PS Soyatal Formation and Related Strata: Onset of Sedimentation in the Cretaceous Foreland-Basin System, Central Mexico*

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Abstract

Turbidites of the Soyatal Formation and broadly equivalent units represent the beginning of sedimentation in the Cretaceous-Paleogene foreland basin system in central Mexico. The Soyatal is well exposed in the Zimapan Basin, where we identify a transitional contact with the underlying Upper Tamaulipas Formation, which represents basinal deposits equivalent to carbonate platforms (pre-foreland basin deposits) developed during the Early Cretaceous in eastern Mexico. Maximum depositional ages (MDAs) from U-Pb detrital zircon analyses obtained near the base of the Soyatal Formation are correlated with MDAs obtained from exposures of foreland-basin units exposed to the south and to the north. Geographic variation is evident in MDAs of the oldest turbidites. Western deposits of the foreland basin, corresponding to the informal sandstone at Mineral de Pozos exposed 280 km to the NW of Mexico City, consists of sediment-gravity deposits with sandstone olistoliths and angular carbonate and volcanic lithic grains, suggesting a nearby source. This sandstone yielded a weighted mean MDA of 96 ± 1 Ma (MSWD = 1.09, n = 8). Eastward in the basin, a broadly equivalent unit exposed 85 km to the SE, near of Vizarrón, named the Soyatal Formation, consists of sandstone-poor synorogenic turbidites. The stratigraphically lowest sandstone of the Soyatal, collected ca. 15 m above the transitional contact with the Upper Tamaulipas, yielded a weighted mean MDA of 92 ± 3 Ma (MSWD = 1.5, n = 4). A second sample somewhat higher in the section yielded a weighted mean MDA of 93 ± 1 Ma (MSWD = 0.92, n = 3). Eighty km SE of this site, near Tolantongo, an analyzed sandstone contains a dominant population (~90% of total) of Early Cretaceous grains (100-81 Ma) with an MDA of 82 ± 1 Ma (MSWD = 1.04, n = 6). We interpret the observed MDAs to indicate diachronous onset of sedimentation and eastward migration of the foreland basin from Cenomanian to early Campanian time. In addition, the presence of 50% or more zircons with ages of 100-80 Ma suggests that much of the sediment was derived from a contemporary magmatic arc represented by the “La Posta-type” plutons (98-92 Ma) present along the western margin of Mexico. The active arc indicates that retroarc shortening and basin subsidence slightly postdated initial subduction of the Farallon plate, which was already established in the Cenomanian, slightly before the first deposits recorded in the Mexican foreland basin.

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Proposal

The goal of this work is to study the evolution of a foreland-basin system (North Mexican foreland basin; NMFB) linked to the developing "Laramide" orogen in Mexico north of the Trans-Mexican volcanic belt.

Hypothesis

1. Was there a progressive chronology of thrust uplift in the Mexican fold-thrust belt (and its possible precursors), and if so, can a reliable age progression be discerned in the Upper Cretaceous strata of the foreland basin?

2. What was the nature of the sediment-dispersal systems that delivered detritus from the orogen to the foreland?

Methods

To test the above ideas we use classic field stratigraphy, facies interpretation, and paleocurrent measurements, as well as standard provenance techniques including sandstone petrology and detrital-zircon U-Pb dating. Sandstone samples with appropriate grain-age populations will be double dated by the (U-Th)/He method.

Introduction

The foreland basin system, linked to the developing Mexican Fold-thrust Belt (MFTB), includes the Parras (PB), La Popa (LP), Sabinas (SB), and Tampico-Misantla basins (TMB), as well as unnamed depoenters in the Mesa Central and basins in the MFTB such as the Zimapán basin (ZB).

Study Area

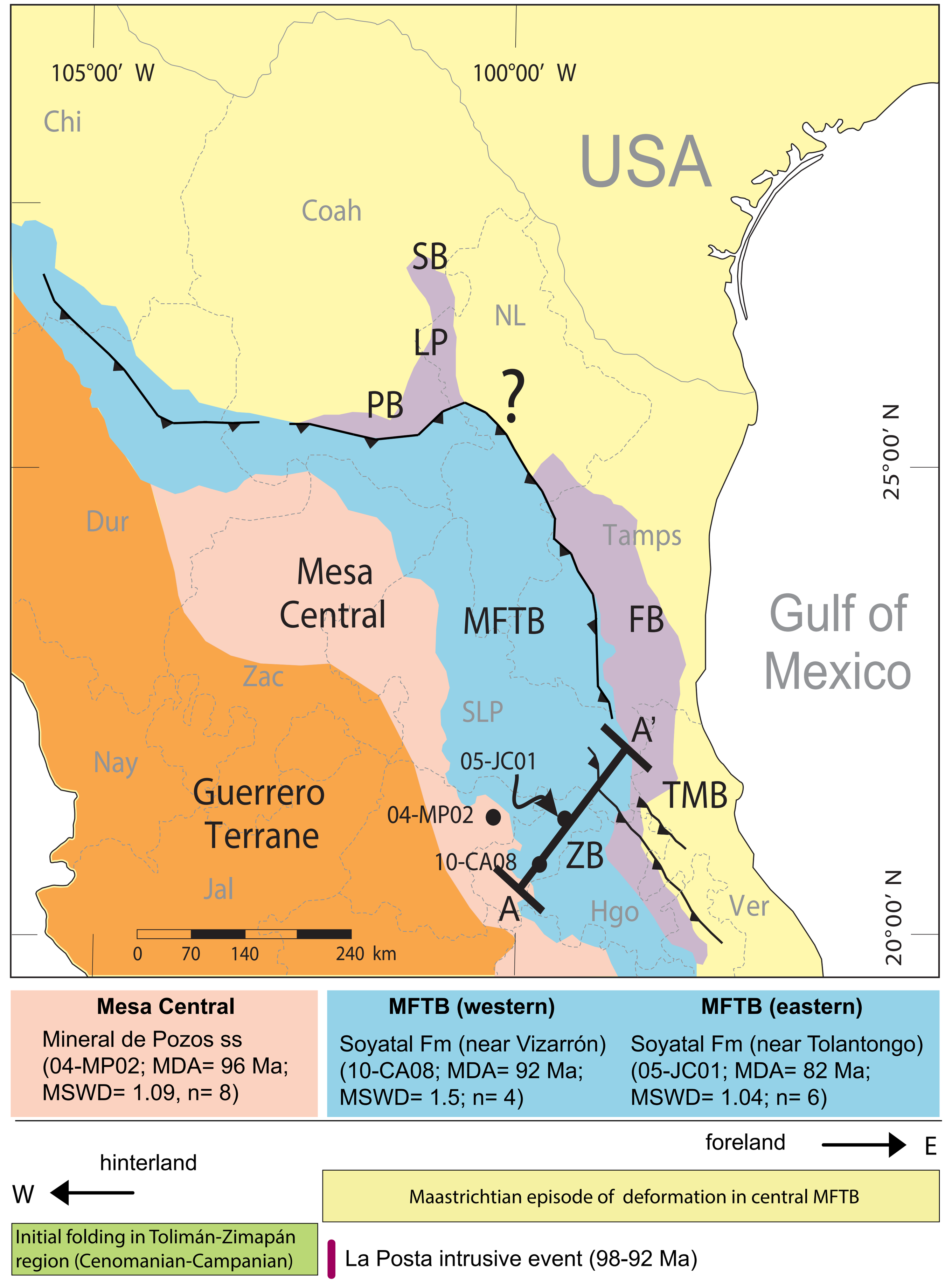

Fig. 1. Location map of the Laramide orogen and foreland basin of northern and eastern Mexico. The Cretaceous-Paleogene orogen can be divided into four broad belts: the Guerrero terrane, the Mesa Central, the Mexican fold-thrust belt (MFTB), and the extant foreland basin (FB), which includes the basins mentioned at left. Ages of episodes of deformation in Fitz-Díaz et al. (2014).

Stratigraphic Correlation Chart

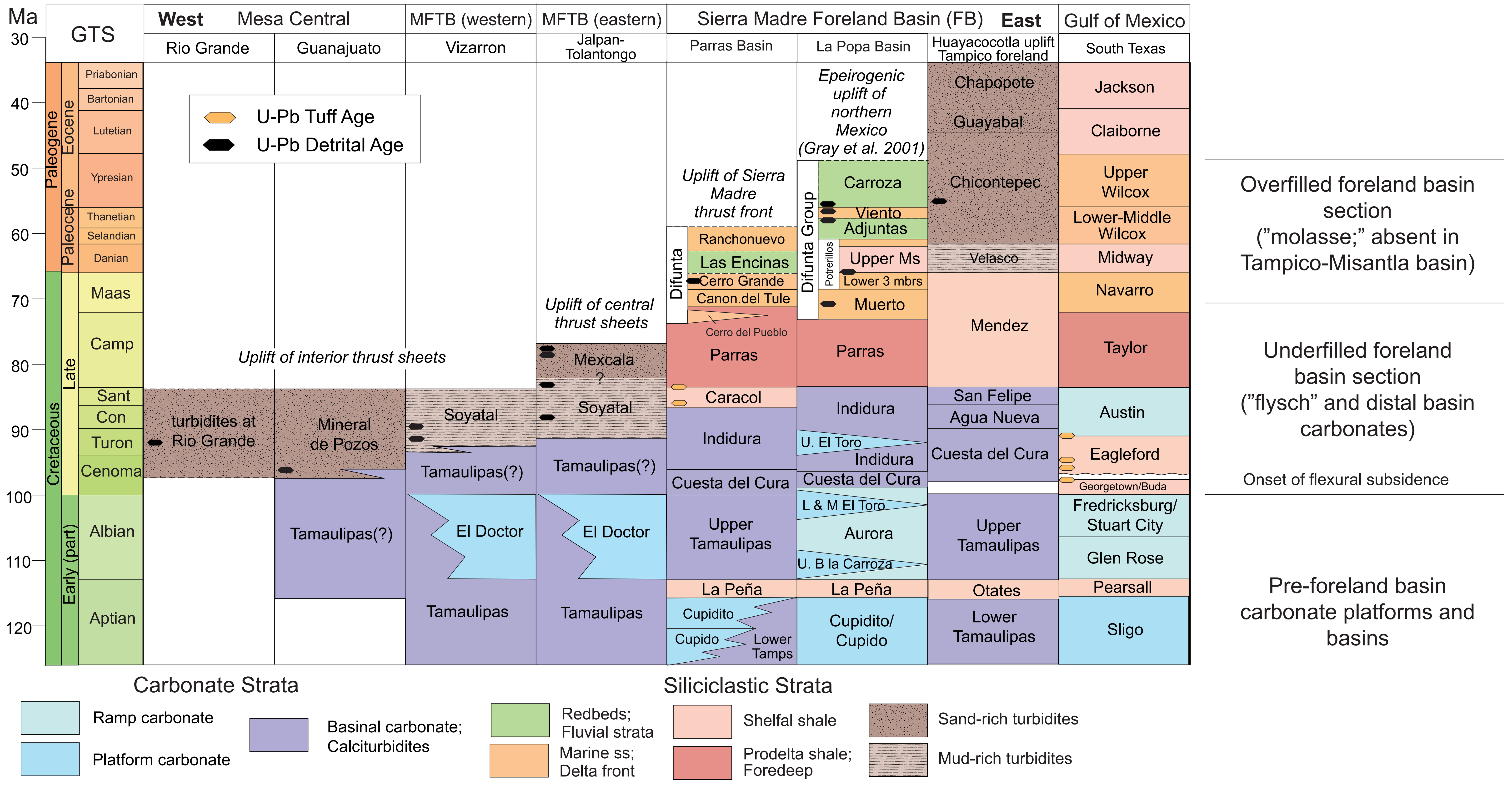

Figure 2. Stratigraphic correlation in central foreland region of Mexico and south Texas. The purple and blue colors of this correlation chart indicate the carbonate platforms and basins plus some transgressive shales of the Early Cretaceous. Calciturbidites of the older carbonate successions interfinger with the lower parts of the interior turbidites, in the western part of the basin. The siliciclastic environments (brown) migrated eastward with time, toward the exterior part of the Sierra Madre orogen. The upper age limits of the foreland basin successions are not well known in the west because the strata are truncated erosionally by uplift of the earlier basin sequences by east-progressing thrust uplift.

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Cross Section of de Mexican Fold-Thrust Belt

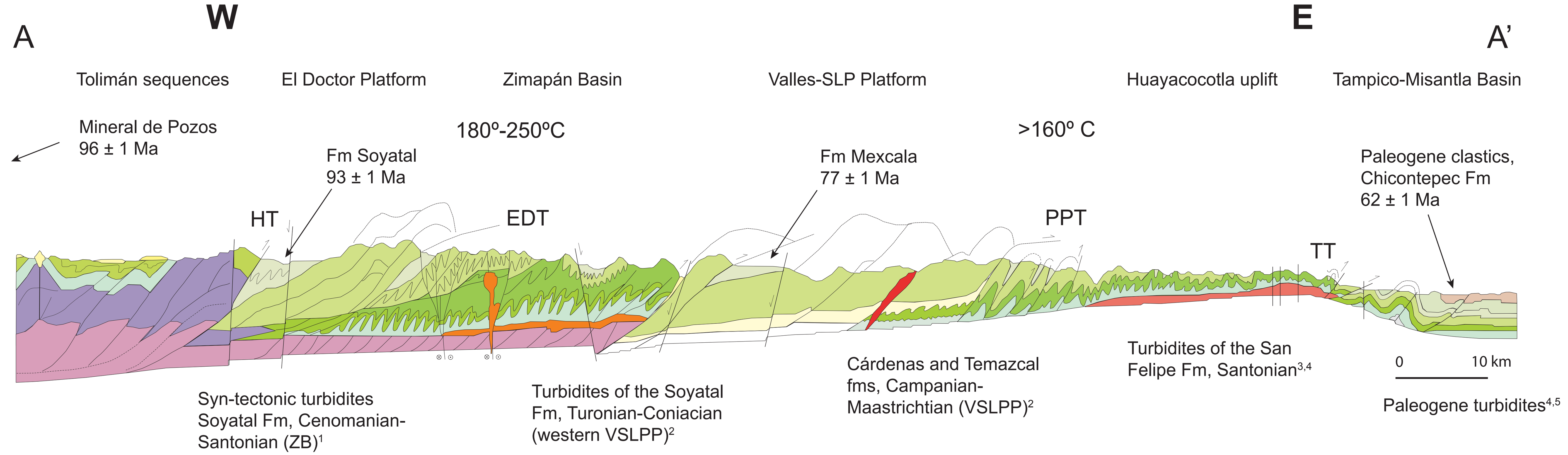
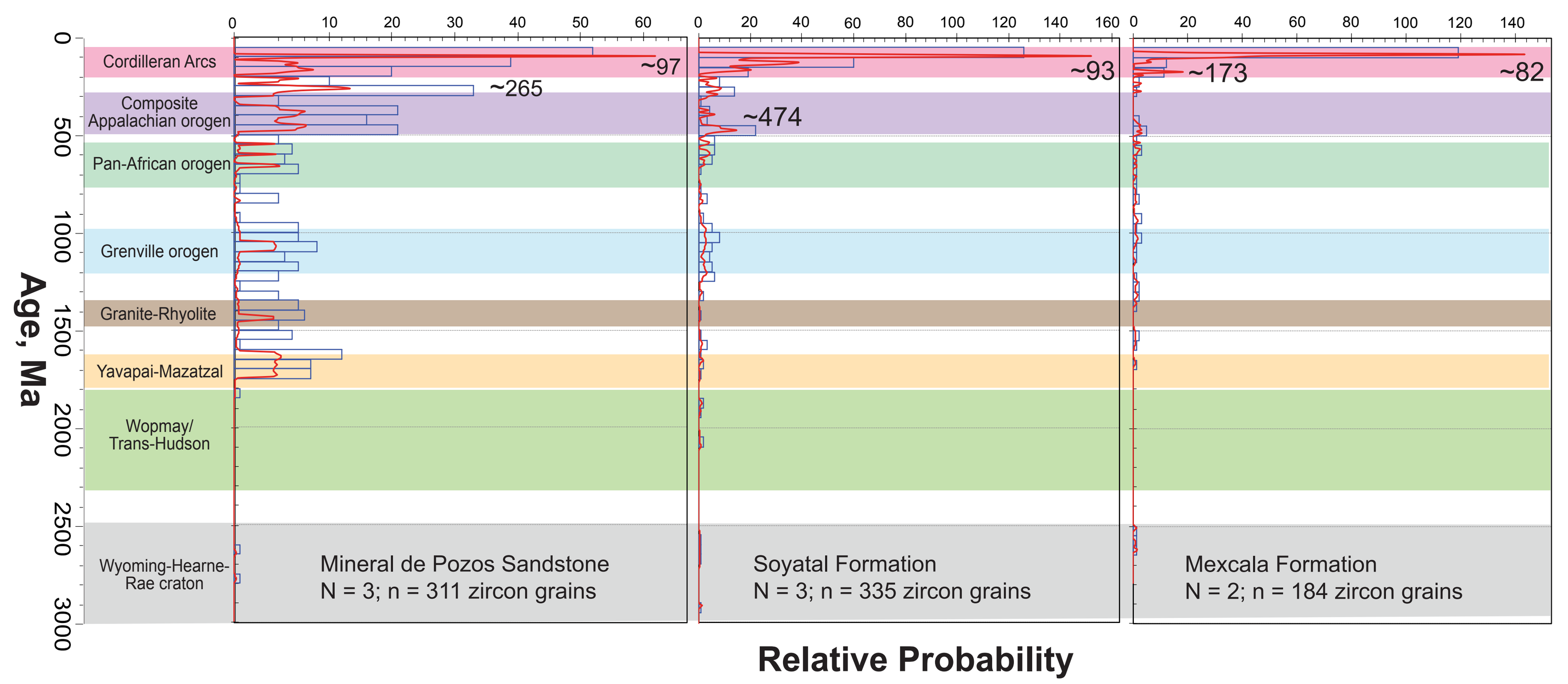


Figure 3. Locations of samples along cross-section A-A' of the Mexican fold-thrust belt in the central Mexico (see Figure 1 for location; from Fitz-Díaz et al., 2014). This figure shows Triassic and Jurassic rocks in pink and violet, Cretaceous rocks in shades of green, and Paleogene rocks in yellow. Biostratigraphic ages (below section) of sampled syn-tectonic turbidites from: 1, Hernández-Jaúregui, 1997; 2, Kiyokawa, 1981; 3, Omaña-Pulido, 2012; 4, Suter, 1990; 5, Alzaga-Ruíz et al., 2009. Explanation, HT= Higuerillas thrust, EDT= El Doctor thrust, PPT= Puerto de Piedra thrust, TT= Tetitla thrust, ZB= Zimapán basin, VSLPP= Valles-San Luis Potosí Platform, TMB= Tampico-Misantla basin.

U-Pb Geochronology



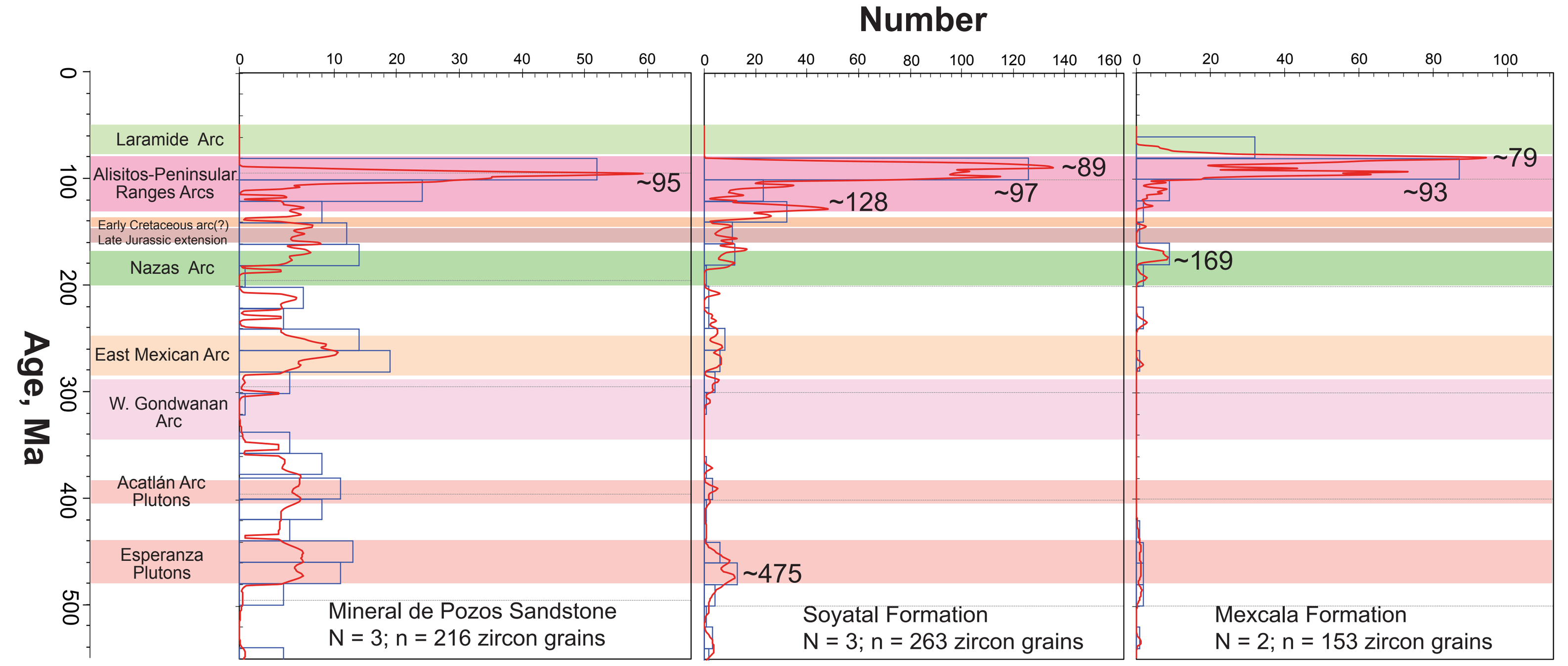


Figure 4. This figure shows the detrital zircon age populations and principal component age groups of three turbidite samples along the orogenic hinterland histograms, probability density (red), and key data of these samples (labeled). The color bands in the Paleozoic age range diagrams represent main magmatic pulses in Mexico (right plots). The color bands in the adjacent diagrams (left plots) represent Laurentian sources. Note the three-fold Laurentian age distribution (1.7 Ga, 1.4 Ga and 1.1 Ga) in the Mineral de Pozos sandstone of the left-hand plots. Grains equivalent to La Posta intrusive event of southern California and "type" La Posta of Baja California Peninsula (100-90 Ma) are the best recorded grain component age in the detrital samples. The data of the Mexcala and Soyatal formations (left plots) show that the three-fold Laurentian zircon signature is missing from these sandstones. One of the Mineral de Pozos Sandstone samples was originally analyzed by Ortega-Flores et al. (2014).

La Popa Basin

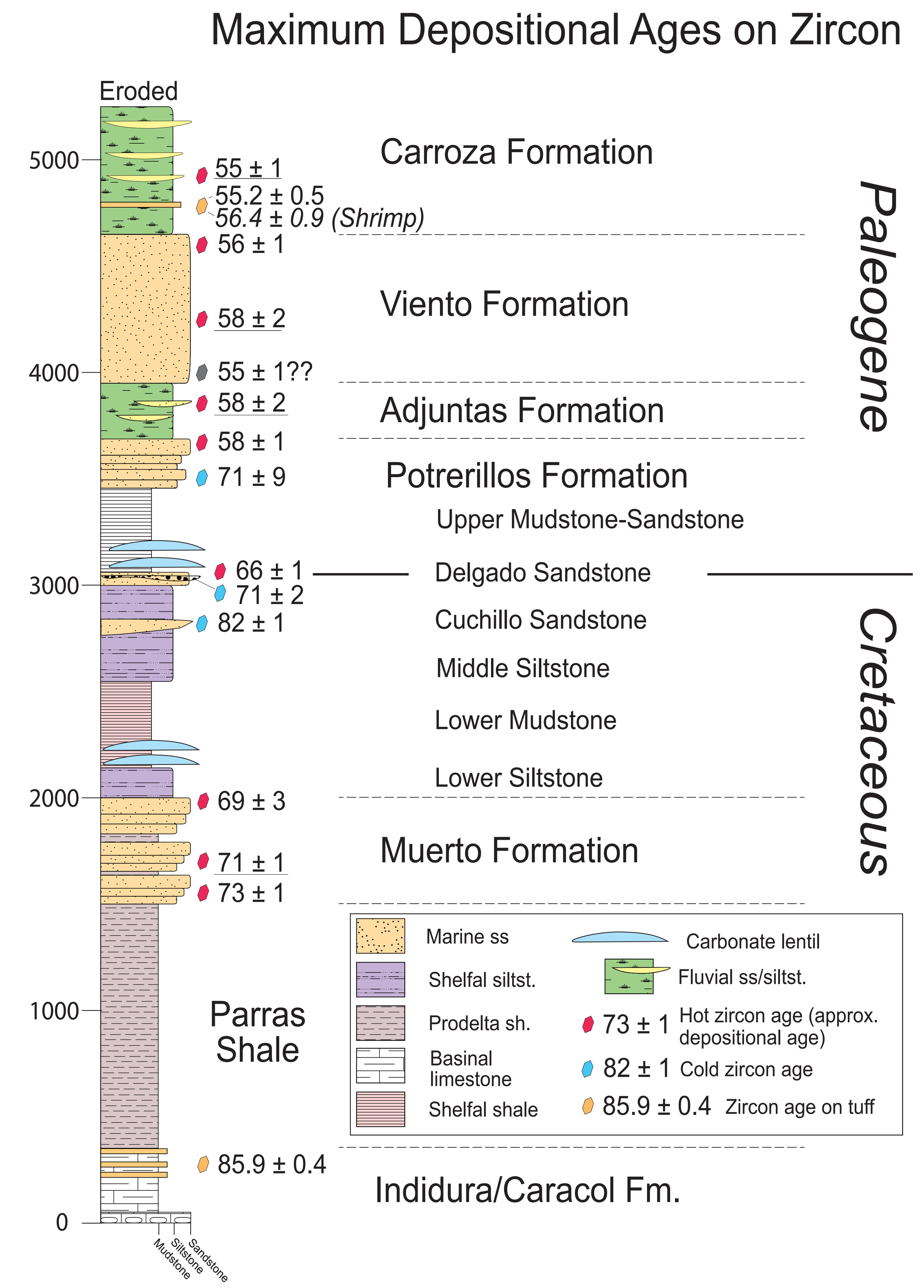


Figure 5. Northeastern Mexico has been documented the increased thickness of rocks belonging to Cretaceous Foreland basin. Onset sedimentary record corresponds deep marine deposits (turbidites) that near the Maastrichtian age, change to coastal deltaic deposits of the Difunta Group, which represents the only type "molasse" deposits documented at the moment.

U-Pb data of Upper Difunta Group

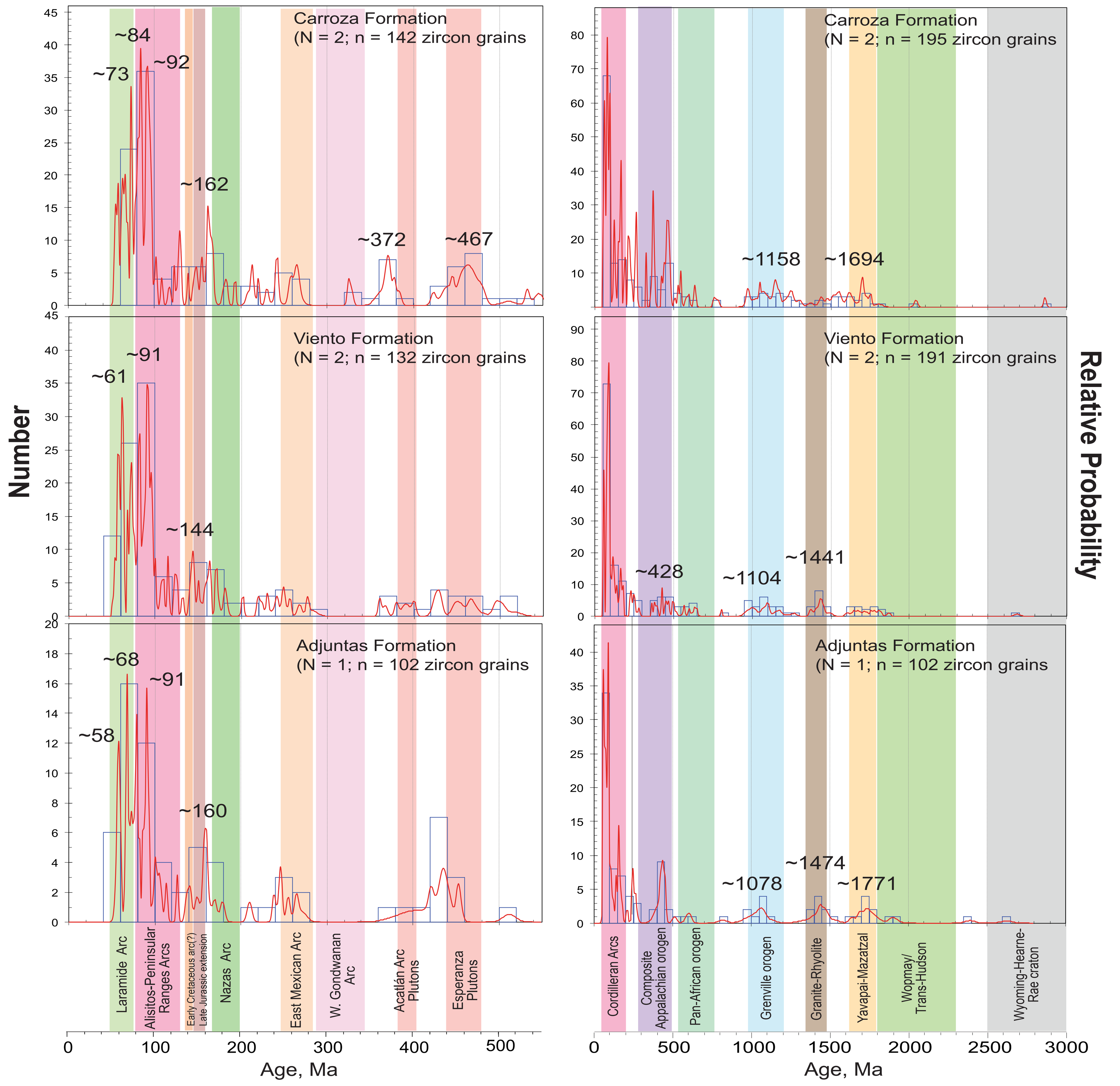


Figure 6. The upper three units of the Difunta Group, equivalent to most of the Wilcox Group, have a strong Laurentian signature, and also contain arc-derived grains that span the interval of Cordilleran arc magmatism up to that time, with abundant young grains that could represent reworked tuffs that fell in the foreland. These young grains yield consistent syndepositional ages, as calibrated by a tuff in the upper part of the section and consistent younging of maximum depositional ages upsection.

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Paleogeography of Foreland Basin

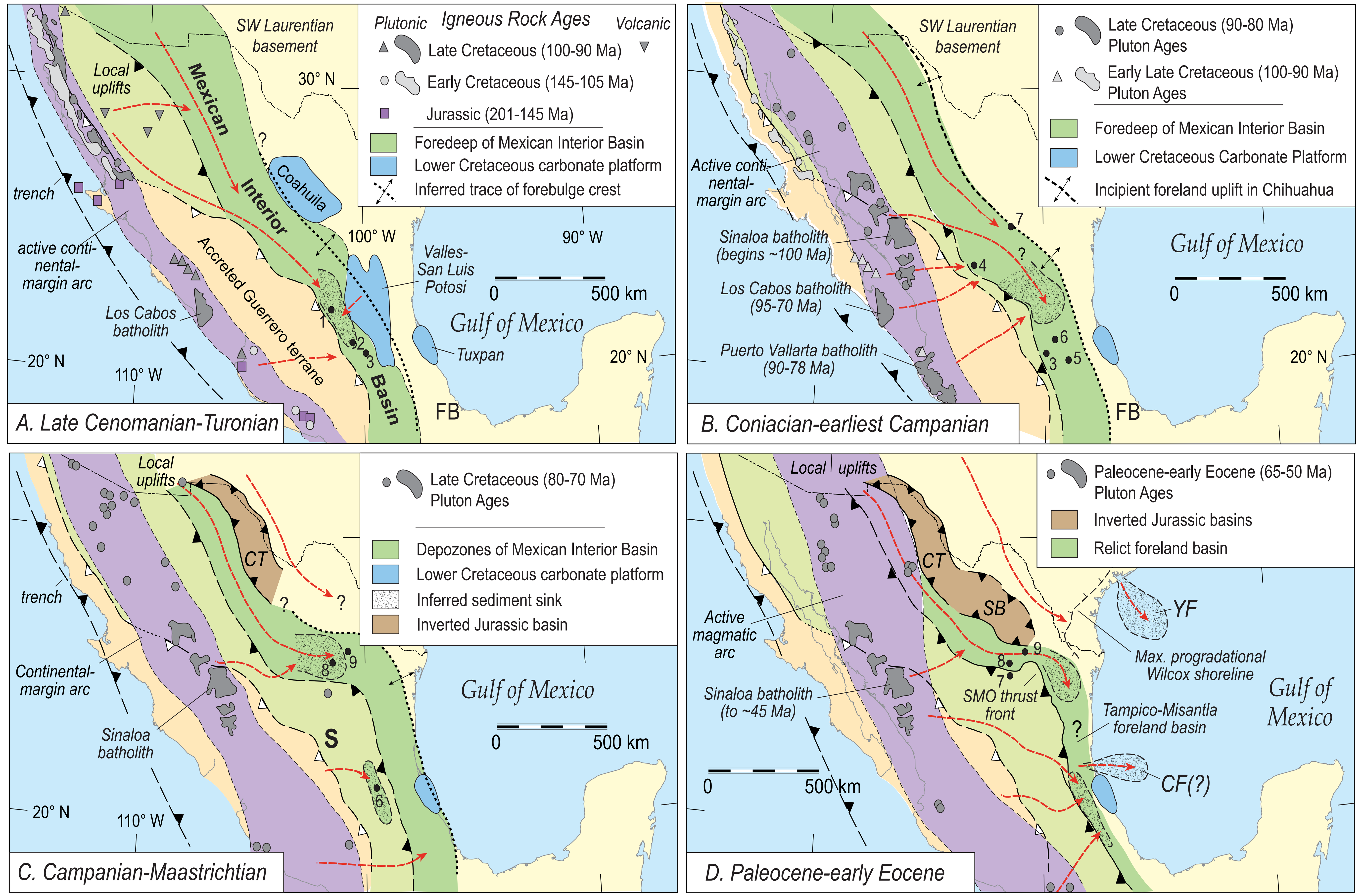

Figure 7. Brown-orogenic hinterland, which consists of accreted oceanic and arc terranes; green—foreland, which will change in shape and width with time, and blue—dominantly Early Cretaceous carbonate platforms of northern and eastern Mexico and the Gulf Rim, some of which persisted into the Late Cretaceous as indicated by composition of some of the foreland basin sandstones. The initial foreland-basin deposits occupied a narrow trough that was bordered on the east and northeast by remnant carbonate platforms. The magmatic arc that resulted from subduction of the Farallon slab was well underway and is represented by the intrusive belts of the Baja Peninsula. Arc grains could be derived from longitudinal transport or from closer parts of the arc that peek out from under younger volcanic rocks farther SE along strike of the margin. The three-fold distribution of zircon grains from Laurentian basement must have come along strike.

Mexican Interior Basin

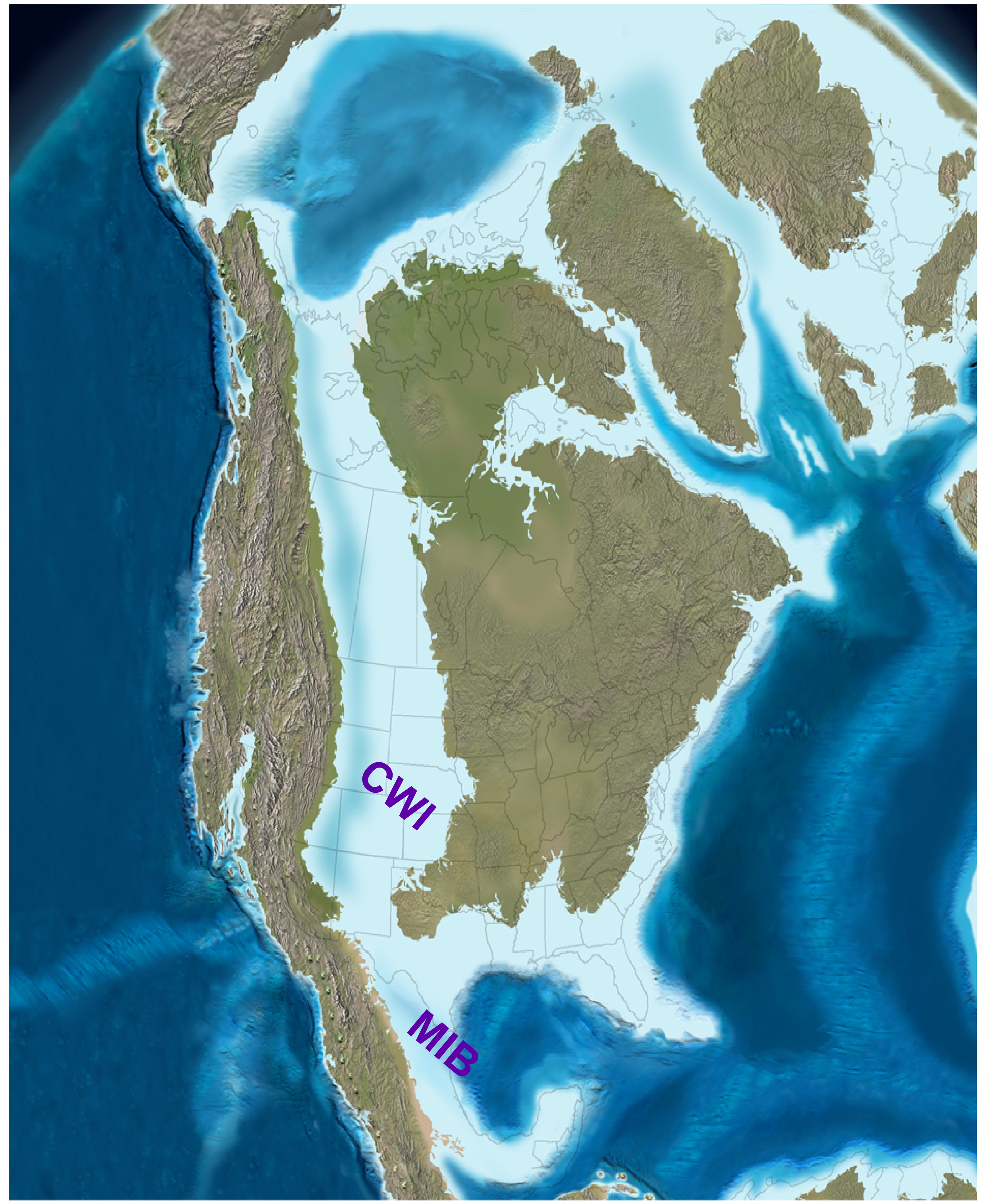

Figure 8. The Late Cretaceous foreland basin developed adjacent to the Cordilleran orogen in Mexico represents the continuation toward the south of the Cretaceous Western Interior basin. We propose to name, Mexican Interior Basin (MIB), for its southern counterpart. Map source: Ronald Blakey, Colorado Plateau Geosystems, http://cpgeosystems.com/namK85.jpg.

Next stage: Comparison of Wilcox and Difunta Groups

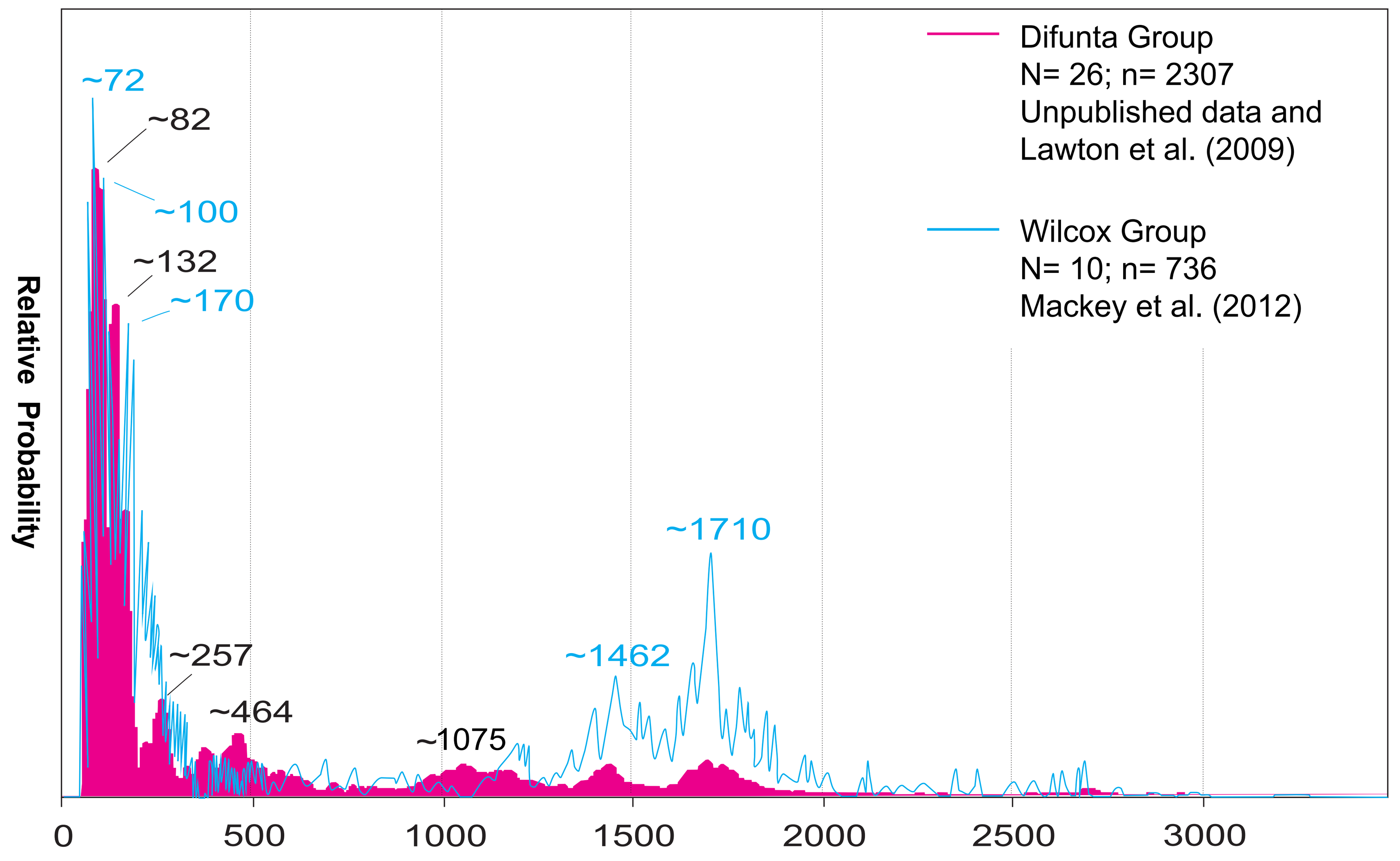

Figure 9. Comparison of detrital zircon relative age-probability curves from Difunta and Wilcox Groups. Numbers indicate prominent age peaks. Note the three-fold Laurentian age distribution (1.7 Ga, 1.4 Ga and 1.1 Ga) and a prominent component ca. 100-72 Ma in both groups. These component ages indicate that there were two primary sources of sediment:
1) Basement of Laurentia (SW United States and NW Mexico, and 2) Cordilleran arc. The zircon age distribution of the Difunta Group records the Late Cretaceous magmatic arc on the western coast of Mexico (e.g. La Posta magmatic event and Sinaloa batholith), which was coeval with shortening in the fold-thrust belt and the evolution of the foreland basin in northern Mexico.

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