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Las Breas de San Felipe, a Quaternary Fossiliferous Asphalt Seep near Martí (Matanzas Province, Cuba)

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Abstract.—Within the Greater Antilles, terrestrial asphalt seeps are unique to the northern coastal region of Cuba. Several such seeps occur in the region designated here as Las Breas de San Felipe, which is situated in the northern part of Matanzas province, 5.5 km northwest of the town of Martí. We report here on two localities (San Felipe I and II) at which fossil elements occur in abundance in asphalt-impregnated sands, silts, clays, and gravels. The taxonomic list includes Mollusca, Arthropoda (Crustacea and Insecta), Reptilia, Aves and Mammalia. Plant macrofossils and several kinds of coprolites have also been found. Geomorphological and taphonomic considerations suggest that, at the time of fossil deposition, San Felipe was a coastal plain where freshwater, brackish marine and dry savannah conditions occurred simultaneously, consequently, or both. The content of the faunule and the stratigraphic position of the fossiliferous deposits indicate that the seeps were 'active' (i.e., fluid enough at surface to incorporate organic material) during very recent times, probably in the terminal Pleistocene or early Holocene.

Introduction

It is somewhat ironic that the first fossil of a Quaternary land vertebrate discovered in Cuba—a sloth jaw from Baños de Ciego Montero, found in 1860 (Alvarez Conde, 1957; Matthew and Paula Couto, 1959)—was recovered from an alluvial basin rather than a cave. In Cuba, as elsewhere in the West Indies, basinal sites like Ciego Montero are extremely rare; virtually all of the sites recorded for this island are located in caves or other karst features (Acevedo and Arredondo, 1982). Because basinal contexts are likely to differ radically from cave sites in taphonomic aspect and species content, discovery of new open-air sites is of great significance. In this paper we describe the relocation and exploitation of one of the most remarkable fossil vertebrate localities discovered in the insular neotropics—the asphalt seeps of Las Breas de San Felipe.

Although many asphalt seeps or 'tar pits' are famously productive as vertebrate localities (e.g., Campbell, 1979, Stock, 1992), the paleontological potential of Cuban seeps is poorly known. The first record of vertebrate remains from a Cuban seep is found in an unpublished report (Chawner, 1932) filed by Atlantic Oil exploration geologist Roy E. Dickerson, who noted that 'at the old oil seeps northwest of the Hamel well [at San Felipe, near Martí] there are abundant bones of birds, alligators, and many typically marine shells enclosed in the now dry mounds'. Samples collected by Dickerson were sent to various experts for identification and description; thus, Horace Richards (1935) reported on the mollusk fauna and Edward W. Berry (1940) described seed macrofossils. Unfortunately, the vertebrate remains, which were entrusted to Carlos de la Torre y Huerta for study, were not described. No additional paleontological collections have been made in the San Felipe area, although the site itself has received incidental mention in the recent literature (e.g., Dzulynski et al., 1984; De la Torre Callejas and González Guillén, 1998).

As part of the investigation of Cenozoic vertebrate localities in Cuba, M. Iturralde-Vinent and Ross D. E. MacPhee, assisted by

Stephen Díaz-Franco, attempted to locate the original site near the Hamel well in December, 1997, to test its current fossil potential. Although the exact location of the Hamel well was unknown to the field party, with the assistance of local residents we were able to visit a number of seeps in the area of Martí. One promising seep, with fossils exposed on its weathering surface, was assumed to be the Hamel site and slated for further work. The same team, assisted by Inés Horovitz (AMNH) and Marcelo Sánchez-Villagra (Universität Tubingen), visited the site in February 1998 to extract matrix for preparation. More than two tons of matrix were transported to Havana and New York for later work. However, it was soon discovered that the degree of induration and adhesion of the matrix to the fossils made the sample very difficult to prepare.

Shortly afterward, Iturralde-Vinent learned that this locality (now designated San Felipe I) was not the same as Dickerson's site, which was located some 100 m to the northwest of the Hamel well. The original Dickerson locality (now San Felipe II) was located in September 1998 by a second expedition consisting of M. Iturralde-Vinent, Stephen Díaz-Franco and Reinaldo Rojas-Consuegra. The asphalt matrix at San Felipe II is little indurated, highly oxidized, and fossil inclusions are very easy to prepare. More expeditions, with a larger Cuban team, visited the area in November 1998 and early in 1999 to collect additional fossiliferous matrix and to study both sites in detail.

Location

San Felipe I and II are located 5.5 km west of Martí in San Felipe valley (Fig. 1). On the 1:50 000 series map (Martí 4084-IV), San Felipe I (Hamel Well site) and San Felipe II (original Dickerson's site), 100 m to the northwest, are located at X=502 Y=347. These sites can be reached by car from Martí by taking the Sabanilla de la Palma road to the community of San Juán; there, the dirt road should be taken to the northwest for about 600 m.

The site area is overgrown by an introduced African spiniferous plant known in Cuba as *marabú* and, for this reason, the Hamel well (which is east of the existing road) is difficult to locate without local help. The well itself, located in a broad clearing covered with extraction spoil, is a large (2 m × 3 m) shaft cladded in stone. In the immediate area are several pieces of rusted equipment that was used in the extraction process. San Felipe II is even less evident because it is smaller and located deep within the marabú bush, but it may be relocated by walking west from the Hamel well along an animal trail which intersects with a northeast-trending trail that heads to the local 'cooperativa'.

This paper describes the geology around Las Breas de San Felipe, the nature of the fossiliferous deposits, and provides a preliminary account of the fossil assemblage. Because of the incredible richness of bone deposition, it will be some time before a comprehensive assessment of the biotic content of the San Felipe sites can be given. The results presented here are based on topomap and aerophoto interpretation (scale 1:20 000, 1: 26 000, 1: 62 000), field geological cartography and geomorphological observations, extensive trenching around the asphalt seepages and paleontological sites for stratigraphic exploration, as well as evaluation of available geographical, geological, and paleontological reports.

Geology, Taphonomy and Origin of the Deposit

The San Felipe paleontological sites are located within the northern coastal plain of Matanzas, not far from the wetlands of Cienaga de Majaguillar (Fig. 1). Active asphalt seeps occur sporadically in the small, flat-bottomed valley located between the Sierra de Bibanasí in the south and a group of unnamed limestone hills in the northeast (Fig. 1, insert; hereafter, 'Lomas del Noreste'). This valley is mapped as approximately 15-20 m above sea level, and is underlain by Cretaceous and Eocene limestones, and serpentinite (Fig. 2). The lowest parts of the valley, where the active seeps

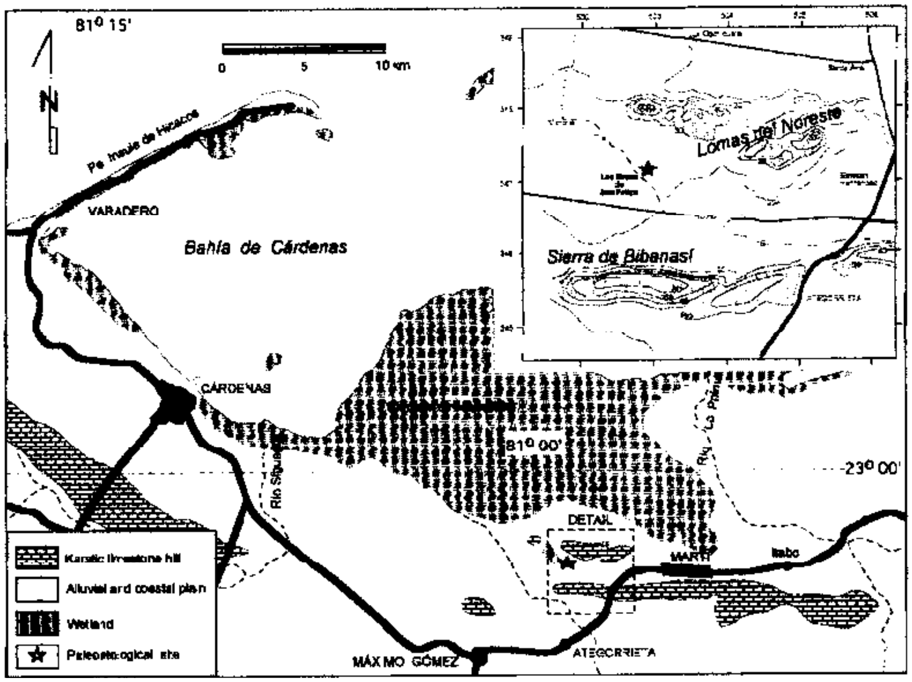

FIG. 1. General location of Las Breas de San Felipe paleontological site. The site is very close to the north coast and wetlands (Cienaga de Majagüillar). Insert: Topography of the San Felipe Valley. Oil seeps are very common in the area, even subaquatic ones at Bahía de Cárdenas.

come to surface, are ponded during the rainy season. Local soils are of two types: black humus-rich clays, located within the zone of seasonal inundation, and *in situ* oxisols derived from weathered serpentinite located in higher parts of the valley. Fragments of chalcedonite, serpentinite, or limestone occasionally are embedded in the soils. Serpentinite and limestone locally outcrop directly to the surface.

Older and now inactive seeps occur as small hillocks (Dickerson's 'mounds') at higher elevation and are therefore rarely submerged. As seen in Figure 2, the extinct seeps are located along vertical faults and fractures trending northeast-southwest (average trend, ca. 60°). The hills comprising the Sierra de Bibanasí are elongated east-west and are underlain by strongly karstified Miocene limestones (highest elevation, 81 m). The Lomas del Noreste facing the valley are formed in equally strongly karstified Cretaceous and Eocene limestones (highest elevation, 57 m). The karst systems in both series of limestone hills present vertical and horizontally wandering cave systems. The horizontal galleries in the Lomas del Noreste drain the valley during rainstorms. In the past, these galleries were filled with calcified, water-lain laminated red sediments, but except for occasional patches on walls and ceilings, these have been largely eroded away.

The fossiliferous sites

To study local stratigraphy, trenches were dug to the level of the underlying serpentinite. In several trenches, asphalt-filled fissures that had not broken through to the present surface were encountered. Upon excavation, the asphalt in the fissures

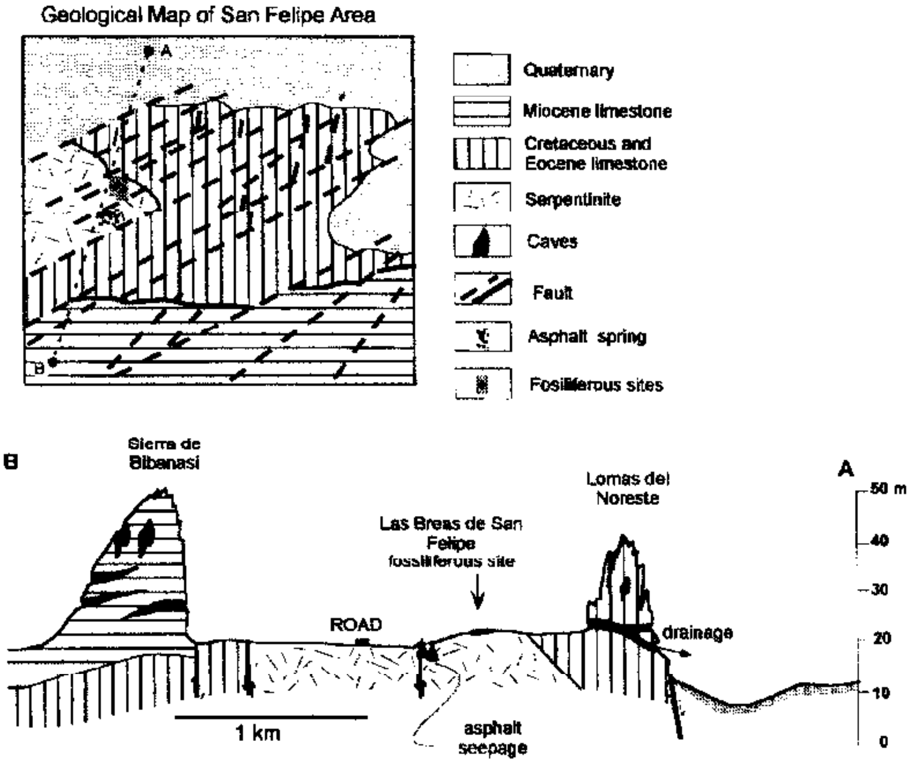

FIG. 2. Geological map and cross section of the San Felipe valley and its surroundings. This map differs from those of Dickerson, (1932) and Pushcharovsky (1988). Non fossiliferous active seepages are now located west of San Felipe I and II, within a seasonally inundated plain, topographically below the San Felipe I and II sites. Cartography by the first author.

started to slowly flow out into the trench cut (cf. Table 1, trench 5). The occurrence of asphalt fluid enough to flow easily was expected, as asphalt mining continued in this area until the 1960s. However, the asphalt at San Felipe seems now to be flowing or moving laterally rather than toward the surface of the fossiliferous deposit (see Discussion below). The fossil zones are very shallow, none being deeper than 1.2 m.

San Felipe I may be viewed as an ameba-like irregular sheet of asphaltic deposit, 0.6 to 0.8 m higher than its immediate surroundings, which grades along its periphery into the present-day soil covering of the valley floor (Fig. 3). The locality is dominated by a small man-made dugout (~ 5 m in diameter) that appears to be permanently filled with water. Maybe the dugout marks the points where the seep originally came to the surface (and was subsequently enlarged by mining operations). During our work at this site, the dugout was drained and cleaned, but we found no definite trace of an asphalt source within it. Perhaps the seep came to the surface at several locations, as there are several asphalt accumulations with fossils in the area around the dugout.

The central part of San Felipe I comprises approximately 0.6 m of thick, asphaltic gravels, sands, and silts, whose surfaces have been both eroded and mechanically disturbed (Fig. 3). Serpentinite, lateritic

TABLE 1. Lithological descriptions of the trenches in San Felipe I site.

Depth (M)	Description
Trench No. 1	
0.00-0.10	Red fine grain sandy soil
0.10-0.60	Brown clay with a few spots of dried asphalt
0.20-0.30	Reddish to gray sands with small asphalt pockets
>2.2	Serpentinite
Trench No. 2	
0.20-0.30	Brown fine grain sandy-clayish soil
0.20-0.31	Brown sandy clayish soil
>0.4	Indurated asphalt in serpentinite
Trench No. 3	
0.20-0.30	Brown sand contaminated with fragmentary china
0.20-0.31	Indurated asphalt
>30	Brown clayish soil
Trench No. 4	
0.20-0.30	Brown sandy soil with small asphalt pockets
0.20-1	Serpentinitic structural brown sandy-clayish soil
>2.00	Serpentinite
Trench No. 5	
0.00-0.35	Black clayish soil contaminated with fragments of asphalt and serpentinite
0.20-0.30	Indurated asphalt layer with veins of fluid asphalt
0.20-0.31	Dark red ferralitic soil with veins and pockets of fluid asphalt
0.20-0.32	Brown-yellowish ferralitic coarse to middle grain sandy soil with veins of indurated asphalt
0.20-1	Greenish structural serpentinitic clayish soil with veins of asphalt
>2.00	Serpentinite
Trench No. 6	
0.20-0	Weathered serpentinite as red-brown sandy-clay
>1.00	Serpentinite
Trench No. 7	
0.00-0.20	Indurated asphalt crust
0.20-0.30	Red-brown structural serpentinitic sandy-clay
>0.50	Serpentinite
Trench No. 8	
0.20-0.30	Red soil
0.20-0.31	Red soil impregnated with asphalt
>0.30	Serpentinite

soil, or hardened asphalt crust—too hard to be penetrated with simple tools—underlies the deposit in several places. Small pools of semiliquid asphalt, occuring sporadically at surface, are still capable of entrapping small birds. Peripheral to this central area, the San Felipe I deposit thins to a bed, up to 0.2 m thick, of soft to locally indurated asphalt (cf. Table 1, trench 8). This latter bed is located in the lowest zone and is nonfossiliferous.

Three areas within the central part of San Felipe I (A, B and C in Fig. 3) were significantly fossiliferous and accessible. Because of the thinness of the deposit, it was posible to remove most of the fossiliferous matrix in blocks for later preparation in the laboratory. Area A, the fossiliferous area closest to the dugout, was originally about 6 m^2 × 0.6 m in thickness (Fig. 3). From it we have recovered numerous rodent, sloth, and bird bones; as well as insects, fragments of wood, and other plant macrofossils. The bones in the matrix present no pattern of organization or deposition. They are very abundant and, unfortunately, rather fragmentary. Area B is a dry asphalt bed, originally about 4 m^2 and a few hundred mm thick. It is underlain by indurated asphalt that we could not breach. Fossils, chiefly bone and wood fragments, are highly concentrated. Interestingly, at area B an articu-

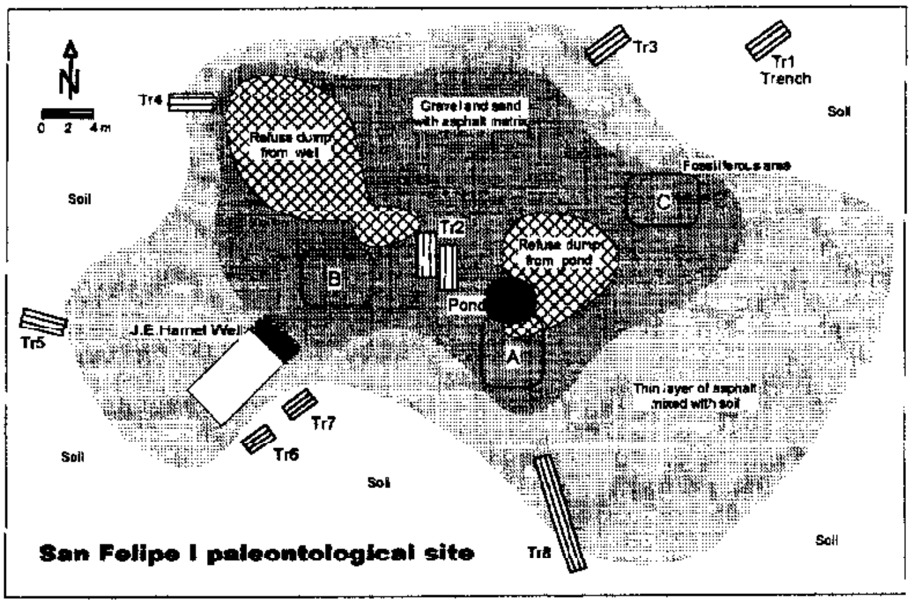

FIG. 3. Sketch of the San Felipe I site. Note the original ameba-like shape of the asphalt deposit. Tr identify the treches described in Table 1.

lated and largely complete—although very weathered—upper limb of a sloth was preserved on the surface. Area C is about 8 m^2 and very fossiliferous, yielding abundant remains of crocodiles, sloths, and turtles; as well as wood fragments. Excavations in areas B and C were made difficult by the high concentration of hardened asphalt in the bed.

As a paleontological locality, San Felipe II was almost obliterated several years ago when heavy machinery was brought in to clear bush. The central part of the site is still intact, as are some parts of the periphery (which is very irregular due to erosion as well as mechanical disturbance) (Fig. 4). The fossiliferous deposit occurs in the form of pockets of coarse gravels within sands and sandy gravels (Fig. 5), up to 1.2 m thick and all strongly impregnated with asphalt. In addition to fragmentary bones and wood, the gravels and sands contain large, irregular to subrounded fragments of chalcedonite and serpentinite. As at San Felipe I, surfaces are still patchily fluid and plastic flow features are obvious. Cross-cutting the site is an old man-made trench, very possibly the one from which Dickerson recovered the fossils described by Richards (1935) and Berry (1940). Additional excavation of the trench revealed that the fossiliferous deposit overlies a horizon of gravel infiltrated by fluid asphalt, gas and water. Lenses of fluid asphalt, up to 150 mm thick occur in places along the periphery of the fossiliferous deposit, where the latter merges with soil.

Bones from the fossiliferous deposit at San Felipe II are sometimes rather battered, suggesting that they were originally accumulated (and weathered) elsewhere, then were transported and deposited in topographic lows where they became impregnated with asphalt seeping onto the surface. Fossils are usually easy to remove from the gravel-sand matrix because of its very low asphalt content, but the uppermost 100-200 mm tends to be somewhat indurated and therefore more difficult to work. In contrast to San Felipe I, fossils oc-

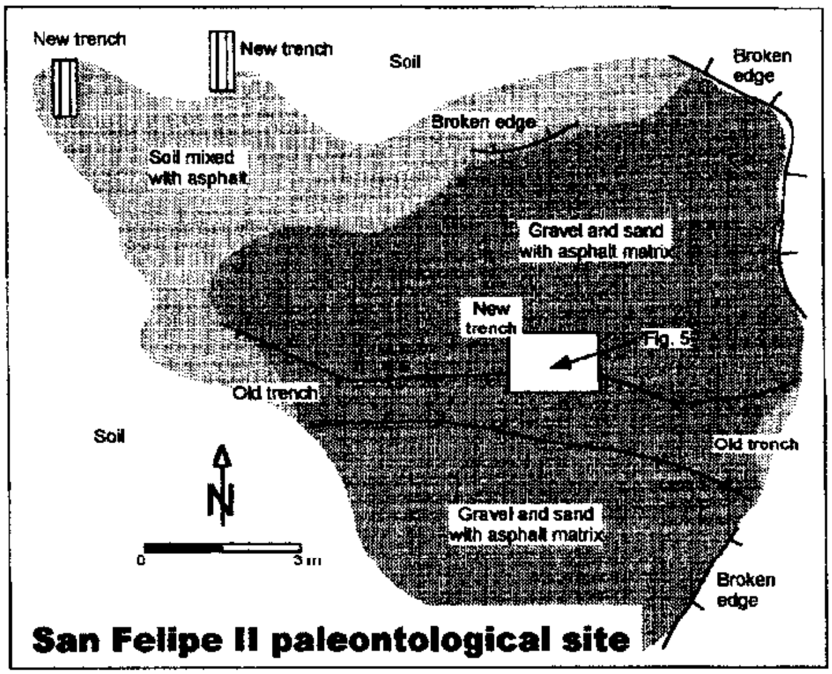

FIG. 4. Sketch of the San Felipe II site. The original shape of this deposit was obliterated recently by heavy machinery. From this site a 1 m^3 block was recovered and deposited at the MNHNCu in Havana (Fig. 5).

cur throughout the deposit, rather than in isolated concentrations (Fig. 4). Another difference is that the bones and wood fragments are associated with large numbers of seeds, coprolites, marine and terrestrial mollusks, and some crustaceans.

Taphonomy of the deposit

Articulated skeletons are rarely found in tar seeps and Las Breas de San Felipe is no exception. Lack of association is partly due to carcass degradation as a result of scavenging, decay, and other processes. However, because any natural asphalt concentration is highly plastic, anatomical associations are soon disrupted by the flow of the matrix itself. This process has been described by Stock (1992: 16) for Rancho La Brea, where internal 'movements of the mass [of asphalt] has tended to separate the bones laterally and vertically.'

As would be expected in a matrix capable of plastic flow, there is no pattern of distribution of inclusions (bones, plants, invertebrates, rock fragments), as each new inclusion may break up or disaggregate into constituent elements that become thoroughly mixed with others already in the deposit. This style of deposition produces a non-bedded pattern of stratigraphic accumulation (Fig. 5), in which fossils of differing ages and origins become highly commingled (cf. fossil associations at Rancho La Brea, where elements may exhibit radically different radiometric ages; Stock, 1992).

The wide variety of faunal elements in the San Felipe deposits indicates that the area of the seepages was visited by the whole spectrum of Cuban Quaternary vertebrates, including herbivores (sloths, rodents, insectivores), carnivores (crocodiles, raptors) and scavengers (condors).

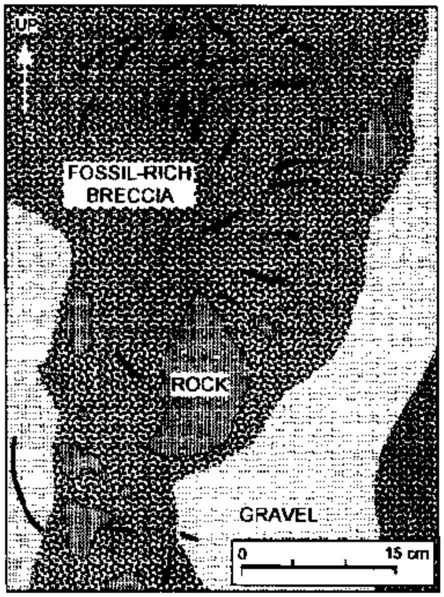

FIG. 5. Drawing from a photo of the trench wall at San Felipe II, where a pocket of fossiliferous breccia including large angular rock fragments (serpentinite) is clearly penetrative within the older gravel bed. Black strips are the axis of long-bone fragments. The bottom part of the section is impregnated with fluid asphalt and water. This sketch illustrates how the discharge of a heavy loaded flashflow bed (fossiliferous breccia) above the asphalt seep can induce slow sinking of newly deposited material into the older one (gravel), dragged by large serpentinite fragments.

A peculiarity of material from Las Breas de San Felipe is the fragmentary nature of most vertebrate specimens (Fig. 6A). This is not unusual, as bones from tar seeps and oil sands are often finely fissured due to sediment compression. However, in the case of material from San Felipe, breakage is almost universal, with very few complete specimens.

As noted above, fossils in the San Felipe I locality tend to occur in clusters (Fig. 2). Even in San Felipe II there are pockets of fossiliferoues sediments penetrating previous non-consolidated beds (Fig. 5). On a different scale, this pattern, which is due to the columnar flow of asphalt to the surface, is also recorded for Rancho La Brea (Stock, 1992). Fluid or viscous asphalt is most likely to entrap animals; as asphalt comes to the surface, it start loosing its more volatile components, becomes harder and, therefore, less likely to catch the unwary. It is also possible that in areas with indurated surficial crust the animals did not sink sufficiently to be entombed.

It is evident that accumulation of fossil material at San Felipe I and II took place in several ways. One is direct entrapment in soft matrix, as exemplified by some vertebrate fossils (Fig. 6B), some aquatic invertebrates (beetles and crustaceans), and certain plant elements that fell directly into fluid asphalt (Fig. 6E). The relative abundance of the delicately-built arboreal snail *Liguus* suggests the presence of large colonies on nearby trees, from which individuals must have frequently fallen into the deposit.

Indirect entrapment also occurred, as indicated by specimens bearing signs of weathering or erosion, as well as other indicators. In some instances, bones of animals that died elsewhere in the valley may have been transported by rainstorms and flashfloods to the location of the seeps, where the bones became entrapped. This is indicated chiefly by the presence of angular rock fragments and other serpentinite weathering products embedded in the asphalt and associated with the bones (Fig. 5). Additionally, the occurrence of brackish-water mollusks at San Felipe II (Fig. 6D) implies that marine flooding of the valley occurred, perhaps during periods of elevated sea level. Seed deposition may have occurred by air or water transport, but seeds may have also been brought by entrapped herbivores. Some carcasses of recently-entrapped birds (*Crotophaga ani*) at San Felipe I contain seeds in their guts.

Paleoenvironments during the formation of the deposit

The diversity of the fossil assemblages at San Felipe indicate that the biota came into the seeps from different environmental contexts. We can discriminate three such contexts. The first, and most obvious, is the freshwater environment, signaled by the

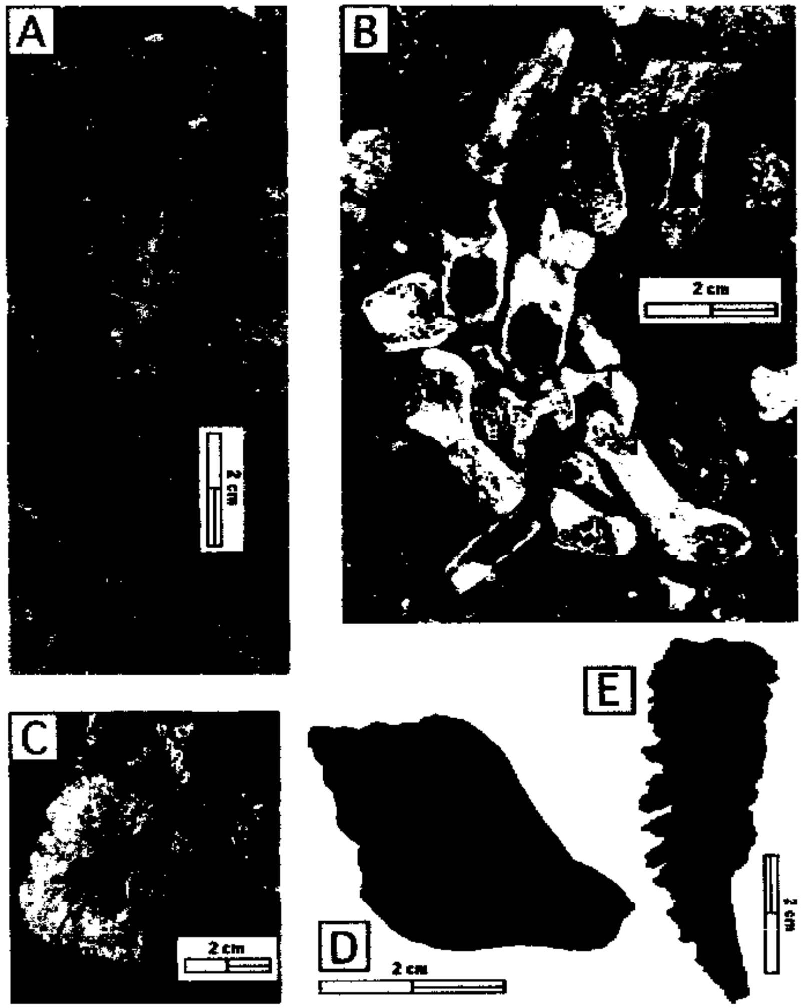

FIG. 6. A. Asphaltic matrix with fragmentary long bird bones showing open fractures due to extensional post-burial stress in San Felipe II. Secondary fragmentation of the bones is a result of the plastic flow of the asphaltic matrix. B. Asphaltic matrix with articulated arm of a ground sloth associated with many other post-cranial elements. This is a unique example of direct entrapment in San Felipe I. C. Dermal skuts of *Crocodylus* sp. from San Felipe I. D. Marine brackish-water gastropod *Melongena melongena* from San Felipe II. E. Cone of *Pinus caribea* from San Felipe II.

occurrence of such taxa as crocodiles (Fig. 6C) and fresh water turtles, insects, plants, and birds (Fig. 6; Table 2). These taxa would have lived in or come to the valley bottom whenever it was totally or partially inundated, as would occur annually during the rainy season, or in times when the standard water table in the plain was higher due to high sea-level stand. Active seeps would not have been detectable to animals

TABLE 2. Taxa identified from San Felipe I and II sites, *Richards (1935), **Berry (1940).

Taxa	A-Extant E-Extinct	Habitat
PLANTS		
*Chrysobalanus icaco***	A	Coastal areas
Pinus caribaea	A	Dry land
*Spondias lutea***	A	Inland and coastal areas
Thrinax radiata	A	Well drained limestone
Coccothrinax sp.	A?	Dry land
Calophyllum sp.	A?	Various habitats
Ficus sp.	A?	Usually from rain forest
Cordia galeottiana	A	Dry land
Cordia sebestena	A	Coastal dry land
Insects		
Family Dytiscidae: *Cybister* sp.	?A	Aquatic dweller
Family Scarabeidae	?A	Non-aquatic
CRUSTACEA (Decapods)	?	
MOLLUSKS		
Liguus fasciatus	A	Arboreal
Zachrysia auricoma	A	Arboreal
*Bulla amygdala**	A	Brackish marine dweller
Bulla striata	A	Brackish marine dweller
Cerithidea cf. *costata**	?A	Brackish marine dweller
Cerithium cf. *algicola**	?A	Brackish marine dweller
Cittarium pica	A	Brackish marine dweller
*Fasciolaria tulipa**	A	Brackish marine dweller
Marginella cf. *apicina**	?A	Brackish marine dweller
Melongena melongena	A	Brackish marine dweller
*Nassa ambigua**	A	Brackish marine dweller
*Potamides scalatus**	A	Brackish marine dweller
REPTILES		
Crocodylus sp.	?A	Swamp and pond dwellers
Chelonia	?A	Swamp and pond dwellers
Squamata Fam. Boidae	?A	Land raptor
BIRDS		
Gymnogyps varonai	E	Dry savannah, grassland
Grus cubensis	E	Fresh water and semiaquatic
Burhinus sp.	?E	Dry Savannah
Accipiter sp.	?A	Tropical forest
Titanohierax borrasi	E	Dry savannah, grassland
Caracara sp.	?A	Dry savannah, grassland
Tyto sp.	E	Tropical forest, dry savannah, grassland
Ornimegalonyx cf. *O. oteroi*	E	Nearly flightless raptor in dry savannah, grassland, or forest
Corvus nasicus	A	Tropical forest, savannah
MAMMALS		
Solenodon sp.	E	Tropical forest
Capromys antiquus	E	Arboreal hervivore
Megalocnus sp.	E	Terrestrial hervivore
Megaocnus cf. *M. zorrei*	E	Terrestrial hervivore
Miocnus cf. *M. antillensis*	E	Arboreal hervivore
Neocnus sp.	E	Arboreal hervivore

walking or swimming in shallow ponds. Even today, cattle crossing the valley during the rainy season are sometimes entrapped by active seeps.

Existence of drier conditions, due to lower rainfall or lower sea level (with consequent drawdown of the water table) is primarily indicated by the presence of macrofossils of *Pinus caribbea*, *Cordia galeottiana*, *C. sebestena*, bones of large ground sloths (*Megalocnus* and *Mesocnus*), bones of birds (*Burhinus* sp.), land snail shells, and mammalian coprolites (Table 2). It is uncertain whether dry and wet environments occurred simultaneously at a regional level (mosaicism), or whether they alternated at this locality over hundreds or possibly even thousands of years. If mosaicism occurred, the fossils representing drier conditions might have been transported by surficial drainage and buried by indirect entrapment as described above.

A third environmental scenario is brief marine flooding, suggested by the occurrence of *Chrysobalanus icaco* and brackish-water mollusks at San Felipe II (Table 2). The San Felipe valley is very close to current sea-level and it was surely closer in the past, as geomorphological features discussed below clearly indicate. Thus, occasional transgressions would be expected.

Origin of the asphalt hillocks

The origin of the fossiliferous asphalt hillocks is schematically illustrated in Figure 7. In Figure 7A, an asphalt deposit forms as a seep beneath a shallow body of water on a coastal plain, as at San Felipe. (This scenario is not the only possibility; as discussed above, seasonally the San Felipe valley was also dry). In Figure 7B, the San Felipe area experiences mild uplift, on the order of 15 to 20 m; this scenario is echoed by the present topography of San Felipe and the elevation of horizontal cave passages in the Lomas del Noreste, mentioned earlier. The erosion of the laminated terra rossa fill in these caves also indicates a phase of uplift. Subsequent to uplift, erosion exposed the asphaltic deposits, which were then subjected to surface weathering, loss of volatiles, and induration.

As described previously, asphalt in liquid phase is found in diverse places at San Felipe I and II: in small patches at the surface of the raised hillocks (both localities), embedded gravels at the bottom of the deposit (San Felipe II), and as a thin bed of soil impregnated with asphalt surrounding the central mound (both localities). Patches of liquid asphalt at the surface are obviously due to solar heating and are therefore more apparent during the summer (Fig. 7C). In February of 1998 soft patches were rare, but many capable of entrapping small birds existed during our subsequent visit in September.

Solar heating should produce not only sticky surfaces on hillock summits, where exposure to sunlight is continuous, but also pooling of fairly viscous asphalt around the periphery of the hillock, as was probably the case at San Felipe I. In San Felipe II the fluid asphalt bed can be better explained as a result of active flow from the gravel layer under the dry deposit. This radial flow probably produces secondary effects in the sediments, such as progressive compaction, concentration of fossils, and fracturing of brittle bone material.

The age of the deposit

The age of the asphalt deposits at Las Breas de San Felipe is not known precisely, but there are some relevant indicators. The first is the stratigraphic position of the deposits. It is evident (Fig. 2) that the localities must be younger than Middle Miocene, the age of the limestone in Sierra de Bibanasí. They must also be younger than the lateritic crust of weathered serpentinites that underlie the fossiliferous sediments at San Felipe I and II, because some of these elements are reworked in the asphalt matrix. The age of the laterites cannot be well constrained, but they must be younger than the Miocene limestone and are plausibly Late Miocene to Pliocene. Since more than 0.2 m of Recent soils overlie the fossiliferous beds in undisturbed areas, we infer that the beds themselves are earlier than late Holocene. Thus, the fossils can be generally dated as Quaternary according to local stratigraphy and geomorphology.

The second set of indicators are the fossils and their associations. Richards (1935) and Berry (1940) stated that the mollusks and plants at San Felipe II date the sediments as Pleistocene, but all the specimens identified by these authors belong to extant species. Nevertheless, such a date agrees with the presence of extinct and extant spe-

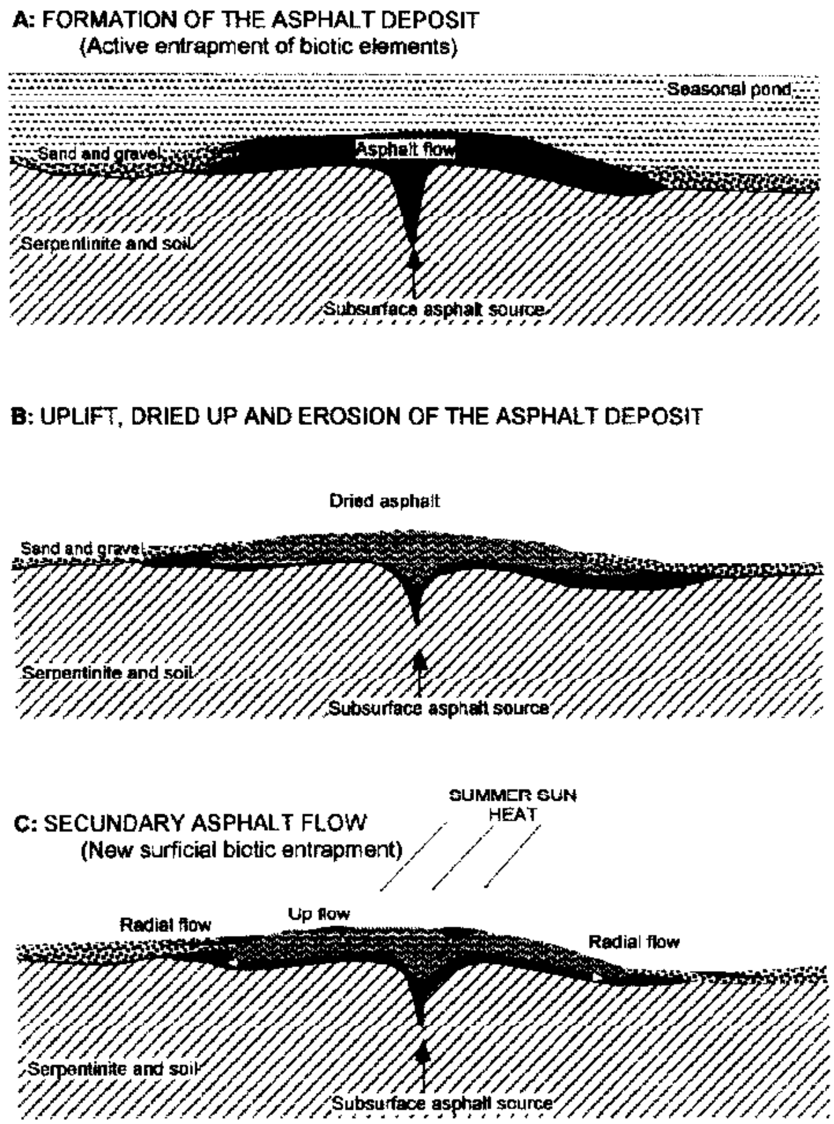

FIG. 7. Formation and evolution of the asphalt deposit. A. Late Pleistocene-Holocene. Asphalt flowed to the surface and produced a local topographic high within the seasonally inundated coastal plain. Contemporaneous biotic elements are being entrapped directly by the asphalt, while others may arrive in occasional flashflows or marine transgresions. B. Late Holocene. Local areas of the San Felipe valley were uplifted and the partially indurated asphaltiferous deposits become local topographic highs (hillocks), as they are more resistant than soil to weathering and erosion. The hardened asphaltic matrix reduced its entrapment possibilities. C. Recent. Fluid hydrocarbons flood below the indurate asphaltic deposit and spread laterally, impregnating the surrounding soil from the botton. At San Felipe II, it is reported by farmers that the active asphalt flow sometimes produces small ponds. Old asphalt located at the surface of the hillocks can seasonally become partially fluid due to summer sunheat and may capture small extant birds and seeds.

cies in the assemblage of vertebrates (Table 2). The land vertebrates represent a broad swath of taxa known from cave localities in various parts of the island. These are generally described as 'Pleistocene' in the literature (e.g., Acevedo and Arredondo, 1982), but 'Quaternary' would be a better age because radiocarbon dating is beginning to show that many of the larger species survived until the early-Holocene (MacPhee et al., 1999).

Preliminary Survey of the Fossil Assemblage

There is little information on the paleontology of the site called here San Felipe II (Chawner, 1932; Richards, 1935). These authors reported 'alligator' (sic) and bird bones, as well as plant seeds and mollusks. Our preliminary work on the material from this site has considerably extend the list (Table 2).

The present list of taxa is not exhaustive, but provides a good idea of the great range of fossils that occur at Las Breas de San Felipe. The birds were identified by W. Suárez, the reptiles and mammals by S. Díaz Franco, the insects by P. Valdés, the mollusks by Alina Lomba, the plants by Isora Baro Oviedo, and the coprolites were measured by S. Díaz Franco and Reinaldo Rojas.

Plants

Fossil are very abundant in both sites, and are represented by seeds and wood fragments. Tree seeds from San Felipe II were identified by Berry (1940) as *Spondias lutea* and *Chrysobalanus icaco*. We have found seeds and fragmentary wood and branches which can be refered to *Pinus caribaea* (Fig. 6E), *Ficus* sp., *Thrinax radiata*, *Coccothrinax* sp., *Cordia galeottiana*, *Cordia sebestena* and *Callophylum* sp..

Coleoptera

Coleoptera are reported for the first time from a Cuban fossiliferous context. They are not abundant and occur as mummified fragments or whole bodies. We have recognized a Dytiscidae of the genus *Cybister*, and an unidentified scarab.

Crustacea

San Felipe II contains fragments of decapods belonging to marine or freshwater crabs.

Mollusks

From San Felipe II, Richards (1935) identified brackish water mollusks including *Bulla amygdala*, *Marginella* cf. *apicina*, *Fasciolaria tulipa*, *Nassa ambigua*, *Cerithium* cf. *algicola*, *Cerithidea* cf. *costata*, and *Patamides scalatus*. At the site we encountered *Fasciolaria tulipa*, *Zachrysia auricoma*, *Cittarium pica*, *Melongena melongena* and *Bulla striata*. A new species of land snail (*Liguus richardsi*) was described from the site by De la Torre and González Guillén (1998), and we found several specimens of *L. faciatus* in the same locality.

Reptiles

Reptilian remains in San Felipe were reported by Dickerson (1932) as 'aligators'. We found abundant fragmentary bones identified as *Crocodylus* sp. (Fig. 6C), Chelonia and Boidae (Table 2).

Birds

Bird remains are very common in San Felipe, both in terms of abundance and number of taxa entrapped. Some fossils recovered from San Felipe (*Gymnogyps varonai*) have been reported by Suárez (2000). We report a preliminary evaluation of the fossil birds (Table 2), but we are confident that many more taxa will be found.

Mammals

Fossil mammals are here reported for the first time from San Felipe. Remains of sloth and rodents are very common in both sites, while insectivores have been found only in San Felipe II (Table 2). These fossils are common elements in Quaternary cave deposits of Cuba (Acevedo and Arredondo, 1982).

Coprolites

Mammalian coprolites of the size and shape of rodentia are fairly common at San Felipe II, and are here reported for the first time from these sites. In general, the elements are cigar-shaped, with rounded, subrounded or broken ends; a few are conical or subconical, some present a longitudinal groove.

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