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 Zimapán 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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The goal of this work is to study the evolution of a foreland-basin system (North Mexican foreland basin; NMB) 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 paleocean 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 depocenters in the Mesa Central and basins in the MFTB such as the Zimapán basin (ZB).

**Study Area**

![Location map of the Laramide orogen and foreland basin of northern and eastern Mexico.](image)

**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 basinal carbonate; the brown colors indicate the mud-rich turbidites. Sand-rich turbidites are orange. The green colors indicate the shelfal carbonate, and the yellow colors indicate the overfilled foreland basin. The light brown colors indicate the "molasse" absent in Tampico-Misantla basin.

**Stratigraphic Correlation Chart**

- **West**
  - U-Pb Tuff Age
  - U-Pb Detrital Age
- **East**
  - U-Pb Tuff Age
  - U-Pb Detrital Age

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*Note: The text contains a diagram with stratigraphic correlation data, and the actual values are not provided due to the format limitations.*
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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 turbidites of the Soyatal Formation and related strata and Cretaceous turbidites of the Mexican foreland basin (VSLPP2).

Figure 4. The 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 relative probability (blue). The detrital zircon age populations of the Paleogene, Cretaceous, and Tertiary are plotted on the left axis, and the detrital zircon age populations of the Paleozoic, Precambrian, and Archean are plotted on the right axis. The principal component age groups of the Paleogene, Cretaceous, and Tertiary are plotted on the left axis, and the principal component age groups of the Paleozoic, Precambrian, and Archean are plotted on the right axis.

Figure 5. Northeastern Mexico has been documented the increased thickness of marine turbidites in the Cretaceous and Paleogene, which represents the increased thickness of marine turbidites in the Cretaceous and Paleogene. The increased thickness of marine turbidites in the Cretaceous and Paleogene is due to the increased thickness of marine turbidites in the Cretaceous and Paleogene.

Relative Probability

Relative Probability

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, in the absence of syndepositional ages, are correlated by a left-in the upper part of the section and consistent younging of maximum depositional ages upsection.
Paleogeography of Foreland Basin

Mexican Interior 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 trench continuance. We propose to name, Mexican Interior Basin (MIB), for its southern counterpart. Map 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 in Mexico represents the continuation toward the south of the Cretaceous Western Interior Basin.

Figure 8. The Late Cretaceous foreland basin developed adjacent to the Cordillera of Mexico represents the continuation toward the south of the Cordilleran Western interior basin. We propose to name, Mexican Interior Basin (MIB), for its southern counterpart.

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