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# A CRETACEOUS-TERTIARY BOUNDARY SECTION AT RIO LORA, MERIDA ANDES, WESTERN VENEZUELA

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## ABSTRACT

In Northern South America the Cretaceous to Paleocene transition usually occurs at a change from predominantly marine depositional conditions of the Late Cretaceous to continental (fluvial/lacustrine) conditions in the Early Paleocene. This makes reliable age dating of the boundary interval difficult, especially when it is necessary to rely solely on terrestrially derived palynomorphs (spores, pollen) that are not well calibrated to the marine fossil record. At Rio Lora located in the Merida Andes of Western Venezuela a measured section through the Cretaceous (Mito Juan Formation) to Paleocene (Catatumbo Formation) transition has been sampled for palynology, and contains dinoflagellates, together with a diverse assemblage of spores and pollen. Within the section there is a covered interval of approximately 65 feet; based on dinoflagellate assemblages the sediments below this interval are latest Cretaceous and above are earliest Paleocene. It is possible that a more or less complete Cretaceous-Tertiary boundary section may be preserved, assuming continuous deposition and preservation of sediments. Age calibration of the dinoflagellate assemblage, which includes (in ascending stratigraphic order) *Glaphyrocysta perforata, Dinogymnium pustulicostatum, Danea californica, Fibrocysta bipolaris, Kenleya lophophora,* and *Carpatella cornuta,* to a global database, makes it possible to better define the age ranges of some key spores and pollen that have previously been used to define the Late Cretaceous *Proteacidites dehaani* Zone in South America.

## INTRODUCTION

Scientists have been intrigued by the Cretaceous-Tertiary (K-T) boundary event for several decades and it is in this regard that this paper sheds what may be some interesting light on the discussion, especially as it relates to the Caribbean region. The hypothesis that a meteorite hit the earth at the end of the Cretaceous eliminating many plant and animal groups (the most publicized being the dinosaurs), and the recent interpretation that the 180km diameter buried circular structure at Chicxilub on the Yucatan Peninsula in Mexico is the K-T boundary impact crater (Hildebrand et al., 1991; Pope et al., 1991), has focused attention on sites throughout the Caribbean. Discoveries of unusual clastic deposits at the paleontologically defined K-T boundary in Haiti (Izett et al., 1990), Mimbral in northeastern Mexico (Smit et al., 1992), the deep Gulf of Mexico (Alvarez et al. 1992), and onshore in the southern Gulf Coast of the United States (Smit and Romein, 1985; Hansen et al., 1987; Bourgeois et al., 1988), has provided further evidence that some sort of disturbance occurred at the boundary, maybe in the form of a tsunami or similarly large seismically-induced wave. Most of the attention has so far been directed to the northern Caribbean and southern United States; to date no K-T boundary sites have been reported from the present day (paleogeography) southern Caribbean and northern South America. The nearest is the K-T boundary site at Guayaquil in Ecuador (Barker et al., 1994; Stein and Pocknall, 1996).

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Unlike many of the sections previously mentioned, the K-T sections in Venezuela and Colombia, where preserved, were thought to be deposited in non-marine environments making calibration to a marine fossil record difficult. Reconnaissance palynological studies of the Rio Lora section (Fig. 1) located on the northern flank of the Merida Andes in Western Venezuela, indicated that a potential K-T boundary section was present within a covered section and that the sediments above and below the "boundary" were of marine origin and contained well preserved assemblages of dinoflagellates, in addition to spores and pollen; calibration to the marine fossil record was therefore possible. A subsequent recollection reduced the amount of covered section and provided the opportunity to examine the fossil succession across the Cretaceous to Paleocene transition zone. This paper describes the palynological assemblages across the transition zone in the light of previous work in the northern South American region and highlights the value of dinoflagellates in defining the stratigraphic position of the K-T boundary.

Many palynological studies have been conducted in Cretaceous and Paleogene rocks in Colombia and Venezuela; the classic work of Germeraad et al. (1968) remains the foundation of palynological studies in rocks of Late Cretaceous and Paleogene age in the region, although the early work of Kuyl et al. (1955) was instrumental in defining the ages of many of the lithostratigraphic units defined in the region. Over the past 30 years several zonal schemes (Fig. 2) have been developed for northern South American Cretaceous and Tertiary sediments, some of which span the K-T boundary (e.g. Muller et al., 1987; Sarmiento, 1994). In this study we have not assigned zones, but have used Amoco's corporate paleontological database, assigning ages using graphic correlation (see discussion under "Results") and a K-T boundary composite standard consisting predominantly of dinoflagellates.

### Lithostratigraphy of the Rio Lora Outcrop

The section is located on the western bank of Rio Lora, approximately 5 miles (8 km) south of highway No. 1 between El Vigia and La Fria ( 8'25.15'N, 7 1'51.63'W; Figs 1,3). The section under discussion in this paper is only a small part of the exposure along Rio Lora which has its base in the open marine to marginal marine and deltaic sediments of the Colon and Mito Juan formations, and passes successively into a largely continental sequence consisting of the Catatumbo/Barco, Los Cuervos, Mirador, Carbonera, Leon, and Palmar formations (see Fig. 3, geological map). For the purposes of this paper we restrict our discussions to the Mito Juan to lower Los Cuervos interval (Fig. 4).

The Mito Juan Formation, originally defined by Garner (1926), consists of black shales, similar to the underlying Colon Formation, with occasional interbeds of thin sands and glauconite; at Rio Lora the predominant lithology is shale. The overlying Catatumbo Formation, defined by Notestein et al. (1944), consists of interbedded fine sandstones, shales, and occasional limestones. In the Rio Lora region, it is often difficult to see a lithological distinction between the Mito Juan and Catatumbo formations. The rich assemblage of dinoflagellates and the presence of some nannofossils indicate that fully marine conditions prevailed during deposition, although in the lower part of the Mito Juan the predominance of palm and mangrove elements in the palynoflora indicate a nearshore estuarine depositional setting.

## RESULTS

19 samples were collected across the K-T transition in Rio Lora (Fig. 5). The majority were collected in February 1993 but a subsequent recollection was made in February 1994 in an attempt to decrease the extent of the covered section. Palynological samples were prepared using standard processing techniques (Wood et al., 1996) and all contained well preserved, and at times, diverse assemblages of spores, pollen, freshwater algae, fungal remains, and dinoflagellates. Four of the 19 samples processed for nannofossils yielded low diversity assemblages.

The age relationships of the Mito Juan and Catatumbo sections in Rio Lora are summarized in a graphic correlation plot (Fig. 6). This plot compares the Rio Lora section (scaled on y-axis) to the chronostratigraphic scale (on x-axis) of a composite biostratigraphic database. Microfossil ranges in the composite database were compiled by graphic correlation of multidisciplinary datasets on selected K-T boundary sections worldwide.

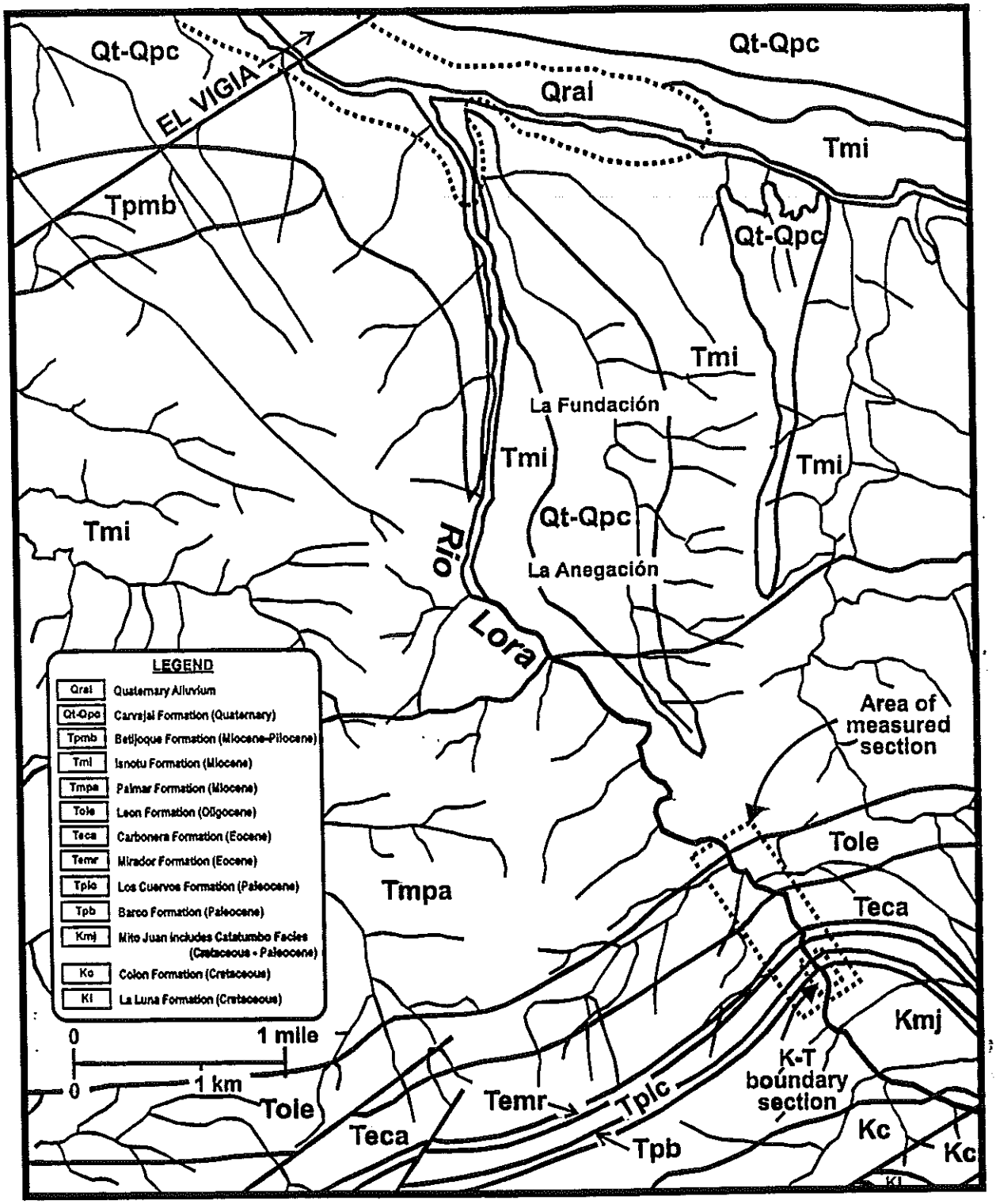


Figure 3. Geological map of the area around Rio Lora; based on work carried out by Creole Petroleum Corporation (drafted in May 1960).

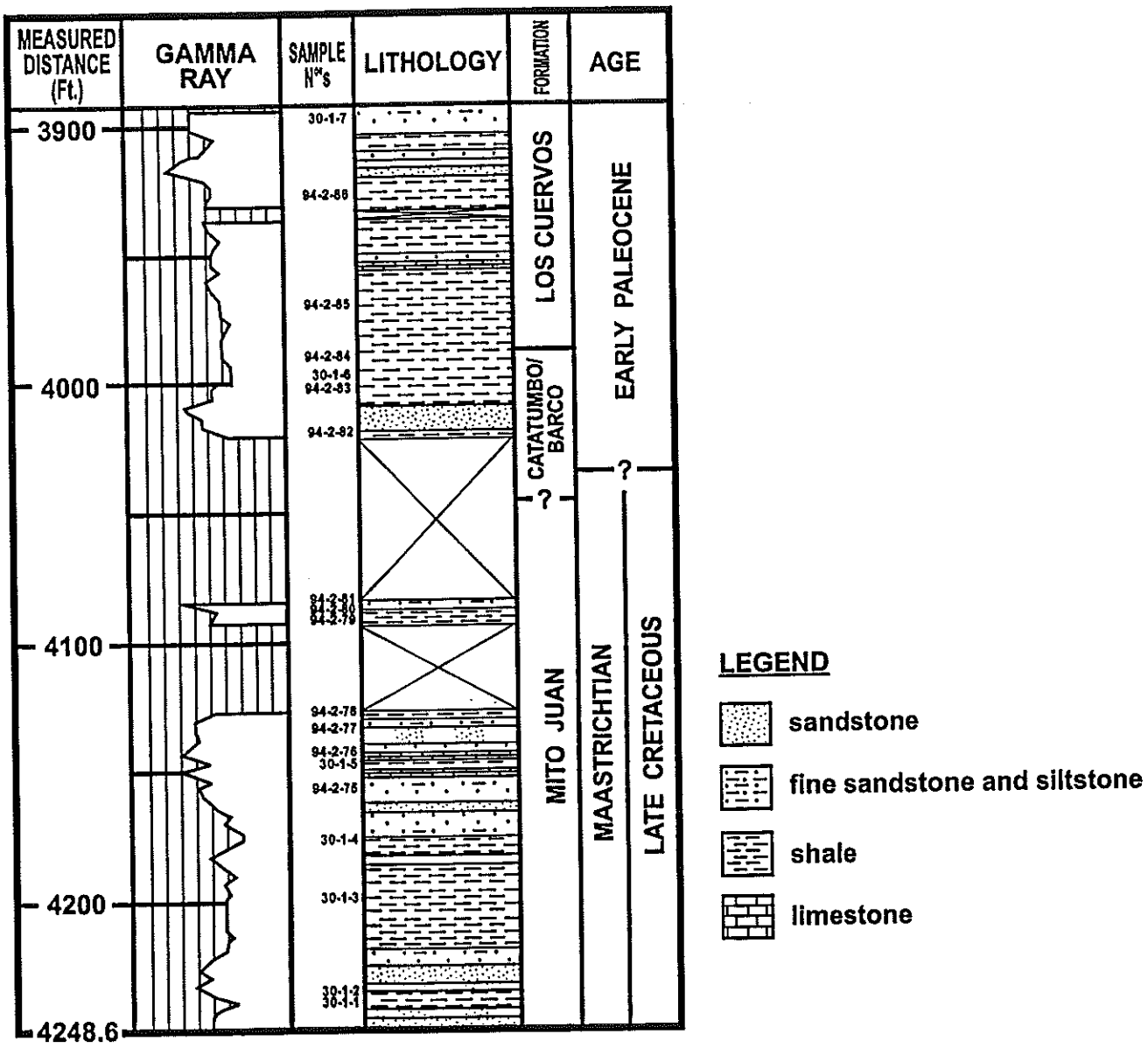


Figure 5. Measured section for Rio Lora with gamma ray, lithology, age, formation, and sample locations.

The composite standard was scaled to absolute time based on a calibration of calcareous nannoplankton and planktic foraminiferal datums established in the chronostratigraphic standards of Berggren et al. (1995) (Tertiary) and Gradstein et al. (1994) (Mesozoic). The calibrated composite standard also includes the ranges of dinoflagellate cysts and certain of these cyst taxa provide the basis for time correlating the Rio Lora section. A range chart (Fig. 7) shows the ranges of key palynomorphs (dinoflagellates and pollen).

Dinoflagellate occurrences and graphic correlation indicate that the K-T boundary is located in the covered interval between 4019 and 4084 feet (1253-1273 m) in the measured section (Fig. 6). This is based on the presence of latest Maastrichtian aged palynomorph assemblages characterized by *Glaphyrocysta perforata* and *Dinogymnium pustulicostatum,* below the covered interval, and earliest Danian (Paleocene) age species *Danea californica, Fibrocysta bipolaris, Kenleya lophophora, Turbiosphaera filosa, Carpatella cornuta,* and *Cassidium fragile,* above the covered interval. Within the covered interval there may be a more or less complete boundary section, assuming continuous deposition and preservation of sediment. Additional support for a Late Cretaceous (Maastrichtian) age of the section below the covered interval is provided by the presence, in four samples, of low diversity nannofossil assemblages dominated by *Kamptnerius magnificus* (normally a rare species in the Late Cretaceous).

The succession of dinoflagellates found in the Rio Lora section both above and below the covered interval is consistent with studies carried out on other K-T boundary sections. The sections at El Kef, Tunisia (Brinkhuis and Zachariasse, 1988) and the Brazos River, Texas (Wrenn et al., 1989; Stein and Pocknall, 1996) provide a basis for comparison. To a lesser extent the section at Guayaquil, Ecuador (Barker et al., 1994) affords the same opportunity although the assemblages are much sparser as a result of the deep marine depositional environment. One element in common with the aforementioned sections, but absent in Rio Lora, is the abundance of the species of the genus *Manumiella* just below the boundary and extending into the basal Tertiary. Assuming the K-T boundary is preserved at Rio Lora, this bio-event should be recorded because there are marine deposits both above and below the covered interval.

In general, the transition from Cretaceous to Tertiary aged sediments in Western Venezuela and Colombia has been determined on the basis of terrestrially derived spore-pollen assemblages. The transition is generally considered (e.g. Muller et al., 1987) to span the boundary between the *Proteacidites dehaani* (Late Cretaceous) and *Foveotriletes margaritae* (Early Paleocene-Danian) zones as defined by Germeraad et al. (1968) for northern South America. Germeraad et al. (1968) noted that the P. *dehaani* Zone is associated with the smaller foraminifera *Globotruncana gansseri, G. lapparenti, G. stuarti, Guembelitria cretacea, Siphogeneroides bramletti,* and the ammonite *Sphenodiscus* sp., clearly indicating a Maastrichtian age. However, because the top of the zone is in predominantly coastal facies it was not possible to correlate the top of the zone with the top of the Maastrichtian without sufficient marine fossils. The Rio Lora section provides an opportunity to examine previous published palynological zonation schemes (Fig. 2) and determine more precisely the age ranges of some of the spores and pollen. Our results indicate that some of the spores and pollen that have been used to define the Late Cretaceous in Venezuela (in particular) appear to range into the Paleocene. These include *Crussafontites grandiosus* and *Periretisyncolpites giganteus.* Muller et al. (1987) indicate that the top of the zone is marked by the basal occurrence of *Spinizonocolpites baculatus* but in the Rio Lora section this species appears well down in the Maastrichtian Mito Juan Formation. The age of the overlying *Spinizonocolpites baculatus* Zone, restricted to the Orocue Group according to Muller et al. (1987), is not constrained by marine fossils but is assigned to the Paleocene. Some of the fossils used to define this zone appear to range down into the Maastrichtian at Rio Lora.

The present study highlights the significance of Rio Lora in understanding the fossil succession across the K-T boundary in northern South America and identifies the location of a new boundary section. In all K-T sections so far studied the thickness of section across the latest Maastrichtian to earliest Danian measures no more than a few feet, rarely as much as 20 feet (6.2 m). At Rio Lora there may be up to three times that thickness.

This work has identified what is apparently an important new K-T boundary section in northern South America. However, further work is required (such as excavating the covered section) in order to better define the complete record of the boundary section at this locality.

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