

EVOLUTION OF THE MID-CRETACEOUS IN NORTHERN MEXICO UNDER PALEOCEANOGRAPHIC ASPECTS

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ABSTRACT

The lithologic units of the northern Mexican mid-Cretaceous are described and their distribution is outlined. Biological aspects for the paleogeographical and oceanographical interpretations are given by the mixture of boreal and Tethyan faunas such as ammonites, inoceramids, belemnites and rudists. A trans-Atlantic correlation (northern Mexico-northwestern Europe) is given by event-stratigraphic comparison. A sea bottom relief could be elaborated that caused a complex system of boreal bottom and Tethyan surface waters.

Key words: middle Cretaceous, evolution, paleoceanographic aspects, northern Mexico.

RESUMEN

Se describe las unidades litológicas del Cretácico medio del norte de México y se explica su distribución. Se pone de manifiesto los aspectos biológicos para su interpretación paleogeográfica y oceanográfica en la mezcla de faunas boreales y tetisianas como amonites, inocerámidos, belemnites y rudistas. Se establece la correlación transatlántica (norte de México-noroeste de Europa) por la comparación evento-estratigráfica. Se elaboró un relieve del fondo del mar, que fue causado por un sistema complejo de agua del fondo boreal y de las aguas de la superficie tetisiana.

Palabras clave: Cretácico medio, evolución, aspectos paleoceanográficos, norte de México.

INTRODUCTION

Based on the calibration of the sections by means of nanno-, micro-, and macrofossils, as well as the supervision by transatlantic correlation via event stratigraphy (northern Mexico/northwestern Europe), the different lithofacies-types (formations) are interpreted paleogeographically and oceanographically. Sediment transport, stream marks and direction, as well as erosion and condensation are main features. Biological aspects are given by the mixture of boreal and Tethyan faunal elements. This study is part of the project "The mid-Cretaceous of northern Mexico" financed by the German Society of Investigations (Fi 136/11-3). It is a contribution to the IGCP-Project 381 "South Atlantic Mesozoic correlation".

PALEO GEOGRAPHIC OUTLINE

The mid-Cretaceous ocean of northern Mexico, the area which corresponds to that of continental western Europe has been studied in the last thirteen years by several authors with different approaches: geology, paleontology, paleogeography, stratigraphy, etc. (Young, 1983; Kauffman, 1984; Schoenherr, 1988; Stass, 1988; Seibertz, 1996). As a result of these studies the area was subdivided into widespread depressions and basins, swells and platforms. This relief got its origin in large tectonic units which were established in the Triassic, and

which partly still existed as continental blocks during the Jurassic. Only in the Lower Cretaceous, a homogeneous ocean settled, due to a general subsidence of the whole area. The names of these structural units are given in Figure 1.

LITHOSTRATIGRAPHY

The lithologic units of the northern Mexican mid-Cretaceous are traditionally combined in formations (Figure 2). Though being limited in certain cases, e.g., concerning sediments at extreme nearshore positions in the westernmost part of the Aldama and Altiplano Platforms, where Albian to Cenomanian strata show a mixture of different lithologies/formations, this concept will be followed. Generally, the sequence can be divided into a simplified scheme (Figure 2). Above, a series of sometimes several hundred meters, consisting of limestones and limy shales comprising the lower and middle part of the Lower Cretaceous, the Albian to middle Cenomanian Cuesta del Cura Formation follows with its eastern equivalent which is the Tamaulipas Superior Formation. The first consists of a sequence of dark grey, thin-layered limestones with undulated seams and bands of black flint; while the latter is built up by thick-layered limestones with stylolitic contact. This formation occurs only north and east of the Miquihuana Platform and represents therefore the basal equivalent of the shallow water Cuesta del Cura Formation. From the upper Cenomanian onwards, the sediments become more detritic, documenting the influence of the lifting Unnamed Western Continent. The Indidura Formation, comprising upper Cenomanian to early middle Turonian times, rep-

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Figure 1. Paleogeographic units in the mid-Cretaceous of northern Mexico.

resents a sequence of thin-layered, laminated, dark grey to black limy shales and limestones with different amounts of detritus. As a synchronous equivalent, in the eastern part, the sapropelitic Agua Nueva Formation is found, the distribution of which is restricted to deeper basinal areas (Sabinas Depression, Magiscatzin and Chicontepec Troughs). Onto the Miquihuana Platform, this formation thins out and disappears. In the shallow water shelf areas of the Tamaulipas Archipelago, it loses its characteristic content of saprolite and appears as an alternation of laminated limestone, limy shale, and claystone (Seibertz, 1988, 1990). In western regions, the Caracol Formation represents the higher middle Turonian to early Coniacian time span, consisting of a predominant clastic series as an alternation of partly glauconitic graywackes, clayey shales, and marly limestones. In eastern areas, the time interval of the higher middle Turonian to the Turonian/Coniacian boundary is represented by the San Felipe Formation, which is an alternation of turbiditic greensands associated with porcellanites, glauconitic marly limestones, and limestones. This sequence indicates a rejuvenation of the Jurassic Tamaulipas Archipelago during mid-Cretaceous times. On the centrally located Altiplano Platform, the Caracol and San Felipe Formations are interfingering, while the Indidura Formation changes gradually into the Parras Formation in the northerly neighbouring Parras Depression. As far from shore equivalents in eastern regions, the grey green limy shales and claystones of the Méndez Formation are found.

BIO- AND EVENT STRATIGRAPHY

Ammonites are found specially in the Albian and Cenomanian, while Turonian sediments are nearly free of them with the exception of the carbonates of the Burro-Peyotes Platform and the northern Chihuahua Depression. As biostratigraphic important groups, Tethyan Vasoceratids, boreal Mammitids, Collignoniceratids, and Scaphitids have to be mentioned among others (Renz, 1936; Kennedy *et al.*, 1987).

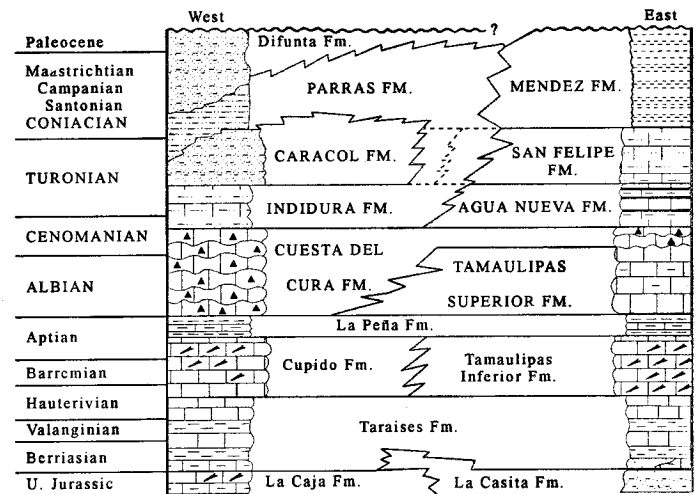


Figure 2. Lithostratigraphic units in the mid-Cretaceous of northern Mexico (modified and actualized after Padilla y Sánchez, 1982).

In contrast with ammonites, inoceramids occur in all mid-Cretaceous lithofacial units of northern Mexico. Difficulties exist mainly in the nomenclature because Albian to Coniacian forms of North- and Middle America and Europe are often identical, or at least nearly related, but got different names. Another interesting faunal element are belemnites (Spaeth, 1988; Seibertz and Spaeth, 1995). Appearing rarely since the Jurassic, they show a flood occurrence during the late Aptian with typical boreal Neohibolitids. The Albian is characterized by different species, diminishing in the Cenomanian and lower Turonian (Seibertz, 1996). In general, the occurrence of these in the European boreal region typical forms, is restricted mainly to the northern margin of the Altiplano Platform and to the shelf areas of the Tamaulipas Archipelago. Tethyan faunal elements of biostratigraphical importance are rudists. Moreover, their occurrence is a good tool for paleogeographic and oceanologic interpretations. The whole surroundings of the Gulf of Mexico, including the northern Mexican mid-Cretaceous shelf areas, were restrained by rudist reefs and their detritus in Aptian times. During the Albian to Coniacian interval, they were moved from north to south, being restricted to the Miquihuana Platform, and south of the Transverse Volcanic Zone onto the Yucatán shelf. As shown in Figure 3, lots of events of various types occur in the mid-Cretaceous of northern Mexico. On one hand, they can be correlated event by event with those of northwestern Europe; on the other hand, general trans- and regression trends are correlatable with the mid-Cretaceous of the Western Interior, where a stratigraphically detailed event scheme has not been worked out until now (Seibertz, 1996).

LITHOFACIES DEVELOPMENT AND PALEOGEOGRAPHY

For more than 15 years, the opinion has been established that the shoreline of the Cretaceous sea changed its position more or less gradually from west to east. Another concept was

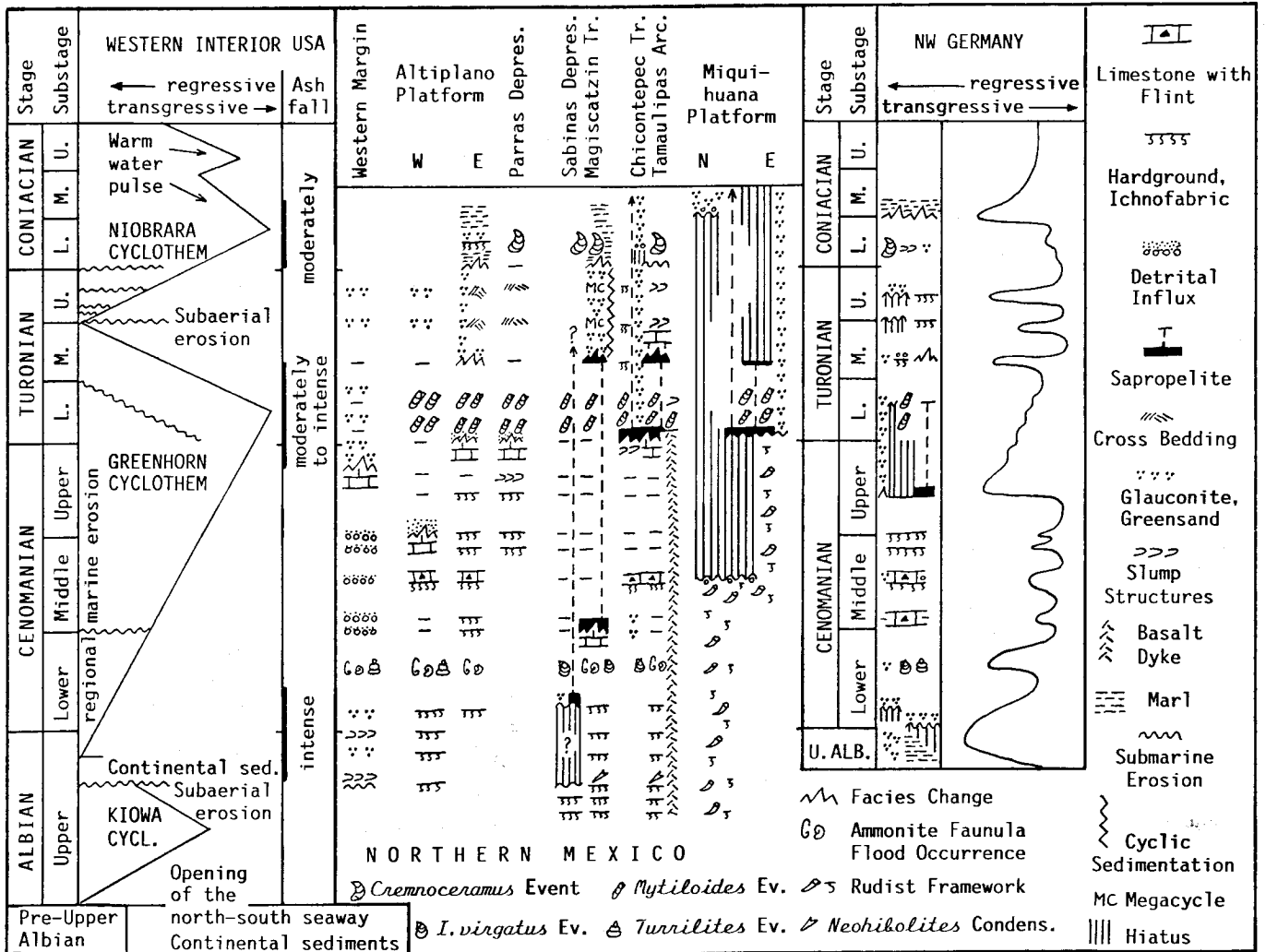


Figure 3. Event stratigraphic correlation of the mid-Cretaceous of northern Mexico with the Western Interior (left column modified after Kauffman *et al.*, 1976) and northwest Europe (right column modified and actualized after Ernst *et al.*, 1983).

elaborated for the Parras Depression, explaining the shoreline movement as a progradation model which then was applied to the whole northern Mexican region. These two models may be relevant for restricted areas, but in general one has to imagine the following pass off: as compensation of a traceable uplift of the Unnamed Western Continent, the whole northern Mexican region subsided and was filled with erosional debris from west to east. Toward the end of the Late Cretaceous, subsidence and refilling were held in balance, as can be proved by marine clastics of the Difunta Formation of Maastrichtian age found in the southern Chihuahua Depression, and in the carbonates of the Burro-Peyotes Platform. During the whole Cretaceous, the shoreline continued to exist far in the west, forming a hinge for the counterbalance. Within a very short time, presumably around the K/T boundary, the shoreline displaced to the east up to the eastern shelfside of the Tamaulipas Archipelago due to an increase of the silting up of the whole northern Mexican region.

PALEOCEANOGRAPHIC INTERPRETATION

Leaving aside considerations regarding lithofacies development, distribution patterns of boreal and Tethyan faunas, interpretation of sedimentation phenomena as well as some regions known with pre-mid-Cretaceous bathymetric conditions, a sea bottom relief could be constructed for Albian to Coniacian times (Figure 4). This relief caused a complex system of boreal bottom and Tethyan surface waters. From the north, where the seaway to the Western Interior had been opened during the Albian (see left column in Figure 3), cool bottom streams penetrated into the Chihuahua Depression coming around the western margin of the Burro-Peyotes Platform, splitting off at the western shelf of the Coahuila Platform. The southerly directed branch splitted off once more, one streaming into the Parras Depression, the other into the eastern foredeep of the Unnamed Western Continent partly upwelling onto the Altiplano Platform. The second main branch streamed through the Sabinas Depression, bounced

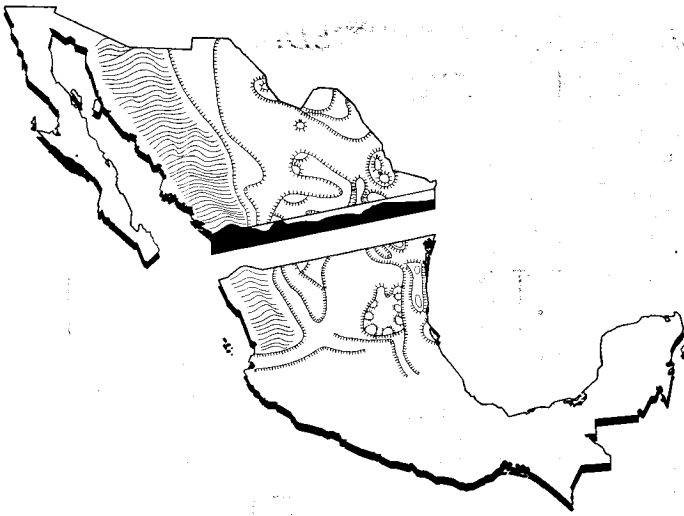


Figure 4. Paleooceanographic reconstruction of northern Mexico during mid-Cretaceous times (paleorelief adopted from Seibertz, 1996).

against the northwestern shelf of the Tamaulipas Archipelago and was deflected to the south by another bottom stream which passed southwards around the eastern margin of the Burro-Peyotes Platform. This cold bottom water partitioned the Magiscatzin Trough from the open circulation leading to the formation of an anoxic milieu with sapropelite. One part of this southerly directed stream welled up onto the eastern Altiplano and farther south onto the Miquihuana Platforms entering the eastern Balsas Basin. The other part remained in deeper areas, passed into the Chicontepec Trough, and lead there to the formation of sapropelite, too. In regions where these cold bottom waters bounced against slopes, started upwelling. This process lead to an instability of the sediments which moved down slope more or less rapidly and eroding. Counter directed to these cold bottom waters there was a warm surface stream (Figure 4), the northwestern direction of which can be deduced from the Proto-Gulf Stream. A part of this water mass was deflected directly to the north by the relatively high rised shelves of the Tamaulipas Archipelago, while another branch penetrated into the northern Mexican area coming from the southeast and south. In regions where cold bottom streams advanced into shallower areas they stroke warm surface waters in an acute angle, so that both systems were deflected partly to the east. This stream convergence was responsible for the fact that clastic material of the Unnamed Western Continent is found distributed over the whole Altiplano Platform, as far as the western foredeeps of the Tamaulipas Archipelago (see Figure 4).

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