico was constructed in this last tectonic environment. Both domains interacted tectonically and sedimentologically, resulting in a complex stratigraphic and tectonic record in central Mexico.

The collision of the East Pacific rise against the active margin of western North America since the Oligocene, as well as the formation and subsequent eastward displacement of the Caribbean plate, produced significant changes in the tectonic interactions of the Cenozoic Pacific margin of Mexico. These changes include the development of a transform plate boundary between the Pacific and North America plates, the opening of the Gulf of California and the margin truncation of southwestern Mexico. The effects of the displacement of the Caribbean plate on southern Mexico, and their influence in the construction of the Sierra Madre de Chiapas fold and thrust belt, are still a matter of debate.

The construction of the main tectonic episodes in the geological evolution of continental territory indicates that the Mexican realm was the site of recurrent concurrence of plate boundaries and interaction between major tectonic elements (North/South America), framed by formation and dispersal of supercontinents (Rodinia, Gondwana, Pangea).

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Microfacies and depositional environments of the northern portion of the Huayacocotla anticlinorium, Middle-Late Jurassic (Callovian-Kimmeridgian), Hidalgo and Veracruz states, central-southern Mexico

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The Huayacocotla anticlinorium is a large folded structure of the Sierra Madre Oriental (López-Ramos, 1978), considered as an aulacogen developed during the opening of the Gulf of Mexico (Schmidt-Effening, 1980). In its north-eastern flank, between the limits of Hidalgo and Veracruz states, it exhibits a northeast-trending thrust folded stratigraphic sequence composed of Jurassic and Cretaceous rocks (López-Reyes *et al*., 1997). In order to interpret the depositional environment of a limestone package which overlies redbeds, cropping-out between Oloteco, Hidalgo state, and Jalapa, Veracruz state, a microfacies analysis of a stratigraphic section was carried out. The studied rocks are of Middle Jurassic (Callovian)-Late Jurassic (Oxfordian-Kimmeridgian) ages, belonging to the Tepexic, Santiago, and Tamán formations. Textures of the microfacies were described and classified according to Dunham (1962), by means of thin section analyses on a *Leitz* petrographic microscope, using plane and crossed-polarized light. These were categorized and assigned to standard microfacies types (SMF), as defined by Wilson (1975), and to their corresponding facies zones (FZ) proposed by Flügel (2004, 2010). In the area of study, the Tepexic Formation overlies the redbeds of the Huizachal Formation. This unit is made out of dark gray limestone in fresh that turns to light gray in weathering surfaces. Capping this unit, we recorded the Santiago Formation, which consist of siltstone and black limestone. Concordantly underlies the Tamán Formation, composed of gray limestone with chert and calcareous concretions, interbedded with black shale. According to the textural arrangement and the allochemical content of these stratigraphic units, different microfacies types have been recognized. The Tepexic Formation presents cortoidal packstone-grainstone, with a predominance of coated grains (peloids and few oncoids), and abundant fragments of gastropods, pelecypods, algae, and corals. It also displays sandstone and volcanic clasts, as well as iron oxides, scarce monocrystalline subangular quartz, and potassic feldspar crystals. Interparticle porosity is filled with micro- and ortho-sparite. This rock package is related to SMF 11, *Coated bioclastic grainstone*, which occurs in FZ 5 (reefs) and FZ 6 (winnowed platform edge sands). Due to the presence of coated grains and macrofossils in a fragmentary state, we infer a shallow marine environment about ten meters of depth, in a high-energy zone near the coast assigned to the FZ 6. On the other hand, the base of the Santiago Formation corresponds to impure packstone with coated grains (such as oncoids, ooids, and peloids), but in lesser quantity than those in the Tepexic Formation. Skeletal allochems consist of coral and mollusk fragments, mainly from gastropods, algae remains, and scarce radiolarians replaced by calcite. Its facies also display monocrystalline subangular quartz, potassic feldspar, iron oxides and muscovite, besides veins filled with calcite. Spaces between grains are filled with microspar. This portion of the Santiago Formation are attributed to the SMF 4, *Microbreccia, bio-lithoclastic packstone or rudstone*, which can be recorded either from FZ 1B (Craton deep-water basin), FZ 3 (toe-of-slope settings), or FZ 4 (slope settings). Because of the predominance of poorly classified terrigenous material and bioclasts derived locally or imported from shallow waters, we refer this sedimentary association to the FZ4. In the middle-high portion of the Santiago formation it can be distinguished a wackestone-packstone bearing bivalves, and poorly preserved radiolarians replaced by calcite, algae remains, and detritus of monocrystalline subangular quartz. Prominent diagenetic features of these rocks, are shown by compaction fabrics and stylolites filled with iron oxides and calcite. Upwards, the Tamán Formation consists of wackestone-packstone with radiolarians replaced by calcite, and displaying a preferred orientation. This unit is marked by the presence of few stylolites filled with calcite. Both packages are assigned to SMF 3, *Pelagic lime mudstone and wackestone with abundant microfossils,* and can occur either in FZ 1-B (deep basin) or FZ 3 (deep-shelf toe-of-slope). According to the textural characteristics (wackestone) and the prevalence of pelagic organisms (radiolarians), we consider this sequence as indicative of the FZ 1B, placed on a deep marine environment between the deep shelf and the slope (*sensu* Flügel, 2010). Thus, the microfacies analysis presented herein, indicates that the Tepexic Formation was deposited in a shallow-high-energy marine environment, probably in a margin platform setting. This environment is characterized by a strong influence of tidal currents, low infaunal diversity, and the presence of common large bivalves and algae. Settling of this unit represents the shift of clastic into carbonate deposition in the area of study. The basal portion of the Santiago Formation apparently corresponds to an environment between the margin platform (200-300 m) and slope, with benthic fauna redeposited mainly from shallow settings, including some benthic and deep-water planktonic organisms. On the other hand, the upper part of the Santiago and the Tamán formations represent deeper environments, probably related to a basinal setting.

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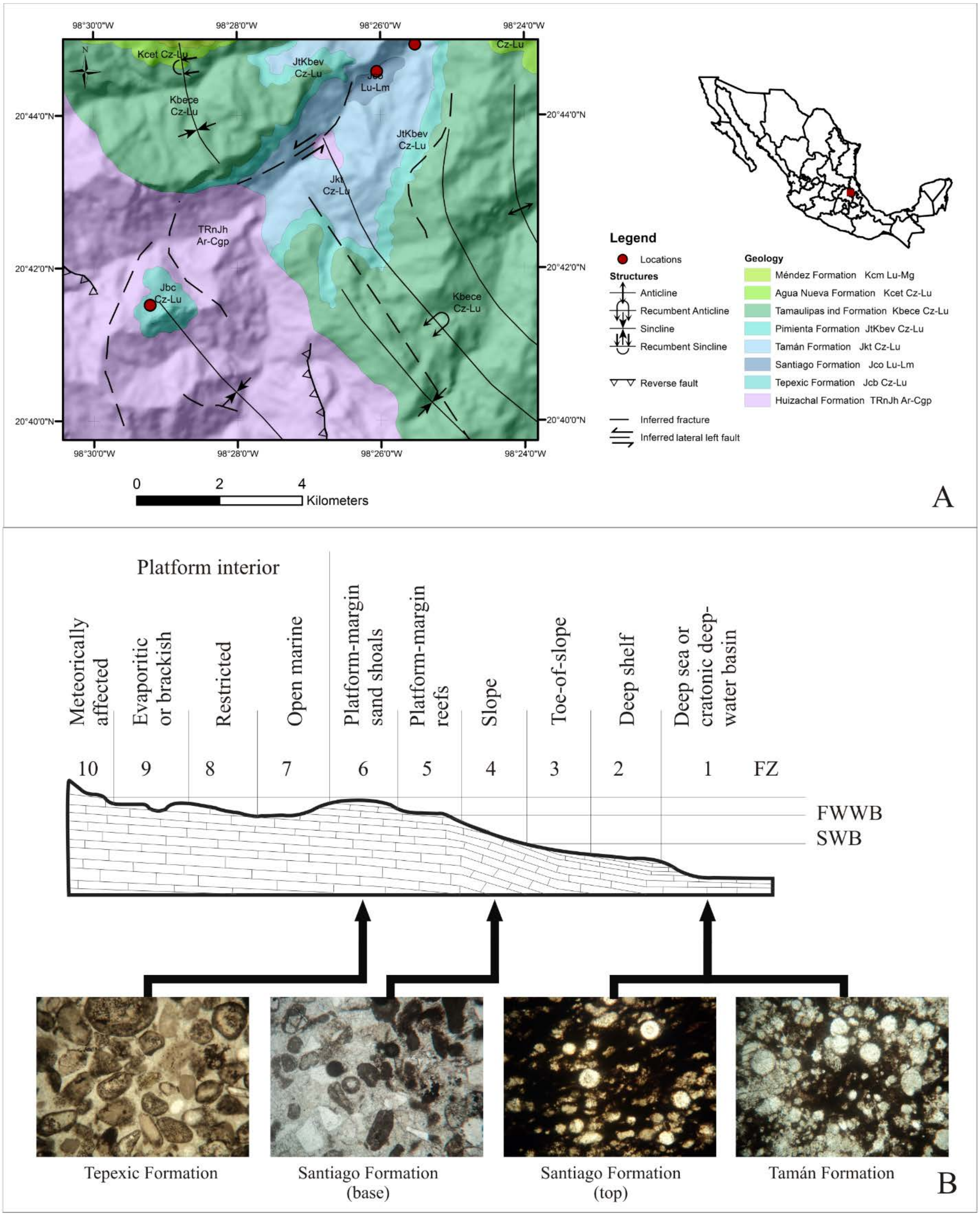

Figure 1. A. Geological map of the studied area. B. Idealized marine topographic profile showing the Facies Zones (according to Flügel, 2010). The arrows indicate the proposed depositional environmental in the studied area.

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Outcrops of the Upper Jurassic Pimienta Formation as analogues of the unconventional petroleum systems of eastern Mexico and their use for the calibration of the subsurface geological models

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Building of a geological model requires as many data as possible; however, well coring and cutting samples are often limited. Indirect data, such as seismic interpretation and geophysical logs provide valuable information, although vertical and horizontal resolution, respectively are insufficient for a detailed study of petroleum reservoirs. Because of that, the study of analogue outcrops is a useful tool for obtaining sedimentological, stratigraphic, geochemical, paleontological and geophysical data in order to correlate to actual reservoirs. This type of studies increases the certainty of the geological model.

In order to calibrate Upper Jurassic geological models of unconventional oil systems in eastern Mexico, fieldwork was carried out in several localities of the Pimienta Formation in the states of San Luis Potosí, Hidalgo and Puebla, Mexico.

The Pimienta Formation outcrops in the state of San Luis Potosí consists of black limestones intercalated with shales rich in organic matter and intensely deformed.

The outcrop in the state of Hidalgo (Atempa River), exposes the complete stratigraphy of the Pimienta Formation as a succession of light gray, brown and dark gray limestone and argillaceous limestone in thin strata, with nodules, lenses and bands of black chert, abundant organic matter and pyrite disseminated.

Three outcrops of the Pimienta Formation were studied in the state of Puebla. In Xicotepec de Juárez town, the Pimienta Formation is outcropping on the NE flank of the San Mateo Anticlinal and is formed by a succession of limestones, argillaceous limestones and sporadic black shales rich in organic matter. Along the San Marcos River, the Pimienta Formation presents intense compressive tectonic deformation and frequent hydrothermalism. In Ometepetl town, this formation is also intensely deformed and is made of by black limestones and calcareous shales in thin stratification, both rich in organic matter with calcareous nodules and fragments of ammonites. In Mazatepec town, along the Apulco River, the Pimienta Formation is exposed from base to top, transitionally overlapping the San Andres Formation and underlying the Tamaulipas Inferior Formation. The Pimienta Formation in this locality is composed by black limestones and argillaceous limestone, rich in organic matter, with frequent fragments of ammonites and horizons of bentonite throughout the entire interval.

The analogue outcrops of the Pimienta Formation have contributed to the detailed study of the Upper Jurassic geological framework, including the stratigraphic architecture, vertical and horizontal sedimentary facies distribution and the biostratigraphic analysis. Additionally, the analogue outcrops also allowed diagenetic, geochemical, petrophysical and geomechanical studies for the calibration of subsurface geological models of unconventional petroleum systems of eastern Mexico.

Keywords: Pimienta Formation; analogue outcrops; unconventional petroleum systems; Upper Jurassic.

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Agglutinated foraminiferal morphogroups and microfacies analysis of a Lower Jurassic *ammonitico rosso* section from the Perşani Mts. (Eastern Carpathians, Romania)

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Pelagic red nodular limestone facies (*ammonitico rosso*) are typical deposits in the Jurassic Tethys, and their ammonoid fossil faunas have been widely used in biostratigraphic and paleogeographic studies. Although the foraminiferal assemblages from these facies received much less attention, they can better constrain the depositional environment. The widely-known localities in the Perşani (Persány) Mts. have yielded the most abundant and diverse Lower Jurassic fossil assemblages in the Eastern Carpathians (Tomas and Pálfy, 2007), where olistoliths of *ammonitico rosso* are embedded in Lower Cretaceous wildflysch sequences. The ammonoids assemblages recovered from these sites play a key role in the regional paleogeographical reconstruction, and attest their Tethyan affinity.

Agglutinated foraminifera from the classical locality near Racoş (Alsórákos), one of the oldest known occurrences of *ammonitico rosso* facies in the Lower Jurassic, were first reported by Neagu (2004), although without detailed stratigraphic context. Our studied material was collected from the nearby the Fekete Hill outcrop where intercalated red, clayey *ammonitico rosso* limestone and marls are exposed as a single, large olistolith with a thickness of 18 m. This exposure with several hiatuses represents a stratigraphic interval from the upper Hettangian to lower Toarcian, based on ammonite biostratigraphy.

The 25 samples were dissolved in acetic acid, sieved through 63 µm sieve, and ~300 foraminifera specimens were picked from the 63 µm to 2 mm residue of every sample. The stratigraphic distribution of different agglutinated foraminifera morphogroups corroborated with data on modern and fossil assemblages was applied to infer on the paleoecology of the assemblages and to reconstruct the paleoenvironmental setting. In addition, the microfacies and the abundance distribution of foraminifera was also studied in thin sections to better constrain our conclusions.

In the studied samples 7862 foraminiferal specimens were identified. They represent 31 genera and 48 species, belonging to 10 suborders. In the upper Hettangian Angulata Zone, a strong dominance of *Glomospira* and *Trochammina* (70–73%) is recorded. This opportunist, low diversity epifaunal assemblage suggests abundant availability of organic material in less well-oxygenated substrate, with frequent perturbations of the environmental factors. In the lower Sinemurian Bucklandi Zone the relative abundance of *Trochammina* along with shallow infaunal *Haplophragmoides* and *Recurvoides* increased. The highly divers assemblage characterized with the abundance of tolerant taxa points to a stable, oligotrophic but well-oxygenated environment. In the lower Pliensbachian the uniserial and biserial forms gradually become significant (16–62%), whereas higher up in the Toarcian part of the section *Ammodiscus* and the epifaunal specimens become more diverse and abundant.

The lithology of the studied section is characterized by predominant bioclastic wackestone microfacies, and less common intraclastic, bioclastic wackestone with crinoid fragments. The common Fe-Mn hardground clasts along with corroded bioclasts and encrustation suggest oxygenated environment but low sedimentation rate.

The agglutinated foraminiferal taxa in the examined section are characterized by long stratigraphic ranges, thus they cannot be applied for high-resolution biostratigraphy. Subdued diversity in the oldest, Hettangian strata may reflect a protracted recovery following the end-Triassic mass extinction. As there is only a limited number of previous studies available on agglutinated foraminifera from a*mmonitico rosso* facies, paleogeographical comparison with other areas would be promising, but will require more data from other sections.

Key words: Lower Jurassic, agglutinated foraminifera, morphogroups, Eastern Carpathians, Tethys

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Faunal and floral turnovers, carbon-isotope fluctuations and sea-level changes from passive southern Iberian Palaeomargin (Southern Spain)

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Jurassic rocks of the southern passive palaeomargin of Iberia (Betic Cordillera, Southern Spain) contain abundant pelagic fauna and flora (ammonites, radiolarians, foraminifers, calcareous nannofossils, etc.) and therefore show optimal conditions for performing analyses on diversity and biological turnover related to major discontinuities, sea-level changes, and carbon-isotope fluctuations.

The ammonite data set in our study contained about 400 genera and more than 1600 ammonite species belonging to 67 ammonite zones covering the entire Jurassic System. These data are used in the construction of curves of faunal turnover and ammonite diversities, which correlate with sea-level fluctuation curves (Sandoval et al. 2000, 2001) and with the carbon-isotope curves (O'Dogherty et al. 2006, Sandoval et al., 2008, 2012). Most of these faunal turnovers correlate with regressive-transgressive cycles in the Exxon, and/or Hallam's curves. In most cases, the extinction events coincide with regressive intervals whereas origination and radiation events are related with transgressive cycles and the turnovers frequently coincide with major or minor discontinuities in the Subbetic basin (Betic Cordillera).

The analysis of carbon-isotope curves ($\delta^{13}C$) shows that values of bulk carbonates from the different localities of the Subbetic basin have similar trends from the uppermost Pliensbachian to the Oxfordian suggesting changes in the original dissolved inorganic carbon (DIC) isotopic composition. The transition from Pliensbachian to Toarcian is marked by increasing $\delta^{13}C$ values from ~1.2 to 2.0‰, interrupted in the Serpentinum Zone by a negative shift concomitant with the Toarcian oceanic anoxic event (T-OAE), with the major ammonite extinction event of the Toarcian (most of the ammonite species and all the Ammonitina genera (Sandoval et al. 2001, 2002), and an important turnover in the calcareous nannoplankton assemblages (Sandoval et al. 2012; Reolid et al., 2014). The negative shift observed in the Serpentinum Zone confirms the global perturbation of the carbon cycling documented along the Tethys and the palaeo-Pacific in both, organic material and marine carbonates (Sandoval et al. 2012, and references therein). The interval from middle to uppermost Toarcian shows relatively constant $\delta^{13}C$ values, with only a relative minimum (around 1‰) in the Upper Toarcian, minor ammonite turnovers, and is associated with increasing diversity of calcareous nannoplankton. A positive shift, small in amplitude (~2‰), occurs in Lower Aalenian. Decreasing $\delta^{13}C$ values (~1–1.5‰) in the Middle Aalenian are followed by a positive peak (2.5–2.7‰) in the lowermost Upper Aalenian, which correlates with meso- to eutrophic surface-water conditions indicated by calcareous nannofossil assemblages (Aguado et al., 2008), and end in a new relative minimum (1.5–1.7‰) at the Aalenian/Bajocian boundary. Through the Lower Bajocian, the $\delta^{13}C$ values increase constantly to reach a relative maximum (~3–3.5‰) at the uppermost Lower Bajocian. This trend is concomitant with a gradual eutrophication of surface waters and a shallowing of the nutricline/turbidity increase recorded by calcareous nannofossil assemblages and the rise in biogenic silica production (Aguado et al., 2017) which suggest a climatically driven fertilization. The $\delta^{13}C$ curve returns to median values and stabilizes with a slightly negative trend during the Upper Bajocian and the Bathonian (reaching a maximum negative shift in the Upper Bathonian).

Major unconformities and associated hiatuses are common in the Uppermost Bathonian-Lower Oxfordian interval of the Southern Iberian palaeomargin, which does not allow a fully completed chemostratigraphic analysis; however, relative minimum $\delta^{13}C$ values are detected in the uppermost Bathonian and lowermost Callovian and a relative maximum in the Middle Callovian.

A comparison of the $\delta^{13}C$ values with different biotic events (ammonite diversity and turnover, fluctuations in calcareous nannofossil assemblages, and radiolarian abundances) point out some interesting relationships between the carbon cycle and the biotic evolution (O'Dogherty et al. 2006; Aguado et al. 2008, 2017; Sandoval et al. 2012; Reolid et al., 2014). The carbon-isotope curve is not exactly linearly correlated with the extinction rates and ammonites diversity, but the main faunal turnovers follow minimum $\delta^{13}C$ values, where extinct taxa are replaced by new ones. Likewise, radiation episodes are associated with increasing $\delta^{13}C$ values and with a transgressive sea-level rise. All these data, obtained in the southern Iberian Palaeomargin, support the idea that perturbations in the global carbon cycle reflect rapid palaeoenvironmental changes.

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Key words: Betic Cordillera; Jurassic, carbon-isotope stratigraphy

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Approaching paleoenvironmental conditions across the Jurassic-Cretaceous boundary in epicontinental deposits north of Veracruz state, eastern-central Mexico

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Tithonian rocks are significant hydrocarbon resources in Mexico. Eastwards and in the GoM region, they are predominantly assigned to the Pimienta Fm. (López-Palomino & Piña-Arce, 2007). In the area of interest, the latter is dominated by calcareous silt- and mudstones with clayey to shaley intercalations and the local development of stratigraphic horizons with concretions; siliceous horizons occurring in the upper part. A six-meter-thick section located to the northeast of Veracruz state has been investigated for age-calibration of the upper Pimienta Fm., the potential for precise identification of the Jurassic-Cretaceous boundary, and the interpretation of the paleoenvironmental, eco-sedimentary context at that time.

High-resolution biostratigraphy of calpionellid, coccolithophorid and ammonites has been attempted based on a bed-by-bed sampling. Sedimentologic observations have been made at the centimeter scale. Data from stable isotope stratigraphy and magnetostratigraphy have also been used.

Calpionellid biostratigraphy allowed the precise recognition of the stratigraphic horizon containing the epibole of small, isometric *Calpionella alpina* Lorenz, which indicates the Jurassic-Cretaceous boundary according to the recent agreement at the Berriasian Working Group, and subsequent recommendation (ISCS Annual Report 2016; and internal report about the Berriasian WG meeting in the Vienna Symposium 2017). Calcareous nannoplankton investigations, yield mostly resistant species of limited stratigraphic importance, uncertainty created when attempting a precise correlation with Tethyan events and assumed proposals of more or less global validity (Gradstein *et al.*, 2012). The biochronostratigraphic interpretation of *Nannoconus wintereri* is illustrative (Wimbledon *et al.*, 2011; Gradstein *et al.*, 2012; Ogg *et al.*, 2016), its scarce record in the investigated section approximating to the above mentioned System boundary. Precise ammonite biostratigraphy indicates that

Durangites, *Proniceras* and *Salinites* range across the Jurassic–Cretaceous boundary in the studied section.

Stable isotope stratigraphy in bulk samples and the organic matter fraction shows values of δ^{13}Ccarb, δ^{18}Ocarb, and δ^{13}Corg, as well as those inferred from the water column, indicate fluctuating but relevant amounts of organic matter of continental influence (major heterotroph system), fluctuating nutrient levels, and high but decreasing temperature throughout the stratigraphic interval investigated (Erba, 2004; Katz et al., 2005; Föllmi, 2012; Phelps et al., 2015). No particularly relevant C-O isotope record characterizes the stratigraphic horizon selected for representing the Jurassic-Cretaceous boundary in the studied section.

Biochronostratigraphic calibration and correlation of the accepted Jurassic-Cretaceous boundary horizon with the obtained magnetostratigraphic data were made with the only limitations of these being the first data obtained from the area, at a single section, and without the field test since unnecessary and radiometry because of the absence of magmatic rocks (Opdyke & Channel, 1996). On this basis, the stratigraphic horizon interpreted to represent the System boundary –the horizon characterized by small, isometric *C. alpina*– locates within the M19n (Prüner e*t al.*, 2010; Wimbledon *et al.*, 2011), as previously established from Tethyan areas and promoted for global correlation as the M19n.2n (ISC Annual Report 2016).

Paleoenvironmental conditions approached through an integrated stratigraphic and ecostratigraphic analysis indicates a relatively shallow and restricted environment, under the potential influence of episodes of continental inflows, as well as pulses of improved connection with comparatively open-sea waters, most probably from the east. Data supporting this interpretation include: (i) Scarce record of ammonite-rich horizons. (ii) Scarcity and low diversity of plankton composed of radiolarians, tintinnoids and coccolithophorids, the latter peaking in horizons with ubiquitous and resistant taxa, as well as short episodes of higher diversity and abundance. (iii) Poor record of macrobenthos. (iv) High organic matter content/accumulation; (v) C-O stable isotope data revealing persistent but variable continental influence. (vi) Episodic sets of subtle laminations of fine grains enriched in detrital quartz. All of these features occurred in the context of dominant carbonate-siliciclastic sedimentation with common siliceous horizons.

Key words: Jurassic/Cretaceous boundary; biochronostratigraphy, chemostratigraphy; magnetostratigraphy; paleoenvironment.

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The Pre-Mesozoic deep crustal foundations of Mexico

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Crustal provinces of thoroughly deformed and metamorphosed pre-Mesozoic rocks cropping out or inferred in the substructure of Mexico comprise at least 10 lithotectonic units ranging in age from the late Paleoproterozoic (*ca* 1800 Ma) to the early Permian (250 Ma). They represent all sort of tectonic settings, including continent-continent, arc-continent, and ocean-arc collisional orogens. However, because the country is widely covered by Mesozoic and Cenozoic supracrustal deposits, the exposure of most of these orogens is incomplete or fragmented, and therefore difficult to correlate with formerly and probably associated orogenic belts now sited along the cratonic margins of the Americas. Several of the Phanerozoic deep orogens of Mexico are marked by tectonic limits that include disrupted ophiolites or wide mylonitic belts that suggest considerable paleogeographic displacements, whereas many others have proved to have evolved rather anchored to the cratonic margins of Laurentia or Gondwana. Major tectonic features such as the apparent truncation of the Paleoproterozoic and Mesoproterozic North American orogenic provinces, and the late Palaeozoic Marathon-Ouachita orogen in northern Mexico, as well as the Mesoproterozoic and Palaeozoic metamorphic belts of southern Mexico are now playing key roles in the reconstruction and dispersion of the supercontinents Rodinia and Pangea.

The main objective of this talk is to present an updated description and critical tectonic interpretations for such metamorphic systems representing the lower or middle levels of the exposed Mexican pre-Mesozoic crust, which was built up during the last 1,600 million years of Earth's history.

Key words: Proterozoic-Paleozoic basement, Mexico, Rodinia, Pangea

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Geochemical characterization of the Upper Jurassic Pimienta Formation as a prospective unconventional shale gas/oil reservoir

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The Upper Jurassic Pimienta Formation is considered as the main source rock within the conventional petroleum systems in the Tampico-Misantla Basin, and recently it has been targeted as an unconventional shale gas/oil reservoir in Mexico. The aim of this study is to assess the petroleum potential of this formation, with an unconventional approach, based on its organic matter content, kerogen type and thermal maturity.

A detailed geochemical characterization was carried out in a continuous outcrop coring of the Upper Jurassic Pimienta Formation obtained in Mazatepec, Puebla, Mexico. The core comprises a complete record of the Pimienta Formation (64 m of thickness) with a remarkable presence of oil impregnations across the formation. The geochemical analyses performed on 48 core fragments include Rock Eval pyrolysis and TOC (total organic carbon). The selected samples provide a record of the organic matter content along the different sedimentological facies identified in the core.

The TOC varies from 0.32 to 4.24% all through the Pimienta Formation, showing two intervals with higher TOC values. The first interval, located at the top of the lower member, has a very good organic matter content (up to 3.40% TOC) and a moderate presence of free hydrocarbons (S1 Rock Eval pyrolysis parameter, 0.36-0.95 mg HC/g rock). The second interval is observed from the central portion of the middle member to the base of the upper member, with a maximum TOC value of 4.24%, indicating an excellent organic matter richness, and it exhibits a very good to excellent amount of free hydrocarbons (0.19-9.13 mg HC/g rock).

The petroleum generative potential (S2 Rock Eval pyrolysis parameter) for the whole Pimienta Formation is predominantly classified as good (0.16 to 14.98 mg HC/g TOC), with remnant kerogen Type II/III (oil-gas prone) and hydrogen index (HI) fluctuating between 13 to 362 mg HC/g TOC. Furthermore, thermal maturity is equivalent to the oil generation window (436 to 447°C of Tmax) and it does not exhibit significant variations across the core.

The geochemical features indicate that the Pimienta Formation at the continuous outcrop coring in Mazatepec has the petroleum potential and the adequate thermal maturity of a relevant unconventional shale gas/oil reservoir. An oil-source rock correlation will contribute to constrain the interpretation proposed in this study.

Keywords: Upper Jurassic Pimienta Formation; analogue outcrops; unconventional shale gas/oil reservoir, geochemistry.

Carbon isotope stratigraphy across the Triassic-Jurassic boundary: A new global $\delta^{13}C$ stack for correlation and tracking carbon cycle perturbations

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The Triassic-Jurassic boundary (TJB) immediately follows the end-Triassic extinction event, which is one of the five major Phanerozoic mass extinctions (Pálfy & Kocsis 2014). Similarly to the other four events, the TJB is also marked by one or more prominent carbon isotope excursions (CIE). Since their first recognition in three independent studies in 2001-2002, a large amount of data has been assembled which prove that CIEs are recorded in both terrestrial and marine boundary sections, marine strata of different depositional settings, and in both carbonate and organic matter. However, no systematic review of these data has been attempted to date, even though controversies persist in $\delta^{13}C$-based stratigraphic correlation, and the processes and causes of the underlying carbon cycle perturbations remain debated.

Here we address these issues using a compilation of a global $\delta^{13}C$ dataset from sections which span at least parts of the Rhaetian and Hettangian stages. Our underlying age model uses a modified version of GTS 2012 (Gradstein et al. 2012), with a notable update concerning the age of the Norian-Rhaetian boundary, leading to a shorter duration of the Rhaetian. Astrochronology is used to provide additional estimates of durations of chronostratigraphic units. Correlation of the sections is achieved through an integrated web of independent ammonoid, conodont, radiolarian, foraminiferan and palynological biostratigraphies and magnetostratigraphy.

A synoptic view of the global $\delta^{13}C$ stack allows a critical assessment of the reproducibility and global or regional significance of previously identified CIEs, including a Rhaetian precursor CIE, the latest Rhaetian initial negative CIE, the main negative CIE at the TJB, and one or more positive CIEs in the Hettangian. Clearly, not all of the above CIEs are recorded uniformly in different substrates, environmental settings or paleogeographic regions, warranting caution in the use of $\delta^{13}C$ in chemo-stratigraphic correlation.

Overall, the new global compilation will contribute to a better understanding of the processes and causes of carbon cycle perturbations across the TJB. Features of the global stack are compared with the predicted effects of previously proposed mechanisms of volcanogenic CO_2 degassing, methane release, reduction of primary productivity, changes in shallow marine carbonate production, changes in the burial rate of organic carbon and other scenarios.

Key words: Triassic-Jurassic boundary, carbon isotope stratigraphy, carbon cycle perturbation

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Diverse records of the Toarcian (Early Jurassic) Jenkyns Event in Hungary

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The Jenkyns Event (often referred to as T-OAE) is a complex set of interrelated, rapid and major environmental and biotic changes. As an Earth system perturbation thought to be triggered by the release of volcanogenic CO_2 from Karoo-Ferrar LIP magmatism, it is in the focus of much recent research for its relevance as a deep-time analogue of ongoing anthropogenic global change. Although demonstrably global in its extent, manifestation of the Jenkyns Event in the rock record is markedly variable and such differences help reveal the regional effects and spatiotemporal patterns.

In Hungary, Lower Toarcian strata crop out in two different tectonostratigraphic terranes, the Tisza and ALCAPA mega-units. In the Mecsek Mts., which belongs to the Tisza mega-unit, thought to be part of the epicontinental basins near the European margin of the Neotethys in the Early Jurassic, the Réka Valley section contains a prominent, 12 m thick black shale unit. A high-resolution organic carbon isotope curve revealed a characteristic negative anomaly with stepwise drops, oscillations of depleted isotope ratios, and a gradual return towards pre-excursion values. The shape of the curve permits chemostratigraphic correlation, confirmed by calcareous nannoplankton biostratigraphy. Cyclostratigraphic analysis suggests that the duration of the negative isotope excursion is 200 kyr, 350 kyr or 1 Myr, depending on which astronomical forcing parameter controls the most prominent cyclicity (Müller et al., 2017).

Additional Lower Toarcian sections have been studied from the Bakony and Gerecse Mts. in the Transdanubian Range, belonging to the ALCAPA mega-unit characterized by pelagic sedimentation in relatively deep Neotethyan basins controlled by extensional tectonics leading to significant submarine topographic differentiation. In the Bakony Mts., c. 35 m of laminated manganiferous and organic-rich deposits (Úrkút Fm.) include ore-grade beds which were exploited in the underground Mn-mine at Úrkút. New carbon isotope chemostratigraphy data and nannoplankton biostratigraphy are being developed and will complement an existing lower resolution dataset (Vető et al. 1997, Suan et al. 2016). The deepest part of the nearby Lókút subbasin was also sampled at high resolution in the Lókút section, where no Mn-ore is present and the Jenkyns Event is recorded by a c. 4 m thick shale unit. These strata overlie cherty crinoidal limestone beds of the uppermost Pliensbachian (Spinatum Zone), where $\delta^{13}C_{carb}$ anomalies occur and are tentatively correlated with the Pliensbachian-Toarcian boundary event recognized elsewhere.

In the Gerecse Mts., most sections display a prominent gap between the Hettangian–uppermost Pliensbachian Pisznice Limestone Formation and the Toarcian Kisgerecse Marl Formation, with the first ammonoid zone of the Toarcian generally missing. The Kisgerecse section is the only one where the basal Toarcian Tenuicostatum Zone is represented by a single bed, overlain by the Serpentinum Zone. A newly obtained $\delta^{13}C_{carb}$ curve provides chemostratigraphic evidence for the hiatus as the negative anomaly is not recorded due to the gap, only the positive trend is captured across the break. The hiatus and the replacement of pure carbonates by marly sediments may hint to the biocalcification crisis related to the Jenkyns Event. In the Gerecse Mts., the Tölgyhát section is the only locality where a 40 cm thick clay layer is preserved above a Mn-bearing hardground terminating the Pisznice Limestone Fm. The clay layer contains the negative $\delta^{13}C_{carb}$ anomaly correlated with the Jenkyns Event. Comparison of clay mineralogy of the shale-bearing sections will help further characterize the local and regional differences of Lower Toarcian sections in Hungary.

Key words: Toarcian, carbon isotope stratigraphy, carbon cycle perturbation, cyclostratigraphy, nannoplankton biostratigraphy

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Cold seep-related occurrence of the Early Jurassic rhynchonellid brachiopod *Anarhynchia* from the Canadian Cordillera

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Cold seeps, where seepage of methane and/or other hydrocarbon-rich fluids and hydrogen-sulfide occurs in the sea floor, are sites which harbor highly specialized ecosystems associated with distinctive carbonate sediments. Although their Mesozoic record is scarce and patchy, it commonly includes rhynchonellid brachiopods, often of large size. Each new occurrence is valuable in filling gaps and providing additional insight into these peculiar ecosystems. Here we report a monospecific assemblage of *Anarhynchia* from a boulder-sized limestone clast of Early Pliensbachian (Early Jurassic) age in the Inklin Formation of the Whitehorse Trough in Stikine terrane, recovered from a locality at Copper Island in Atlin Lake, northern British Columbia, Canada. Specimens are of unusually large size, up to 9 cm in length, and their external and internal morphology allows assignment to *Anarhynchia* but warrants introduction of a new species. Although $\delta^{13}C$ and $\delta^{18}O$ values of the shells are close to equilibrium with ancient seawater, early precipitated carbonate cement phases of the enclosing limestone are characterised by highly depleted carbon isotopic composition, indicative of the influence of microbial oxidation of methane derived from a cold seep. Carbonate petrography of the isopachous, banded-fibrous cement supports its origin in a cold seep environment. Volcanogenic detrital grains in the micritic matrix of the limestone clast are indistinguishable from those in the sandstone layers in the siliciclastic sequence, suggesting that the seep carbonate is broadly coeval with the enclosing conglomerate. Previously, *Anarhynchia* has been known from the Lower Jurassic of California and Oregon, from both cold seep and hydrothermal vent deposits. Our new record extends the geographic range and species-level diversity of the genus, but supports its endemism to the East Pacific and membership in chemosynthesis-based ecosystems.

Key words: cold seep ecosystem, brachiopod, Early Jurassic

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Late Jurassic (Oxfordian) brachiopods and echinoids from Santa Cruz Tacache area, Oaxaca State, southern Mexico

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The Mesozoic record exposed in the Mixteca area, Oaxaca, includes Jurassic marine and nonmarine clastic rocks, as well as Cretaceous carbonates (Sedlock *et al*., 1993). Among the Jurassic marine units, crops out a fossil-bearing unit recognized as the "Caliza con *Cidaris*" Formation. The main goal of this work is to present a general view of the Late Jurassic invertebrate fossils collected from Tlacotepec Lagunas and El Partideño, in the Santa Cruz Tacache area, northern Oaxaca. All fossil specimens referred here were cleaned up mechanically by means of a stereoscopic microscope and needles. All of them are deposited in the Paleontological Collection, in the Servicio Geológico Mexicano. Aditionally, we provide a lithological description of the "Caliza con *Cidaris*" unit in both newly sites. At Tlacotepec Lagunas, the "Caliza con *Cidaris*" includes interbedded layers of limestone and shale. The limestone is dark gray in fresh surface and white and yellow in weathering surface, with sacaroid to crystalline texture, stratified structure in beds of 15 to 20 cm of thick, composed of calcite with veins of quartz and moderate fracturing. The shale is light gray on fresh and weathered yellow, laminar structure in packages up to 2 m of thickness, composed of clay minerals with strong cleavage, and cemented by calcareous material. The invertebrate fossil fauna belongs to brachiopods *Animonithyris dorenbergi*, varieties A and B of *Sellithyris subsella*, and echinoids referred to *Cidaris submarginata*, and *Pseudocidaris* sp. In the surroundings of El Partideño, the "Caliza con *Cidaris*" consists of interlayed shale and limestone. The former is gray in fresh and weathering white and yellow, with laminar structure in beds of 1.5 m of thick. It is constituted by clay minerals with strong cleavage, embedded in a clay matrix with calcareous cement. The latter is light-to-dark gray on fresh surface and weathering white and dark, crystalline to sacaroid texture, stratified structure of 20 to 150 cm of thick layers, composed of calcite with veins of quartz and moderate fracturing. Also, in this locality the "Caliza con *Cidaris*" units presents karsticity, stylolitic lines, as well as lenses and nodules of light gray chert. The fossil material collected here belongs to nine specimens of *Mexicaria mexicana* (=*Parathyridina mexicana quadriplicata*). Among the identified fossils, *Animonithyris* *dorenbergi* and *Cidaris submarginata* are Oxfordian species hitherto known only from Mexico. The erstwhile occurs 5 km W of Tlaxiaco, Oaxaca, in the unit of "Caliza con *Cidaris*" (Erben, 1956; Cooper, 1983); whereas the second has been identified previously in Puebla and Oaxaca also in this unit (Erben, 1956; Alencaster and Buitrón, 1965; Buitrón, 1968) and in the San Ricardo Formation (Buitrón, 1968). *Sellithyris subsella* is very common in the Upper Jurassic localities of Europe, occurring in the Oxfordian of England, France, Germany, Russia, (Middlemiss, 1973 *in* Alencaster, 1977), and from the upper Oxfordian-Kimmerdgian in Poland (Barczyk, 1969 *in* Alencaster, 1977). In Mexico, this specie has been reported in the San Ricardo Formation, specifically in the localities Sección Constitución, Oaxaca, and the Sección Río Pueblo Viejo, Chiapas, both Kimmeridgian in age (Buitrón, 1978). Moreover, *S. subsella* is present at the Oxfordian-Portlandian in age La Gachupina, 20 km east of Cintalapa, eastern Chiapas (Alencáster 1977). The stratigraphic range of the genus *Pseudocidaris* is from Early Jurassic (Pliensbachian) to Early Cretaceous (Aptian-Albian?) of Europe, North Africa and Mexico (Smith and Kroh, 2011). In Mexico, *Pseudocidaris* is also known from the rocks of the San Ricardo Formation exposed in the locality Sección Constitución, Oaxaca (Buitrón, 1978). Finally, *Mexicaria mexicana* is an Oxfordian species distributed only in Mexico, present in Tlaxiaco, Oaxaca (Ocheterena, 1960; Cooper, 1983). The fossil content of the "Caliza con *Cidaris*" at Talocotepec Lagunas and El Partideño consists entirely of epifaunal species. These organisms and the lithology observed led us to infer a littoral environment, with fresh water inflow, which is consistent with the reports of Ortega-Gutiérrez (1970) and Morán-Zenteno *et al*. (1993). This lithological unit probably accumulated in a paleobay with high energy that restrained the access of planktonic organisms (Morán-Zenteno *et al*., 1993). The record of this invertebrate fossils provides information about the composition of the Late Jurassic brachiopod and equinoid fauna in southern Mexico. The paleontological and geological significance of these fossils and their implications for local and regional level should be discussed in forthcoming taxonomical, biostratigraphical, and paleogeographical studies, which must include a bigger number of fossils collected in a wider geographical area.

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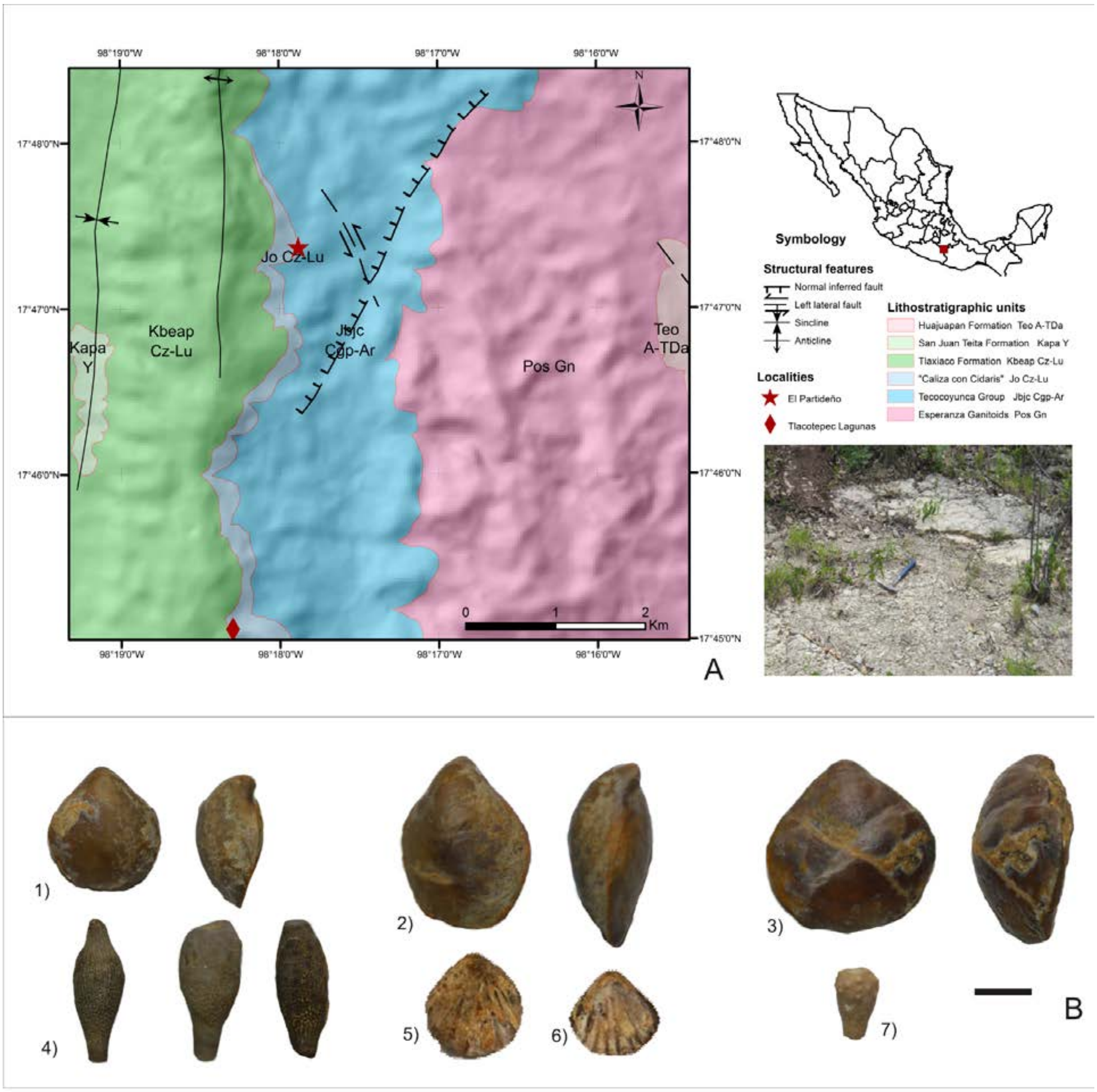

Figure 1. A. Geological map of the studied area showing the fossil localities. B. Peduncular and lateral view of (1) *Animonithyris dorenbergi*, (2) *Sellithyris subsella* var. A, (3) *S. subsella* var. B., view of (4) *Cidaris submarginata*, (5) peduncular view of *Mexicaria mexicana* morphotype globose shell, (6) *M. mexicaria* morphotype subglobose shell, (7) *Pseudocidaris* sp. Scale bar = 1 cm.

Recurrent hardgrounds and their significance for intra-basinal correlations: A case study of Upper Bathonian rocks from the western margin of the Indian Craton

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A set of prominent hardgrounds can be traced for more than 40 km from east to west within the Jurassic succession of the Jaisalmer Basin at the western margin of the Indian Craton (Fig. 1). The formation of these hardgrounds started under subtidal conditions in a mixed carbonate-siliciclastic setting during the last phase of a transgressive systems tract and continued into the Maximum Flooding Zone. Fürsich et al. (1992) recorded the hardgrounds for the first time from the Kuldhar River section of the Jaisalmer Basin (see also Pandey et al., 2014). The age difference between the three hardgrounds is very small, but they differ lithologically. The oldest hardground can be found at the upper surface of a 1-m-thick, calcareous sandstone. It is characterized by a spectacular mega-ripple surface encrustated with oysters and occasionally bored. The hardground is overlain by 10-25 cm of biowacke- to biopackstone with another hardground developed at its top. This second hardground is characterized by abundant bivalve (*Gastrochaenolites* isp.) and worm (*Tripanites* isp.) borings and occasional oyster encrustations. The third hardground can be found within the overlying 60-cm-thick, bioturbated, fossiliferous silty marly packstone. This unit shows common to abundant oyster encrustations and occasional borings together with reworked concretions. The individual hardgrounds can be well recognized throughout the basin based on lithology and biotic components. The second carbonate hardground with abundant bivalve and worm borings is most prominent and widespread, occurring from Jajiya River bed (Fig. 1, location C) in the southwest of Jaisalmer to Kanod River bed (Fig. 1, location D) in the northeast of Jaisalmer.

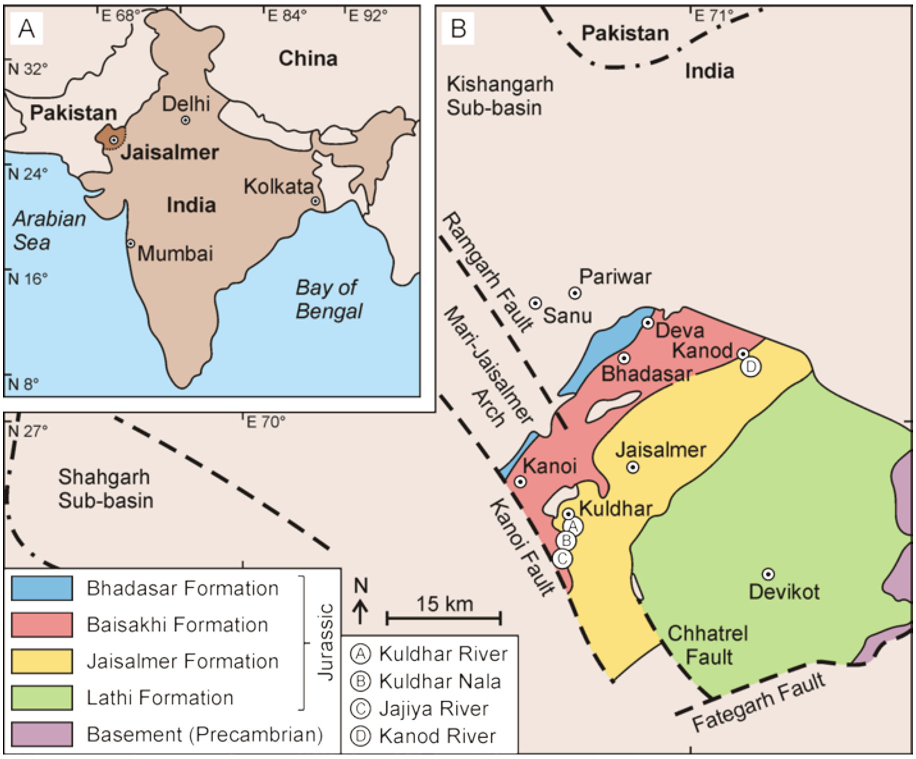

Fig. 1. Geological sketch map of the Jaisalmer Basin in western India showing the outcrops of the three hardground levels (modified after Das Gupta, 1975; Pandey et al., 2014).

Lithostratigraphically, these three hardground surfaces belong to the uppermost part of the Bada Bag Member of the Jaisalmer Formation. Based on the recorded ammonites (e.g., *Sivajiceras congener* (Waagen)), brachiopods, and corals, this interval of the Bada Bag Member has been assigned a Late Bathonian age (Callomon, 1993, Jain 2008, Pandey et al., 2014). The entire succession above the first hardground surface is bioturbated up to the overlying silty marl of the Kuldhar Member of the Jaisalmer Formation, which is already Callovian in age. Carbonate hardground surfaces are more commonly recorded than those on calcareous sandstones. Since hardgrounds on calcareous sandstones often are less encrusted, it has been proposed that these rocks may have been unfavourable substrates for boring organisms (Fürsich, 1979; Vinn, 2015). This phenomenon seems to be supported by the hardgrounds of the Jaisalmer Basin. Their characteristic lithologies together with the ammonite record allow long-distance correlations within the basin emphasizing their importance as valuable marker horizons.

Key words: Hardgrounds; stratigraphy; palaeoenvironment; Jurassic; Jaisalmer Basin

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Jurassic Paleogeography of Central East Mesozoic Basin of Mexico

Jaime Patiño Ruíz

Paleogeographic cognizance in the Mexican sedimentary basins has been developed and updated by the petroleum explorationists, since the systematic geological study was initiated, driven by the activities focused on that objective. However, the dissemination of the results of this work occurred until the XX International Geological Congress in 1956, at the expense of the virtuous bond of the Asociación Mexicana de Geólogos Petroleros (AMGP, founded in 1949) and the Instituto Geológico Mexicano, with the determined support of Petróleos Mexicanos. The research developed by the Instituto Mexicano del Petróleo (IMP), founded in 1965, improved knowledge and increased the publication of the findings related to paleogeography, especially in the Jurassic System. Many master's theses, performed by petroleum geologists, have achieved this goal.

Since that time, never have stops the publications or presentations to contribute to understanding of the main paleogeographic elements. This fact is especially relevant in order to have a really documented hypothesis about the Gulf of Mexico evolution and the former periferic basins.

The Central East Mesozoic Basin of Mexico, comprise the sedimentary basin which received the Triassic, Jurassic and Cretaceous sequences, which outcropping on the Sierra Madre Oriental phyisiographic province or reached by wells below of the Coastal Plain and Continental Shelf, betwen the Huasteca region in Tamaulipas to the north and Misantla town at the south.

The search for hydrocarbon reservoir rocks requires the identification of rocks whose original porosity determined their deposit texture and therefore the sedimentary environment in which it was formed. This has led to the discovery of extensive Jurassic carbonate ramps, predominantly oolitic, that developed on the edges of the old basins, around of the Tuxpan Platform or the islands of the Tamaulipeco Archipelago and developed since the Callovian (Tepexic Formation) and the Kimmeridgian (San Andrés and San Pedro formations) which generated important fields such as: Arenque, San Andrés, Hallazgo, Gran Morelos and Constitutions.

By the other hand, hydrocarbon reservoirs depends on distribution of source rocks. In Mexico it have been determined that the main source rocks are from Late Jurassic Epoch, where the litologic units have the highest values of Total Organic Content (TOC) and have reached the maturity to expelled huge volume of hydrocarbons. In this way, the exploration entities in Mexico performed a variety of studies in order to know the relationship between the paleoenvironments of Sinemurian rocks (Huayacocotla

Formation), Oxfordian rocks (Santiago Formation), Kimmeridgian rocks (Tamán Formation) and Tithonian rocks (Pimienta Formation).

Each time, the petroleum exploration needs to search deeper horizons; these activities have permitted the best knowledge of basement composition, geometry and conformation of the basin and distribution of paleo emergent lands which determined the ancient distribution of continental environments like redbeds from Upper Triassic (Huizachal Formation), Middle Jurassic (Cahuasas and Tenexcate formations) or evaporitic deposition in marginal environments (Huehuetepec Formation).

Seismic interpretation supported by well logs correlation, paleontological and lithologic studies reveal a Jurassic rift basin, oriented NNW -SSE and outlined by high basement blocks distributed at both sides of the basin. Lows were limited by regional faults and experimented a different filling history, showing a disharmonic subsidence along the basin.

Lows were total filled at late Tithonian and its development is contemporaneous with Gulf of Mexico formation as a consequence of the Yucatan Block migration to its final position.

Many of the stratigraphic relationships, lithologic units and paleogeographic elements of this part of Mexico are ignored or not enough considered in order to construct the most popular and divulgated models of evolution of the Gulf of Mexico.

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The Catorce Basin: Sedimentation and tectonic evolution during the Middle Jurassic in the Mesa Central, Mexico

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The Lower Jurassic La Boca Formation and the Middle Jurassic La Joya Formation in northeastern Mexico have been interpreted as a continental to flat marine succession related to the opening of the Gulf of Mexico as a rift basin (Mixon et al., 1959). However the presence of volcanic rocks with a geochemical signature of subduction, is inconsistent with such tectonic setting. The objective of our research is to document the extension, tectonic arrangement and sedimentary history of the Catorce basin, a depocenter placed during the Middle Jurassic in the eastern part of the Mesa Central province of Mexico. Barboza-Gudiño *et al.* (2015) documented red beds and volcanic rocks successions in two main depocenters termed Huizachal Basin to the east, in the Sierra Madre Oriental, and Catorce Basin to the west, in the Mesa Central, and interpreted them as a result of back arc extension related to the so called Nazas arc.

U-Pb detrital zircon geochronology, geochemistry of major and trace elements and petrographic analysis, allow interpreting a maximal age of deposition for the succession exposed in Real de Catorce during Middle Jurassic time.

La Joya Formation shows regional variations in thickness and composition and in some areas was not deposited thus is considered the existence of different extensional basins in a broad zone in north-central and north-eastern Mexico. We studied the Catorce basin as defined by Barboza-Gudiño et al. (2013, 2015) and compared it with the Huizachal basin, placed to the east.

Plotted on the diagrams of Bhatia *et al*. (1986), the geochemical data of sedimentary rocks in the field of a basin are related to a continental arc. According to the diagram of Floyd *et al.* (1987) the source of the components is an acid magmatic arc. On the Mc Lennan (1993) diagram about recycled sediment evidence, an enrichment of zircon in all the samples is evident.

The Bhatia (1983) diagram for provenance shows a predominance of sediments related to a continental island arc and to an active continental margin or a possible back arc basin. Using the rare earth elements on the Bhatia *et al.* (1986) diagram the data plotted in the field of the continental island arc.

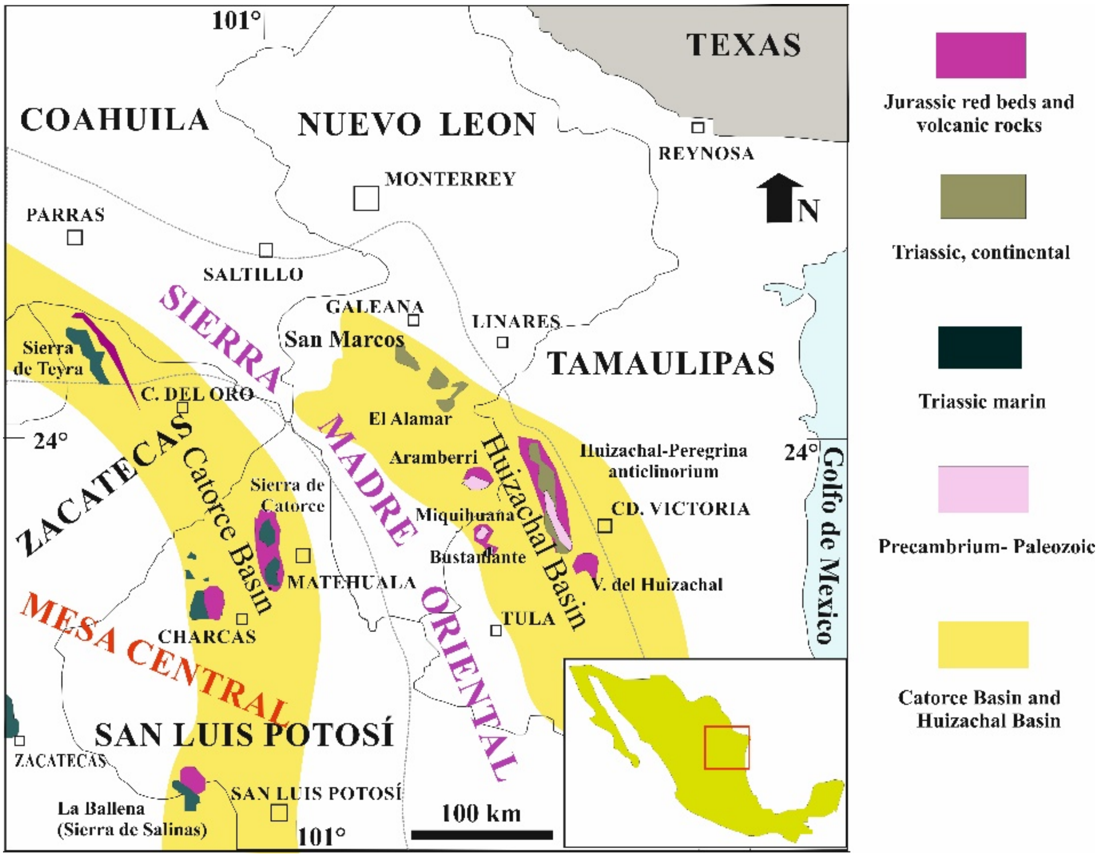

Figure 1 Map of northeastern Mexico showing the Early to Middle Jurassic Huizachal and Catorce basins

The use of geochronology in clastic rocks allows to interpret a maximum age of deposition and provenance for the sampled layers. The U-Pb ages of individual zircon grains in La Joya Formation from Real de Catorce, yielded maximum deposition ages between 166.2 Ma and 167.4 Ma. The provenance accord to four mayor age clusters are as follows: 1) 240-166 Ma (Early Mesozoic volcanic arc); 275-240 Ma (Eastern México Arc); 0.9-0.6 Ga (Panafrican); 1.2-0.9 Ga (Grenvillian Oaxaquia block).

According to petrographic analysis the rocks are sandstone, sublitharenite, litharenite and felsic litharenite. On the tectonic discrimination diagrams most of the samples plot in the recycled orogen field and a few on the dissected or transitional arc fields.

Conclusions

According to petrography studies, the provenance of clastic sediments indicate a recycled orogen to magmatic arc setting for the sedimentary filling of the Catorce and Huizachal basins.

The provenance accord to U-Pb Geochronology on zircon is probable related to the Grenvillian peri-Gondwanic Oaxaquia block, the permo-triassic basement of Yucatan, the Permian-Triassic arc of eastern Mexico and the Early to Middle Jurassic Nazas arc. The sampled layers have a maximal age of deposition between 166-170 Ma.

The geochemistry of sedimentary rocks using mayor elements shows a signature of a continental island arc tectonic setting in an active continental margin. Trace elements reveals also a tectonic setting related to a continental arc, and that the main source of the sediments is an acid arc, followed by andesitic rocks and recycled sedimentary rocks.
Considering all available field and analytical data, the Catorce Basin and the Huizachal Basin as well as other similar extensional basins filled by red beds and interlayered volcanogenic rocks, located in north-central and eastern to southeastern Mexico, are timely related to the Gulf of Mexico opening but also linked to the evolving active pacific margin during the Early Jurassic time.

Key words: Jurassic; Catorce Basin; Middle Jurassic, Mesa Central

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Role of Jurassic Paleogeography and Stratigraphy in the development of structural styles along the western margin of the Burgos Basin, NE Mexico

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The influence of Jurassic paleogeography and stratigraphy in the development of structural styles along the western margin of the Burgos basin is here discussed. Reports and logs of 15 wells and around 500 km of 2D seismic lines were used to put together several stratigraphic and structural sections. They were interpreted recreating part of the author's PhD thesis "Geologic Evolution of the Burgos Basin, NE México". Seismic data quality is good enough to reliably interpret the Jurassic seismic sequences. Velocity data for depth conversion was taken from check shot reports.

The El Burro-Picachos Peninsula and San Carlos Island highs, and climatic conditions prevalent during the Mid-Upper Jurassic, played an important role, not only in determining: lithology, sedimentary facies, thickness and lateral distribution of stratigraphic units of that age, but also, they strongly influenced the resulting structural styles of that region of Mexico.

Structural styles include: 1) SW vergent, basement involved, broad anticlines (Salado, Cadena and Picachos Anticlines); 2) Double vergent, thin skin folds that detach within Callovian to Oxfordian evaporitic sequences (Papagayo Anticline); 3) SW vergent, basement involved anticlines cored by salt, some of them cut by SW vergent thrusts (Vaquerías Anticline); 4) NW-SE trending elongated graben whose normal faults detach over Jurassic evaporites (Nuevo Laredo-Presa Falcon graben) and 5) Regional east dipping gentle monocline cut by numerous thrust faults along the western rim of the Burgos basin. All these styles involve Jurassic to Eocene rocks. In areas were the salt deposits are considerable thick, partial inverted structures cut by thrust faults were formed too.

These structural styles are spread along a 100 km wide region immediately west of the Burgos Basin rim. They are the result of the combined effect of compressional deformation associated with the Laramide Orogeny in Late Eocene and Oligocene regional uplift. It seems that the realm of subsidence associated with a passive margin setting that produced normal listric faulting during Paleocene and Early Eocene was interrupted by a late stage of the Laramide Orogeny, enhanced by regional uplift.

Key words: Jurassic; structural styles; basement involved folds

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Trends in body size of benthic marine macroinvertebrates across the Early Toarcian (Early Jurassic) extinction event in the Lusitanian Basin, Portugal

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The Early Toarcian extinction event is a global, second-order mass extinction that affected benthic and nectonic species. It occurred during an episode of global warming and coincided with widespread oceanic anoxia, thus providing a potential analogue to present-day global change. Body size is a key biological trait of organisms that is closely related to the biotic and abiotic environment. Here, we tested whether the body size distribution within populations and communities of benthic marine macroinvertebrates changed in relation to temperature-related stresses (TRS, including warming, hypoxia, and ocean acidification) associated with the Early Toarcian event. In particular, we expect a decrease in body size as a response to increasing environmental stress because larger body size means higher metabolic demands which would be selected against under TRS. Furthermore, taxon- and ecology-specific differences in body size patterns could hint at the nature of stress and whether changes in body size occurred earlier than changes in diversity and faunal composition.

We studied the Early Toarcian (Early Jurassic) sections of Fonte Coberta and Rabaçal from the Lusitanian Basin, Portugal. The ca. 28 m thick succession from the Pliensbachian–Toarcian boundary (base of the Polymorphum Zone) to the middle of the Levisoni Zone consists of alternations of marlstones, mudstones and wackestones of a middle to distal ramp depositional system below storm wave base. Bed-by-bed sampling of brachiopods, bivalves and gastropods yielded 1.330 specimens from 51 species and the shell size of 821 specimens has been determined as the log geometric mean of shell length and shell height. We focused on body size trends across the 7.30 m thick pre-extinction interval. The abundance of specimens per sample was standardized for sampling intensity in the field by taking constant volumes of bulk rock for each level.

The linear regression of the size data against sampling level shows that the mean body size of faunal samples (community level body size) decreases significantly across the pre-extinction interval (Fig. 1A). Such a decrease is also observed when the trends for brachiopods and bivalves are considered separately (Fig. 1B). Both groups share similar size values in the earliest Toarcian, but these diverge towards the extinction interval with the mean body size of bivalves being generally higher than that for brachiopods. However, only the decreasing trend in brachiopods is statistically significant (Fig. 1B) and body size trajectories of brachiopods and bivalves are not correlated (Spearman's rank correlation test, $p = 0.31$), suggesting a decoupling of the faunal response of brachiopods and bivalves to TRS. Experimental work suggests that bivalves are among the first to be affected by ocean acidification whereas shell growth of modern brachiopods is hardly affected. A lowering of oceanic pH as a main cause of extinction therefore seems incompatible with the observed selective trends in shell size. As hypoxic conditions are also an unlikely extinction cause (the sedimentary rocks of the extinction interval are heavily bioturbated) we tentatively suggest a strong role of heat stress.

Our results indicate significant long-term decreases in the body size of marine invertebrate communities that occur well before the onset of faunal extinctions and local extirpations. This suggests that reductions in body size may serve as an early warning signal of imminent turnover at the community level.

Key words: Portugal, Early Toarcian, temperature-related stresses, body size, bivalves, brachiopods.

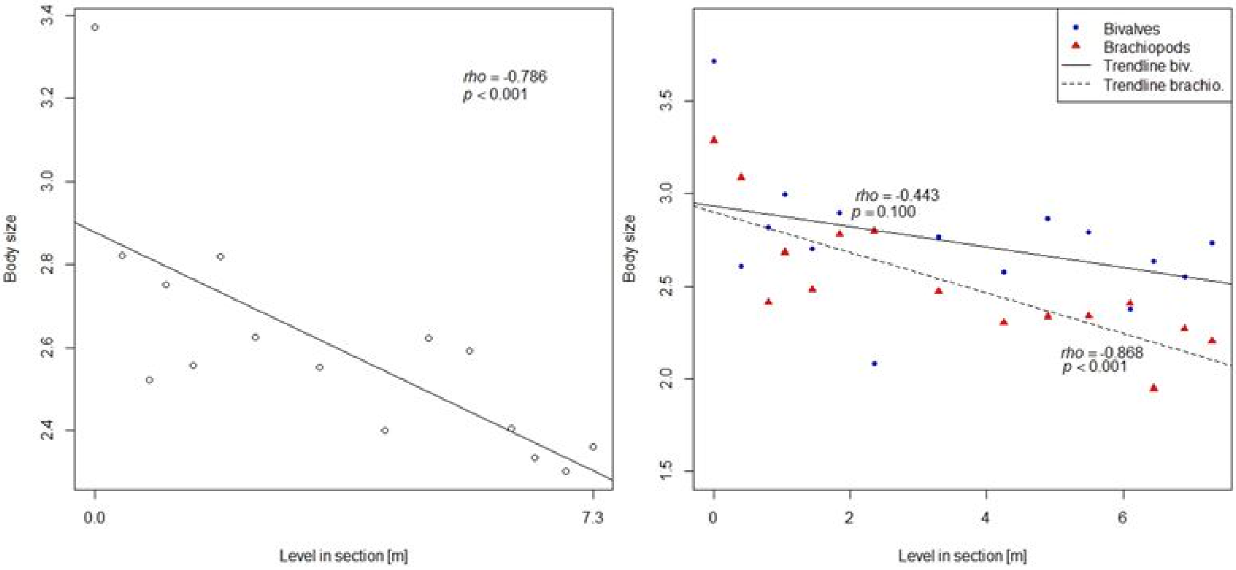

Fig. 1 *Body size variation in the pre-extinction interval, where the body size is represented by the mean of the log geometric mean. Fig. 1A shows the mean body size of the community for each sample. The specific trends for brachiopods and bivalves for the same interval are shown in Fig. 1B. The correlation details, i.e. Spearman's rho (ρ) and the p value of the trends, are also included as a result of the Spearman's rank correlation test.*

Lower Jurassic record of environmental and climatic changes from Poland

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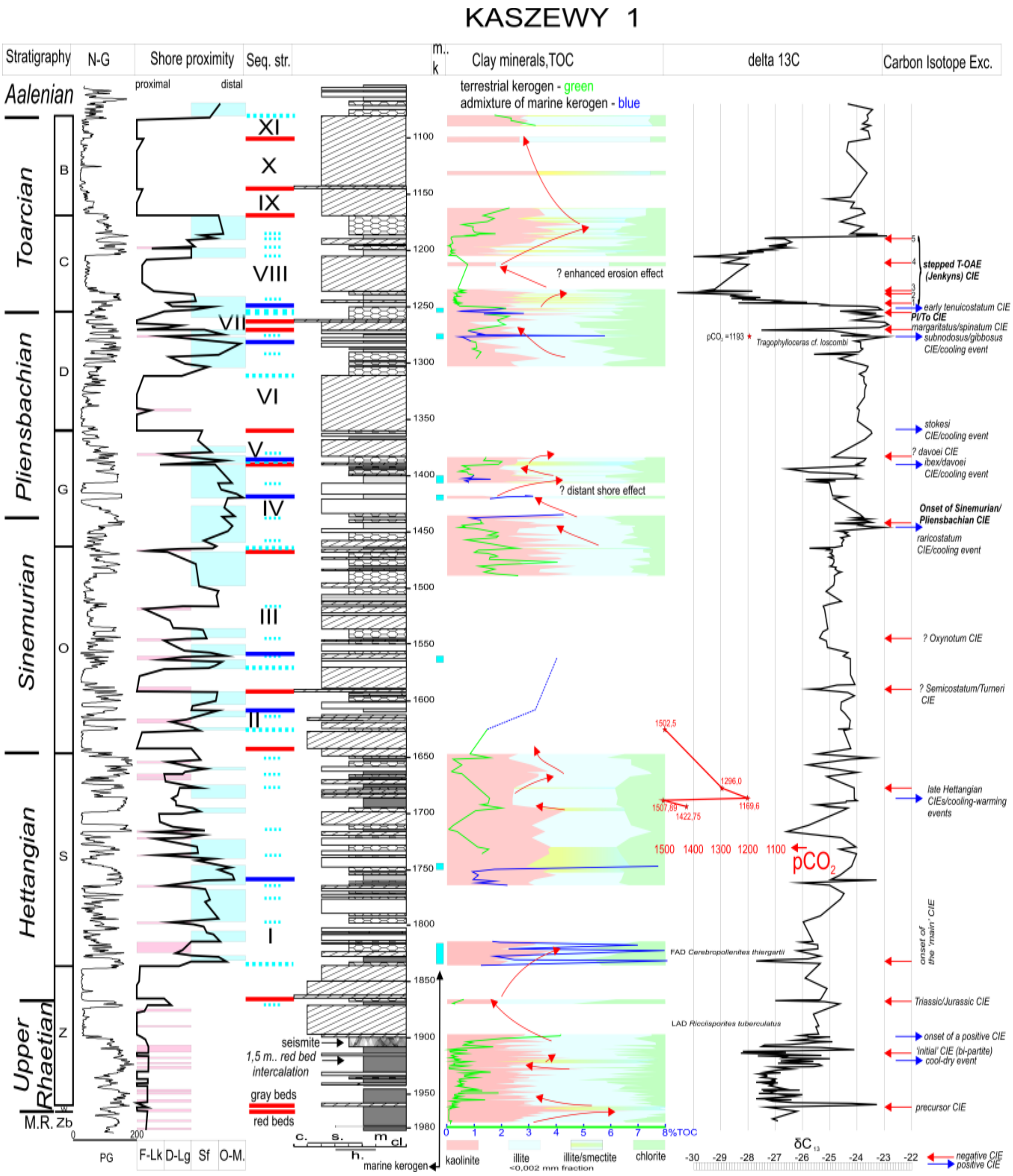
A new fully cored Kaszewy 1 borehole was drilled in central Poland in 2008 by PGE Bełchatów S.A. The Rhaetian section measures 100 m, while the Lower Jurassic series is 782 m thick. Multidisciplinary integration of sedimentology, palaeontology and geochemistry reveals cyclic sedimentation in a wide spectrum of palaeoenvironments (from continental to fully marine), which is interpreted in the context of sequence stratigrahy. Index fossils are few; however, some palynomorph and ammonite provide a general biostratigraphic control. Of crucial significance is a carbon isotope curve based on picked woody phytoclasts showing characteristic excursions, which allows correlation of the Rhaetian-Lower Jurassic strata studied with the existing European stratigraphic standards. A general pattern of the carbon curve shows fluctuating, generally negative values in the Rhaetian section, followed by positive trend in uppermost Rhaetian, and then again negative values at the bottom of Hettangian. There is a general trend towards positive values up to the bottom of Pliensbachian, punctuated by subordinate negative excursions in the Hettangian and mid-Sinemurian section. The Lower Pliensbachian is associated with negative excursions, starting already in the topmost Sinemurian, while the Upper Pliensbachian is characterized by positive values, punctuated by a marked negative excursion representing probably an intermittent event at the *margaritatus*/*spinatum* zone boundary. The Early Toarcian negative excursion (preceded by less significant negative excursion at the Pliensbachian/Toarcian boundary) is very well marked, with 5 characteristic steps. Average clay mineral composition suggests generally warm-temperate and moderately humid climate at paleolatitudes c. 40-45°N, generally without distinct seasonality. We infer that warm and wetter periods with stronger hydrolyse (kaolinite enriched) alternated with drier periods with less significant chemical weathering (kaolinite depleted). Kaolinite peaks are consistent with general trends of the carbon isotope curve. However, the influence of erosion and recycling was periodically important and could strongly modify the climatic record registered in clay mineral composition. Unexpectedly, some super-greenhouse events may result in the temporary decrease of kaolinite content caused by fast removal of highly weathered zones and quick exposure of deeper, less weathered rocks with diverse mineralogy. There is a positive correlation between carbon isotope values and terrestrial TOC content, which points to decomposition of terrestrial carbon pool during hotter periods. Stomatal index was calculated in six samples of Ginkgophyta cuticle representing late Hettangian, early Sinemurian and late

Pliensbachian, which allowed estimation of pCO$_2$ between c. 1200 – 1500 ppm. Reconstruction of standing vegetation was based on statistical calculation from pollen and spores. The Kaszewy section yields the most complete archive of Rhaetian-Early Jurassic mixed continental – marginal/marine and marine strata in Europe. This paper is a part of the project financed from resources of the Polish National Science Centre, granted on the basis of decision no. DEC-2012/06/M/ST10/00478. This is a contribution to the IGCP project 632 "Continental Crises of the Jurassic".

Key words: Early Jurassic; Poland; carbon isotopes; clay minerals; environment; climate



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New U-Pb zircon ages from volcanic ashes and other ammonite-bearing strata, Jurassic Cordilleran foreland basin of western interior Western Canada

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We have produced new high-precision U-Pb ages from zircon grains in volcanic ash layers, as well as detrital zircon age spectra from clastic units, throughout the ammonite-bearing, marine Jurassic succession in SW Alberta and SE British Columbia. The detrital zircon (DZ) ages were obtained by Laser Ablation-Multicollector-Inductively Coupled Plasma Mass Spectrometry (LA-MC-ICPMS) and for ash beds by single zircon grain Thermal Ionization Mass Spectrometry Isotopic Dilution (ID-TIMS). These data contribute to intra-basinal correlations and dating of units, to better understanding of tectonostratigraphic relationships of the basin and the adjacent accretionary orogen to its west, and potentially aid the development of the geological time scale. The units sampled include the Fernie Formation, dominantly shale with sandstones and limestones, which encompasses nearly the entire Jurassic succession in the Cordilleran foreland basin of western interior Canada, and the overlying Nikanassin and Morrissey sandstone-dominated formations. The data from the ash layers complement those reported by Hall et al. (2004) from additional units in the Fernie formation.

Standard DZ analyses of 25 samples of sandstones and siltstones produced significant peaks of approximately depositional age throughout the Jurassic sequence, in addition to the dominant older Phanerozoic and Precambrian ages. The Jurassic ages provide further support for the interpretation of an accretionary arc or arcs and orogen to the west, contributing sediment into the western interior foreland basin since the Early Jurassic.

Thin (cm-thick) volcanic ash layers from the Pliensbachian Nordegg Member, below beds with *Amaltheus* spp. regionally and above a layer with Early Pliensbachian coccoliths at one locality, have produced four ages from 185.25 to 187.2 Ma, and one sample from the partially equivalent Lower Fernie phosphatic shale/limestone yielded an age of 186.2 Ma.

Three detrital zircon samples from the Bathonian informal “Gryphaea Bed” silty limestone member, produced statistically identical ages of 169 Ma, distributed in a narrow coherent group that encompasses nearly all of the zircon ages in the samples. They are therefore from a single source, and likely an aerial ash fall component in the limestone, cross-bedded and thus reworked on the seafloor. This unit contains *K.* cf. *tychonis* and *K.* cf. *costidensus,* early species of the subboreal ammonite *Kepplerites* similar to those in East Greenland and northern Yukon, where they appear just above the boreal Ishmae Zone in East Greenland and within and above it in NW Canada. These associations must be about earliest Middle Bathonian in age, following the discovery of boreal *Arcticoceras harlandi* (boreal lower Ishmae Zone) with southern European Early Bathonian *Oraniceras* by Mitta and Seltzer (2002), near Saratov in the mid-Russian seaway where boreal and Tethyan seas were occasionally connected with limited faunal mingling.

The "Green Beds" glauconitic sandstone member contains Early and Middle Oxfordian *Cardioceras* spp. and the Late Oxfordian-Early Kimmeridgian bivalve *Buchia concentrica*, and it has produced single-grain TIMS U-Pb zircon ages of 152.2, and 157.8 Ma. The laser ablation age spectrum for one sample from the Green beds comprises a tight coherent group with an age of ca. 156 Ma, encompassing most of the grains, and is likely from a single source of approximate depositional age. The depositional model proposed by Amorosi (2012) for thick (several metres) and richly glauconitic beds, involving re-distribution of glauconite beyond its site of slow authigenic formation and maturation over an extended time, can explain the range of U-Pb and ammonite ages, and the disturbed sedimentary structures in the unit.

The new Middle and Late Jurassic U-Pb ages, integrated with the ages of associated ammonites and *Buchia*, cannot be reconciled well with the ages on the International Chronostratigraphic Chart where the stage boundaries in this interval are essentially uncontrolled by modern high-precision radiometric ages. However, they are consistent with the 2009 age of 164.64 Ma for the base of the Callovian by Kamo & Riccardi (2009) from the southern East Pacific ammonite sequence of Argentina, and with several other fairly recent studies by other workers globally, who have produced refined radiometric ages, using various techniques, for Middle and Late Jurassic biostratigraphically controlled sequences. We have therefore compiled our data in a correlation chart which incorporates ages for the Middle and Upper stage boundaries that differ from those on the most recent International Chronostratigraphic Chart.

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Evolution and palaeogeographical dispersión of the radiolitid rudist genus *Auroradiolites* (Bivalvia: Hippuritida), with descriptions of new material from Tibet and archived specimens from Afghanistan

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Diagnostic characters of the recently established new genus of radiolitid rudist *Auroradiolites* include an entirely compact outer shell layer, a distinctly convex upper (left) valve and a robust myocardinal apparatus surrounding a strongly internally projected ligamentary infolding (Rao et al. 2015). Until now, *A. biconvexus* (previously considered as exclusively Late Albian in age) has been reported only from the Langshan Formation, which crops out along the northern portion of the Lhasa block, Tibet. ere, recorded for the first time in addition from the Sangzugang Formation of the Xigaze Forearc Basin, situated on the southern margin of the Lhasa block. *A. biconvexus* differs from the southwest Asian type species *A. gilgitensis* (Late Aptian to Albian) by its relatively larger size, more strongly domed left valve and distinct radial undulations of the outer shell layer (Douvillé 1926; Rossi Ronchetti 1965; Pudsey et al. 1985; Sano & Masse 2013). The characters of *A. gilgitensis* are further clarified from archived material from central Afghanistan, also newly identified and described herein. All *Auroradiolites* records to date are revised. The recognition of examples of *A. biconvexus* from Upper Aptian strata increases both the stratigraphical and geographical ranges of the species, indicating that it had already branched off from *A. gilgitensis* in the Late Aptian.

So far, the genus *Auroradiolites* has been recorded from Iran, central and eastern Afghanistan, the type locality of Yasin in northwestern Pakistan, southern and northern Ladakh, the Lhasa block, as well as Hokkaido in northern Japan. During the Late Aptian to Albian interval, all these localities were associated with terranes and blocks that were limited to the northeastern margin of Tethys and the western Pacific margin, making *Auroradiolites* an indicator of a SW Asian to Pacific faunal province.

Key words: Lhasa block; Sangzugang Formation; Cretaceous; *Auroradiolites*; *Eoradiolites*; SW Asian/Pacific faunal province

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Cephalopods of the Triassic-Jurassic boundary in west-central Argentina

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Existence of marine upper Triassic and lowermost Jurassic strata was first recorded in the Andes of Argentina in 1986 (cf. Riccardi et al., 1988, 1991, 1997) at Arroyo Alumbre, in the Atuel River area, Malargue province. The section, exposed in an anticline nucleus, consists of a c. 300 m thick continuous succession of uppermost Triassic and basal Jurassic strata, ascribed to the Arroyo Malo Formation, containing a relatively diverse, but rather scarce and poorly preserved fauna of marine invertebrates. Since then, this section has been sampled several times and its sedimentology, biostratigraphy and fossil content exposed in a number of papers (cf. Riccardi et al., 2004; Lanés, 2005; Riccardi, 2008; Damborenea & Manceñido, 2012). Although presence of identified ammonoids was then (cf. Riccardi & Iglesia Llanos, 1999) restricted to *Choristoceras* cf. *marshi* Hauer and *Psiloceras* cf. *rectocostatum* Hillebrandt, other cephalopods are present at different levels, as mentioned below. The sequence lower half contains a succession of levels with different taxa, at the base: ?*Rhabdoceras* sp., ?*Peripleurites* sp., *Aulacoceras* cf. *carlottense* Whiteaves, and *Choristoceras* cf. *marshi* Hauer. Higher up are other levels with *Psiloceras tilmanni* Lange, *Psiloceras* cf. *planocostatum* Hillebrandt, *Psiloceras* cf. *polymorphum* Guex, and *Psiloceras* cf. *rectocostatum* Hillebrandt. *Choristoceras* cf. *marshi* is indicative of the Upper Rhaetian Marshi Zone, and the taxa occurring below indicate that the lowermost part of the section is Norian-Lower Rhaetian, whereas the taxa of the overlying beds are indicative of the Tilmanni, Primocostatum and Rectocostatum Zones of the Hettangian South American zonation (cf. Hillebrandt, 2000). The Triassic-Jurassic boundary is located between the occurrences of *Choristoceras* cf. *marshi* and *Psiloceras tilmanni*. This fauna can be referred and/or correlated with those recorded at the Triassic-Jurassic boundary in Chile, Peru and North America (cf. Hillebrandt, 1994a, b; González-León et al., 2000; Lucas et al., 2007; Schaltegger et al., 2008; Schoene et al., 2010).

Key words: Triassic-Jurassic boundary; ammonoids, coleoids, Argentina

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Identification of the hydrocarbon hoard in stratigraphic and mixed traps in Jurassic facies, Campeche, México

Jaime J. Ríos-López, Luis Juárez, Gabriel Hernández, Cecilia Acevedo

Pemex E & P

The goal of the research is mapping the reservoir rock in Jurassic facies and estimates their reserve potential. To identify new opportunities with potential hydrocarbon reserves extracted previously from fields in Cretaceous formations, the approach of research was made at Jurassic formations where some accumulations of hydrocarbon in stratigraphic traps were detected. Geological data from similar fields and results obtained recently from seismic techniques were used, as well as true production data from near fields that support the representativeness of proposals. The seismic image quality, the limited technology and theory concepts have been a problem to identify the type of stratigraphic traps in the shallow waters region at Campeche, inasmuch as, the trends in exploration had focused on drilling wells in localization of anticline structures whose probability of success was relatively high. The hydrocarbon accumulation potential is identified at the northeastern zone from Sonda de Campeche; this belongs to a zone where the petroleum system has evidence of source rocks and suitable thermal condition. The reservoir rock quality and its distributions represent the element of greater uncertainty, which in turn represents a challenge to understand stratigraphic and sedimentology of the Jurassic facies.

Methodology

The regional stratigraphic wells sections are used in the drilling of successful wells and wells adverse in production, a priori zones are located, whose analysis complement some tectonic-sedimentary events interpreted on the seismic section. Using methods in seismic stratigraphy and sequence stratigraphy it has been possible to understand the relationship between litho-stratigraphic units and behavior in the production of hydrocarbons, identifying patterns between oolitics facies and their textural variant with rock reservoir quality and hydrocarbon production capacity.

The applications of technologies to improve the seismic signal and its frequency spectrum has been useful in areas without wells to visualize and interpret the Upper Jurassic morphology, as well as the presence and arrangement of the sedimentary, pretectonic, syntectonic and post-tectonic packages. Nevertheless with the tectonic-sedimentological processes that have been recognized the exercise in reconstruction of the paleotopography is realized where they have the best possibilities of oolitic facies and infering their textural and spatial variations

Some features of the evolution of the tectonic events of distension with sedimentary fill due to the opening of the Gulf of Mexico have also been observed, it has also recognized the local effects of the saline deformation that causes bulging and dislocation of blocks, in which paleotopography shows that areas with moderately high relief favors sedimentation of high energy or areas exposed to favorable conditions to deposit oolitic sediments during the Upper Jurassic.

Results

The original volume of hydrocarbon considering the potential reservoir of Upper Jurassic rocks estimates an average probability greater than 1100 MMb. 14 to 30% of this amount could be recovered, considering similar oil field.

Conclusions

Stratigraphic traps are identified in zones of mature oil field. Two zones in six blocks were defined that represent a prospective zones and risk zone.

The first zone is located in the shallow part of the internal ramp; the longitudinal geometry of these bodies is discontinuous as they appear to be cut by tide channels.

The second zone is located in the distal part of the ramp or external ramp, which constitutes an open circulation zone with growth faults. In this zone the tipping of the blocks and geometries are truncated against faults. The quality of the facies decreases towards the lower parts of these blocks.

Jurassic conifer woods of the Rosario Formation from Oaxaca, southern Mexico

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The Rosario Formation in Mexico has been extensively studied mainly for its Jurassic plants. The plants have been preserved as impression/compression fossils and represent leaves and reproductive organs of Cicadales, Bennetttitales, Pteridospermales, Filicales. Permineralized gymnosperm woods, which are less abundant and to date little studied in detail, are the materials introduced in this presentation. The age of this unit has not been accurately dated yet, but a lower Jurassic (Toarcian) to the Middle Jurassic age has been suggested. Two fossil wood types are recognized from the Paleobotany Laboratory of the Institute of Geology, UNAM, collection. They were collected in the Rosario Formation, close to the village of the same name in the northwest part of Oaxaca state. They were prepared with the conventional thin-section technique, and ca. 40 thin-section of the specimens were obtained, representing the three anatomical wood planes. These were observed with an optical microscope and anatomically described both qualitatively and quantitatively. The first specimen in cross section has quadrangular tracheids, and bordered pits of the araucarioid type in the radial walls; they are contiguous and alternate, and pluriseriated; axial parenchyma with obscure contents and arrangement in unicellular bands; rays are mostly biseriate and tall, and cross-field pits are large, of window-like type. Wieland 1914-16 described this type of wood from the same Formation, however, it was identified as *Araucarioxylon mexicanum*, but since this type of wood lacks araucarioid pits in the cross-fields, it is in need of re-assignation to a new genus. The second specimen has uniseriate to occasionally biseriate bordered pits in the radial walls of the tracheids, all with an araucarioid type arrangement, axial parenchyma with smooth transverse walls and dark contents, uniseriate to partially biseriate rays, with 1-18 (28) cells high, and one to two podocarpoid pits (oculipores) in the cross-fields, with occasional oopores. These attributes allow to recognize the wood sample as a member of *Metapodocarpoxylon libanoticum*, a common taxon in different localities of what was the North of Gondwana. It has been suggested that it formed part of a forest of conifers that had limited distribution areas with wet summer, mainly found in the northern zone of Gondwana. Therefore, this record suggests that the summer wet conditions extended to the Rosario Formation area where seasonality could be an important component.

Key words: Rosario Formation, Jurassic, Oaxaca, conifers woods, *Araucarioxylon mexicanum, Metapodocarpoxylon libanoticum*, Gondwana, summer wet.

Review of the Jurassic climates of Siberia

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Reconstruction of past climates (especially high-latitude ones) is among the most complex but interesting tasks for geoscientists, attracting much attention during the last decades. However, information which is important for accurate climate reconstruction (especially for palaeotemperature oscillations) in some cases is scattered through the numerous papers deals with regional geological studies and should be extracted at first. Here we are providing review of Jurassic climate changes in Siberia, based on the multiple proxies, including faunal and floral changes, oxygen stable isotope records in molluscan shells, glendonite, dropstone and black shale occurrences (Fig. 1).

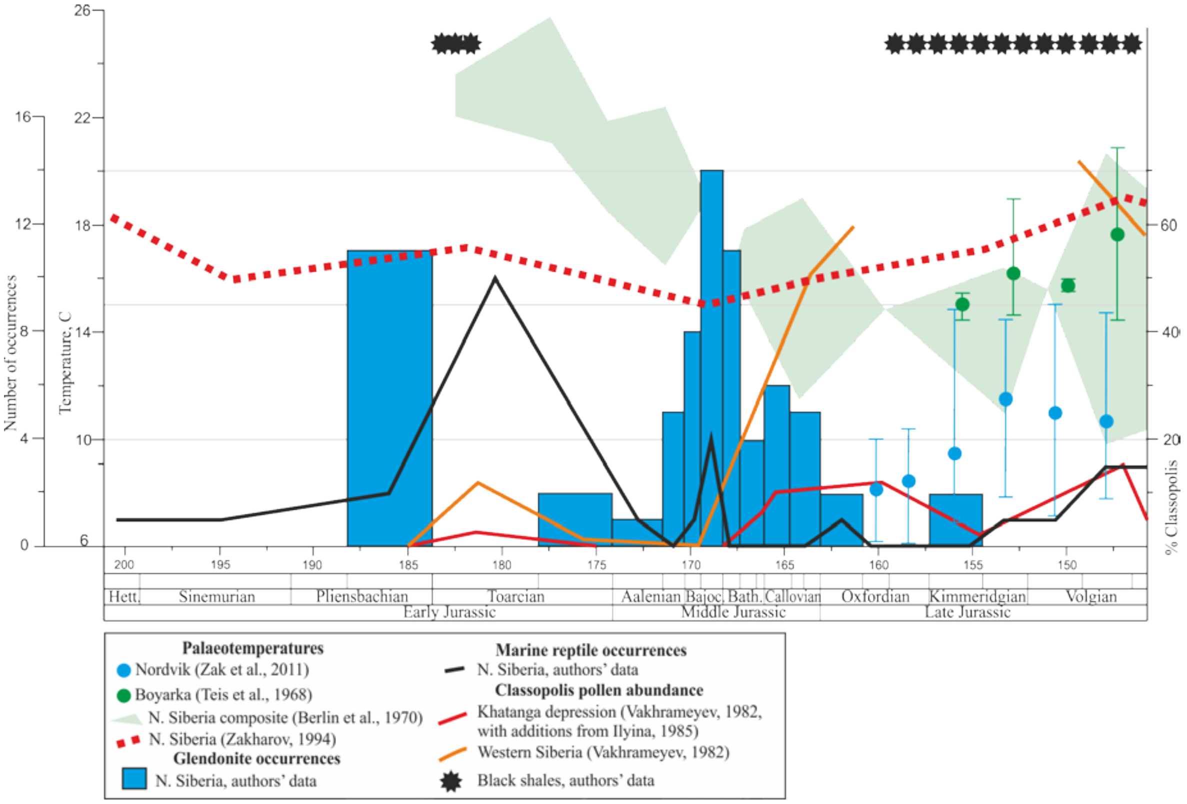

Fig. 1. Oscillation of different proxies used for palaeoclimate reconstruction in the Jurassic of Siberia.

Palaeotemperature studies of Jurassic molluscan shells (mainly belemnite rostra) in Siberia started from 1960th, providing more or less complete set of data from Toarcian (as in pre-Toarcian belemnites are missing in Siberia) to Volgian (fig. 1). All these studies are showing relatively high palaeotemperatures for Early Toarcian followed by the Mid-Jurassic cooling and by gradual palaeotemperature rise during the Late Jurassic. Oldest Jurassic glendonite records in Siberia are known from the numerous Upper Pliensbachian localities. They are totally disappeared at the beginning of the Toarcian, but since the latest Toarcian glendonites gradually became more abundant with peak occurrence during the Late Bajocian – Early Bathonian, where their records are associated with dropstones. Later glendonites gradually decrease in abundance and nearly disappeared again in the latest Jurassic. Toarcian and Late Jurassic warming events are clearly corresponding with rise of the *Classopolis* abundance, northward penetration of southern faunal elements and relatively abundant marine reptile records. Nevertheless, diverse marine reptiles were also known from 'cold' intervals (Late Pliensbachian and Late Bajocian), but very uncommon during the warmer ones (such as Callovian and Oxfordian). Warming events mentioned above are also associated with black shale deposition, although duration and spatial distribution of such black-shale-rich events was different for the Toarcian and Late Jurassic.

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Key words: Jurassic; climate, Siberia

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Geodynamic evolution of the Gulf of Mexico, since Late Triassic to Late Jurassic, based on palynological, paleontological, geophysics, tectonic data and metamorphic quartz origin for knowing its Paleogeographic Early History

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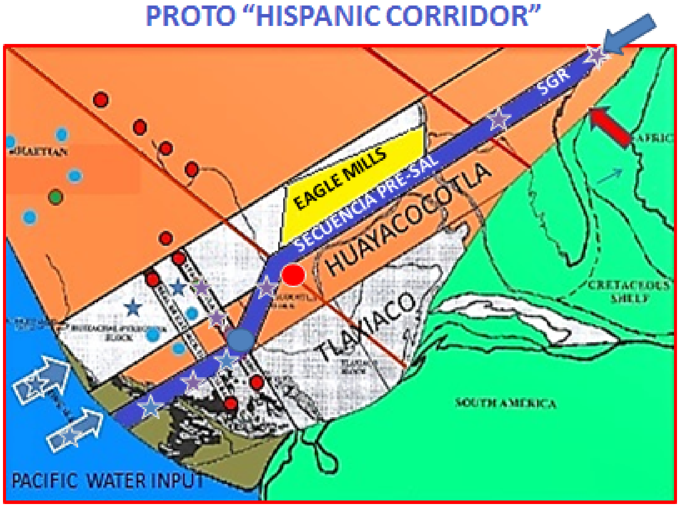
New and revised data, permitted to reconstruct a new Triassic-Jurassic Paleogeography where an incipient Hispanic Corridor could connect the Early Atlantic and the Pacific oceans, through the eastern South Georgia Rift and the western Portal del Balsas epicontinental sea. In Mexico, Triassic-Jurassic redbeds and salt units are located around and in the Gulf of Mexico, located in three anticlinoria: Huizachal, Huayacocotla, and Tlaxiaco. Palynostratigraphical data permitted to know that liassic sediments of three anticlinoria were deposited in the same El Alamar-Tlaxiaco Rift Basin, one of two half-grabens formed during Late Triassic, when North America was part of Pangea. During this time the southern North America was composed by three blocks (Huizachal-Ouachita-Appalachian, Huayacocotla and Tlaxiaco), limited by two main Paleozoic faults and two active pre-Cambrian megashears. Mexican alignments, permitted to stablished three main Paleozoic Mexican blocks and a Mesozoic triple junction, formed by the Texas-Boquillas-Sabinas, Campeche Escarpment and Nautla arms. All palynostratigraphical and tectonic data allow reconstruct Triassic-Jurassic Paleogeography and conclude that a Proto "Hispanic Corridor" existed before the Gulf of Mexico, because the South Georgia Rift, was postulated as a Late Triassic-Liassic redbeds and flood basalt basin, which is the NE sector of the Huizachal-Ouachita Block, as a part of the Newark System. Following to SW, recently, in the central Gulf of Mexico, it was reported a Late Triassic-Liassic 5000 m "pre-salt sedimentary sequence", underlying the Bathonian-Callovian salt. This sequence has also the same age as the salt domes from the Eagle Milles Fm., in Texas and Louisiana; so, during this time early Atlantic waters arrived to the eastern Florida and a marine incursion advanced SW ward, through the South Georgia Rift and the "pre-salt sedimentary sequence", up to the sinking Huayacocotla Block, where Late Triassic-Liassic marine microfossils and Pacific-Tethysian ammonites and palynomorphs are present into redbeds deposited in the El Alamar-Tlaxiaco Rift Basin. In fact, during Liassic, Huayacocotla Block sank and Pacific and Tethysian waters with ammonites filled the basin named "Portal del Balsas", and advanced into the half-grabens, where marine palynomorphs found into La Boca Allofm., at the Huizachal Anticlinorium, and Rosario Fm., at Tlaxiaco Anticlinorium proven this event. Little later, in the intersection of Texas-Boquillas and Lázaro Cárdenas-Tampico faults a hot spot with triple junction appeared; the remnant hot spot is still present at the central Gulf of Mexico. A doming stage and cratonic erosion began, as shown

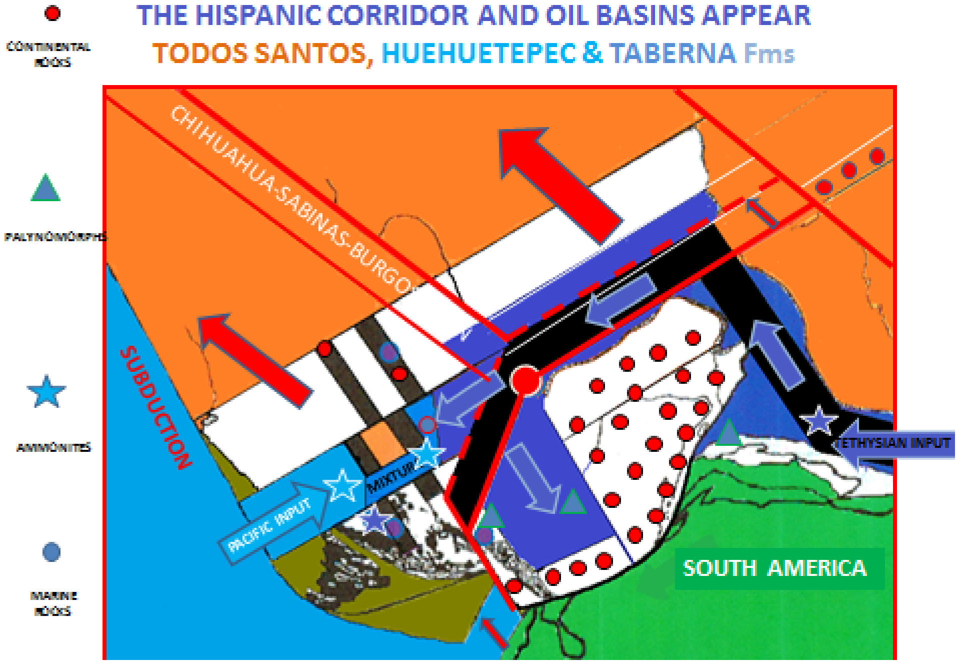
the increasing upward presence of metamorphic quartz among redbeds from Huizachal and Tlaxiaco Anticlinoria. During Toarcian-Aalenian times, the doming stage increased when Huayacoctla and Tlaxiaco blocks and South America moved SW ward and the Tethysian waters came into the Gulf of Mexico region from the SE. This compressional movement increased the cratonic erosion and huge volumes of metamorphic quartz and rock fragments were transported W and SW ward by rivers and deposited above redbeds. These metamorphic sediments correspond to the Cuarcitica Cualac Fm., outcropping at Huizachal and Tlaxiaco anticlinoria. Later, the movement also uplifted the Triassic-Liassic sequences deposited in half-grabens; they were eroded and their clastic sediments deposited around the uplifted regions, as the redbed Cahuasas Fm. with abundant pollenospores. As a product of the Bajocian-Bathonian rifting and sinking stages of the hot spot evolution, the "Hispanic Corridor" formed across the early Gulf of Mexico, where Zorrillo and Taberna formations represent cycles of retrogradation and abandonment and transgression and subsidence of the basin allowing the Pacific and Atlantic oceans connection, inferred by the mixture of ammonites found in the Taberna Formation. During Callovian-Oxfordian drifting stage, because the Chiapas-Yucatán South American subplates were joined, the Texas-Louisiana and Western Region of Mexico subplates were displaced northwestward reactivating the Texas-Boquillas-Sabinas and the Vancouver-Bahamas megashears and the subduction zone, along the Pacific border of the North-American Plate. The Campeche Escarpment and Nautla-Pico de Orizaba arms became wider ridges and seafloor spreading zones, giving origin to the Gulf of Mexico and its sedimentary sub-basins. During Tithonian, the SW continental border rise, and the Gulf became a closed basin with euxinic sedimentary conditions (Pimienta Fm.) where their oil and gas systems, and type and abundance of hydrocarbons, are mainly the product of the hot spot evolution. During Early Cretaceous, Chiapas-Yucatan and South America subplates separated and the Caribbean Sea Way appeared.

Key Words: Gulf of Mexico Origin, Proto and "Hispanic Corridor", hot spot evolution; Jurassic Palynostratigraphy, Geochemistry, Petrology, Paleontology, and Paleogeography.

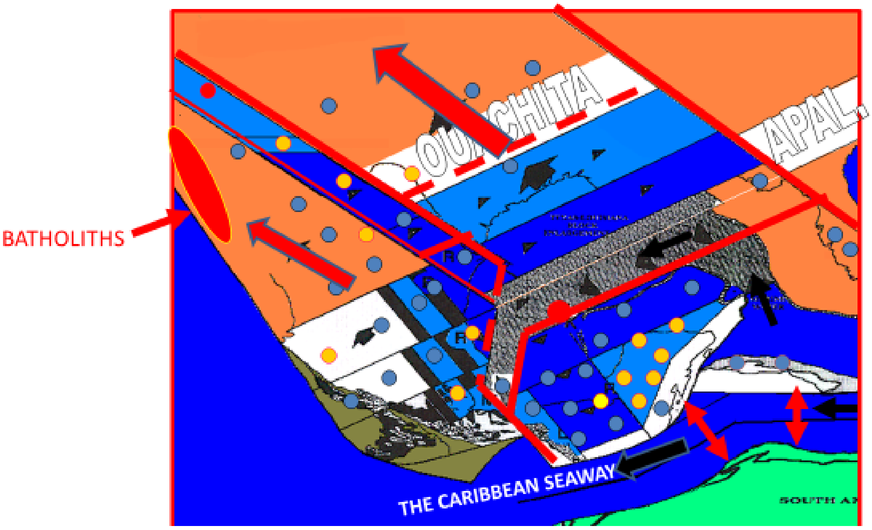


FROM LATE TRIASSIC TO EARLY LIASSIC
EXISTED THE
PROTO "HISPANIC CORRIDOR"

DURING BAJOCIAN-BATHONIAN RIFTING AND SINKING STAGE
THE HISPANIC CORRIDOR AND OIL BASINS APPEAR
TODOS SANTOS, HUEHUETEPEC & TABERNA Fms



EARLY CRETACEOUS
(THE CARIBBEAN SEAWAY)
AN OPEN-OCEAN CONNECTION



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The systematic and taxonomic revision of the Lower Bajocian type species of Sonniniids (Ammonitina, Cephalopods) described by W. WAAGEN 1867

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In 1867, W. Waagen described 19 species of Sonniniids (Ammonitina) from the Middle Jurassic (Lower Bajocian) of southern Germany. Eight of these species were considered to be new. The aim of this work is to present a review of the type material of Waagen deposed in Bavarian State Collection for Palaeontology and Geology of München.

In his monograph, Waagen had presented the original drawings that were later refigured by Dorn in 1935, and after by Schlegelmilch in 1985. However, these illustrations are reproduced with a low quality and with different scales that sometimes make their use not easy.

Moreover, many more recent works [Chandler et al. (2006); De Baets et al. (2008); Dietel (1980); Dietel and Haag (1980); Dietze et al. (2003, 2005, 2006, 2007); Donovan et al. (1981); Galacz (1991); Hall (1989); Morton (1975); Ohmert (1988); Sadki (1994, 1996, 2010); Sandoval & Chandler (2000), see also Sadki et al. (2015)] can provide review the nomenclature of these type species, specify their stratigraphic position and reconstitute their paleobiogeographic distribution.

Key-Words: Ammonitina, Cephalopods, Systematic, Taxonomic revision, Middle Jurassic, Bajocian, W. Waagen, Type material.

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Tithonian Ammonites from the Baños del Flaco Formation, Central Chile

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In Central Chile, the Baños del Flaco Formation contains abundant and well preserved Tithonian (Late Jurassic) ammonites. 12 species referred to 10 genera are recorded for this unit. *Windhauseniceras internispinosum*, *Corongoceras alternans* and *Substeueroceras koeneni* were informally recorded by other authors. *Aulacosphinctes proximus*, *Micracanthoceras spinulosum* and *Corongoceras evolutum* are new records for the Baños del Flaco Formation. *Pseudolissoceras* cf. *zitteli*, *Euvirgalithacoceras malarguense*, *Choicensisphinctes windhauseni*, *Catutosphinctes* cf. *americanensis*, *Virgatosphinctes scythicus* and *Micracanthoceras microcanthum* are first registers for Chile. *Micracanthoceras spinulosum* shows strong ontogenetic changes not recorded previously. *Virgatosphinctes scythicus* is here considered a morphologically variable species and considered synonymous with classical South American taxa such as *Virgatosphinctes andesensis*, *V. mendozanus*, *V. mexicanus* and *V. leñaensis*. *Windhauseniceras internispinosum* is a rare taxon elsewhere but relatively abundant at Rio Maitenes; its morphology varies considerably during ontogeny. *Virgatosphinctes* aff. *pseudolictor* and *V.* cf. *raja*, both recorded for Argentina, and *V. guadalupensis,* are considered synonymous with *E. malarguense,* while *V. tenuilineatus* is synonymous with *C. windhauseni* and *Aulacosphinctes chilensis* with *A. proximus*. Other synonymies include *Micracanthoceras lamberti* and *M. tapiai,* with *M. microcanthum,* and *Corongoceras rigali* with *C. alternans*. *Windhauseniceras internispinosum* and *Corongoceras alternans* indicate a Tithonian age for most of the Baños del Flaco Formation. *Virgatosphinctes scythicus* and *Micracanthoceras microcanthum* are Tithonian index fossils for the Russian platform and Tethys, respectively. Their unexpected occurrence in central Chile confirms a Tithonian age for most of the Baños del Flaco Formation. The presence of *Substeueroceras koeneni* indicates, however, that the uppermost levels of the unit extend into the basal Berriasian.

Key words: Upper Jurassic, cephalopods, systematic palaeontology, biostratigraphy.

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Hammatoceratids and erycitids, (Hammatoceratoidea, Ammonitida) of southern Spain (Westernmost Tethys): taxonomy, biostratigraphy and phylogeny

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Hammatoceratidae and Erycitidae (Hammatoceratoidea Ammonitida) are common from the Upper Toarcian to the Lower Bajocian (Ovale Zone) of different stratigraphic sections of the Subbetic domain (Betic Cordillera, southern Spain). The Betic Cordillera belongs to the Mediterranean province and constitutes the westernmost mountain range of the Tethys. In several sections of this Mediterranean area, mainly those consisting of pelagic or hemipelagic marly-limestone rhythmites, and where ammonoids are abundant, the stratigraphic range of the diverse taxa present can be easily and accurately determined. This also shows the morphological changes through geological time and the evolutionary processes that took place in the ammonite taxa that appear in the stratigraphic record.

A great number of specimens from the Subbetic domain, belonging to the families Hammatoceratidae and Erycitidae (Hammatoceratoidea, Ammonitida) and collected in sections which were minutely sampled bed by bed, have been analysed in detail. Studies of the Subbetic material together with the bibliographic review of other Western Tethyan erycitids and hammatoceratids have yielded significant results.

Taxonomical analyses allow the family Erycitidae Spath, 1928 to be subdivided into three subfamilies: the Mediterranean subfamilies Erycitinae Spath, 1928 and Zurcheriinae Hyatt, 1900 and East Pacific Podagrosiceratinae Westermann & Riccardi, 1979. The genera *Erycites* Gemmellaro, 1886, *Abbasites* Buckman, 1921, *Abbasitoides* Géczy, 1966 and *Cagliceras* Rulleau & Elmi, 2001 are included in Erycitinae in which 10 species have been differentiated. *Ambersites* Buckman, 1921 is considered synonymous of *Abbasites*. *Praerycites* Venturi, 1881, regarded by diverse authors as the first Erycitidae that could be a Phymatoceratidae rather than an Erycitidae. In the Subbetic domain, erycitins extend from the Upper Toarcian (Speciosum Zone) to the uppermost Aalenian (Concavum Zone, Limitatum Subzone). A detailed review to the species level shows that a considerable number of the Mediterranean species previously described, mainly from Hungary, may be synonymous (Sandoval et al. 2015).

In the Subbetic, the Zurcheriinae are represented by 17 species belonging to the genera *Zurcheria* Douvillé, 1885, *Haplopleuroceras* Buckman, 1892, *Spinammatoceras* Schindewolf, 1964, *Malladaites* Linares & Sandoval, 1986 and *Parazurcheria* Fernández López et al., 1988 (Linares & Sandoval, 1986, 1996). Subbetic Zurcheriinae extend from the Lower Aalenian (Opalinum Zone, Comptum Subzone) to the Lower Bajocian (Ovale Zone).
Hammatoceratids are also common in the Subbetic domain (Betic Cordillera, southern Spain), but less abundant than in other Mediterranean areas. About 35 Hammatoceratidae "species"

pertaining to the genera *Hammatoceras* Hyatt 1867, *Geczyceras* Martínez, 1992, *Crestaites* Elmi & Rulleau, 2001, *Planammatoceras* Buckman, 1910, *Bredyia* Buckman, 1910, *Accardia* Cresta, 1997, *Paviaites* Cresta, 1997, *Eudmetoceras* Buckman, 1920, *Euaptetoceras* Buckman, 1922, *Pseudaptetoceras* Géczy, 1966, and *Fissilobiceras* Buckman, 1919, have been recognized in this palaeogeographic domain and their stratigraphic ranges have been determined. Subbetic, hammatoceratids extend from the Upper Toarcian (Fallaciosum Zone) to Lower Bajocian (Ovale Zone). Most these species are typical Mediterranean in character. The analysis of the stratigraphic range of hammatoceratids and erycitids helped to establish a detailed biostratigraphic scheme based only in Mediterranean Hammatoceratoidea (Sandoval et al., 2011).

Phylogenetic analyses indicate that Hammatoceratidae originate possibly from Phymatoceratidae (Variabilis-Thouarsense Zones). *Cagliceras picenum* Fossa-Mancini, 1915 is perhaps the earliest Erycitidae, originating from some species of the genus *Geczyceras* or *Crestaites* in the Speciosum Zone. The major evolutionary events that can be recorded are as follows: a) separation of Hammatoceratidae, b) first great diversification of Hammatoceratidae and origination of Erycitidae (Speciosum Zone); c) new diversification affecting both lineages (Comptum Comptum Subzone-Murchisonae Zone); d) the last diversification in the lowermost Upper Aalenian, which is followed by the first records the Sonniniidae and the Strigoceratidae, from hammatoceratids; e) disappearance of the last hammatoceratids in the Ovale Zone.

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Key words: Betic Cordillera; Jurassic, ammonite biostratigraphy

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The Sonniniidae (Hammatoceratoidea, Ammonitida) of the southern Spain (westernmost Tethys): taxonomy and biostratigraphy

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Sonniniidae are abundant or common (depending on the localities) from the uppermost Aalenian (Concavum Zone, Limitatum Subzone) to uppermost Lower Bajocian (Humphriesianum Zone, Romani Subzone) of some areas of the Subbetic domain (Betic Cordillera, southern Spain). The Betic Cordillera, located in the Mediterranean province, constitutes the westernmost mountain range of the Tethyan Domain. For late Early Jurassic-Late Jurassic, the physiography of the Subbetic basin was very irregular with two high swell areas (External and Internal Subbetic) and one relatively deep trough (Median Subbetic) in the Southern Iberian palaeomargin. During the late Early-Middle Jurassic, the Subbetic domain was a typical basin of the Hispanic Corridor connecting the Tethys and the Eastern Pacific.

Sonniniids are especially abundant in some areas of the Median Subbetic subdomain, mainly at the central sector of the Cordillera (Sandoval, 1983, 1990). In this domain, dominant sediments consist of pelagic or hemipelagic marly limestone rhythmites together with levels of cherty limestones. In swell areas (External and Internal Subbetic), the dominant lithologies are cherty limestone or nodular limestones and, although ammonite can be locally abundant, sonniniids are scarcer.

Diverse groups of ammonites of Subbetic Middle Jurassic were previously studied in detail taxonomically and biostratigraphically (Sandoval 1983, Sandoval, 1985, 1986; Sandoval et al., 2012; Sandoval el al., 2015 and references therein; Sandoval et al., in prep; Sandoval & Chandler 2015; Martínez et al., 2016). However, although the Subbetic sonniniids are frequently cited in literature and some isolated specimens were figured (Sandoval 1990, Hernández Molina et al. 1991), previous taxonomic studies do not exist, except for the genus *Euhoploceras* (Sandoval & Chandler 2000).

A great number of specimens from the Subbetic domain, belonging to the Sonniniidae (subfamilies Sonniniinae Buckman, 1892 and Witchelliinae Callomon and Chandler, 2006), coming from sections which were sampled bed by bed, have been analysed here. *Euhoploceras* Buckman, 1913 [(*E. acanthodes,* (Buckman), *E. marginatum* (Buckman), *E. modestum* (Buckman) and *E. adicrum* (Waagen)] are common and extend to the Upper Aalenian (Concavum Zone) and Lower Bajocian (Discites and Ovale zones). *Sonninia* Douvillé, 1879 is represented by *S. sowerbyi* (Waagen), *S. corrugata* (Sowerby) and *S. propinquans* (Bayle) being abundant only in the Propinquans Zone. *Sonninites* Buckman, 1923 (*S. felix* Buckman, *S. celans* Buckman and *S. simulans* Buckman) is abundant in the upper part of the Laeviuscula Zone and in the Propinquans Zone. *Papilliceras* Buckman, 1920 is scarcer in the Subbetic, with only few specimens in the Propinquans Zone. The genus *Witchellia* Buckman, 1889 is very abundant in the Median Subbetic. The species *W. nodatipinguis* (Buckman), *W. sayni* (Haug), *W. albida* (Buckman), *W. romanoides* (Douvillé), *W. rubra* (Buckman), *W.*

connata (Buckman), *W. hyalina* (Buckman)*, W.* n. sp. (a very evolute species) and *W. laeviuscula* (Sowerby) appear successively in the stratigraphic record, extending from the Ovale Zone to the lower part of the Propinquans Zone. Except in some beds (both Subbetic or western External Subbetic), D*orsetensia* Buckman, 1892 is not abundant, but *D. hebridica* Morton, *D. eduardiana* (D'Orbigny) and *D. liostraca* Buckman occur in the upper part of the Propinquans Zone (Hebridica Subzone) and in the Lower part of the Humphriesianum Zone (Romani Subzone).

The dimorphism is very pronounced in the sonniniids, differentiating macroconchs with relatively large size and with simple peristome and microconchs, invariably of small size, and peristome with lateral lappets. However, it is not easy to distinguish the dimorphic microconchs of *Euhoploceras*, *Sonninia*, *Papilliceras, Witchellia* and *Dorsetensia*. Tuberculate microconchs could be the dimorphous pairs of *Euhoploceras*, *Sonninia* and *Papilliceras* while non-tuberculate ones would be the dimorphic couples of *Witchellia* and *Dorsetensia*. The following "species" which appear successively in the stratigraphic record (from Discites Zone to upper part of the Propinquans Zone) have been identified: *Pelekodites zurcheri* (Douvillé), *Maceratites* sp., *M. aurifer* Buckman, *M. minimus* (Hiltermann), *Pelekodites schlumbergeri* (Haug), *P. moisyi* (Brasil), *Nannina lennieri* (Brasil), *N. regrediens* (Haug), *N. evoluta* Buckman, and *Pelekodites sulcatus* (Buckman).

The western Pacific genus *Latiwitchellia* Imlay, 1973, which occurs in the Ovale Zone of some Median Subbetic sections, was originally included in Sonniniidae, but it has a very simplified septal suture, which is typical of the Grammoceratinae (Sandoval et al., 2012). The taxonomic status of the genus *Fontannesia* Buckman, 1902 is not clear because, although many authors place it in Sonniniidae, the septal suture and ornamentation show characteristics of Grammoceratinae.

The comparison of the Subbetic sonniniids with the types of the different species, many of which come from the Subboreal province (United Kingdom, Germany) shows a great similarity between the forms of the two palaeogeographic provinces, indicating that there was good communication between the two. This is logical, if it is admitted that the Early Bajocian is a strongly transgressive interval.

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Key words: Jurassic**;** ammonite**;** Subbetic

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The Sonda de Campeche: A natural laboratory to quantify the generation and storage of hydrocarbons derived from Upper Jurassic rocks

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Objective

The objective of this work is to show that in Mexico there is an oil and gas production zone, where the stored hydrocarbons are closely related to a source rock that was subjected to different thermal stresses.

20 wells of different depths and locations of the Sonda de Campeche were analyzed, this zone is located off the coast of Tabasco and Campeche States in the southern Gulf of Mexico. Core rock of Tithonian type calcareous black shale, dark marls and gray clay limestones from Edzna Formation were sampled, which is considered the most prolific source rock of the region, containing a typical kerogen type IIS.

Methodology

Geological, geochemical, optical, and molecular methods were applied to rock samples, oils and gases to calibrate the variations in composition, quality and maturity of the products derived from the source rock, as well as petrophysical analysis in the well logs.

The organic matter maturity in the recovered cores oscillates between immature (0.45% Ro) and overmature (1.35% Ro), corroborated by more than 20 maturity parameters, this transformation occurred both by increasing the depth in direction NE -SW, as well as the thermal history of the region. While the organic facies variation is insignificant in short distances <50 km on the study area.

Lower maturity kerogen of Edzna shale was used to perform pyrolysis in micro scale sealed vessel (MSSV) and to simulate the thermal evolution and composition of the products generated, between temperatures of 150 and 600 ° C, with heating times between 1 and 10 days. This was done to determine quantitatively the amount of hydrocarbons generated and expelled during maturation and to make a comparison between the maturity of the natural *vs* artificial series, the transformation ratio was almost 95%. At the same time, the gas oil ratio (GOR) agrees in both these laboratory experiments, as well as those measured at the wellhead, by extrapolation. While the kinetic parameters of the kerogen series were determined experimentally, where the activation energies ranged from 54 to 74 kcal/mol and the frequency factors ranged from 2.7 E $^{+16}$ to 7.7 E $^{+21}$ min^{-1}.

Another set of samples was analyzed, 15 crude oils from 15 different reservoirs, where the quality varied from 10 to 47 ° API, none of these oils showed an evident biodegradation. The oils showed the same tendency of the source rocks, in addition, in the heavier oils were found high contents of sulfur compounds and high viscosities. Consequently, the correlation between biomarkers of bitumen extracts from the source rocks and the crude oils stored at the fields suggests that the source rock is the precursor of such oils, there is even correspondence between the asphaltenes and kerogens parent.

Conclusions

The characteristics of this region make that will be considered a super-charged, vertical migration and high impedance petroleum system, covering the total oil window. Therefore, it is one of the few natural hydrocarbon generation laboratory in the world.

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Fossils witnessed the major formation processes of Tibetan Plateau

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The majestic Tibetan Plateau is composed of various blocks/plates. Qiangtang Block, Lhasa Block and Indian Plate including South Tibetan Block, however, were situated in the area south of ~30ºS during the middle Cisuralian of Permian. The major processes of northward drift and impacting Eurasian plate of these blocks/plates and the rapid uplift of Tibetan Plateau as a whole could be revealed on the basis of various fossils from different areas/latitudes, ages and environments.

In the Carboniferous or earlier periods, there existed a vast Ocean, Longmoco-Yushu/Jinsha Palaeotethys, which was deep at the north but shallow at the south. During the Carboniferous-Middle Cisuralian of Permian, Lhasa and South Tibetan blocks was situated in northern Gondwana, the Cimmerian island chain consisting of Qiangtang terrane, Karakorum terrane and so forth was distributed along the northeastern margin of Gondwana. By the end of Guadalupian of Permian, Qiangtang Block came into collision with Eurasian plate. Such collision caused the deep ocean of north Palaeotethys closed, and the Hohxil Block mainly composed of accretionary wedges was formed. During the late Middle Triassic-early Late Triassic, Lhasa Block was successively split from the South Tibetan Block/Indian plate in south and the Palaeotethys in north, creating Indus-Yarlung Neotethys (bough) and Bangongco-Nu Neotethys (branch). With the rapid drift and squeezing northwards of Lhasa and Qingtang blocks, Hohxil Block and northern Qiangtang Block were folded into mountains, and Palaeotethys was thus disappeared near the end of Triassic. The Lhasa Block has come collision with the Qiangtang Block since the latest Jurassic. As a result, the sea was retreated southwards from Qiangtang Block and Qiangtang and Hohxil blocks were got a highland. In the earliest Late or latest Early Cretaceous, Lhasa and Qiangtang blocks were completely pieced together and Bangongco-Nu Neotethys was replaced by lands. In Aptian times, Indian plate split from Antarctic-Australia and drift northwards at a high speed, resulting in the rapid expanding of Indian Ocean. During the latest Cretaceous, Indian plate reached near the northern margin of Neotethys and started to impact the Eurasian plate, the Indus-Yalung Neotethys was reduced as a narrow stripped sea with rift. By the end of Eocene, the Neotethys was totally retreated from Tibet area and began to rapid uplift as a whole, though the uplift speed varied with the time and area, and the “roof of the

world”, where is the river source of Asia, and many areas are the realms of freedom of rare creatures, the restricted zones of mankind, unique landscape land of idyllic beauty, was formed.

Keywords: Formation processes, Tibetan Plateau, fossil evidence

Boreal–Tethyan correlation of the Lower Bathonian: paleontological and non-paleontological data from the Sokur section, Central Russia

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The Boreal–Tethyan correlation of the Bathonian successions is one of the most complex problems of Mesozoic biostratigraphy. The standard chronostratigraphy of the Bathonian is based on the ammonite zonal successions of NW European taxa such as Parkinsoniidae, Perisphinctidae, etc. In a large part of the Lower–Middle Bathonian interval, this scale works well for the Sub-Mediterranean and Mediterranean sections (Fernández-López et al., 2009). The zonal scale of Boreal Bathonian is based on the succession of taxa belonging to the subfamily Arctocephalitinae (family Cardioceratidae) and therefore can be only provisionally correlated with the standard scale. However, the discovery of ammonites of the Peri-Tethyan family Parkinsoniidae and Boreal Cardioceratidae in the East European Sokur section in the vicinity of Saratov reopened the possibility of direct Boreal to Tethyan correlation in the Lower Bathonian (Mitta & Seltzer, 2002). Herein, we introduce the results of paleontological, C-isotopic and paleomagnetic studies of this section.

The Sokur section is exposed in a former quarry in the northwestern suburb of Saratov. The paleogeographic maps for the Middle Jurassic show that the Saratov region was located between 45° and 50° N paleolatitudes during Bathonian time. Recent studies (Mitta et al., 2014) show that the Late Bajocian marine transgression over the Russian platform resulted in the mixing of Boreal and Tethyan water masses, because the taxonomic composition of fossil assemblages from the Sokur section points to the existence of a seaway connecting cooler northern and warm southern waters at the end of the Late Bajocian–Early Bathonian. The end of the Early Bathonian is marked by the beginning of a regressive phase.

The *Oraniceras besnosovi* Zone recognized at the base of the Sokur section is overlain conformably by beds containing *Arcticoceras harlandi* and *A. ishmae*. The *O. besnosovi* Zone was correlated with the Convergens and Macrescens Subzones of the Zigzag Zone (Mitta et al., 2014), because the interval of distribution of the genus *Oraniceras* in the Peri-Tethyan regions is restricted to the two lowest subzones of the Zigzag Zone. The co-occurrence of the last *Oraniceras* and first *Arcticoceras* suggests an Early Bathonian age of the *A. harlandi* Subzone, which supposedly corresponds to the upper part of the Zigzag Zone of the NE European primary standard. The *A. ishmae* Subzone overlapping the *A. harlandi* Subzone is provisionally correlated with the uppermost part of the Zigzag Zone and Tenuiplicatus Zone.

The upper barren 8 m-thick siltstone stratum was earlier assigned (only provisionally based on its stratigraphic position) to the Middle Bathonian.

In addition, this section contains belemnite beds with *Pachyteuthis optima* and *P. bodylevskii*, beds with *P. optima*, as well as *Retroceramus bulunensis* and *R. vagt* bivalve zones, and the upper parts of the *Lenticulina volganica–Vaginulina dainae* and *Trochammina* aff. *praesquamata* foraminiferal zones (Mitta et al., 2014). The identified biostratigraphic units are well correlated with the ammonite zones of the Jurassic Boreal standard. The first appearance of Boreal belemnites and *R. polaris* Koschelkina, an index species of a zone underlying the Siberian *R. bulunensis* Zone was reported in the middle part of the *Oraniceras besnosovi* ammonite Zone.

The integrated biostratigraphy revealed systematically older successions of Boreal biostratigraphic units than previously reported. In practical terms, this can be expressed as (1) the approval of the *Arctocephalites greenlandicus* Zone (which is regarded as a time equivalent of the Central Russian *Oraniceras besnosovi* Zone) as a basal Bathonian ammonite zone in Boreal sections and, as such, the Boreal *Arctocephalites arcticus* Zone formerly identified at the base of the Bathonian is placed in the Upper Bajocian; (2) placing the *Arcticoceras harlandi* and *A. ishmae* Zones/Subzones formerly assigned to the Middle Bathonian of Boreal sections in the uppermost Lower Bathonian; (3) placing the *A. cranocephaloide* Zone formerly assigned to the lowermost Upper Bathonian of Boreal sections in the Middle Bathonian (Mitta et al., 2014, 2015). In view of the above, the proposed biostratigraphic zonation requires verification by independent paleomagnetic and isotope-geochemical methods.

Belemnite rostra of the genus *Pachyteuthis* (Cylindroteuthididae) were collected for C and O isotopic analysis within a 4 m thick interval from the *Oraniceras besnosovi* and *Arcticoceras ishmae* zones. A total of 24 specimens were analyzed (Dzyuba et al., 2017). All the analyzed species (*Pachyteuthis optima*, *P. bodylevskii*) were identified as migrant taxa from the Artic (Mitta et al., 2014, 2015), which are not known from Tethyan seas. The accuracy of stable isotope analysis of carbon and oxygen in carbonates (0.1‰ for $\delta^{13}C$ and $\delta^{18}O$) was controlled by measurements of the international standards (NBS19 $\delta^{13}C = +1.9‰$, $\delta^{18}O = -2.2‰$).

The $\delta^{13}C$ values increase from the *Oraniceras besnosovi* Zone toward the *Arcticoceras harlandi* Subzone and decrease in the *A. ishmae* Subzone. The largest variation of $\delta^{13}C$ is observed in the *A. harlandi* Subzone: as indicated by a gradual decrease in $\delta^{13}C$ to 1.3‰ followed by a rapid increase to 3.4‰. The general trend exhibited by the $\delta^{13}C$ curve from the Lower Bathonian interval of the Sokur section fits well for the Lower Bathonian interval of Mediterranean sections, Southern Spain (O'Dogherty et al., 2006), where the $\delta^{13}C$ values increase considerably within three subzones (Dimorphitiformis, Macrescens, and Yeovilensis), and then decrease substantially in the Postpolubrum Subzone of the Aurigerus Zone (= Tenuiplicatus Zone of the Standard scale). The best correlation was established with the La Cornicabra section (central part of the Betic Cordillera), with highly detailed biostratigraphy. The C-isotope variation curve obtained in this study strongly supports the previous proposal of Mitta et al. (2014) to correlate the *Oraniceras besnosovi* Zone and the *Arcticoceras harlandi* Subzone of the Sokur section with the Zigzag Zone and the *A. ishmae* Subzone mostly with the Tenuiplicatus Zone.

Magnetostratigraphic data were obtained from oriented hand samples collected from 66 levels within a ~16 m thick stratigraphic section. Paleomagnetic studies were performed following the standard procedure described by Molostovskii and Khramov. Measurements of Jn were performed using the JR-6 spin magnetometer after a stepwise alternating field demagnetization of the samples (up to 50–100 mT at a 5 mT increment step) using the LDA-3

AF apparatus at a temperature ranging from 100 to 550 °C at a 50 °C increment) in the Aparin-type furnace.

The magnetic polarity column of the section contains a dominantly reversed polarity, with three normal polarity intervals, one in Lower Bathonian deposits (uppermost part of the *Oraniceras besnosovi* Zone and *Arcticoceras harlandi* Subzone) and two in Middle Bathonian deposits. Possible correlations between our data and geomagnetic polarity timescale (GPTS) are the following: the lower N-zone of the Sokur section is equated with the Early Bathonian normal polarity chron 'e-Bath N'; the long overlying R-zone is a reliable equivalent of 'm-Bath R'; an interval of alternating polarity at the top of section is probably correlated with the lowermost part of 'lt-Bath N' (Dzyuba et al., 2017). Thus, the correlation of the *Arcticoceras ishmae* Zone with the Lower Bathonian can be unambiguously supported by paleomagnetic data only within the *A. harlandi* Subzone. New data show that the overlying *A. ishmae* Subzone of the Sokur section has a reversed polarity and can be theoretically correlated, in terms of magnetic polarity, either with the uppermost Lower Bathonian or the Middle Bathonian.

Key words: Bathonian; biostratigraphy; magnetostratigraphy; chemostratigraphy; Boreal–Tethyan correlation; Russian platform

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Local, regional and global organization of the geological events from Huizachal-Peregrina and Diquiyú anticlinoria sedimentary sequences during Late Triassic-Late Jurassic, based on the Scalar Typological Method

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In Mexico, the red beds of Liassic of Huizachal-Peregrina and Diquiyú anticlinoria correspond to a sequence of continental rock. Rueda-Gaxiola *et al.* (1993) and Jiménez-Rentería (2004), based on the Palinostraestratigraphic Method, found evidence of marine palinomorphs at the botton and the middle part of the La Boca Alof. (Huizachal-Peregrina Anticlinorium) and Rosario and Conglomerado Prieto formations (Diquiyú Anticlinorium) indicating that, they were deposited in a demigraben denominated the Alamar-Tlaxiaco Basin, affected by tectonic processes (*Doming, Rifting & Drifting*) related to the Opening of the Gulf of Mexico, based on a hot spot evolution with triple junction during Jurassic. The petrological studies by De Anda-García (2008) and Rueda-Gaxiola *et al*. (2015) of the metamorphic quartz of the sandstones at the botton and the middle part of the La Boca Alof. and the Rosario Fm. and Conglomerado Prieto Fm. allowed to know that it came from a tectonic environment related to a Recycled Orogen, product of the collision between Laurentia and Gondwana continents during Carboniferous-Permian time; by the other hand the origin of quartz of the top of the La Boca Alof. and the Cuarcítica Cualac Fm. had a tectonic environment by the erosion of an Interior Craton, during a dome originated by a hot spot during Liassic-Early Middle Jurassic, related to the opening of the Gulf of Mexico.

As a result of the analysis of the backgrounds, it was recognized that, although the processes of stratigraphic, tectonic and historical evolution affected the units deposited in the El Alamar-Tlaxiaco Basin during the Late Triassic-Early Cretaceous were known, there was not a hierarchy of local, regional and global levels of these processes; therefore, with the objective of finding answers, it was proposed the application of the Scalar Typology Method, created by Delfaud (1986), based on the bio-, chrono- and lithostratigraphic characteristics of the sedimentary sequences in order to determine a local, regional and global hierarchy of the internal or external dynamic events. Also, based on result of the Scalar Typology Method, it was established equivalence in terms of stratigraphic sequences and with the global cycles of Vail *et al.* (1987) (Table 1).

Thus, it was possible to know that at **Local Scale** (Table 1): the section of Peregrina Canyon of the Huizachal-Peregrina Anticlinorium, is constituted by 133 m at the La Boca Alof. sequence (Petrozones A, B & C) corresponding to 3 rhythms that comprise 3 carbonate zones indicating marine influence. Based on the hierarchical classification of the sedimentary sequences of Delfaud (1986) it has an order 5. Stratigraphically, this unit is concordantly overlaid by 33 m of the Cuarcítica Cualac Fm sequence (petrozones D & E) of order 4, corresponding to 2 rhythms. Based on De Anda-García (2008), Osorio-Nicolás (2009) and Vite-del Ángel (2014), in the Diquiyú Anticlinorium, it is known that at the Encinar Castro Hill, section is constituted by 114 m of the sequence of the Rosario Fm. and Conglomerado Prieto Fm., of order 5, corresponding to 3 rhythms that comprise 3 carbonated zones that indicate marine influence. This unit is concordantly overlaid by 53 m of the Cuarcítica Cualac Fm. sequence (petrozones D, E & F) of order 4, corresponding to 2 rhythms. While in the section of the Rosario Nuevo Ravine, it is constituted by the sequences of the Zorrillo Fm., of order 3, and Taberna Fm. of orden 2. Due to the lithostratigraphic characteristics, changes were proposed to the nomenclature of these sequences (Table 1):

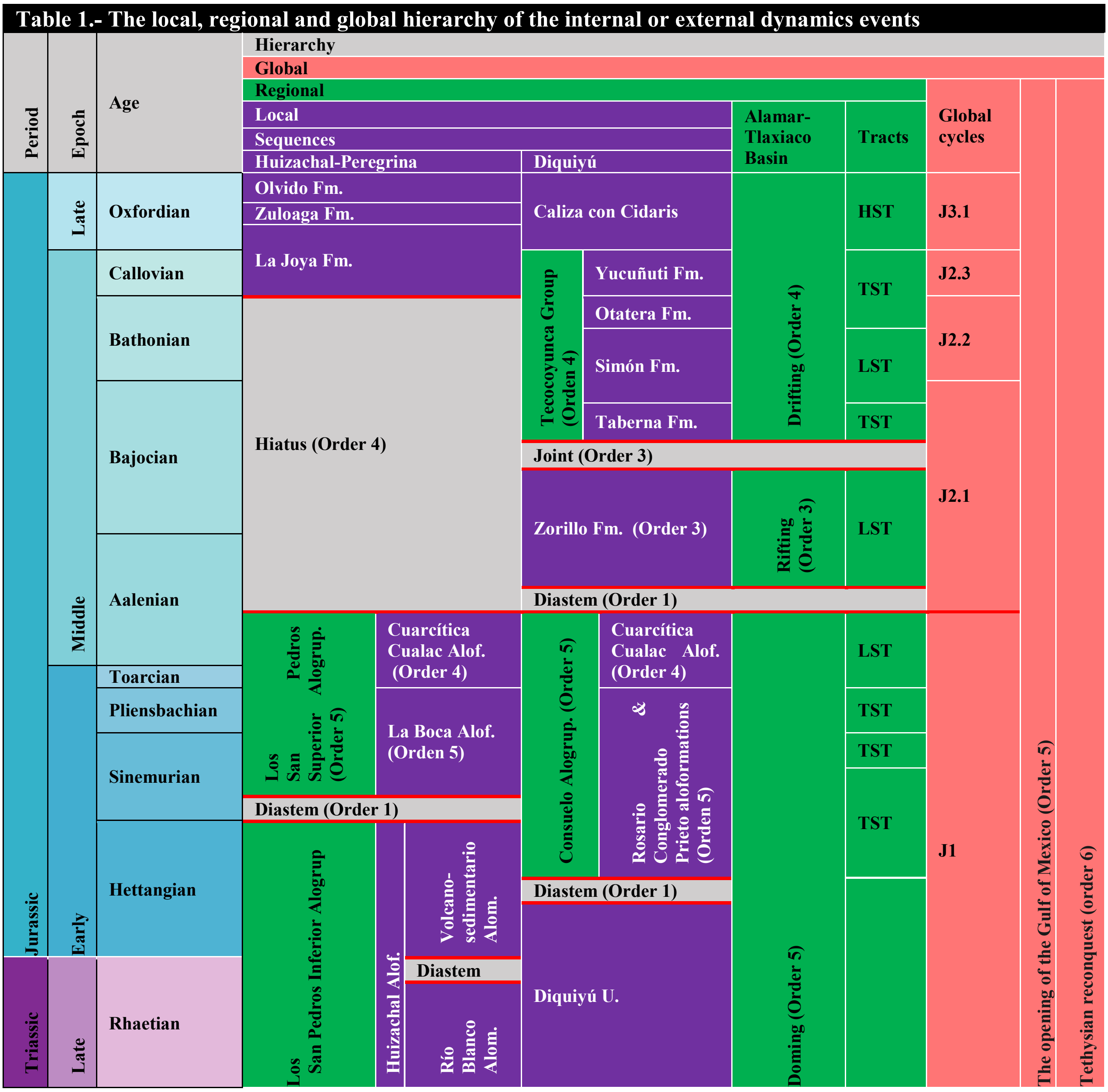
1. The Cuarcítica Cualac Fm. changes to Cuarcítica Cualac Alof. and together with the La Boca Alof. integrate Los San Pedros Superior Alogroup Megasequence.
2. The sequences of the Rosario, Conglomerado Prieto and Cuarcítica Cualac formations change to alloformations, and they are grouped in Consuelo Alogroup Megasequence, considering the sequence of Zorrillo Fm. as independent lithostratigraphic unit.

At **Regional Scale** (Table 1) was concluded, that the Alamar-Tlaxiaco Basin was affected by the Opening of the Gulf of Mexico tectonic events: During the "Doming stage (order 5)", the megasequences of Los San Pedros Superior and Consuelo alogroups, were deposited in continentally dominant conditions, with 3 episodes of marine influence, derived from the Late Triassic-Liassc invasion, of the "Proto-Hispanic Corridor" (Rueda-Gaxiola, 2016), than deposited the ammonites of Tethysian affinity in Huayacocotla Fm. described by Esquivel-Macías *et al.* (2005), Meister *et al.* (2009) and Blau *et al.,* (2009); also in terms of stratigraphic sequences corresponds to "3 transgressive systems tracts (TST)" and “lowstand system tract (LST)”, product of the global cycle J1 of Vail *et al.* (1987). In the “Rifting stage (order 3)”, the sequence of the Zorrillo Fm. was deposited in the Tlaxiaco Block, related to a "LST", product of the global cycle J2.1, while in the Huizachal-Peregrina Block the sedimentation suffered an interruption that gave result to a hiatus of order 4. During the "Drifting stage (order 5)", the sequence Taberna Fm. was deposited in a “TST” and the Tecocoyunca Group megasequences and the sequences of the Caliza con Cidaris Fm. (Tlaxiaco Block), La Joya, Zuloaga and Olvido formations (Huizachal-Peregrina Block) were deposited as a product of the "Hispanic Corridor" that communicated the Tethys Sea with the Pacific Ocean at Rosario Paleobay, during a "highstand system tract (HST)", of global cycles J2.2 to J3.1

Finally, at **World Scale** (Table 1), there was a period of simple eustatism called by Delfaud (1986), as "Tethysian reconquest" whose order is 6, which took place in two periods: from the Late Triassic to the Early Jurassic and Middle Jurassic to Early Cretaceous based on the correlation of Aquitania, Bética, Atlas (Delfaud 1986), the Chihuahua Basin (Ortuño-Arzate, 1985) and Diquiyú Anticlinorium megasecuences, including the all levels of lower hierarchies.

Key words: Hierarchy, Sequence, Scalar Tipology, Gulf of Mexico, Diquiyú, Huizachal-Peregrina, Triassic, Jurassic Cretaceous, Tethysian reconquest, Stratigraphic Sequences & global cycles

Table 1.- The local, regional and global hierarchy of the internal or external dynamics events



Period	Epoch	Age	Hierarchy								
			Global								
			Regional						Global cycles		
			Local				Alamar-Tlaxiaco Basin	Tracts			
			Sequences								
			Huizachal-Peregrina		Diquiyú						
Jurassic	Late	Oxfordian	Olvido Fm.		Caliza con Cidaris		Drifting (Order 4)	HST	J3.1	The opening of the Gulf of Mexico (Order 5)	Tethysian reconquest (order 6)
			Zuloaga Fm.								
			La Joya Fm.								
	Middle	Callovian			Tecocoyunca Group (Orden 4)	Yucuñuti Fm.		TST	J2.3		
		Bathonian	Hiatus (Order 4)			Otatera Fm.			J2.2		
						Simón Fm.		LST			
		Bajocian							J2.1		
						Taberna Fm.		TST			
					Joint (Order 3)						
					Zorillo Fm. (Order 3)		Rifting (Order 3)	LST			
		Aalenian									
					Diastem (Order 1)						
			Los San Pedros Superior Alogrup. (Order 5)	Cuarcítica Cualac Alof. (Order 4)	Consuelo Alogrup. (Order 5)	Cuarcítica Cualac Alof. (Order 4)	Doming (Order 5)	LST	J1		
	Early	Toarcian									
		Pliensbachian		La Boca Alof. (Orden 5)		Rosario & Conglomerado Prieto aloformations (Orden 5)		TST			
		Sinemurian						TST			
								TST			
			Diastem (Order 1)								
		Hettangian	Los San Pedros Inferior Alogrup	Huizachal Alof. Volcano-sedimentario Alom.							
					Diastem (Order 1)						
					Diquiyú U.						
Triassic	Late	Rhaetian		Diastem							
				Río Blanco Alom.							

Ammonites from Lower Jurassic sections of Sonora, Northwest Mexico: taxonomy, biostratigraphy and palaeobiogeographical implications

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The Antimonio terrane is an allochthonous tectonostratigraphic unit known from the northwestern part of Sonora state of Mexico, where it is developed on the basement of the Proterozoic to Permian Caborca block. The Upper Permian to Lower Jurassic Antimonio Group, which includes the Lower Jurassic Sierra de Santa Rosa Formation, is the most extensive stratigraphic unit of this terrane (González-León et al., 2005). Biostratigraphic dating of the thick Lower Jurassic sedimentary succession is crucial for the reconstruction of the tectonic history of the Antimonio terrane. However, the Lower Jurassic ammonite faunas have only been partially treated in previous works (e.g. Taylor et al., 2001), therefore a comprehensive paleontological and biostratigraphical study was carried out here.

Ammonoids were collected from sections exposing the Sierra de Santa Rosa Formation, including Sierra del Alamo (type locality of the Antimonio Group), Pozos de Serna, Sierra de Santa Rosa and Sierra la Jojoba. From 425 moderately well preserved specimens, a total of 52 taxa were distinguished, 30 of them identified at the species level, which belong to 20 genera.

The ammonoid assemblages represent three stages of the Lower Jurassic, from the Upper Hettangian through the Sinemurian to the Lower Pliensbachian. Provincialism of the fauna warrants the use of the recently developed North American regional ammonoid zonation. Eight zones were distinguished and documented in the studied sections.

The oldest one, the Upper Hettangian Rursicostatum Zone is found in the type section of Sierra del Alamo, occurring above the disconformity marking the Triassic/Jurassic system boundary. Overlying strata yielded several species of *Arnioceras*, together with common *Coroniceras* and *Caenisites*, which together indicate the Lower Sinemurian Involutum and Leslei zones. The appearance of *Epophioceras* marks the Carinatum Zone from the lower part of Upper Sinemurian, whereas higher upsection poorly preserved echioceratids indicate the Harbledownense Zone.

The section of Pozos de Serna yielded *Paltechioceras* and the higher part is dominated by small sized polymorphitids, permitting assignment to the Harbledownense Zone of the uppermost Sinemurian and the Lower Pliensbachian Imlayi Zone, respectively.

The oldest assemblage in the Sierra de Santa Rosa is dominated by *Paltechioceras,* which is assigned to the Harbledownense Zone. The Middle Member yielded *Metaderoceras*, representing the Lower Pliensbachian Whiteavesi Zone, whereas the Upper Member is characterized by *Metaderoceras*, *Dubariceras* and *Fuciniceras,* which together represent the

Freboldi Zone. Correlation of the three sections in Sierra de Santa Rosa is possible using *Fuciniceras perplicatum* as a marker species. The poorly known section of Sierra de la Jojoba yielded *Reynesocoeloceras,* thus assigned to the Lower Pliensbachian Imlay Zone.

Lower Jurassic ammonoids of the Antimonio terrane has regional significance, inasmuch they help test the applicability of the North American regional zonation. An important finding of this study is that the first appearance of hildoceratids in Mexico is earlier than elsewhere in North America, but agrees with the biostratigraphic distribution of this group in the western Tethys (Blau & Meister, 2011). Although the proximity of the Antimonio terrane and localities in Nevada is proposed by some tectonic models, their ammonoid assemblages show some important differences. A possible explanation is the increasing influence of the Hispanic Corridor (Damborenea & González-León, 1997; Scholtz et al., 2008) as a migration route during the Sinemurian and Pliensbachian, as demonstrated by the similarity of Mexican assemblages with Tethyan faunas known from Morocco, Tunisia and Italy.

Key words: Ammonites; Lower Jurassic; Sonora; Sierra del Alamo; Hispanic Corridor

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Subsurface Data in the Southern part of the Tampico-Misantla Basin, Mexico

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Objective

To give information about some data of thermal maduration of organic matter and its characteristics in two subsurface stratigraphic successions located in the southern part of the Tampico-Misantla Basin.

Methodology

The information was compiled from petroleum geology's thesis and other sources. The collected data were: Two stratigraphic successions with rocks from Oligocene to the Callovian ages. As well as analyzed samples, in those two stratigraphic successions, by the optical microscopy method of light reflection, in which values the power reflectance of the vitrinite (%Ro) and petrographic-organic characteristics were obtained. The Ro data were compared and correlated for the two stratigraphic successions of subsurface denominated A and B. Also the Ro data were compared with the Time–Temperature Thermal Index (TTI) of maduration (Lopatin, 1973 and Waples, 1980), and particularly with the TTI data for the Oxfordian rocks.

Conclusion

The correlation of the Ro between stratigraphic successions A and B has shown that they have the same thermal history. The two stratigraphic successions are between 0.3 % to 0.6 % of vitrinite reflectance from the Oligocene to Callovian rocks as shown in the charts of depth vs Ro. The stratigraphic successions A and B have a gradient of 0.006 %Ro/100 m, which is considered like a low value.

For shales and mudstones of the Oxfordian age, % Ro data are abnormal with respect to the chart line Ro versus depth, because it has a low value. The % Ro are from 0.49 to 0.58 in both stratigraphic sequences. If we compare the Ro and TTI data of the Oxfordian rocks, it will be shown that there is a certain concordance between both.

Results

The thermal history of both stratigraphic successions is very similar, inclusive the Oxfordian rocks which have a minor vitrinite reflectance with respect to the depth tendency. The two stratigraphic successions A and B, reached maximum thermal maturation of 0.69 or 0.70 of %Ro from 3497 to 4463 meters of depth where Callovian rocks are confined. However, this difference in depth can mean that stratigraphic successions A and B had already their maximum thermal maturation when it comes a tectonic dislocation could be dated as Middle or Late Oligocene.

In the Oxfordian rocks, the organic matter and the organo-mineral matrix were observed with a microscope with fluorescent light where organic matter was identified as algal or Alginite. The presence of algal with no transformation to bitumen is explained for the low rank of thermal maturation, which is 0.40 to 0.58 of vitrinite reflectance probably caused by the presence of sulfur components in the sediments and in the structure of dispersed organic matter fossil of Oxfordian age.

Key words: thermal history; reflectance vitrinite; Tampico-Misantla.

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Some Remarks about the Upper Jurassic in the Zongolica Fold and Thrust Belt from the View of Petroleum Geology

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The Zongolica Fold and Thrust Belt is located in western Veracruz and the neighboring states of Oaxaca and Puebla. This structural belt forms the southern portion of the Sierra Madre Oriental fold and thrust belt south of the Transmexican Volcanic Belt. It is bounded to the southwest by the Tehuacan graben and to the northeast by the Veracruz Tertiary basis that corresponds to the foreland basin of the Laramide foldbelt. The foldbelt is divided into a Western Mountain Range -the Sierra de Zongolica *sensu stricto*-; and an Eastern Chain covered by the Gulf coast plain called "Buried Tectonic Front" (Meneses Rocha et al, 1997) that geographically corresponds to the eastern part of the Cordoba Platform as it was depicted by Gonzalez Alvarado (1967).

In the thirties of the ninety century Nyst and Galeotti disclosed the results of a scientific travel to the Tehuacan region; however, it was not but Bose (1899) who began the systematic research of this sector of the Sierra Madre Oriental under the auspice and direction of the Mexican Geological Institute. Between 1921 and 1938, foreign oil companies made scattered works in the Veracruz basin, including drilling of three wildcats to prove the Upper Tertiary oil's potential. In 1948, PEMEX began to work firstly in the Veracruz basin, with a small group headed by Francisco Viniegra Osorio and his collaborators Edmundo Cepeda de la Garza and Roberto Oñate Espinosa. At the beginning of the fifties, PEMEX's surveys encompassed both the Veracruz basin and the fold belt (Viniegra, 1950; Oñate, 1950; Rios Mcbeth, 1952; Meneses de Gyves, 1953; Ayala Castañares et al, 1954; Lozano Romen, 1955; De la Fuente, 1959; Mena Rojas, 1960, 1962; Olivas, 1962; Viniegra, 1965), and by mid- sixties the IMP incorporated into this assignment.

By 1953, PEMEX efforts led to the discovery of oil production in Upper Cretaceous carbonate breccias of the Buried Tectonic Front (Angostura Field) and to mapping and describe around 150 meters of Kimmeridgian-Tithonian bituminous shales with pyrite and absence of benthonic fauna interbedded with thin layers of limestones, in the northwestern part of the Western Mountain Range (Tepexilotla Formation, Mena Rojas, 1960; 1962). In the seventies, PEMEX field works and exploration drilling extended in most of the Zongolica fold and thrust belt; hence Kimmeridgian-Tithonian thick-bedded dolomitized bioclastic limestones 200-400 meters thick, were mapped and assigned to the San Pedro Formation, in the southeastern part of the Western Mountain Range, specifically in the structural domain known as the Usila monocline.

No wells have cut the Upper Jurassic System in this foldbelt and outcrops are scarce and scattered. Therefore, the paleogeographic and tectonic conditions of the Upper Jurassic are still speculative. We surmise that these two lithostratigraphic unites were deposited in an enclosed marine basin in which the facies change from the carbonate platform (San Pedro Formation) into oxygen deficiency conditions –deep water?- (Tepexilotla Formation) occurred in a southeast-northwest direction.

Thus, the sea-arm was probably enclosed between two basement highs. The eastern and northeastern limits of the enclosed sea was a shear fault zone along which the Chiapas Massif was moving into its present position; while its southern and southwestern border was the post-Devonian metamorphic terrain (Ortega 1990), also referred as the Oaxaca Peninsula (Reyes,1975). To the northwest the sea- arm was connected with the open sea of the Tampico embayment that was bordered to the east by pre-Jurassic basement highs that made up the Tamaulipas-Yucatan archipelago (Murray, 1961). The southeastern border is uncertain and its definition is crucial to refine Late Jurassic paleogeographic reconstructions in this part of Mexico.

In this presentation, we will discuss this presumably Late Jurassic regional paleogeographic and tectonic setting and its implications in terms of source rocks, reservoir rocks, and possible basement – involved structures at Jurassic level. Remarks and discussion on these issues are crucial in order to open new lines of economic geology research of the Upper Jurassic System of this part of Mexico that lead to reassess its petroleum potential.

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Paleofloristic comparison between the Otlaltepec and Ayuquila basins, Middle Jurassic, Oaxaca, México

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During the fragmentation of Pangea in the occidental margin of Mexico numerous sedimentary basins were generated. Some of them are exposed in Guerrero, Puebla and Oaxaca States. The evolution of each basin caused complex associations of facies with different conditions such as climate, lithology, topography, etc. These could have been important barriers that helped the differential development of vegetal communities established in each place, impacting in the diversity and abundance of the flora established during the Middle Jurassic. The objective of this paper is to compare the paleoflora of the Otlaltepec and Ayuquila basins, based in paleontologist and lithofacies analysis.

The Otlaltepec Basin (CO) is located between the States of Oaxaca y Puebla, in the north-central sector of the Mixteco land, outcrops with the Tianguistengo, Piedra Hueca and Otlaltepec formations. Otlaltepec is the only formation considered in this paper due to the fact that it was the only one deposited during the Middle Jurassic (167± 4 Ma). Overall, it is characterized by a rhythmic alternation of conglomerate and sandstone emplaced by traction and with the formation of paleosols during a long period of time without deposits and with subaerial environments. The total thickness of this formation has been estimated between 826.5 m and 2000 m. The Ayuquila Basin (CA) includes the Ayuquila and Tecomazúchil formations, both from the Middle Jurassic. The first one was deposited on the basal part of the basin and it is characterized by showing a massive and wide monomictic conglomerate with fragments of sedimentary rock, including gravel size quartz schist and cobblestones inside a matrix of fine to medium-sized sandstone and some conglomerates, with a lacustrine deposit of fresh water pelecypods and gastropods and impressions of fossil plants. The upper part shows rocks squeeze with a dike-layered of granodioritic composition. The total thickness of the formation was estimated in 2000 m and it is unconformably covered by the Tecomazúchil Formation described as a succession of a monomictic conglomerate of metamorphic rock through the base, intercalated with sublitharenite and subarkose, that towards the top of the unit change to limolite, with an abundance of fossil flora and dinosaur’s ichnite. The collected material was consigned in the Paleontology Collection of the Facultad de Estudios Superiores Zaragoza (UNAM) with the acronyms CFZ Ot (Fm. Otlaltepec), CFZCh (Fm. Ayuquila) and CFZA (Fm. Tecomazúchil), describing the foliar architecture and the morphology of each organ, assigning it into a taxonomic category. The taxonomic identification on a level of genus of

leaves and leaflets of Bennettitales and other gymnosperms, was done using the proposal of Watson and Sincok (1992) and specialized bibliography. Floristic lists of each formation were made, the foliar area of all the samples was calculated by grouping them in seven categories of size (Ortiz et al., 2013). Finally, the floristic lists were compared to the lithologic characteristics described for each basin. (Campos-Madrigal et al., 2013; Martini et al., 2016). The taxonomic review of the collected fossil samples permitted to elaborate the floristic lists of each basin. Broadly, 10 genera of fossil plants were identified, some with an age of Middle Jurassic. The presence of reproductive structures of the genera *Williamsonia* and *Weltrichia* shows the reproductive maturity of the vegetal communities established in the studied basins. In both cases the order of the Bennettitales was the most abundant, represented by the *Zamites, Otozamites, Ptilophyllum, Pterophyllum, Williamsonia* and *Weltrichia* genera, being the two first ones the most plentiful. Another order in existence in both basins is the Coniferales with the genera *Brachyphyllum* and *Pelourdea*. For this CA is present the order of the Caytoniales with the *Sagenopteris* genus, meanwhile for the CO the *Mexiglossa* genus was registered (Incerta sedis). In relation to the diversity there is a meaningful difference between the basins, the CO was the least diverse with only half of the genera existent. In both basins, the flora represents a major percentage of foliar areas no bigger than 1.36 cm^2 (Microphyll I) allowing the decreasing plants evapotranspiration. In the base of the CA the percentage relation of the foliar categories by locality indicates the presence of favorable conditions for the development of flora with foliar area Microphyll I, characteristic category of the Bennettitales from the Mixteco Land. Whereas in the top of the CA the category Nanophyll I (*Brachyphyllum*) represents approximately half of the percentage. The floristic list and foliar categories show the establishment of two communities of plants inside the CA. In the CO the second category best represented was the Nanophyll I with the 14% characteristic size of the termophillic genus *Brachyphyllum*, that could have been part of a coniferous forest. The small foliar area showed by the plants in both basins, the red coloration in the rocks that shows oxidant conditions in the CA and the existence of subaerial environment in the CO allow us to propose an environment with high temperatures and low humidity most of the time. Probably there were seasonal rains that allowed the existence of a lacustrine body where organisms of the genera *Pelourdea* and *Sagenopteris* were established at the shore. This paleoenviromental proposal is in accordance for the CA with the interpretation given by Campos-Madrigal et al. (2013) who pointed out dry weather inferred by the presence of alluvial fans, red layers and the lack of coal deposits. Regarding the paleoenviroment of the CO the layering of sandstone from a fine grain to a thick one, where the fossils were preserved, the existence of flood plains and paleosols allow to interpret seasons marked by strong environmental changes.

The genera in existence, the quantity of organisms collected of each one and the different lithologic characteristics for each formation shows the Bennettitales like the generalist plants, distributed in both basins. In the CA conditions for the development of two kind of communities were allowed, one shrubby constituted by the different genera of Bennettitales and other forest where the characteristic genus was the *Brachyphyllum.* Whereas in CO a shrubby community with a lack of tree elements was established.

Key words: Ayuquila, Tecomazúchil, Otlaltepec; Bennettitales; Paleobasins

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Reappraisal of the ammonoid genus *Lytohoplites* Spath, 1925 in west-central Argentina: variability and updated stratigraphic occurrence

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Spath (1925) erected the genus *Lytohoplites* and designated *L. burckhardti* (Mayer-Eymar in Burckhardt, 1900) from the Neuquén Basin, Argentina, as its type species. However, up to date, *L. burckhardti* was poorly known as neither well preserved nor complete specimens were illustrated. Although a Neocomian age was originally envisaged for this genus (Burckhardt, 1900; Gerth, 1925), it was later on included in the Andean upper Tithonian *Corongoceras alternans* Assemblage Zone (*Microcanthum* to *Durangites* Zones) by Leanza (1945). Therefore, the aim of the present contribution is threefold: to present new specimens of *Lytohoplites* from the Neuquén Basin, to analyze the spectrum of morphological variability of *L. burckhardti* and to specify the genus stratigraphic occurrence in Argentina.

Methodology included the study of more than 70 specimens retrieved from four bed-by-bed sampled cross-sections of the Vaca Muerta Formation in the southern Mendoza sector of the Neuquén Basin. Measurements were arranged in a digital matrix of quantifiable shell characters, while bivariate plots, whorl cross-sections and suture lines sketches were also produced. As a result, two species of *Lytohoplites* were recognized: *L. subcylindricus* Collignon, 1962 and *L. burckhardti* Mayer-Eymar. The former, which is recorded for the first time in Argentina, is represented by a single small subevolute specimen, with a narrow furrowed venter and well-spaced single ribs bearing pointy lateral tubercles and ventral projected clavated spines over the last whorl. The later species encompasses the rest of the specimens, most of which correspond to macroconchiate shells of moderate final size (estimated at 80 mm in diameter). Macroconchs assigned to *L. burckhardti* are discoidal, ranging from subinvolute to subevolute, and show a broad and furrowed venter and a simple peristome. Simple ribs outnumber bifurcated ribs and both are variably sickle shaped over the external third of the flanks on middle and outer whorls where intercalar ribs and secondary ribs looping are more frequent. Pointy to rounded lateral and ventral to lateroventral tubercles are set over the last whorls, but not periumbilical swellings can be appreciated. Potential microconchiate specimens are of smaller size (estimated at 45-50 mm), discoidal and weakly compressed since inner whorls and with narrow-based lappets, as observed in one specimen. Their venter is narrower and falcoid ribbing is usually restricted to the upper third of the flank of the last portion of the phragmocone and over the body chamber. Simple ribs are also more frequent than bifurcated ribs and bear pointy to rounded lateral and ventral tubercles on outer whorls and body chamber. Intercalar ribs are not common but some secondary ribs loops do occur.

The intraspecific morphological variability observed in *L. burckhardti* can be accommodated in a tripolar spectrum concerning modifications in height to width whorl ratio, shell evolution, ribbing intensity and/or tubercle ontogenetic setting. Extreme morphologies, including compressed, robust and slenders variants, are connected by an arrange of transitional morphotypes, between which the one portrayed by the species *L. vetustoides* (Burckhardt, 1903) can be positioned.

Both *L. subcylindricus* and *L. burckhardti* specimens were found in beds assigned to the Andean *Substeueroceras koeneni* Assemblage Zone (*Durangites* to *Jacobi* Zones) and, in at least two localities, in association with *Corongoceras alternans* (Gerth, 1925) and *Micracanthoceras inaequicostatum* (Gerth, 1925). These findings not only suggest a late Tithonian to early Berriasian age for the genus *Lytohoplites* in the Neuquén Basin but also challenge its hitherto assumed biostratigraphic condition as a component of the earlier Andean *Corongoceras alternans* Assemblage Zone.

Keywords: Late Jurassic; Early Cretaceous; Neuquén Basin; Vaca Muerta Formation.

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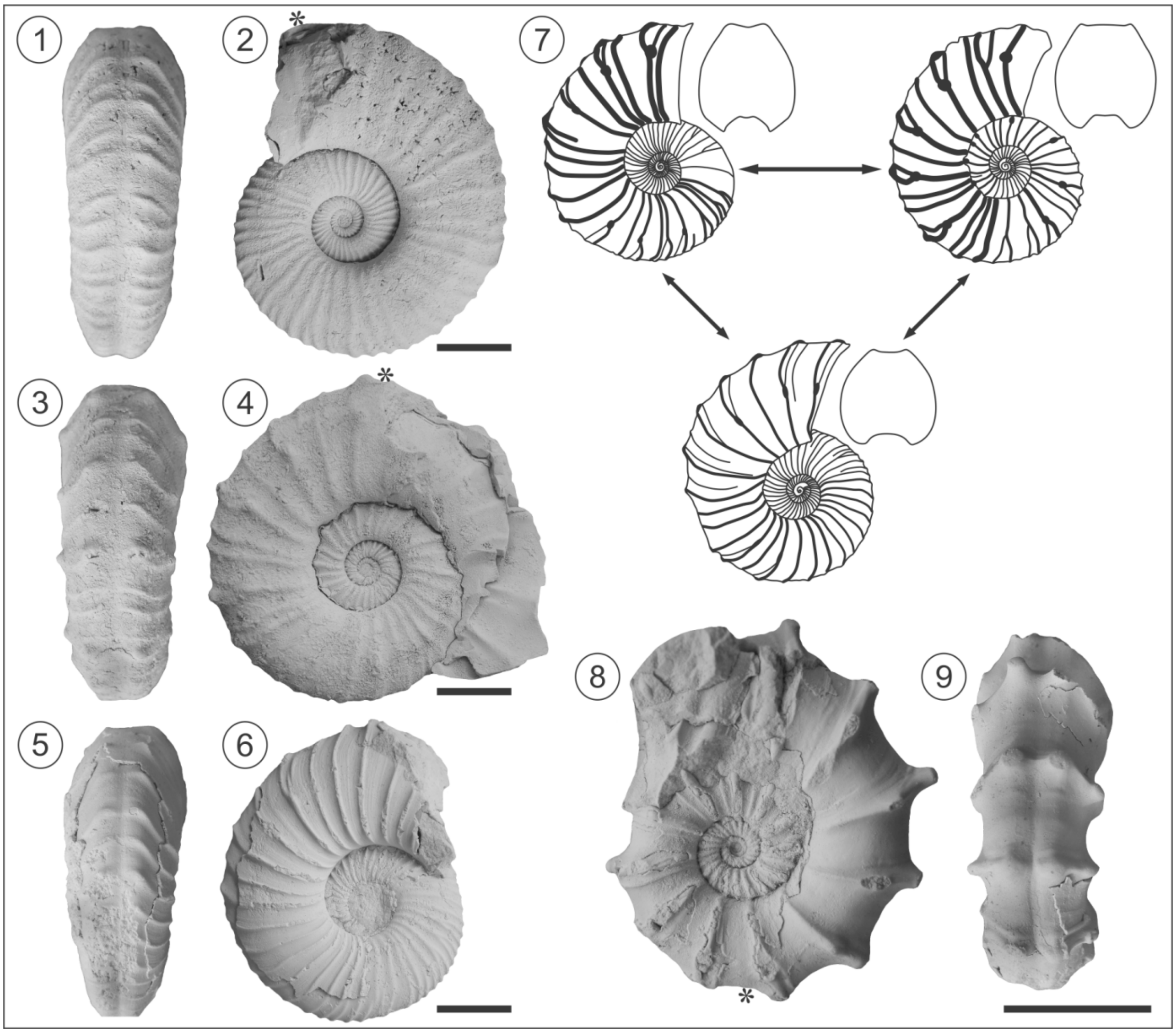

Figure caption:
1-6, *Lytohoplites burckhardti* (Mayer-Eymar); **1-2,** MCNAM-PI 24597, compressed variant, **1,** ventral view, **2,** right lateral view; **3-4,** MCNAM-PI 24598, robust variant, **3,** ventral view, **4,** left lateral view; **5-6,** CPBA 24636.4, slender variant, **5,** ventral view, **6,** left lateral view; **7,** scheme depicting the tripolar morphological variability observed in phragmocones of *L. burckhardti*, upper left: compressed variant, upper right, robust variant, down, slender variant; **8-9,** *Lytohoplites subcylindricus* Collignon, **8,** right lateral view, **9,** ventral view. The asterisks indicate the beginning of the body chamber. **1-6** at 1x, scale bar= 1 cm. **8-9** at 2x, scale bar= 1 cm.

Biostratigraphy of the middle-upper Jurassic deposits in Oaxaca (Mexico)

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Jurassic deposits in Oaxaca have been studied for many years, however, the correlation between them are already under the scope of recent multidisciplinary studies. Continental deposits are well known by their content on fossil plants, however palynology is a more accurate tool for biostratigraphical purposes. This work is focused on the palynological study of the Jurassic Otlaltepec Formation from Otlaltepec Basin in the northern Oaxaca, which corresponds to a braided depositional system. Previous palynological studies in Oaxaca were reported from the Todos Santos Formation and from Conglomerado Prieto and Cualac formations near Tezoatlán of Tlaxiaco Basin (Jiménez-Rentería, 2004; Rueda-Gaxiola, 2009), so this study corresponds to the first palynological work from Otlaltepec Formation and Otlaltepec Basin.

Objective

The objective of the present work was to determine the age of the Otlaltepec Formation and indirectly also the unconformities associated to this deposit in order to a better understanding of the stratigraphic history of the Otlaltepec Basin.

Methodology

Ten samples were processed with standard palynological techniques (Erdtman, 1943), from which only three were positive. The spores and pollen grains were studied under BX50 Olympus optical transmitted light microscope. More than 400 specimens were counted for each positive sample.

Results

A total of 83 morphotaxa were found. Gymnosperm pollen morphotaxa (mainly *Inaperturopollenites*, *Spheripollenites* and *Araucariacites*) comprise approximately half of the total specimens, but also spores are abundant and rarely acritarchs and algal spores. There are some indicative key taxa present in herein studied palynological assemblage such as: *Aratrisporites minimus* whose first appearance datum is at the Hettangian; genera *Leptolepidites* and *Manumia* appear at the Pliensbachian-Toarcian boundary; and other key genera that appear in the early Toarcian age are *Ischyosporites* and *Klukisporites* (Dybkjaer, 1991). Although the biostratigraphic range of *Leptolepidites bossus*, which has been observed in our samples, is from late Toarcian to Middle Jurassic in Greenland (Lund and Pedersen, 1985), it has been reported in the Bajoacian-Bathonian in Northern Western Desert in Egypt (El-Beialy et al., 2002). The latter seems to be a more accurate biostratigraphical data for these deposits due to closer paleogeographic location at that time, and also a Bajocian age (167 ± 4 Ma) was reported from U/Pb study in the same deposit (Martini et al. 2016).

Conclusions

Studied palynological assemblage together with geochronologicak data support a middle Jurassic age for Otlaltepec Formation in Santo Domingo de Tianguistengo (Oaxaca, Mexico).

Key words: Jurassic; continental biostratigraphy; pollen; Mexico

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Mexican *Kossmatia* -historical review and proposed revision

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C. Burckhardt (1912) introduced the use of the taxon name *Kossmatia* for Latest Jurassic ammonites collected from north-central Mexico, improving the knowledge about the new taxa announced by Uhlig five years earlier (1907), when reporting the relevant contribution made by C. Burckhardt (1906) to the Field Guide in the 10th International Geological Congress held in Mexico the same year. Only two years after the formal proposal of the new genus *Kossmatia* Uhlig, 1910 to embrace four species of late-Middle and Upper Jurassic ammonites showing ventral projection of ribs, Burckhardt reinterpreted the mere, original morphologic meaning proposed by Uhlig (1910).

Burckhardt (1912) used *Kossmatia* for some of his Upper Portlandian ammonites from Mexico, including four species he previously described from Mazapil (Burckhardt, 1906), and some other erected by Aguilera from Sierra de Catorce (Del Castillo and Aguilera, 1895). Burckhardt (1912, 1930) provided detailed descriptions and biostratigraphy in accordance with the highest standard of geological science at the time. Burckhardt's contribution determined taxonomic stability to the taxon *Kossmatia* while other Tithonian perisphinctids reported from Mexico were submitted to diverse interpretations through time –e.g., *Perisphinctes*, *Aulacosphinctes*, *Aulacosphinctoides*, among others.

After Burckhardt, authors studying Mexican *Kossmatia* from the mid twenty century onwards mainly referred first to the Upper Portlandian, and then to the Upper Tithonian. Verma and Westermann (1973) first approached the paleobiological interpretation of Mexican *Kossmatia,* and only few reports refer to Mexican *Kossmatia* occurring in the upper Lower Tithonian (two-fold division) or Middle Tithonian (three-fold division) before the past 90s. The wide sense used for interpreting the genus *Kossmatia* continued during the past 90s, in parallel to informal proposals for a more restricted interpretation on the genus.

Partial reconsideration of Mexican *Kossmatia* occurred in the early 90s with separation of a single species to erect the new genus *Fierrites* Cantú-Chapa, 1993, while the first contribution to precise biohorizon biostratigraphy for Mexican *Kossmatia* species collected from a type section in Sierra de Catorce was made in the lastest 90s, endorsing its record from Tithonian horizons below the Upper Tithonian. Early during the 21th century, regional analyses of circum-Pacific ammonite assemblages maintained the wide sense applied to interpreting *Kossmatia*, Mexican *Kossmatia* included.

During the late 90s, an emerging alternative of revision of genus Kossmatia can be identified in authors working on Himalayan ammonites, who progressively introduced doubts about the true meaning of Mexican *Kossmatia* among others. Some

years ago, Enay (2009) finally proposed the restricted use of the genus *Kossmatia* to interpreted assumed earliest Tithonian ammonites from the Himalayas.

The present research provided an updated revision of Mexican *Kossmatia*, and allied forms, based on bed-by-bed sampling and the revision of the type material available. Two new genera are erected, and interpreted as endemics of the southern North American Plate since no records of *Kossmatia*-like ammonites can be proved from Cuba and northwestern South America.

Key words: *Kossmatia*; Tithonian; Mexico

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Shell beds and paleoenvironmental conditions: a case study from the Upper Kimmeridgian in the north-central Mexico

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Shell beds are fossiliferous deposits reported under a variety of names such as *condensed beds, coquinite*, *lumachelles*, *fossil concentrations, fossil-rich horizons*, etc., which have received increasing attention by paleontologist and sedimentologists. *Shell beds*' analyses base on the informative feedbacks from stratigraphic, sedimentologic and paleontologic data, the later including special contribution from taphonomic observations. In Mexico, reports of precise description and analysis of shell beds are scarce, and no case-study had been noticed from the Upper Jurassic.

As a preliminary approach to this topic in the Mexican Upper Jurassic, we worked-out a sub-section 410 cm thick belonging to the upper Kimmeridgian at the Cañón de San Matias, Zacatecas. There, contrasting paleoenvironmental interpretations were proposed for Kimmeridgian deposits in terms of dissaerobic-poikiloaerobic shelf deposits (De la Mora *et al*., 2000) and slope-to-basinal deposits at batial-to-abisal depths (Pessagno & Martin, 2003).

To exemplify with a case of a rather "obscure" discontinuous sedimentation approaching the paleonvironmental context that forced such a depositional pattern, we focused on gray-to-pinkish siltstones with intercalated dark-gray concretionary, phosphoritic silty-limestones. A sampling strategy conducted on the centimeter scale provided with 1175 macrofossil remains, which were obtained under the control of both precise biostratigraphy and relative position. Bed geometry, thickness, and fabric or internal organization were also taken into account, complemented with transmitted-light microscope analysis.

Mollusk remains overwhelmingly dominate among macrofossils (above 72% of epicontinental ammonites with secondary bivalves and occasional gastropods); rare brachiopods are present. Under microscope, floatstones-to-wackestones with calcisiltite matrix of coarse-to-medium silt size, floated skeletals, and patches of bioclastic packstone show microfossils of silt-to-fine sand size such as articulate bivalves, which locally clearly dominate over radiolarian, calcispheres, ammonitellas, and "filaments". In addition, floatstones-to-wackestones of radiolaria also include scarce dinoflagellate cysts and rare small benthic forams –a single arm's ossicle of *Saccocoma* was identified by the first time in the area. Remains of macrofossils are locally common in thin-sections. Neither *microboring* nor epibionts were identified. Mainly low energy deposits in neritic depths well adapt the fossil content in accordance with depths above the assumed implosion depths for ammonites, as well as with paleoecological approaches based on combined records of ammonites and bivalves.

Ammonite biostratigraphy at the zone-subzone level indicate a stratigraphic interval with imprecise potential correlation within the Eudoxus Zone of the Upper Kimmeridgian in the European standard. Thus, eco-sedimentary processes of high-frequency during a relatively short-time interval must be involved and are advocated to explain shelly accumulations.

Bed geometry was mainly planar for siltstones while phosphoritic, silty limestone beds are concretional. Bed thickness for more calcareous beds shows values greater than 15 cm (10%) while related siltstones are 10-15 cm thick (20%), and overlying tabular siltstones are 5-10 cm thick (40%) y less than 5 cm thick (30%). Combination of relatively "higher" and mainly low energy conditions with common erosions/omissions are coherent with planar stratification, while episodes of higher energy would relate to deposition phosphoritc sediments with probable contribution of upwellings and resulting in concretional-to-irregular beds.

The macroscopic fabric or internal organization shows dominant parallel lamination in siltstones, and discontinuous shelly horizons with local record of subtle oblique lamination and more common patches of caotic settlement of skeletals in phosporitic beds. In the latter, five types of fossil-rich deposits were identified as *shell beds* and *pavements* (s. Kidwell *et al*., 1986). They are interpreted as variations of an elemental, genetic sequence showing three members in response to vanishing energy in eventites (s. Seilacher, 1982). The record of these *shell beds* indicated discontinuous deposition, which forced a discontinuous stratigraphic record, in this case clearly below biostratigraphic resolution. The ultimate factors controlling these epicontinental deposits showing a subtle record of sedimentary structures were short-term, high-frequency fluctuations in relative energy affecting a distal setting in the proximal sector of the outer shelf, close the storm wave base. In this context, the studied *shell beds* cannot be merely interpreted/described as *condensed beds*.

Key words: Eventites, shell beds, Upper Jurassic; epicontinental; paleoenvironment.

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Early-Middle Jurassic Inception of the Gulf of Mexico in Tlaxiaco Basin, Oaxaca, Mexico

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The first stage in the rift phase of the Gulf of Mexico started with the uplifting of cratonic blocks in the actual central part of the Gulf of Mexico, which caused an erosion of these terranes causing the deposit of these materials in the Tlaxiaco Basin, in Oaxaca, Mexico. Petrographic analysis of sandstone provenance supports that Cuarcítica Cualac, Zorillo and Taberna formations had a continuous supply of material from an ancient craton. However, for Cuarcítica Cualac formation a second provenance from a recycled orogenic source is shown as well. According to paleogeography and lithologic units’ distribution, two paleotopography highs in Early Jurassic, close to Tlaxiaco Basin have been inferred, the Grenvillian terranes as part of ancient North American craton which in the actual central part of the Gulf was uplifted due to the Hotspot that break up the craton and Caledonian-Appalachian orogenic belt, whose domain in the supply of sediments in the basin was displaced when started the supply from Grenvillian terranes.

Grenvillian terranes could have been the most important units that provided sediments for the studied sequence due to great amount of metamorphic quartz and metamorphic rock clasts presence. In Mexico, Oaxacan Complex is the closest metamorphic lithological unit to our studied area whose origin have been related to Grenvillian Orogeny from Middle-Late Proterozoic Age, which during Paleozoic-Mesozoic times could became internal part of the ancient North American Craton. This ancient craton was eroded during the early formation of the Gulf of Mexico and provided great amounts of sediments to Jurassic sequences in the Tlaxiaco Basin through fluvial currents.

On the other hand, Caledonian-Appalachian Orogen formed during the Paleozoic could have been a secondary tectonic source for studied formations, mainly for Cuarcítica Cualac Formation owing to ternary diagrams showing an influence of recycled orogenic source. Close to our studied area, the Acatlán Metamorphic Complex is the stratigraphic unit whose tectonic evolution has seen related with this orogeny, hence, a possible supply of sediments from this complex cannot be ruled out. This orogeny also could have provided sediments for the Consuelo Group insomuch as a recycled orogenic as tectonic provenance has been inferred as well. This source could indicate a domain provenance during Hettangian-Pliensbachian times of these tectonic terranes.

The tectonic provenance and transitional environments determined in this study permits to relate the Early-Middle Jurassic tectonics events to sedimentological sequences proving how the hot spot that originated the opening of the Gulf of Mexico, caused an uplifting and the erosion of the ancient craton bringing about a great discharge of sediments in a short time, which in turns, originated the deposition of the studied sequence and other similar sequences in the north of Mexico.

Through a sedimentological analysis based on lithofacies description and facies association, braided fluvial, estuarine and shallow marine platform environments have been determined for Cuarcítica Cualac, Zorrillo and Taberna formations respectively. The braided fluvial environment can show the great discharge from the Grenvillian terrane which was deposited in the Tlaxiaco Basin, which in turns, was submitted to a continuous subsidence. In this study, we link the main process which cause this transitional sequence, so that, the transition from braided currents to estuarine environment can be explained taking into account the sedimentary models for fluvial systems and associated discharge, whereas the sedimentary cycles of deposition-abandonment of sedimentation and transgression-subsidence can explain the transition from estuarine to shallow platform of Zorrillo and Taberna formations, along with Simón and Otatera formations form the Middle Jurassic transgressive cycle in Tlaxiaco Basin. These events indicate the beggining of a marine invasion in the central part of Mexico through the “Hispanic Corridor” which has been determined, in other studies, by the presence of ammonites with Pacific and Tethysian affinities inside Taberna Formation. During Middle Bajocian, marine invasion continued and caused the Taberna Formation deposition; in this sequence the occurrence of *Humphriesianum* and *Subfurcatum* (Westerman, 1981; Gómez Alvarez et al., 2012) biozones show a coexistence of ammonites from Pacific affinity and Tethysian affinity. This ammonites coexistence has allowed to propose the existence of Hispanic Corridor during Early Bajocian, which was formed and flowed in the center of Mexico and connected Tethys and Pacific oceans. However, an ancient connection has been proposed by other authors for the Sinemurian, so that, this Bajocian connection would be the second connection in the case of the previous one is confirmed.

According to theoretical models, a rift phase starts with an uplifting and crustal thinning leading to clastic sediments in alluvial fans, river valleys (our case) and lakes, with horst erosion and grabens filling. This model could explain perfectly the sequence of events, which starts with a doming-rifting phase during Early-Middle Jurassic with the deposition of the sequence studied and lately, continues with the seafloor spreading at Late Jurassic.

Key words: Ancient craton, Hotspot, Hispanic Corridor, Marine transgressions.

End-Triassic losses and Early Jurassic (Toarcian) extinction of the last two spire-bearing brachiopod orders (Spiriferinida and Athyridida)

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Brachiopods were severely hit by several mass extinctions which fundamentally shaped their long evolutionary history. After the devastating end-Permian extinction, the fate of the four surviving orders differed significantly during the Triassic and Jurassic. Two orders, the rhynchonellids and terebratulids are extant today, whereas spiriferinids and athyridids, which possess spiral brachidia, suffered heavy losses at the end of Triassic and became extinct in the Early Jurassic (Toarcian) Jenkyns Event. Although the doom of the spire-bearing orders has been thought to be related to physiological traits, extinction selectivity across the end-Triassic and Toarcian event has not been rigorously assessed previously, and the reasons for their demise at the later and lesser Toarcian Jenkyns Event, rather than at the first and greater end-Triassic crisis remained unexplored. Using primarily the Paleobiology Database, we constructed diversity curves, estimated taxonomic rates, and assessed the temporal changes in geographic distribution of the two spire-bearing and two other orders in the Triassic-Jurassic interval. After shared trends and similar origination rates in the post-Permian recovery leading to a Late Triassic diversity maximum, the end-Triassic extinction was selective and preferentially hit the spire-bearers. In contrast to the rebound of rhynchonellids and terebratulids, spire-bearers failed to recover in the Early Jurassic and their repeated selective extinction at the Toarcian Jenkyns Event led to their final demise. The end-Triassic event also terminated the worldwide geographic distribution of spire-bearers, confining them to the Western Tethys, whereas the other groups were able to reestablish their cosmopolitan distribution. The morphologically diverse spire-bearers represent specialized adaptation, which further increased their extinction vulnerability compared to the other groups with conservative biconvex shell morphology. Another key difference is the physiological disadvantage of fixed lophophore and passive feeding of spire-bearers, which became critical at times of increased environmental stress. The spire-bearing spiriferinids and athyridids were “dead clades walking” in the Early Jurassic and their disappearance in the Early Toarcian represents the last major, high-level extinction event for the brachiopods.

Key words: extinction, Toarcian, end-Triassic, brachiopods

Regional stratigraphic scheme of the Middle (Callovian) and Upper Jurassic of the Russian part of Caucasus (author's version): problems and prospects for their solution

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The official regional stratigraphic schemes of the Caucasus were published by Rostovtsev & Krymholtz (1984). The more modern schemes were proposed in the fundamental book «Jurassic of Caucasus» (1992), but in a non-official scheme. The creation of a new generation of maps of the scales 1:200 000 and 1:1 000 000 in Russia makes it necessary to improve the official regional stratigraphic schemes.

The new prepared scheme and explanatory note were written in accordance with data published after the adoption of the last stratigraphic scheme (Rostovtsev & Krymholtz, 1984) for the given territory and based on the modern results of the geological survey. Unlike the last published scheme, in the new scheme the regional biozonal scale for ammonites has been updated, regional divisions have been introduced, biozonal scales for brachiopods and bivalves have also been presented, and the distribution of foraminifer zones and local zones has been shown for almost on all Caucasus. The explanatory note briefly describes the mentioned biozonal scales, as well as the peculiarities of the distribution of Middle and Upper Jurassic in various parts of the Caucasus, introduced some local stratigraphic subdivisions that are actively used in the creation of modern geological maps of the scales 1:200 000 and 1:1 000 000.

This work is a contribution to the IGCP 632.

Key words: Jurassic; biostratigraphy; Caucasus

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General stratigraphic scale				**Ammonites biozonal standart**		**Subregional stratigraphical units**			**Paleontological characteristic of the subregional units**				
				Biostratigraphie du Jurassique Ouest-Europeen et Mediterraneen, 1997; The Jurassic of Denmark and Greenland, 2003		**Horison** Jurassic of Caucasus, 1992			**Ammonites**	**Foraminifers**			
System	**Series**	**Stage**	**Substage**			Scythian epihercynian plate	Folded zone of the Great Caucasus	Transcaucasian massif	Jurassic of Caucasus, 1992; Biozonal stratigraphy..., 2006	**Western Caucasus and Precaucasus** Hofman,1967; Azbel, Grigelis, 1991; Vuks, 2005, 2007, 2012			**Central and Eastern Caucasus** Makar'eva, Matsieva, 1985; Azbel, Grigelis, 1991
Jurassic	**Upper**	**Tithonian**	**Upper**	*Durangites vulgaris*		**Matlam**	**Babadag**	**Tskhanari**	no ammonites	***Anchispirocyclina jurassica-Lenticulina ponderosa*** **local zone**	***Melathrokerion spirialis*** **local zone**		***Quinqueloculina verbizhiensis - Trocholina elongata*** **zone**
				Micracanthoceras microcanthum	*Paraulacosphinctes transitorius*				*Paraulacosphinctes transitorius* local zone			***Spirillina*** **cf.** ***kuebleri*** **local zone**	**no foraminifers**
					Simplisphinctes				*Lithacoceras albulus* local zone				***Trocholina*** **ex gr.** ***solecensis - Textularia densa*** **local zone**
			Middle	*"Micracanthoceras" ponti*		**Balta**							**local zone is not established**
				Semiformiceras fallauxi									
				Semiformiceras semiforme					*Lithacoceras ulmense* and *Glochiceras nimbatum* local zone				
			Lower	*Virgatosimoceras albertinum*									***Trocholina friburgensis*** **local zone**
				Hybonoticeras hybonotum									**local zone is not established**
		Kimmeridgian	**Upper**	*Aulacostephanus autissiodorensis*					no ammonites	***Alveosepta ukrainica?*** **local zone**	***Alveosepta jaccardi*** **local zone**	***Marssonella doneziana - Ophthalmidium strumosum*** **local zone**	
				Aulacostephanus eudoxus									***Alveosepta jaccardi - Mesoendothyra izjumiana*** **zone**
				Aulacostephanus mutabilis					*Aspidoceras* and *Idoceras* local zone				
			Lower	*Rasenia cymodoce*									
				Pictonia baylei		**Ironskii**			*Sutneria platinota* local zone				
		Oxfordian	**Upper**	*Ringsteadia pseudocordata*					?				***Nubeculinella gigantocamerata - Quinqueloculina frumenta*** **local zone**
				Perisphinctes cautisnigrae					*Perisphinctes cautisnigrae* local zone				
			Middle	*Perisphinctes pumilus*					?				
				Perisphinctes plicatilis				**Tsesi**	*Perisphinctes plicatilis* local zone				
			Lower	*Cardioceras cordatum*			**Kvarelskii**		*Cardioceras cordatum - C. vertebrale* local zone				***Marssonella jurassica - Trocholina transversarii*** **local zone**
				Quenstedtoceras mariae									
	Middle	**Callovian**	**Upper**	*Quenstedtoceras lamberti*					*Quenstedtoceras lamberti* zone	?	***Labalina costata-Lenticulina tumida*** **local zone**		***Lenticulina tumida*** **zone**
				Peltoceras athleta					*Peltoceras athleta* zone				
			Middle	*Erymnoceras coronatum*		**Kamennomostskii**			*Erymnoceras coronatum* zone				***Labalina costata*** **zone**
				Kosmoceras jason					*Kosmoceras jason* zone				
			Lower	*Sigaloceras calloviense*					*Sigaloceras calloviense* and *Macrocephalites macrocephalus* local zone		***Haplophragmium coprolithiforme*** **local zone**		?
				Proplanulites koenigi									***Recurvoides ventosus - Pseudonodosaria terquemi*** **zone**
				Macrocephalites herveyi									

Fig. 1. Fragment of the regional stratigraphic scheme of the Middle (Callovian) and Upper Jurassic of the Russian part of Caucasus (author's version)

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Early Jurassic volcanic arc successions in western San Luis Potosí, Mexico

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Introduction: In the Mesa Central, north-central to northeastern Mexico, the oldest rocks exposed are sedimentary and volcanic rocks interpreted as stratigraphic and paleogeographic remnants of the ancient western Margin of Pangea during the latest Triassic-Early Jurassic time. However more geochronology as well as petrographic and geochemical studies are needed to correlate between the several localities and to interpret more properly a tectonic setting for each stratigraphic unit.

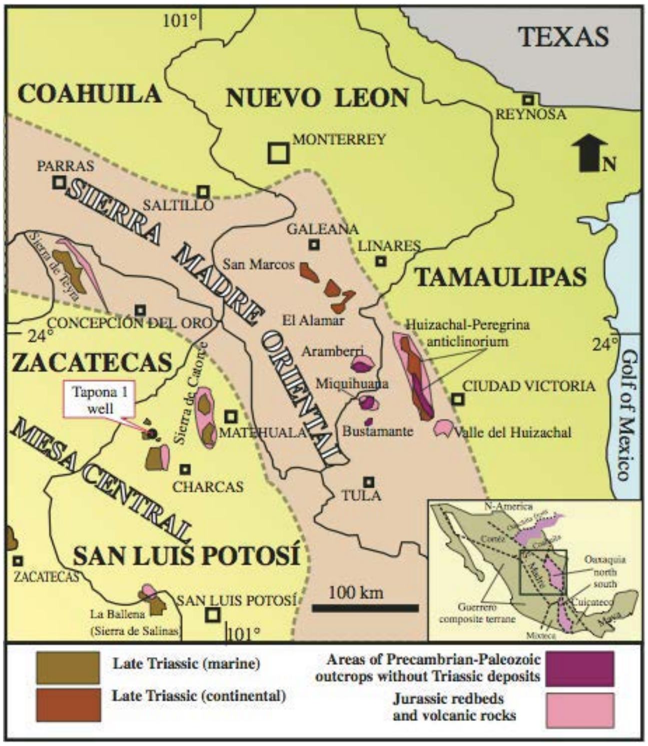

Figure 1: Illustration of the Mesa Central region and the Sierra Madre Oriental. The three study areas (La Ballena, Charcas and Real de Catorce) are shown by arrows. Map taken from Barboza-Gudiño et al. (2010).

Objective: The main goal of our research is to characterize and correlate Late Triassic to Early Jurassic sediments and volcanic rocks outcropping in several localities of the Mesa Central province.

Methodology: Different analytical methods including petrographic analysis, geochemistry, heavy mineral analysis and U–Pb geochronology in zircons are employed on samples taken in Sierra de Catorce, Sierra de Charcas and Sierra de Salinas, in San Luis Potosí and Zacatecas states.

Results: The results obtained from the petrographic analysis show that the analyzed sediments are composed of monocrystalline and polycrystalline quartz, chert, feldspar and volcanic fragments. The occurrence of volcanic fragments is a key observation and leads to the separation of the samples into sediments without or with minor amounts of volcanic fragments and sediments with more than 10% volcanic fragments. Both groups predominantly illustrate a recycled orogen provenance.

Due to the advanced weathering conditions in central Mexico and the mobility of major elements during weathering, trace element analysis is considered more reliable than major element analysis. Employing trace element ratios (e.g., Zr/TiO2 vs. Nb/Y) the volcanic rock samples are identified as dacite and rhyolite. The upper continental crust-normalized multi-element diagrams primarily provide that the sediments with and without volcanic fragments originated from a felsic to intermediate source. Depletions in Cr and Ni including the majority of the analyzed samples exclude input from an ophiolithic source. A slight weathering trend for the sediments without volcanic fragments and for those with volcanic fragments can be inferred from the Th/U ratio vs. Th. The Th/Sc ratio vs. the Zr/Sc ratio illustrates low sediment recycling rates in the source area(s).

Generally, the heavy mineral abundances including the majority of the heavy minerals (Pxn Amp, Ep, Spn, Grt, Chl, Tur, Rt, Ant) are scarce in all samples. The low abundances of the unstable heavy minerals might be caused by burial and dissolution. The most frequent heavy minerals occurring in the samples are zircon and apatite. The sediments without volcanic fragments illustrate higher zircon abundances compared to the sediments with volcanic fragments indicating higher sediment recycling rates in the source area(s). Due to the calculated ZTR indices (zircon, tourmaline, rutile), the source area(s) for the sediments without volcanic fragments can be characterized by a greater maturity. Apatite grains decrease from the southeast (La Ballena) towards the northeast (Real de Catorce) either indicating stronger weathering conditions in the realm of Real de Catorce or a source area that delivered detritus exclusively for the realm of Real de Catorce.

The sediments without volcanic fragments can be distinguished from those with volcanic fragments either due to the maximum depositional ages or on the basis of source area characteristics. The sediments without volcanic fragments illustrate maximum depositional ages ranging from Norian to the Hettangian/Sinemurian boundary. Most likely they received detritus from the Amazonian craton (~1780–1300 Ma), the Oaxaquia microcontinent (~1290–900 Ma), Maya (Yucatan–Chiapas), Chortis, Oaxaquia, Coahulia and Florida blocks (~720–450 Ma) and the Permian–Triassic magmatic arc (~300–240 Ma). The Acatlán Complex and the Maya (Yucatan–Chiapas) block are likely source areas for ~445–310 Ma-old zircon grains. The source of the ~240–200 Ma old detrital zircons is uncertain. The sedimentary rocks with volcanic fragments provide maximum depositional ages from the Early Jurassic (Pliensbachian) to the Middle Jurassic (Aalenian, Callovian).

The dominant source areas are the Oaxaquia microcontinent (~1290–900 Ma), Maya (Yucatan–Chiapas), Chortis, Oaxaquia, Coahuila and Florida blocks (~720–450 Ma). Zircon ages ranging from ~200–150 Ma are indicative for detritus from the Nazas arc, which explains the volcanic fragments. The occurrence of Permian–Triassic ages (~300–240 Ma) and Palaeoproterozoic–Middle Mesoproterozoic ages (~1780–1300 Ma) indicate an activity of these sources until the Lower Jurassic.

Conclusions: The most important finding of this study is the occurrence of volcanic fragments in the samples that can be assigned to the Jurassic La Joya Formation. In contrast, the sediments without volcanic fragments are most likely representative for Upper Triassic rocks.

The results obtained from the U–Pb geochronology shows that sediments without volcanic fragments predominantly reveal Upper Triassic or Lower Jurassic maximum depositional ages (Norian–Hettangian/Sinemurian boundary), whereas those with volcanic fragments illustrate Lower Jurassic–Middle Jurassic maximum depositional ages (Pliensbachian–Callovian).

The lack of volcanic fragments and the Upper Jurassic maximum depositional age of the sample of La Joya Formation collected in La Ballena area, possibly indicate that the La Joya Formation might be much younger than previously thought.

In a Charcas profile we measured a succession beginning with volcanic rocks of the Nazas Formation overlain by sediments assigned to the La Joya Formation. During in a second profile volcanic rocks of the Nazas Formation are lacking and sediments with volcanic fragments, assigned to the La Joya Formation unconformable rests on rocks assigned to the Upper Triassic.

The Real de Catorce profile is the most diversified profile. It starts with sediments without volcanic fragments that can be assigned to the Upper Triassic. A maximum age of deposition determined for litharenites outcropping in the middle part of the Cañon General profile yielded a weighted average age of 199.4 ±4.2 Ma, (near to the Triassic-Jurassic boundary). Volcanic rocks of the Nazas Formation and sediments with volcanic fragments of the La Joya Formation overlie these rocks.

Key words: Triassic-Jurassic; sedimentary-volcanic successions, Mesa Central

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Contributions of Petroleum Geology to the Jurassic System knowledge in Southeastern Mexico

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The southeastern region of Mexico encompassing this work comprises part of Veracruz and Oaxaca states, and Chiapas, Tabasco, and Campeche states; and also the continental shelf and continental slope facing the coastal states of the Gulf of Mexico. This vast region forms part of the Mesozoic Basin of the Gulf of Mexico, which began its formation during Triassic by a rifting process which, during Jurassic, separated the Pangea into two continental masses deriving, one to the north, Laurasia and another to the south, Gondwana; with a consequent marine invasion, first, with seas coming from the Pacific domain and later from the Atlantic domain.

The purpose of this work is to show the results of compilation, analysis, integration and synthesis of the main oil exploration works that gave light on the Jurassic System in this region, carried out from the end of the XIX century until 2013, year that marks a milestone in Mexican oil policy. Emphasis is placed on the protagonists (geoscientists, oil companies and educational and scientific institutions) and their technical and economic motivations.

We have defined three evolution stages for Jurassic System knowledge: Recognition Stage; Systematic Exploration Stage; Integration and Renewal of Knowledge Stage.

Recognition Stage (1894 to 1938). Of particular relevance are the works done by geologists of the *Instituto Geologico de Mexico*, such as Sapper (1894), Böse (1905) and Burckhardt (1930); and the reports of Tschopp (1926) and Dreher (1937), geologists of the “El Aguila” Oil Company. The first three authors had as objective to map, to establish the regional stratigraphy with paleontological bases, and to record useful observations for exploration of natural resources; particularly in the areas of the Isthmus of Tehuantepec and the area of Chiapas State on the border with Guatemala. Thus, the oldest Mesozoic rocks of southeastern Mexico were described as red beds of the Todos Santos Formation and "schistous limestones" of the Mogoñe Formation, both of probable Jurassic-Lower Cretaceous age, in the Isthmus of Tehuantepec. The geologists of the “El Aguila” Oil Company, based on the knowledge of that time, assigned a Permo-Triassic age to salt, as in Germany, Texas, Russia, and Colombia.

Systematic Exploration Stage (1939-1979). Carried out after the Mexican oil expropriation, mainly by geologists, paleontologists and geophysicists of PEMEX Exploration, with the paleontological and petrographic support of the *Instituto Mexicano del Petroleo (IMP)* and to a lesser extent the *Instituto de Geologia-UNAM*. There are several internal reports on this matter, including publications by Alvarez (1950); Benavides (1950); Cornejo (1951); Paz-Rivera (1954), Castillo Tejero (1955); Gutierrez Gil (1956); Gibson (1958); Contreras and Castillon (1960);

Santiago (1962); Sanchez Montes de Oca (1969); Viniegra (1971); Quezada (1975, 1983), Meneses Rocha (1977), among others. To this time corresponds the contributions of Imlay (1956), Richards (1963), Ojeda (1966), and Mulleried (1957). Geological studies of the 50's and 60's mainly dealt with stratigraphy and morphology of the saline domes of *Cuenca Salina del Istmo*. In general, subsequent works describe and analyze with a more regional perspective the age of the salt; and detailed lithology and paleontology of 20-30 sections measured by PEMEX, in northeastern edge of the Chiapas Massif and around the Mixtequita Massif, where the oldest Mesozoic rocks are red beds of Todos Santos Formation, which underlies carbonates of Oxfordian-Kimmeridgian-Tithonian age. Viniegra (1971), based on stratigraphic relations observed in stratigraphic wells in drilling at that time, begins to speculate about a Jurassic age for the salt.

By the end of the 50's, PEMEX had obtained the basic information needed to postulate geological hypotheses that would be tested with stratigraphic wells in structures sketched by gravimetry and surface geology and some of them also with 2D seismology, both in *Sierra de Chiapas* and *Peninsula de Yucatan*. In the early 60's, PEMEX drill a wildcat, obtaining information from Upper Jurassic in Cerro Nanchital Anticline, located at foothills of Sierra de Chiapas. In 1969 and 1973 wildcats extended to the vicinity of Tuxtla Gutierrez and the border with Guatemala with Turipache-1 and Trinitaria-2 wells, to investigate the Mesozoic column and the Paleozoic section that was supposed to be drilled beneath salt (Pre-salt Play).

At the beginning of the 70's, with Rabasa-1 and Gurumal-1 wells, the subsalt horizons (Subsalt Play) were explored to SW of Coatzacoalcos, where Chinameca Formation of Jurassic age is outcropping.

All this information, including subsurface and surface geology, in *Sierra de Chiapas*, combined with seismic information and magnetometry-gravimetry information allowed, in a gradual way but following a logical sequence of exploratory phases, to improve the interpretation of the Jurassic System in the southeast of Mexico, to recognize its economic-petroleum possibilities and to study igneous and metamorphic rocks that form the economic basement of the sedimentary sequence. Thus, the first sketched paleogeographic maps allowed to postulate economic importance of the Jurassic System in *Area Reforma* (discovered in 1972 in Cretaceous rocks), whereupon the first wildcats were drilled with an Upper Jurassic target, such as the well Amatitán-1 (1975), which cut a little more than 1,000 meters of Upper Jurassic calcareous rocks. The information obtained in *Area Reforma* and *Sierra de Chiapas* was crucial to propose that the wildcat well Chac-1, discoverer of the Cantarell Complex (1976), had sufficient depth to reach and to evaluate rocks of Upper Jurassic age. This well cut about 850 m of Jurassic rocks: 100 m of Tithonian limestone, about 450 m of oolitic limestones, dolomites and limolites of the Kimmeridgian and about 300 m of sands, shales and anhydrites of the Oxfordian. Subsequently, these last two intervals would conform first-order oil reservoirs in *Sonda de Campeche*.

Integration and Renewal of Knowledge Stage (1980-2013). The field work decreases; but regional integrations are carried out contained in internal reports of PEMEX and IMP; some papers were published such as Santiago (1980); Meneses de Gyves (1980) and Sanchez Montes de Oca (1980). Among integration and interpretation works not performed by these institutions, the works of Bishop (1980) and Blair (1981) stand out. In the 1980s, regional geological interpretation was influenced by new geological paradigms such as New Global Tectonics and Sequence Stratigraphy that contributed to a better understanding of stratigraphy, paleogeographic reconstructions, history of the evolution of the Gulf of Mexico, geological-structural models and burial history of Tithonian source rocks, in order to reach the best understanding of play concept elements (source rock, reservoir rock, seal rock, trap and synchrony) and to perform the hydrocarbon exploration process more efficiently. With these scientific elements, age of the salt was relocated in Middle Jurassic (Meneses Rocha, 1985, Angeles et al., 1994); and some of these geological concepts could be tested with exploratory wells such Ocotal-1 (1993), drilled in the central portion of the *Sierra de Chiapas*. This well cut about 450 meters of dolomites, limestone and anhydrites of probable Oxfordian age, and anhydrites and limestones of Kimmeridgian age with gas flow.

By the end of the 90's, in collaboration with foreign specialists, PEMEX emphasized the understanding of mechanisms of salt deformation during the Jurassic extension stage associated with the “Yucatan Drift”, and its influence on sedimentation, as well as in its economic-petroleum implications, in the gulf coastal plain, *Sonda de Campeche* (continental shelf) and continental slope; there are several internal reports and some of them published by Gomez-Cabrera and Jackson (2009); Madain Moreno et al (2009); Gonzalez et al (2009) and Miranda et al (2011).

The success of the these three exploratory stages can not only be measured in terms of new exploratory expectations that are opening up in Southeastern Mexico at Cretaceous, Jurassic and older rocks, but also because of the discovery of important hydrocarbons reserves and high production rates, such as in Jujo-Tecominoacan field (1978) and Tsimin-Xux-Kab fields (2009-2010), both producing in oolitic banks facies of Kimmeridgian age; and Ek-Balam field (1991) producing in eolian sands facies of Oxfordian age.

The 2D and 3D seismic acquisition campaigns in onshore and offshore of this region, performed during last 15 years, have allowed to visualize good expectations of northward continuity of the Jurassic plays at the continental slope, because of presence of monticular seismic facies, suggesting shallow water calcareous banks like those of the fields Tsimin-Xux-Kab. This seismic information have been also very valuable for identification of subsalt and pre-saline opportunities located in certain areas of coastal plain, continental shelf and continental slope.

In conclusion, this narrative of Jurassic System knowledge evolution in Southeastern Mexico allows: to highlight who were the protagonists of generating such knowledge; to know and to disseminate the synthesis of this knowledge and its scientific, technical and economic significance; to understand that Oxfordian and Kimmeridgian stratigraphic units contain excellent quality reservoir rocks; to know exploratory opportunities for oil exploration that exist onshore and offshore; and to understand that main source rocks in southeastern Mexico are Tithonian calcareous shale, which have generated almost all hydrocarbons discovered in about 262 oil fields in Mesozoic and Cenozoic rocks, storing an original oil in place around 180 MMM barrels oil equivalent, that undoubtedly have a tremendous economic value generated by the knowledge of the Jurassic System.

Sinistral normal block motion of crustal blocks in southern Mexico during Pangea breakup: new evidence from sandstone provenance analysis of the Tezoatlán Basin

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The structural evolution that accompanied the breakup of Pangea during Jurassic time has been constrained in Mexico only at the regional scale on the basis of global plate tectonics and geometric considerations. According to available regional-scale reconstructions, the Jurassic tectonic evolution of Mexico was characterized by 1) anticlockwise rotation of the Yucatán block along NNW-trending dextral faults and 2) sinistral block motions along W- to WNW-trending faults, which are geometrically needed to avoid the overlap between North and South America in the reconstruction of Pangea. Reports of W- to WNW-trending sinistral faults that were active in Mexico during Jurassic time are presently few, and the existence, extension, and age of some of these structures have been questioned by many authors. In this work, we present the provenance analysis from a Jurassic clastic succession deposited within the Tezoatlán Basin in southern Mexico. Whole-rock sandstone petrography integrated with chemical analysis of detrital tourmaline and U–Pb detrital zircon geochronology documents that the analyzed stratigraphic record was in part deposited during rapid exhumation of the Paleozoic metamorphic rocks of the Acatlán Complex along the Río Salado fault, which is a WNW-trending sinistral normal fault that extends along the northern boundary of the Tezoatlán Basin. U–Pb zircon ages and biostratigraphic data bracket the age of the Río Salado fault between 179 and 170 Ma. This indicates that the Río Salado fault was involved in the crustal attenuation that accompanied breakup of Pangea and that sinistral motion of continental blocks along WNW-trending structures was taking place in southern Mexico as predicted by global plate tectonic reconstructions.

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Key words: Jurassic; Pangea breakup; sandstone provenance; southern Mexico.

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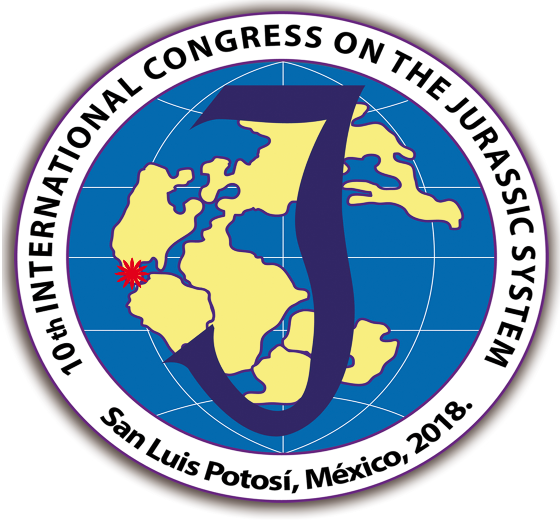
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