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The Cretaceous–Tertiary Boundary in the Beloc Formation, Southern Peninsula of Haiti, West Indies

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INTRODUCTION

The southern Peninsula comprises the southwestern portion of the island of Hispaniola which extends westward to form the Gulf of La Gonave, separated from the rest of the Caribbean Sea to the south. The eastern portion of the Peninsula also extends into the mainland areas where it curves southward into the Barahona Peninsula and becomes the landward extension of the Beata Ridge (Figure 1). This whole southern unit of Hispaniola is distinctly separated from the rest of the island by a remarkable fault-bounded depression, the Cul-de-Sac/Enriquillo valley (Plaine du Cul-de-Sac and Hoya de Enriquillo (Figures 2 - 3). The Peninsula is characterized by some of the highest reliefs of the island, which can be grouped into two distinct geomorphologic area separated by a narrow north-south-trending graben, the Jacmel-Fauche depression (Figures 2 - 3). The western areas of the Peninsula constitute the Massif de la Hotte, with its highest elevation at Peak Macaya (2,347 meters), whereas the eastern areas contain the Massif de la Selle, with its highest elevation at Peak La Selle (2,674 meters, in Haiti), and the Sierra de Bahoruco, with its highest summit at Peak Loma del Toro (2,367 meters, in the Dominican Republic).

The general physiography is essentially fault controlled, and the most prominent such feature is the Trans-Xaragua fault system that transects the entire length of the Peninsula diagonally (Figure 1, 3). This fault system continues seaward to the west toward Jamaica, whereas it extends into the Muertos Trough to the east (Figure 1). The road to Jacmel crosses this fault immediately south of Carrefour Dufort located west of Riviere Rouyonne (Figure 3).

The remarkable orographic system that constitutes the southern Peninsula can be essentially related to transcurrent faulting associated with tectonic activities along the northern boundary of the Caribbean plate. Transpressional stresses acting along this particular area of the Caribbean played an important role in the uplift and the present structural mode of southern Hispaniola. This portion of the island shows a complex orthogonal fabric of dislocation that controls the patterns of the mountain ranges. The uplift involved terranes equivalent to the Caribbean Sea crust to several thousand meters above the sea floor. Gravity surveys (Bowin, 1976; Reblin, 1973) suggest that igneous rocks of oceanic character probably underlie most of the southern Peninsula.

Differential uplift throughout the Cenozoic that led to the present distribution of the various tectonostratigraphic terranes in the southern Peninsula is comparable to that observed in the adjacent Beata Ridge (Figure 1). In addition to relief influenced by tectonism, the topography is further accentuated by relief inversion caused by faster weathering of the older basaltic terranes relative to the overlying limestone rocks, as will be observed during the crossing to Jacmel.

ROCK UNITS

Rock sequences of the Peninsula that show any kind of evidence related to the K/T boundary event are those of the basement rocks of Cretaceous ages to the early most Paleocene:

Cretaceous

Rocks of Cretaceous age consist of the igneous complex of the Dumisseau Formation, the pelagic limestones of the Macaya Formation, and in the Bahoruco Mountains. The lower part of the Beloc Formation also includes eupelagic limestone of the Late Maastrichtian *Globotruncana contusa zone.*

The Dumisseau Formation

(Maurrasse and others, 1979) forms the basement rocks throughout the Peninsula, and consists primarily of tholeitic basalts. It is "essentially characterized by a sequence of interbedded pillowed and non-pillowed basalts, dolerites, pelagic limestones, intrabasinal volcanogenic and biogenic turbidites, varicolored cherts and siliceous siltstones".

Petrologic and geochemical studies of the basaltic rocks yield compositions similar to those recovered from the adjacent Caribbean Sea (Donnelly and others, 1973), thus supporting the field data implying that the southern Peninsula is composed of uplifted blocks of the Caribbean Sea crust (Maurrasse and others, 1979; Maurrasse, 1982a; 1982b; Calmus, 1983; Sen and Maurrasse, 1986; Bien-Aime Momtplaisir, 1986; Sen and others, 1988). Igneous rocks of the Dumisseau Formation are markedly different from the igneous rocks of the northern areas of the island, which are essentially of island-arc type. In places, the upper part of the Dumisseau Formation is so intensely tectonized that the intercalated limestones and charts become discontinuous and form free-floating pebbles and blocks in the basaltic matrix similar to a melange (Figure 4).

Foraminiferal and radiolarian fauna in the enclosed limestones indicate ages ranging from at least Cenomanian (early Late Cretaceous), and possibly Albian, to the Maastrichtian (Maurrasse and others, 1979; Bien-Aime Momplaisir, 1986). These relative age determinations are compatible with reported radiometric dates of 75 + 1.5 Ma (40K/40 Ar: Sayeed and others, 1978); 85 Ma (40K/40 Ar: van den Berghe, 1983); 95.3 to 102.3 Ma (40K/40 Ar: Bellon and others, 1985); and 87.6 + 1.5 to 89.9 + 1.1 Ma (40Ar/39 Ar: Sinton and Duncan, 1992). Rocks of the

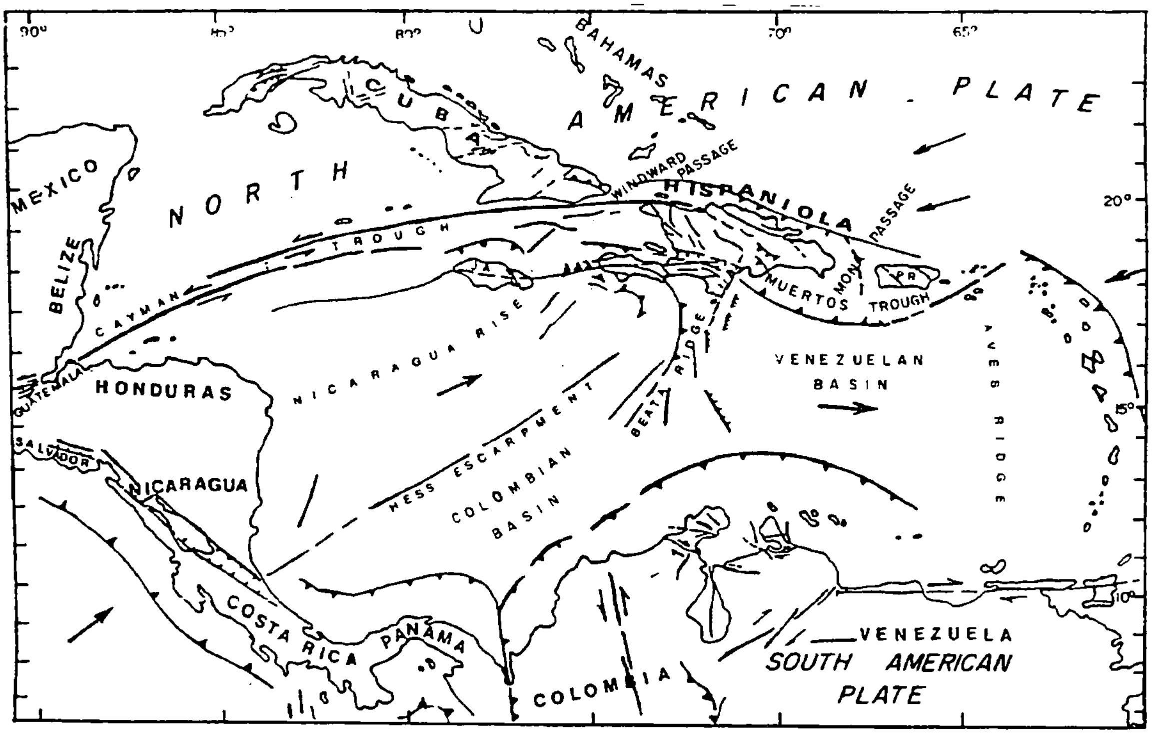


Figure 1. General Structural setting of the Caribbean region (From Maurrasse, 1982)

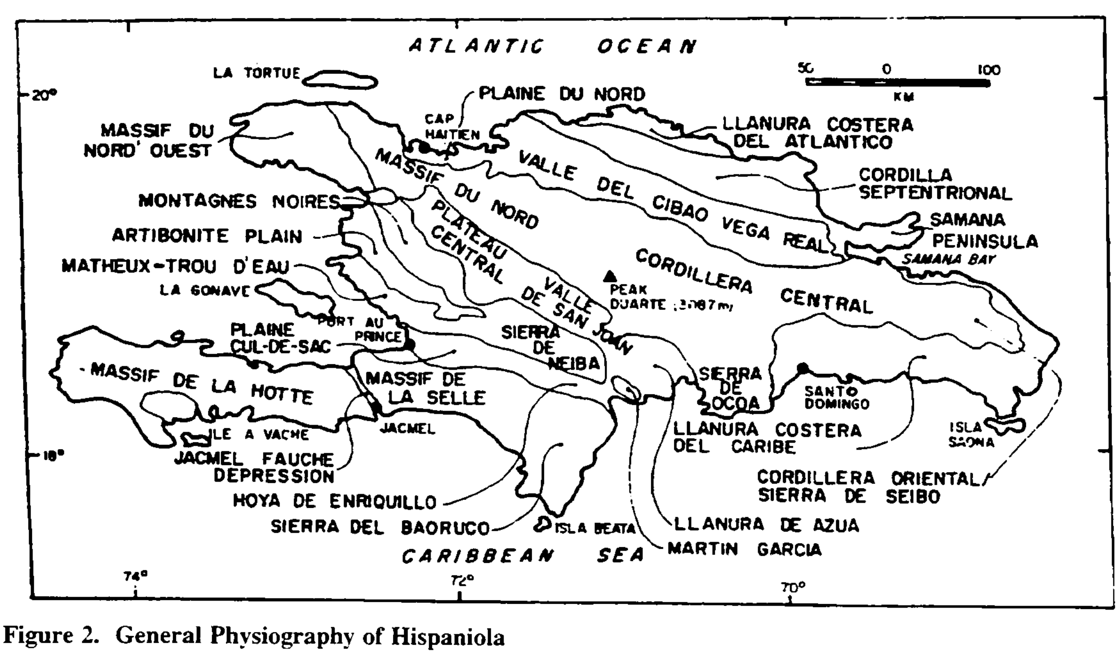


Figure 2. General Physiography of Hispaniola

Dumisseau Formation are very well exposed in the field trip area.

The Macaya Formation (Butterlin, 1954) consists essentially of varicolored, recrystallized and sparsely silicified eupelagic foraminiferal nannoplankton limestones, marls, and cherts. The Formation is characterized mainly by the extensive network of microfractures filled with calcite that occur throughout the different units particularly in the western area as typified in the Massif de Macaya. Facies of the Formation are identical to similar rocks recovered from the Deep Sea Drilling Project Leg 15 sites in the adjacent Caribbean Sea (Edgar and others, 1973; Maurrasse, 1973). The set of microfractures are comparable with those observed at Site 153 at the K/T boundary (Maurrasse, 1973), and may have a common origin related to shock waves generated by the impact at Chicxulub. Planktonic foraminiferal and radiolarian assemblages indicate ages from at least the Santonian to late Maastrichtian (Butterlin, 1954; Ayala-Castanares, 1959; Maurrasse, 1982). Lithofacies associated with the Macaya Formation occur only in the areas of the Peninsula west of the Jacmel-Fauche depression, and in the Beloc/ Jacmel area they occur as allochtonous fragments of a polygenic megabreccia also believed to be associated with the K/T impact event (Maurrasse and Sen, 1991b).

The Rio Arriba Formation

(Llinas, 1972) occurs in the Bahoruco Mountains and is composed primarily of interbedded cream-colored foraminiferal nannoplankton marls and sandy limestones with radiolaria, representative of a pelagic environment with varying amounts of terrigenous components. These rocks show very few microfractures, unlike rock units of the Macaya Formation typical of the western areas of the Peninsula. Tintinnids or Calpionellids present in this Formation indicate a possible lower limit in the Albian stage, whereas planktonic foraminifera imply an upper limit in the Maastrichtian. This formation is thus a lateral equivalent of the Macaya Formation.

Cretaceous to Tertiary

The Beloc Formation (Maurrasse, 1982) is the most important rock unit in the southern Peninsula for the transition between the Cretaceous and the Tertiary because it includes numerous outcrops with the boundary event marker bed. Numerous outcrops of the marker beds can be observed over a distance of approximately 3 kilometers along the road starting immediately south of the hamlet of Beloc (Figures 8, 9), going southward to Jacmel. We will focus our visit on two areas: the outcrops immediately south of the village of Beloc (Stop 1 Figures 8, 9), and the original standard section (Stop 2, Figure 10).

Lithostratigraphy. At the type locality, the complete sequence includes a monogenic basaltic conglomerate 1 to 2 meters thick that overlies and intergrades with weathered rocks of the Dumisseau Formation. The overlying calcareous rocks vary from pale yellowish-gray (5Y8/2) to yellowish-gray (5Y7/2) and moderate grayish-orange (10YR8/4) when dry, but become much darker or nearly moderate yellowish-brown (10YR7/2) when wet. Beds in the lower part of the sequence vary from about 3 cm to 100 cm in thickness but become more even, from about 10 to 20 cm, toward the upper part (Figure 5). Outcrops of the K/T boundary marker bed occur in places along the road and on the mountain slopes in the vicinity of Beloc, but they are discontinuous due to intense vertical and thrust faulting that affect the Formation (Figures 6 - 8). Faulting often causes significant vertical displacement and repetition of units that are not readily apparent within the sequence, but can be determined my the occurrence of the marker bed at widely different altitudes within the areal extent of the Beloc Formation.

The sequence consists of sparse foraminiferal nannoplankton limestones of variable induration (Figures 5, 6). The Cretaceous portion also contains variable amounts of radiolaria, and intermittent dark brownish-gray to dark gray chert stringers.

Microscopically, the limestones consist of sparse foraminiferal nannoplankton micrites with variable of recrystallization showing microspars. Silicification is predominately dispersive, and becomes pervasive only at certain levels in the upper Maastrichtian rocks.

The boundary layer is easily distinguished from the enclosing limestones and appears homogeneous as a simple graded layer to the casual observer. in fact, close examination of that layer at any of the outcrops reveals extensive heterogeneity characterized by recurrent flow structures (Maurrasse and Sen, 1991) that are sometimes very subtle and difficult to observe, particularly if the outcrop is freshly cut. These structures are best observed on an older exposed surface. General features of the marker bed are as typified at the standard section (figure 10) reported earlier (Maurrasse and Sen, 1991). In the field the color and contrast of the K/T marker bed are distinct from those of the underlying rocks (Figure8, 9). Colors vary within the ejecta layer where the lower part is always darker (composed of nearly pure altered tektites), whereas the upper part is lighter due to a constant pattern of increasing carbonate content upward, up to 72% (outcrop A, Figure 8). The marker bed thus varies between light olive gray and light olive brown when wet, but becomes significantly lighter and less conspicuous in the outcrops when dry. In contrast, the adjacent chalk and marlstone beds show various shades of gray and pale yellowish-brown colors. The lower contact of the marker bed at all the different sites is always sharp, but show little evidence of an erosional base. The upper contact is less sharp, although the lithified Tertiary limestone can define its upper boundary, despite marked variations in its thickness from place to place.

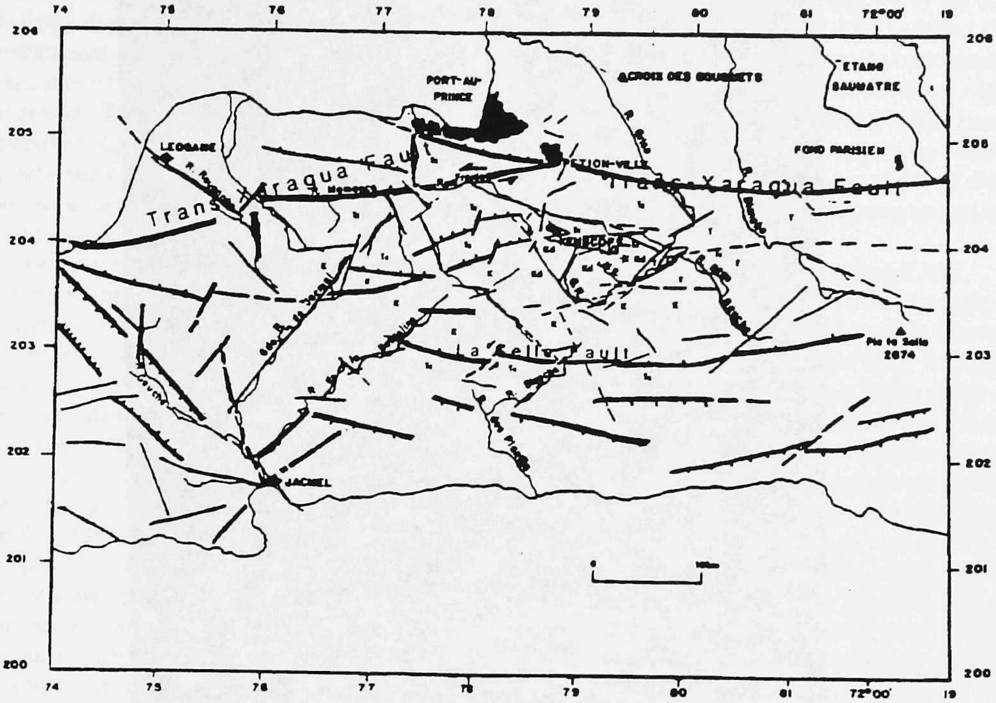


Figure 3. Simplified structural map of the eastern portion of the southern Peninsula (adapted from Maurrasse and others, 1979)

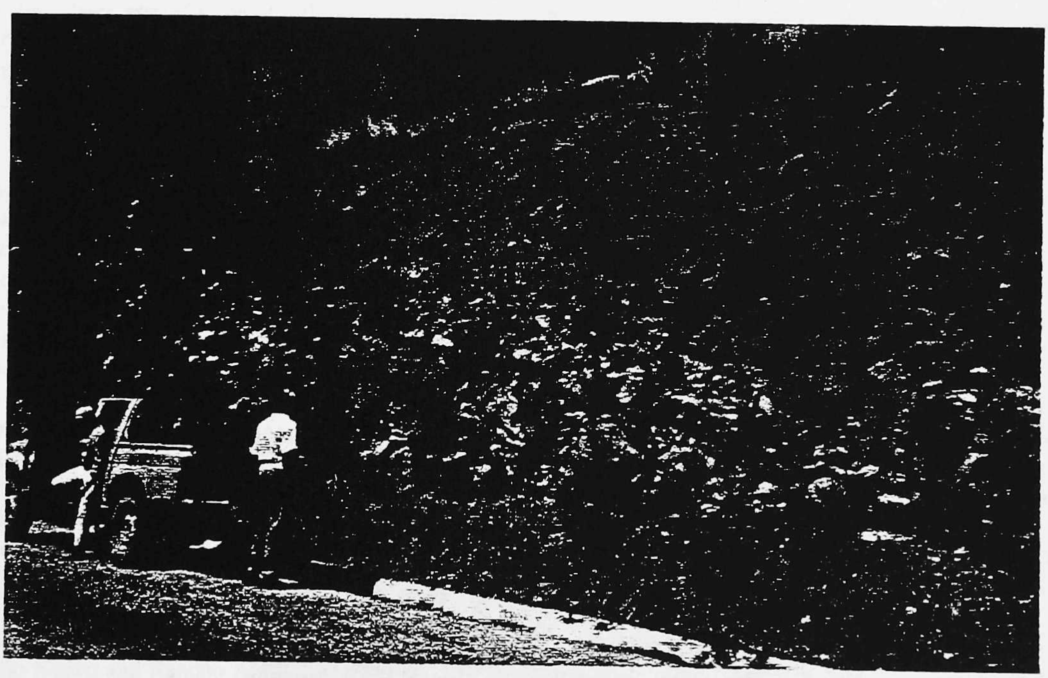


Figure 4. View at the Dumisseau Formation with blocks of limestones

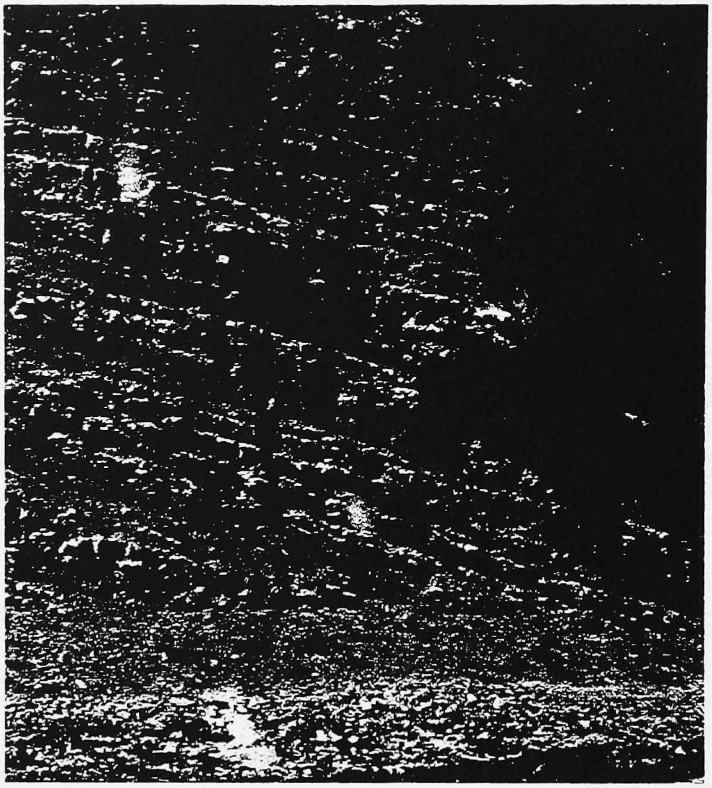


Figure 5. Beloc Formation, near stratotype

Figure 6. Beloc Formation showing minor sets of faults that offset bedding plane

Well defined boundary beds shown in Figures 8, 9, and 10 vary from about 40 cm in places, and up to 72.5 cm at the stratotype (Maurrasse, 1982). Imbrication due to low-angle faulting and slumping may also cause the marker bed to attain greater thicknesses, up to 115 cm thick in places.

At most sites, it is possible to recognize two levels within the marker bed. The lower part that is dominantly (@ 80%) composed of clay spherules (altered microtektites) with interstitial smectite clay (Izett and others, 1990) and minor carbonate. Its thickness at the stratotype is approximately 20 cm, and shows a wavy gradational contact with the upper part. The carbonate becomes more abundant upsection but fluctuates depending on the nature of lenses. The upper part consists of marl with medium grained spherules, and numerous intermingled lenses (up to 1 cm thick) of course clay spherules, and thin (4 to 10 mm thick) lenses of micrite and calcareous shale. Both are embedded in the calcareous zone of the marker bed which also contains scattered microspherules smaller than those of the enclosing lenses, and the ones that occur in the lower part (Maurrasse and Sen, 1991; Sirgudsson and others, 1991). The number of spherules decreases toward the top of the bed. Both types of lenses may reach lengths exceeding 28 cm, and are parallel or sub-parallel to bedding plane (Figure 11). Gradation and cross-lamination occur within the upper part which displays great lateral variation in geometry and lithology over short distances. However, the various outcrops reveal no consistent lateral or vertical size gradation such as those observed in ordinary turbidites.

Although the amalgamated structures of the boundary bed at Beloc have been argued to be of turbidity origin, the issue is far from clear, because our examination of several coeval Haitian sequences (Maurrasse and Sen, 1991) indicates that the complexity of the observed disturbances does not conform to that of ordinary deep-sea turbidites sequences. At the stratotype (Figure 11), for instance, the boundary layer includes successive series of laterally discontinuous graded bedding structures that are intermingled with coarser materials toward the top (such structures are not so evident in some of the more accessible outcrops along the road (Stop 1), which are also the most popular sites visited by other groups of investigators. As argued before (Maurrasse and Sen, 1991), large scale water movements capable of reaching the deep abyssal floor is inconceivable from presently known mechanisms. Steady deceleration related to normal gravity controlled settling in a turbidity flow would not allow recurrence of coarse-grained tektite lenses and ripped up fragments toward the topmost levels of the marker bed. such occurrences are incompatible with structures developed in the standard Bouma sequence. In fact, the occurrence of similar oscillatory structures in widespread area such as Brazos River, Rancho Nuevo and Rancho Altamira in northeastern Mexico attests of the exceptional intensity of the triggering factor that transcends depth factors and bottom topography that existed at the time. Thus, until an alternative explanation can be formulated in support of the simple turbidite hypothesis, oscillatory waves triggered by the oceanic impact (Ahrens and O'keefe, 1983; Gault and Sonett, 1982; Sonett and others, 1991) is the most viable explanation to account for the structures recorded at such a wide range of depths over such wide areas during the K/T boundary event. Such factor is very important to consider in geochemical and paleontological analyses of the K/T boundary bed where there are apparent unexplained discrepancies.

Micropaleontology and Age

Planktonic foraminifera constitute the main identifiable fauna, but there are also rare benthic foraminifera, radiolaria, and traces of echinoid spine fragments, which are more common toward the west in the valley of Grande Riviere de Jacmel (Figure 3). Planktonic foraminiferal assemblages are well diversified throughout the sequence although specimens may appear poorly preserved (Maurrasse, 1982; Geier, 1993) because they are often recrystallized and coated with indurated matrix. Radiolaria occur mainly within the upper Maastrichtian rocks and become practically extinct in the Danian stage. Maurrasse (1982) and Maurrasse et. al., (1979/1985) identified the marker bed to represent the K/T boundary on the basis of the faunal succession in the Beloc Formation. The age of the sequence ranges from at least the Globotruncana (Rosita) contusa Zone to the earliest Paleocene Globorotalia (Morozovella) psuedobulloides Zone (Maurrasse and others, 1979/1985; Maurrasse, 1982; Geier, 1993). Based on the occurrence of the *Trinitella scotti, Rugoglobigerina reicheli* and *Pseudoguembelina polypleura,* the latest Maastrichtian is represented by the *Trinitella scotti* Zone (Masters, 1977). This zone is coeval with the more commonly used *Abathomphalus mayaroensis* Zone, whose nominate taxon is not identified here (Geier, 1993). The topmost layer of the marker bed is characterized by foraminiferal assemblages assigned to the earliest Danian with *Globigerina eugubina, Globigerina fringa,* although they also appear at lower levels in the marker bed, and Cretaceous taxa continue to occur with Tertiary species (Maurrasse and others, 1979, 1985; Maurrasse, 1982). We believe that, at least, part of this apparent discrepancy in the species ranges can be attributed to extensive mixing that occurred on the deep-sea floor, either contemporaneously with the impact event, or shortly thereafter, as indicated by the flow structures present int he market bed and not in subsequent facies.

Recent $^{40}Ar/^{30}$ Ar age determinations on the Beloc marker bed (Izett and others (1992); Swisher and others (1993) have given a date of 65 Ma for the glasses, which is in agreement with dated obtained for similar materials from the Chicxulub crater in Yucatan, Mexico, one of the closest impact sites that triggered the K/T boundary event recorded in the southern Peninsula.

Petrology

Microscopically, the lower part is packed microtektite sandstone with a matrix of angular glass completely altered into smectite. It also contains rare shocked quartz grains, 1 - 2mm across, with at least three sets of intersecting straight (planar) lamellae (Hildebrand andBoynton, 1990; Izett et al., 1990; Sirgudsson and others, 1991; Maurrasse and Sen, 1991). The matrix in the upper part consists primarily of microspar aggregates, and less than 1% distinguishable nannoplanktons, most dislocated and poorly preserved. Argillaceous components of the matrix are microcrystalline and display a finely isotropic fabric parallel to bedding. Fossil remains also show a distinct preferential orientation of long axes parallel or sub-parallel to bedding. As described by numerous workers on the Beloc section, tektites are greatly variable in size and morphology, up to 8mm long. Spherical and ellipsoidal shapes are prevalent, but teardrop and dumbbell shaped spherules are fairly common as well. In several spherules, the outermost 0.1mm or so rim usually is concentrically altered t a brown smectite, and have a translucent shiny to waxy appearance that is typical of the lower part of the marker bed. The large spherules generally contain smaller spherules within them, and are all altered to smectite in the lower part of the bed (Maurrasse and Sen, 1991). Approximately 10% of the spherules from the middle and upper parts of the boundary bed contains unaltered glass cores (Izett et al., 1990; Sirgudsson and others, 1991; Maurrasse and Sen, 1991). Unaltered glasses are consistently found where the carbonate component is significantly greater in the matrix, i.e, in the upper part of the boundary bed. Several spherules show that the glass is completely surrounded by massive calcite, which may have effectively prevented access of groundwater into the core of these spherules. The amount of well preserved glasses is very low, as about ninety percent of the clay spherules are hollow with their cores either empty or lined with drusy calcite. The color of the glass varies from deep brown (also called black glass) to deep yellow, with the latter variety being extremely rare. Individual glass fragments were found to be fairly homogeneous in composition, and are consistently free of any crystal or microlites (Maurrasse and Sen, 1991; Sirgudsson and others, 1992). This characteristic and the morphology of the glass spherules clearly points to their tektite origin. (Hildebrand and Benton, 1990; Izett and others, 1990; Maurrasse and Sen, 1991). Empty calcite-lined vesicles occur in both yellow and brown glasses, and there is little or no apparent correlation between vesicle abundance and the glass color. As noted by other workers, the glasses have "cratered" surface with sharp ridges.

Geochemistry

Existing probe data (Maurrasse and Sen, 1991) show that the spherules from the lower part of the boundary bed are too altered to yield a reliable composition of the original glass. Thus it still remains uncertain whether or not the original glass composition of the altered spherules from the lower part of the marker bed was similar to the unaltered yellow or dark glasses found within the partly altered tektites of the upper part of the bed. As it has been demonstrated (Izett and others, 199; Maurrasse and Sen, 1991; Sirgudsson et al., 1991; 1991; Blum and Chamberlain, 1992) the two glass types are distance from each other in terms of major elements, trace elements, and isotopic compositions (Figures 12 - 16). The composition of the dark glass type is in the neighborhood of andesites with 58-67% SiO, 4-10% CaO, 2-3% Mg0, 4.3-5.8% FeO* (Figures 12 - 16). In contrast, the yellow glasses have much higher CaO and MgO, but lower SiO2 and La than the dark glasses (Figures 12 - 15). However, their FeO* and alkali contents overlap. Sirgurdsson and others (1991, 1992) suggested that the origin of the yellow type glasses is by melting a mixed source with evaporites (anhydrites) and andesitic materials, whereas Maurrasse and Sen (1991) argued that the CaO was largely contributed by platformcarbonates with significant amounts of dolostone, as can be deduced from the data presented in Figure 14. It is also of interest to point out that significant interlaboratory bias occurs in the analysis of Na and K (Figures 12,13). For example, in Figure 13 it appears that data from Izett and others, (1990) consistently show higher K2O values in the dark glass population than those determined by other workers. In opposite, K20 values from Maurrasse and Sen (1991) are consistently the lowest in both Na2O and K20 (Figures 12,13). It is likely that these lowest values were influenced by the loss of Na and K through volatilization during microprobe analyses. Oxygen isotopic analyses carried out by Oskarsson and others, (1991) and Blum and Chamberlain (1992) on both types of glasses. Blum and Chamberlain showed that they are distinctive in their oxygen isotopic compositions. Their data concur with earlier inferences (Maurrasse and Sen, I 991) that platform carbonates rather than gypsum or anhydrite were involved in the impact melting process.

The topmost layer (2.5cm maximum thickness), and similar lenses that occur in the upper part have been found to contain varying amount unusually high iridium (Maurrasse, 1982, and Asaro written communication, February 1994) implying their origin from an impact event. Highest iridium values consistently occur at the top layer of the marker bed (up to 3.87 ppb), but anomalously high iridium is also recorded in enclosed lenses (up to 5.07 ppb). Significant Ir vs. Ni anomaly found in the Haitian sequence further supports the impact origin of these spherules. Jehanno et al., (1991) observed that the spikes in

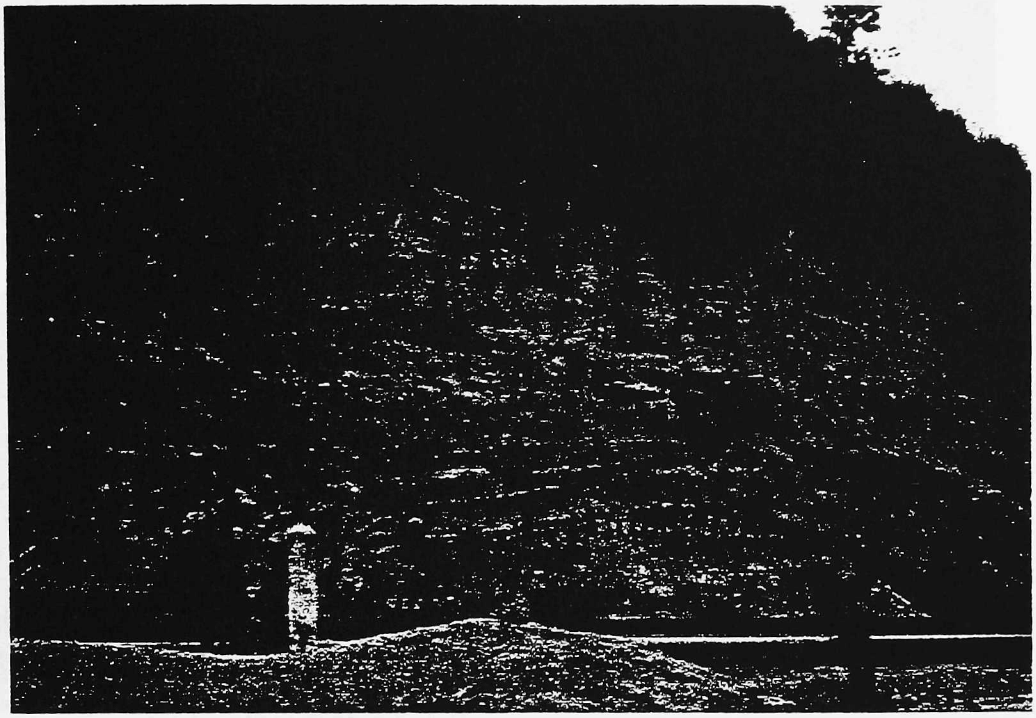


Figure 7. Thrust faulting in Beloc Formation on Road south of village of Beloc

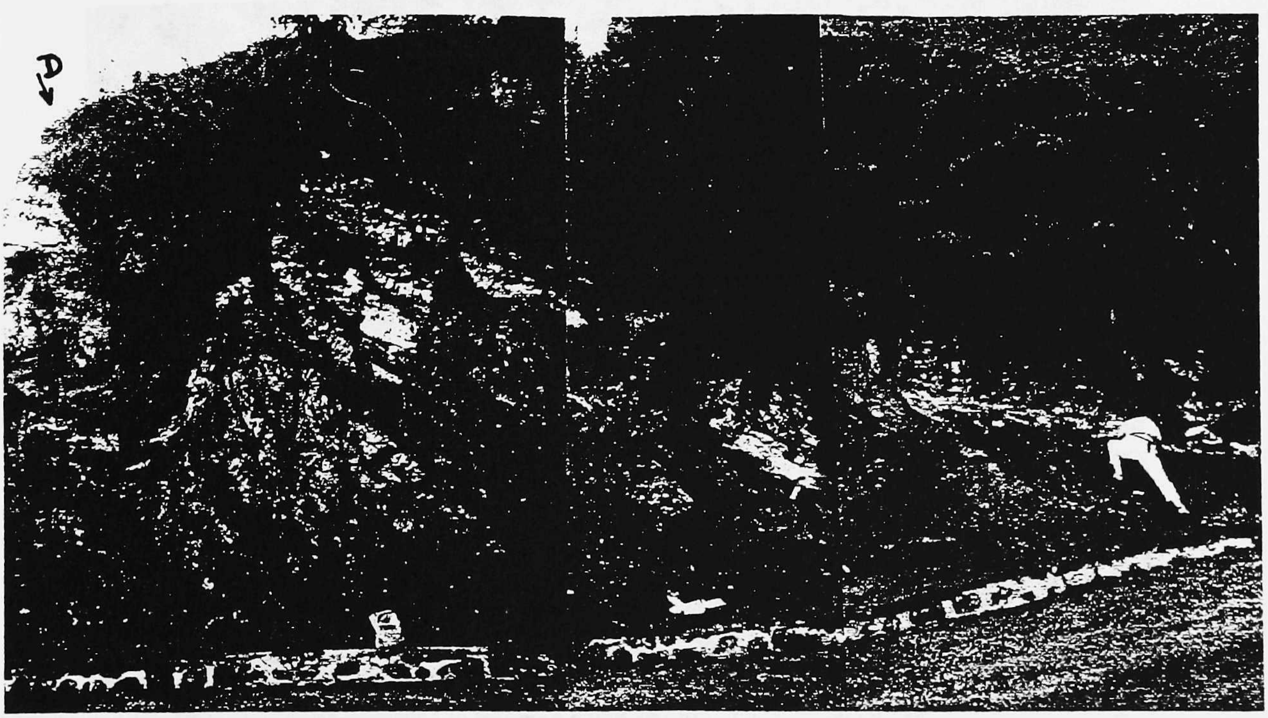


Figure 8. Beloc Formation: Stop 1 stations A, B, C, showing K/T boundary marker bed with different thicknesses

Figure 9. Beloc Formation: Stop 1 station D showing K/T boundary marker bed

Figure 10. View of the stratotype section of the Beloc Formation. Arrow indicates location of K/T boundary marker bed drawn in Figure 11.

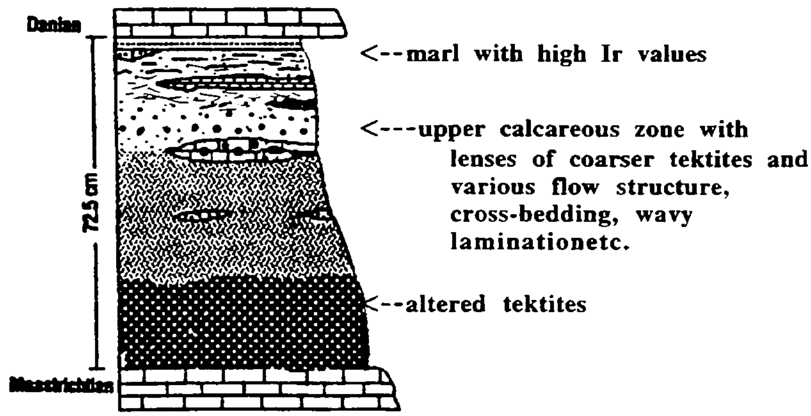
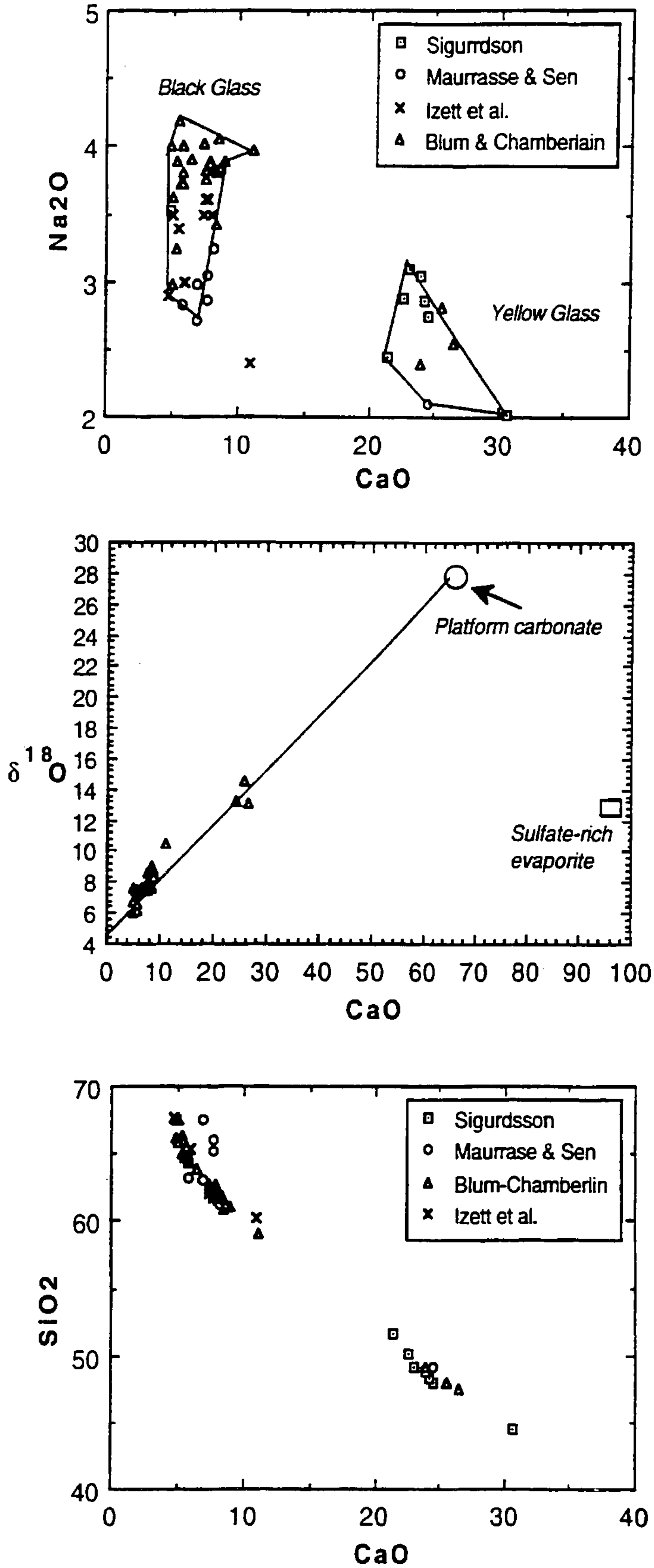


Figure 11. Detail of structures present in the standard K/T boundary bed at the stratotype (From Maurrasse and Sen, Sci.v.252, p. 1690).

Ir versus Ni- magnetite concentrations occur at very different levels in the vertical sequence of the boundary layer. These authors could not provide a satisfaciory explanation for the observed difference in the occurrence of Ir vs Ni- magnetite spikes but noted that both are consistent with an impact origin of the K/T boundary layer. Reworking by the oscillatory waves may be the explanation for the values obtained in the boundary bed.



Sigurrdson
Maurrasse & Sen
Izett et al.
Blum & Chamberlain
Black Glass
Yellow Glass
Na2O
CaO
δ18O
Platform carbonate
Sulfate-rich evaporite
Sigurdsson
Maurrase & Sen
Blum-Chamberlin
Izett et al.
SiO2

Figure 12.

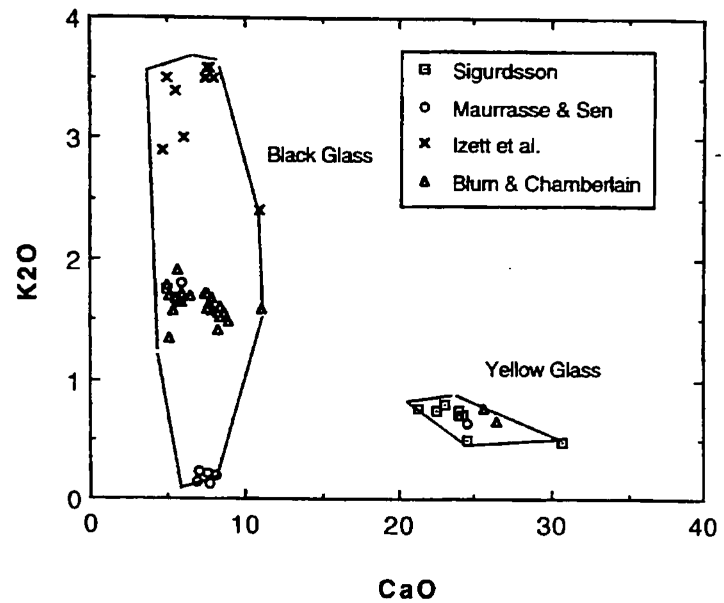


Figure 13.

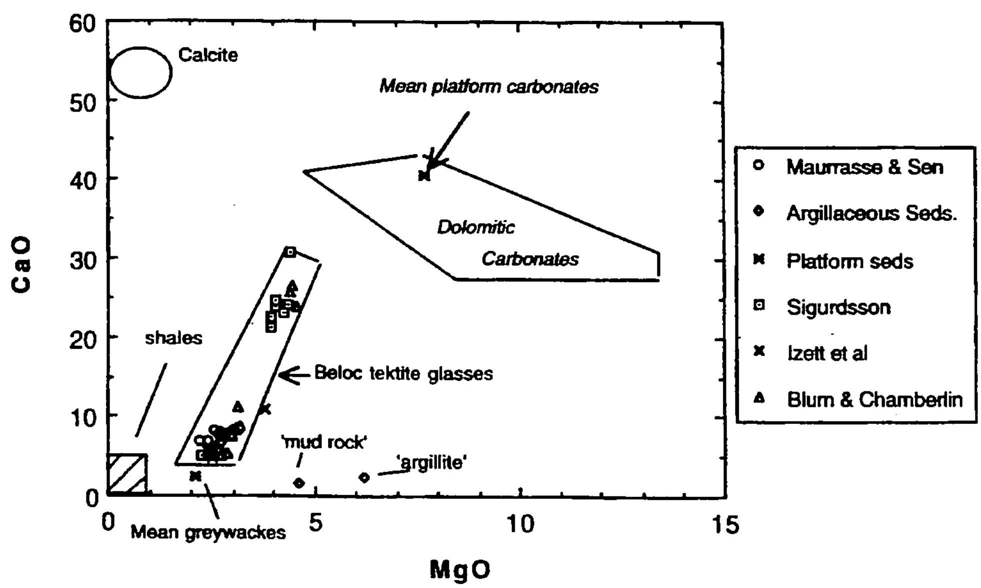


Figure 14.

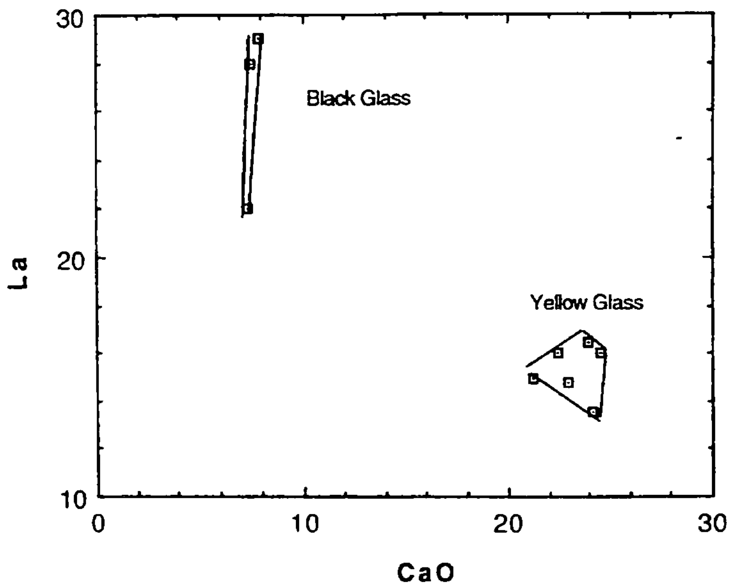


Figure 15.

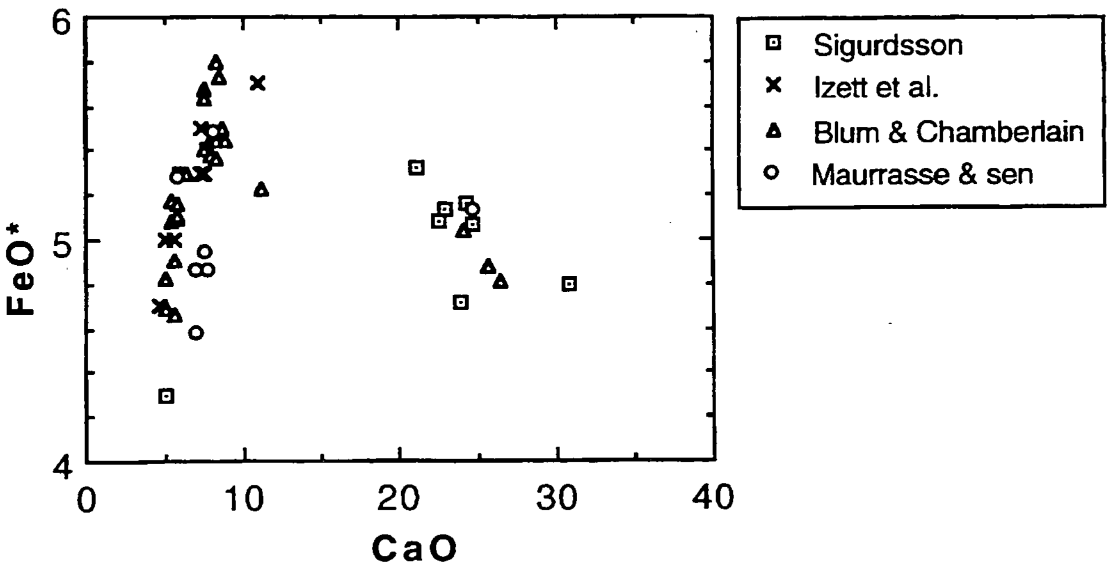


Figure 16.

ROAD LOG

The principal purpose of this field trip is to examine the complexity of the main outcrops where the K/T marker bed occurs in the Beloc Formation of the Beloc area. Two main stops will occupy most of the time of this short excursion and the road log given herein is a general information to acquaint the participant with the general geology of the area along the way to Jacmel.

From the airport in Port-au-Prince the road will run across the bay over alluvial fills of a gigantic Holocene fan developed at the mouths of several coalescing sporadic rivers that become functional only during rainfalls. As we reach the southeastern corner of the bay area you wilt notice the delta of Ravine Bois de Chene that has prograded more than 300 meters into the bay during the past 40 years or so. The mountains in the backdrop of the city constitute the Morne l'Hopital part of the fault-controlled (Figure 3) foothills of the Massif de la Selle. The city is built along the strike of the prominent Trans-Xaragua fault system. and at the southern edge of the Cul-de=Sac/Enriquillo graben.

The road proceeds westward toward Carrefour. the western suburb of Port-au-Prince. Most of the geologic outcrops are now hidden by rapid urbanization in this area. Logging will start from the bridge crossing Riviere Froide at Carrefour.

0.0 Km Bridge crossing Riviere Froide on Nationale I

.76 Km South side of road. slope wash conglomerate where cattle market is.

3.7 Km Mer Frappee: outcrop of bedded limestone and chalk behind the houses.

4.5 Km Hotel le Lambi on north side of the road. From this locality on medial to upper Miocene pelagic limestones and chalk crop out on the south side of the road. These rocks range in age from the Middle Miocene Globorotalia mayeri zone to the late Miocene Globorotalia acostaensis Zone. This sequence shows rapid shallowing with increasing benthonic foraminifera. ostracods. echinoid debris toward the upper part.

4.9 Km Pleistocene chalky conglomerate.

10.0 KmMorne a Bateau: Here the rocks consist of alternating beds of dark yellowish sand and clay. and calcareous conglomerate. which is composed of lumpy aggregates of coral and mollusk fragments. They also comprise abundant benthonic foraminifera. ostracods. some fragments of bryozoan and echinoid. Beds composed of liner constituents include well diversified planktonic foraminiferal assemblages. The planktonic foraminifera yield an age ranging from the late Miocene Globorotalia dutertrei Zone to the Early Pliocene Globoquadrina altispira Zone.

13 Km Gressier. located at the eastern edge of the Leogane Plain. which is the prograding delta of the Momance River.

19.7 KmCrossing of the Bridge on River Momance.

24. I Km Entrance to the city of Leogane. that is located to the right toward about the center of the plain. This city is the site or the pre-Columbian Arrawak city of Yaguana. now distorted and called Leogane since colonial times. Yaguana was the capita! city of the Anawak kingdom of Xaragua. which was governed by queen Anacaona when Columbus first arrived in the island.

31.2 KmCrossing of bridge on Riviere Cormier. immediately north of the junction with the road going to Jacmel toward the left (southward).

Road post 43 Km from Jacmel at Carrefour Dufort

END OF LOGGING BASED ON BRIDGE CROSSING RIVIERE FROIDE ON NATIONALE ONE.

NEW LOGGING USES DISTANCES AWAY FROM JUNCTION ROAD TO JACMEL AND NATIONALE 1.

0.5 - 1.0 Km Road toward Jacmel shows well developed sequence of bedded neritopelagic limestone and chalk with large amount of coral debris. Planktonic foraminifera indicate an age ranging from the latest Miocene Globorotalia dutertrei Zone. to the Late Pliocene Globorotalia tosaensis Zone.

From here on the road starts to climb rather steeply into the backbone of the southern Peninsula by crossing the Tans-Xaragua fault. Disturbed area where limestone and basalt block occur juxtaposed against against one another caught in the fault area.

2.0 Km Limestone breccia (fault gouge) called "Laboule sand," after the name of the locality of La Boule south of Port-au-Prince where it was first quarried for construction purpose. Campanian foraminiferal nannoplankton chalk overlies deeply weathered igneous nock of the Dumisseau Formation. Farther uphill. about 1.6 Km from here. the chalk facies changes into thinly bedded limestone and chalks of the latest Maastrichtian Trinitella scotti Zone.

Note the magnificent drop off of the Trans-Xaragua fault scarp northward of the road.

4.10 KmColumnar basalts occur in the dry valley on the

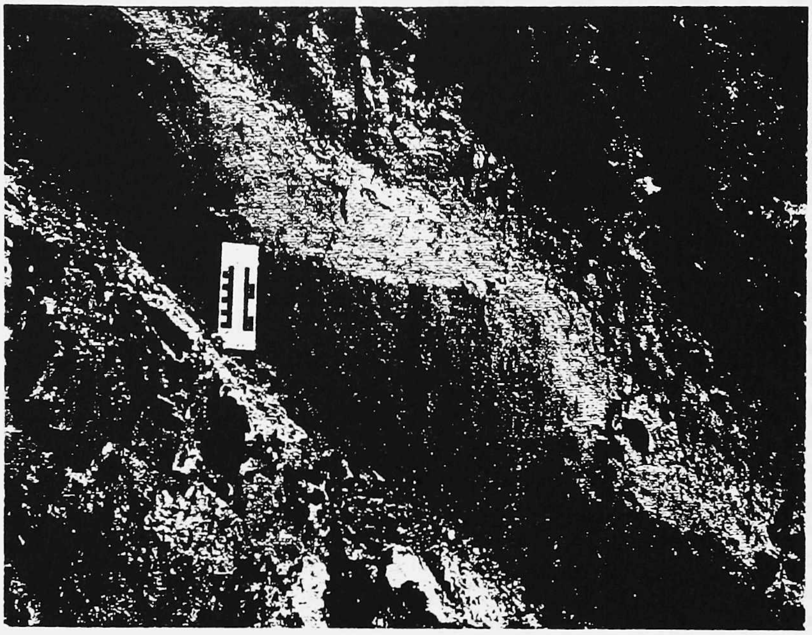


Figure 17.- View of the marker bed at Stop 1 station A, see Figure 8 for location

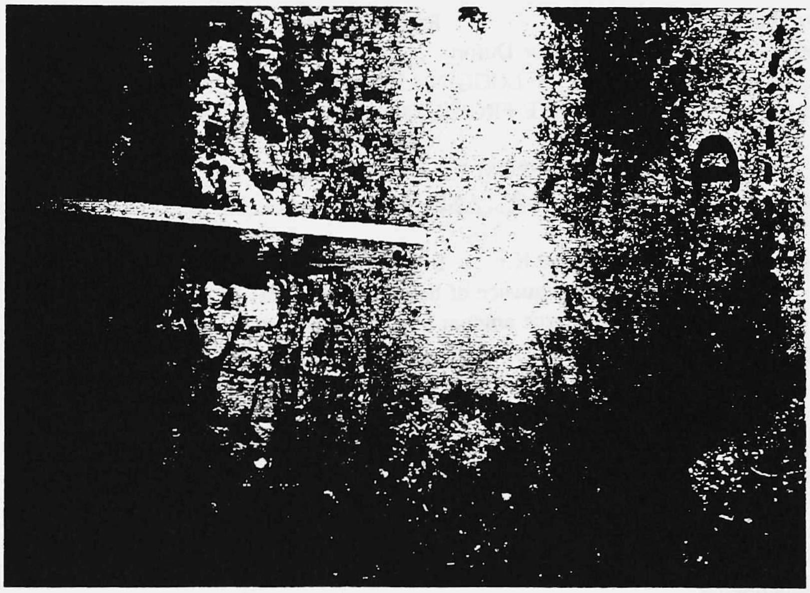


Figure 18. View of the marker bed at Stop 1 station D, see Figure 9 for location

right side of the road. From here onwards toward Jacmel there will be extensive outcrops of the Dumisseau complex.

12.5 - 13.0 Km Dislocated Coniacian limestones as floating blocks within the basaltic rocks.

I 44 Km Large outcrop of steeply dipping to vertical Coniacian limestone. A thin doleritic sill also occurs parallel to the bedding plane of the limestone layers.

16.2 KmA major northeast-southwest trending fault cuts across this area. Farther uphill observe spheroidal weathering of the igneous rocks. Also observe a thick medium coarse volcanogenic conglomerate believed to be the distal equivalent of the coarse basal conglomerate reported at the type section of the Beloc Formation. Minor hydrothermal mineralization of manganese also occurs in this area.

17.5 KmDumisseau Formation rocks unconformably overlain by middle Maastrichtian chalk and limestone intercalated with intrabasinal volcanogenic turbidites with a chalky matrix containing abundant reworked Campanian foraminifera (Globotruncana carinata, Globotruncana elevata, and others. The chalk also includes numerous clear spinet.

18.5 Km Village of Beloc.

19.5 Km **STOP I**

Beginning of the Beloc Formation (Figure 8). Here the marker bed is extensive as it is repeated due to trust faulting. The numerous outcrops will be examined in detail to observe the complicated structures described previously. We will compare structures at outcrops A, B C and D up the steep slope of the road cut.

On the way to stop 2 observe the Beloc Formation rock sand the numerous minor faults that cut across and cause varying amount of dislocation.

22.5 Km **STOP 2**

Beloc standard section. Here the sequence is affected by some high angle faults that cause vertical displacement between blocks and offset the continuity of the marker bed that occurs about 25 meters down the steep slope. Rope is needed for those who are not familiar with steep hiking in order to reach the standard outcrop of the stratotype section, as discussed before.

24.1 Km Limit between "Department de l'Ouest to the north and Department du Sud'Est" to the south. This is also a natural boundary, which marks the end of the Beloc Formation through a fault. Observe volcanoclastic basaltic conglomerate at this contact.

25-2 - 26.0 Km Decouze- Deep lateritic soil developed over the igneous basement rock. Note also calcareous breccia of the Laboule sand which always indicates faulting in the area.

26-1 Km Immediately south of Decouze are lower Oligocene pelagic limestone and chalk of the Globigerina ampliapertura Zone overlain by shallower limestone facies with
Lepidocyclina.

27.0 Km Chalk facies, also of Oligocene age This eupelagic facies of chalk has been described as the Jeremie formation, after of the city of Jeremie along the northwestern coast of the southern Peninsula.

28.8 Km Fault contact between the younger pelagic facies to the south and the oldermiddle Paleogene biocalcarenite and biocalcirudite to the north. The biocalcirudite contains coral fragments and abundant calcareouis algae indicative of a shallow bank.

31.8 - 32.0 Km Nerito-pelagic limestones of late Miocene to earliest Pliocene ages. These rocks are affected by some spectacular thrust folds and faults. Planktonic foraminiferal assemblages are well diversified and include upper Miocene taxa at the base, and Globorotalia margaritae toward the top.

33.8 Km Voluminous slope wash developed in fault zone separating Oligocene chalks from the Miocene limestones.

35.1 Km Recurrence of chalky facies of the Jeremie Formation. Here the foraminiferal fauna is well preserved and include a rich assemblage of taxa such as Globorotalia nana, Globoquadrina venezuelana, Globigerina ampliapertura, Globigerina opima, Globigerina angulisuturalis indicative of early to Middle
Oligocene age.

Farther downhill the road crosses again disturbed medial Miocene limestones.

35.4 - 36.1 Km Shallow-water limestones (biocalcirudite and calcarenite) unconformably overlie thinly bedded yellowish marl of Middle Miocene age.

39.0 Km Middle Miocene chalk with Globorotalia fohsi and Globorotalia mayeri.

41.5 Km Locadi. Road Cut shows a well defined erosional channel filed with coarse
polygenic conglomerate in sharp contrast to the sparse and finer grained conglomerate.
sandstone and marl below.

42.0 Km Flood plain deposits.

43.0 Km Entrance of the city of Jacmel.

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