PALEOREDOX CONDITIONS DURING THE CENOMANIAN–TURONIAN IN CENTRAL MEXICO AND THEIR RELATION TO OCEANIC ANOXIC EVENT 2

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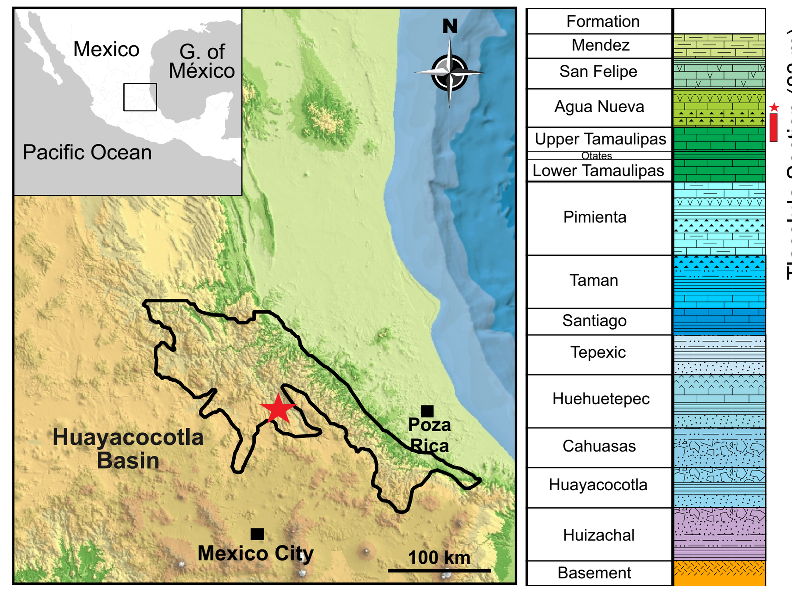
INTRODUCTION

The Cenomanian-Turonian Oceanic Anoxic Event 2 (OAE 2) is an exceptional episode of accelerated global change that produced profound variations in the biogeochemical cycles and evolutionary patterns of several organisms (Föllmi 2012, Kedzierski et al., 2012). In central Mexico (Huayacocotla Basin), the Upper Tamaulipas and Agua Nueva formations contains the Cenomanian-Turonian transition and are mainly constituted by black to dark-gray laminated limestone with interbedded thin layers of shale and bentonite. These units also contain organic matter-rich sediments and pyritic layers. In this study, an integrated approach combining sedimentological, petrographic and geochemical analyses provides information about the paleoenvironmental conditions and their relation to the OAE 2.

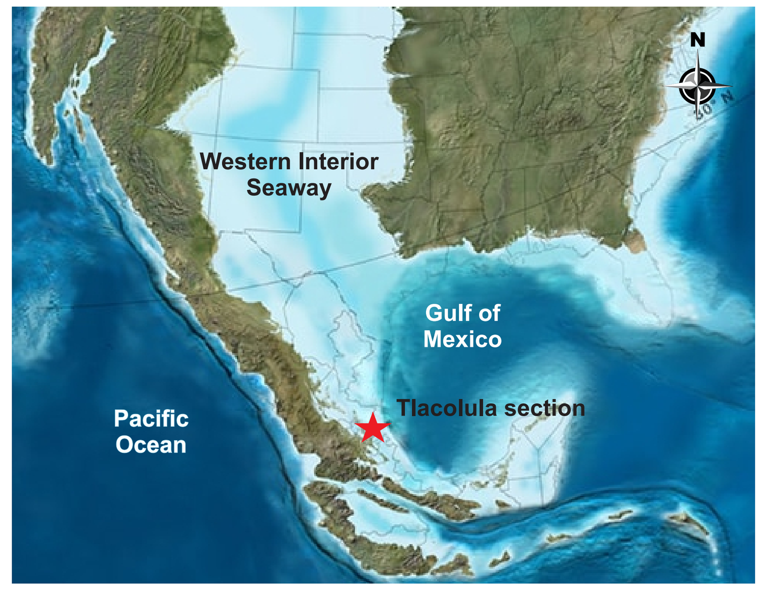
OBJECTIVE

To determine the paleoenvironmental conditions that caused the deposition of organic matter and their relation to the global turnover during OAE 2.

Location of the studied section



Map of central-eastern Mexico with the actual position of the studied outcrop.



Paleogeography and paleotectonics of the Late Cretaceus (Turonian) (Blakey, 2016).

MATERIAL AND METHODS

-Field description and sampling of the Tlacolula section (83 m, 139 samples).
-Microfacies Analysis (139 thin sections; Olympus BX-60 microscope-UNAM).
-Carbonate carbon-isotope data (90 powdered samples extracted from the micrite matrix; Thermo FinniganMAT 253 mass spectrometer-UNIL and UNAM).
-Pyrite sulfur isotope composition (12 pyrite samples, Delta C Finnigan MAT continuous flow mass spectrometer-UPC).
-Concentrations of major and trace elements (117 powdered samples, portable analyzer ED-XRF Niton XL3T and Niton FXL 950-UNAM).
-U–Pb geochronology (1 bentonite sample-33 zircon crystals, LA–ICP–MS spectrometer-UNAM).

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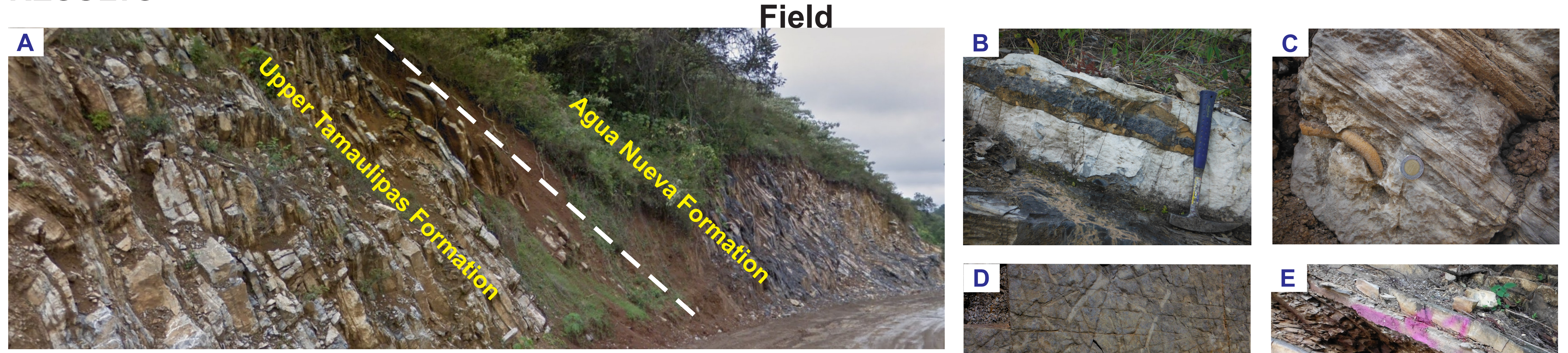
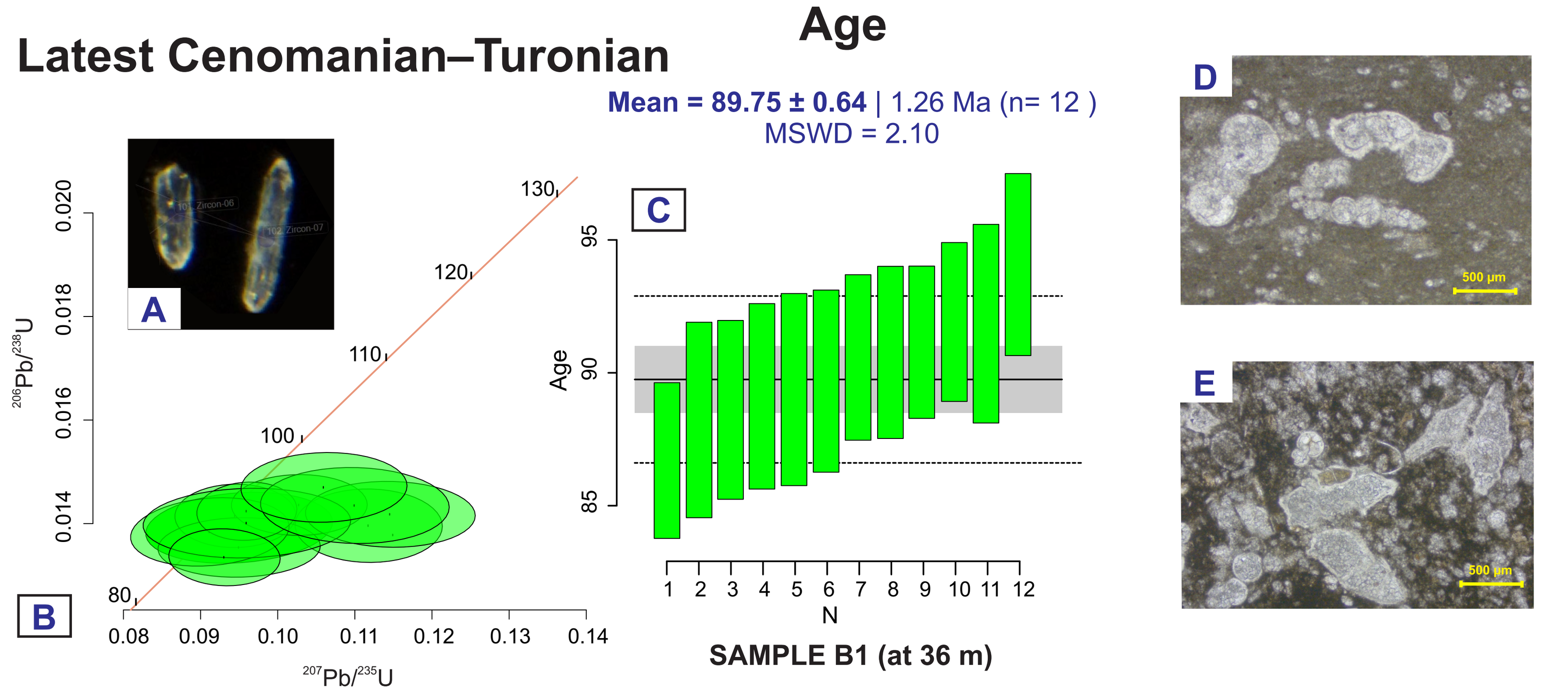
RESULTS

Field



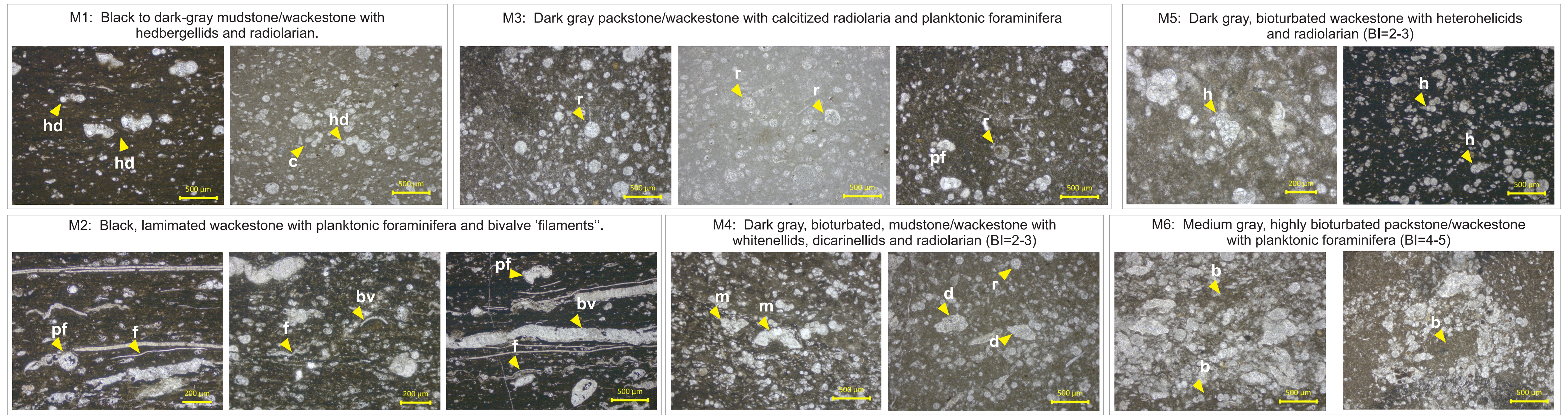
(A) Upper Tamaulipas Formation: Brown limestone with chert nodules, ocassionally intercalated with argillaceous limestone and layers of black chert.
Agua Nueva Formation: Black, laminated limestone bearing chert nodules intercalated with: (1) thin calcareous shale, (2) greenish bentonite horizons, and (3) dark, laminated beds rich in organic matter and pyrite, alternating with bioturbated beds.
(B) Chert nodule
(C) Bedding–parallel burrow filled with pyrite
(D) Burrows on top of the limestone bed
(E) Interbedded limestone and bentonite beds

Age



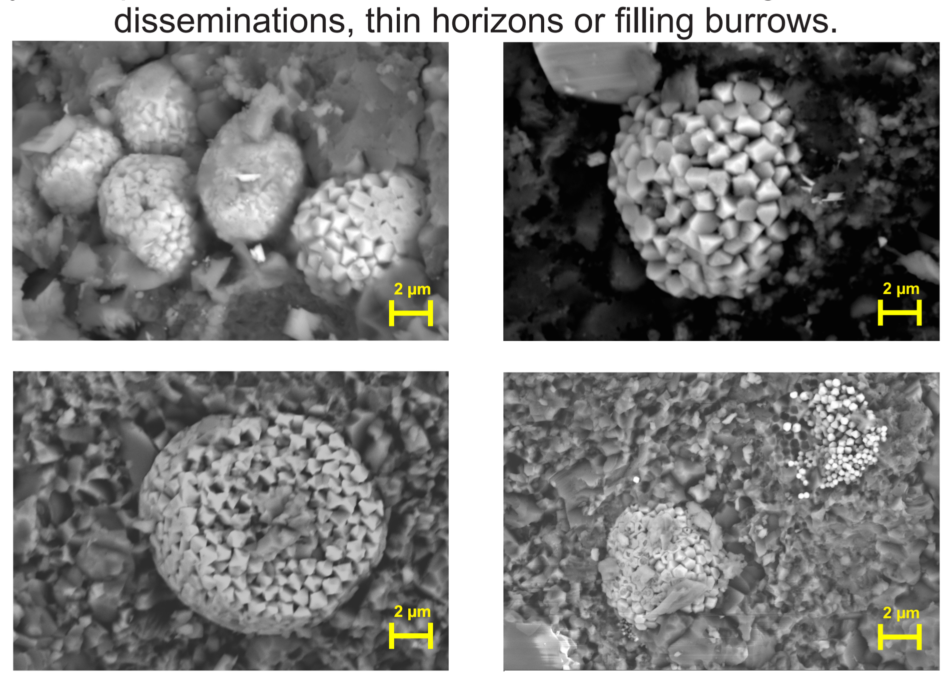
U–Pb geochronology and preliminar biostratigraphic data: (A) Cathodoluminescence images of some zircons, (B) Concordance diagram for the analyzed zircons, (C) Mean age diagram. (D) *Helvetoglobotruncana*, (E) *Marginotruncana*.

Microfacies

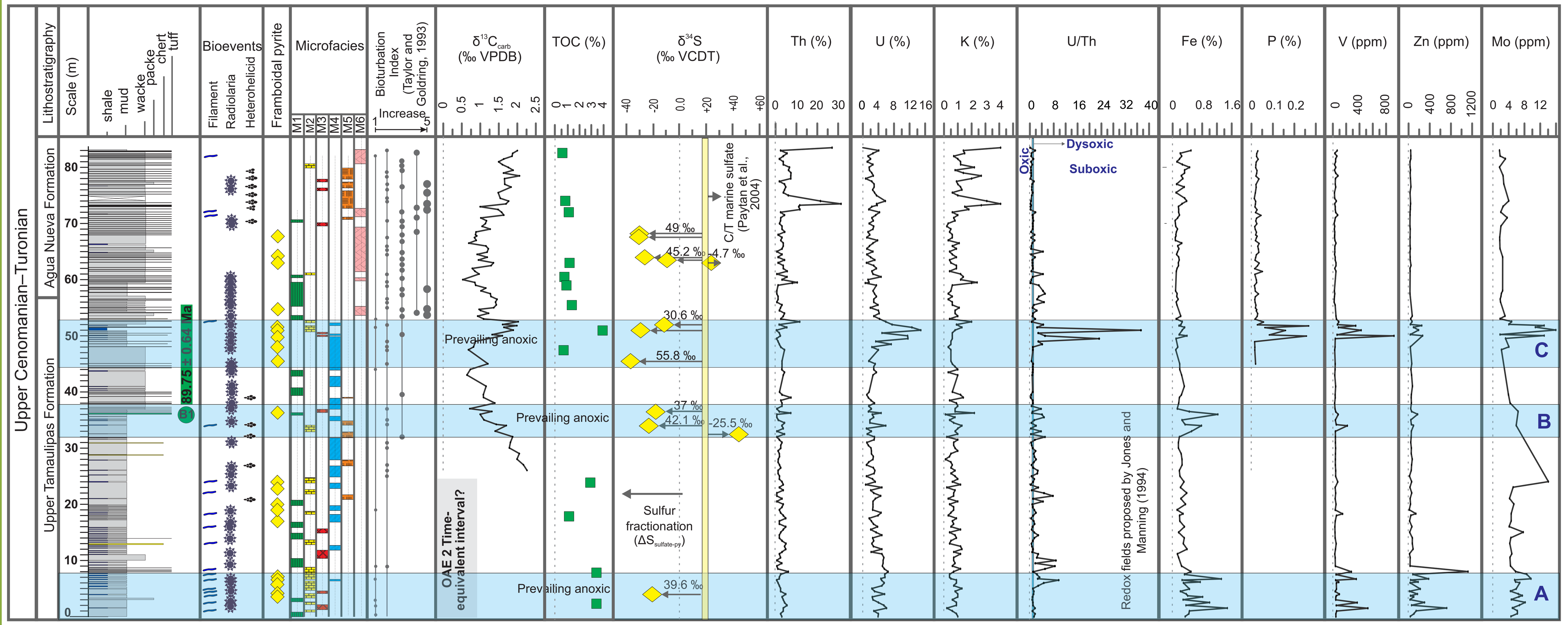


-*Hedbergella* (hd), *Clavihedbergella* (c), *planktonic foraminifera* (pf), *filaments* (f), *bivalve shell fragment* (bv), *calcitized radiolarian* (r), *Marginotruncana* (m), *Dicarinella* (d), *Heterohelix* (h), *and burrows* (b).

Pyrite is present in the form of framboids, occurring as nodules, disseminations, thin horizons or filling burrows.



SEM images showing the main features of the framboidal pyrite. Note the octahedral microcrystals



DISCUSSION AND CONCLUSIONS

The Tlacolula section was constrained by U-Pb zircon geochronology (89.75±0.64 Ma) and preliminary biostratigraphic data to the latest Cenomanian–Turonian. It consists mainly of pelagic mudstone to packestone containing radiolarians, planktonic foraminifera and bivalve filaments, with chert nodules, intercalated with thin calcareous black shale and greenish bentonite horizons.
In general, this section was deposited in reducing environments, as indicated by the trace-metal parameters (Fe, P, V, U, Mo and Zn), the U/Th ratio (mostly above 0.75), the TOC content (up to 3.96 %) and the pyrite framboid size mostly around 2 µm.
At least three intervals can be associated with strongly oxygen-depleted conditions (A, B and C). Indeed, they match with the regular presence of microfacies M2 and M3 (rich in bivalve filaments and radiolaria and poorly bioturbated, BI=1-2) in the lower and middle part of the section suggesting reduced conditions. However, the increase in bioturbation (microfacies M5 and M6; BI=3-5) in the upper part indicates less oxygen deficiency.
Due to its lowermost stratigraphic position, the interval A (lowest 25 m) can be correlated with the OAE 2. It can be associated with the end of the positive carbon isotope excursion (CIE) that characterizes this event. Remarkably, the interval A coincides with a short-time CIE (1.3‰), likely reflecting higher eutrophic conditions.
Oxygen deficiency during deposition on intervals B and C was controlled mainly by local redox conditions inherent to central Mexico. Similar conditions during the early Turonian has been also reported for southern (Mexcala Formation- Guerrero-Morelos Platform; Hernández-Romano et al., 1997; Elrick et al., 2009) and northern Mexico (Indidura Formation-Parras Basin; Duque-Botero et al., 2009). Therefore, a regional control of redox conditions during the early Turonian is suggested for this part of the proto-North Atlantic Basin, possibly associated with the intermittent permanence of a weaker oxygen-minimum zone.
On the other hand, the ^{34}S-depleted values found in the pyrite indicate formation mediated by microbial sulfate reduction (MSR) in an open system with available sulfate, favored by a high organic matter burial and the oxygen-depleted conditions. The calculated sulfate-pyrite fractionation match those found in laboratories by MSR of 4 to 46‰ (Ohmoto et al., 1990; Canfield, 2001).

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