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PHYSICAL AND CHEMICAL CHARACTERISTICS AND DEVELOPMENT OF THE CHANGUINOLA PEAT DEPOSIT OF NORTHWESTERN PANAMA

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ABSTRACT

A peat deposit occupying over 80 square kilometers, and averaging 8 meters in thickness, was discovered on the Caribbean coast of northwestern Panama near the town of Changuinola. This deposit occurs inland (behind) the present beach-barrier shoreline. It is thickest in the center and thins toward all edges (as if domed). The surface vegetation in the central regions consists primarily of ombrotrophic plants (especially sedges, grasses, *Sphagnum*, *Sagittaria*, and various scattered shrubs). Toward the edges, the deposit has a surface cover of more minerotrophic plants (such as swamp-forest trees, ferns, and palms).

Petrographic/botanical analysis of the deposit with depth reveals the presence of five peat types (swamp-forest, sedge-grass-fern, *Sagittaria* et al., *Nymphaea* et al., and *Rhizophora*). *Rhizophora* peats are rare, occurring only at the eastern edge of the deposit near Almirante Bay; *Sagittaria* and sedge-grass-fern peats are the most common types, occurring throughout the central portions of the deposit; and swamp-forest peats occur primarily at the base of the deposit or toward its edges.

Typically peats of the thick, central portions of the deposit are very low in ash and sulfur (less than 2% ash and 0.3% sulfur). Ash contents tend to increase abruptly at the base and more gradually toward the edges of the deposit and sulfur contents increasing gradually toward the ocean and bay.

Vertical and lateral variations in botanical, chemical, and physical properties of this deposit can be related to factors that have controlled (1) the surrounding rocks and water chemistry, (2) the source vegetation, and (3) the environments in which these source ingredients were deposited.

INTRODUCTION

Purpose and Scope

The purpose of this paper is to give a brief overview of the geometry and chemical and physical properties of a newly-discovered peat deposit near the town of Changuinola in northwestern Panama (Figure 1). This peat deposit is of interest to us for two reasons: (1) it is formed in a tropical, back-barrier setting and is, consequently, a good analog for certain types of ancient coal seams, and (2) it is being evaluated as a possible source of fuel for an electrical power plant for the town of Changuinola. Both of these areas of interest require detailed characterization of the deposit, the former to better understand and predict the economic characteristics of coal seams and the latter to determine the requirements for mining and design of the power plant. For a more detailed treatment of the methodology and discussions of results, see Cohen et al. (1987).

Geomorphic and Geologic Setting

The Changuinola deposit was formed on top of recent unconsolidated sediments behind (and roughly parallel to) a beach-barrier feature that extends continuously to the southeast for about 10 kilometers (Figure 1). The Rio Changuinola delta forms the northwestern boundary of the deposit and a low mountain range containing Upper Cretaceous to Miocene sedimentary and volcanic rocks forms its southwestern boundary. Miocene rocks of the Gatun Formation, consisting of shales, mudstones, sandstones, coals, conglomerates, and pyroclastics crop out closest to the peat at its southwestern border and may extend beneath the peat. Almirante Bay borders the deposit to the southeast.

PEAT DEPOSIT GEOMETRY

Figure 2 is a peat thickness map for the Changuinola deposit. Since no topographic map of the upper surface has yet been made,

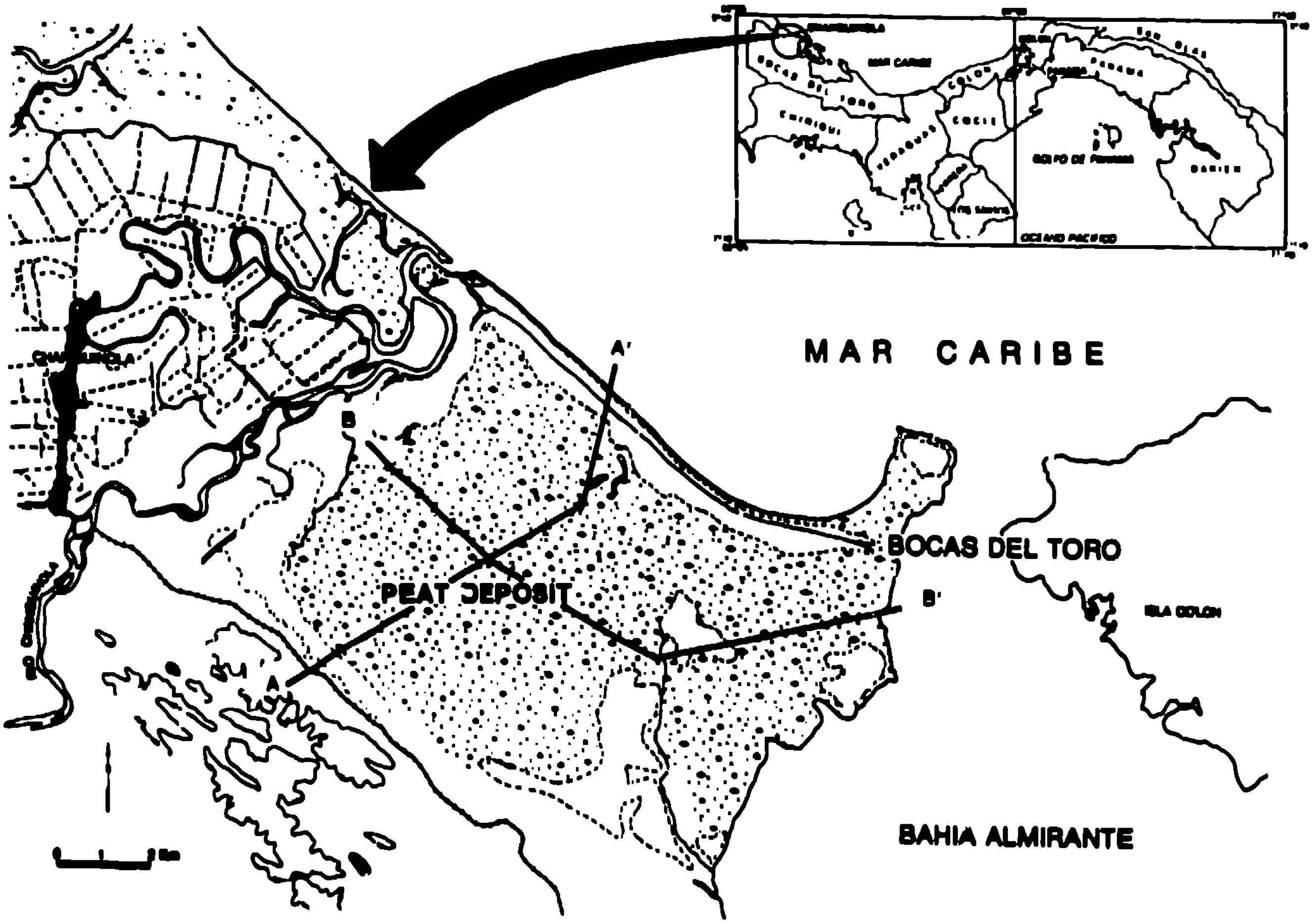

Figure 1: Locations of Changuinola peat deposit and transects A-A' and B-B'.

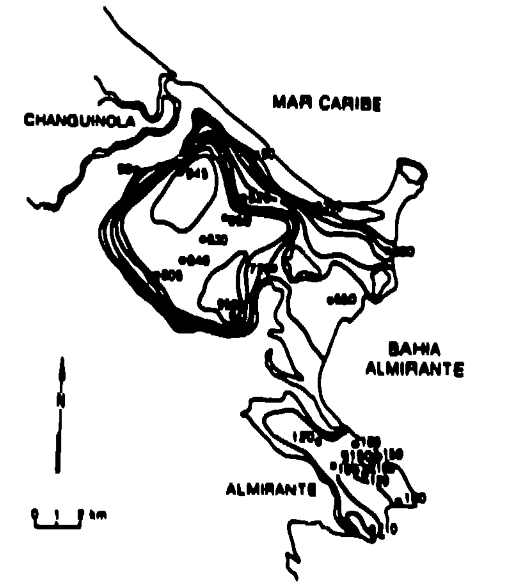

Figure 2: Peat thickness (cm), Changuinola Panama.

It is difficult for us to know for certain whether: (1) the upper surface of this deposit is flat and the peat has formed in a depression; (2) the underlying surface is flat and the peat is domed; or (3) the peat formed in a depression but later was domed. As of this writing, a topographic survey is being conducted so that our next report will contain this information. However, due to the high rainfall and the ombrotrophic nature of the surface vegetation, it is likely that some doming has occurred and we would propose the hypothetical geometry illustrated by Figures 3a and 3b to explain the peat thickness. Note that a flattened dome would account best for the vegetational pattern observed for this area. Dense tropical forest vegetation occurs around the edges, where the peat is relatively shallow. On the other hand, the central area is inhabited primarily by low herbaceous plants such as sedges, grasses, peat moss, ferns, and other herbaceous plants that can exist in wet (but

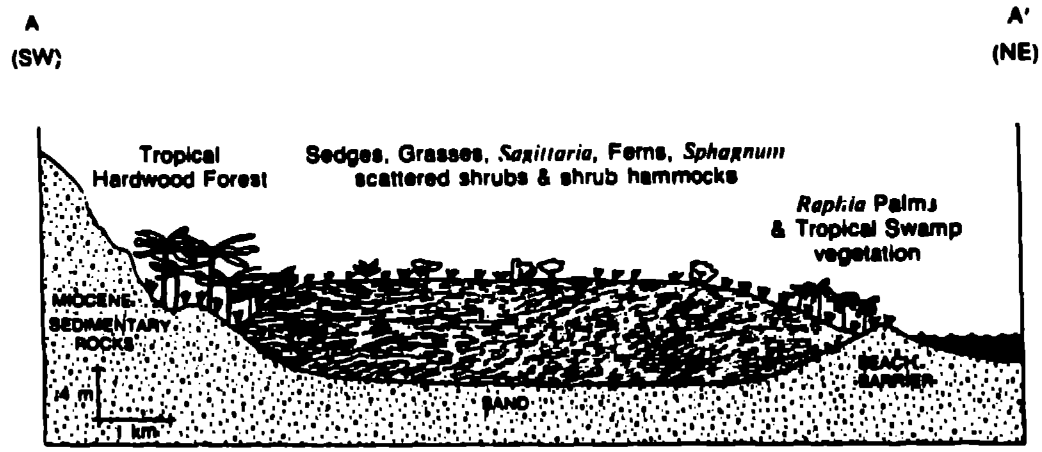

Figure 3a: Schematic cross section and vegetation types, Changuinola peat deposit, Panama.

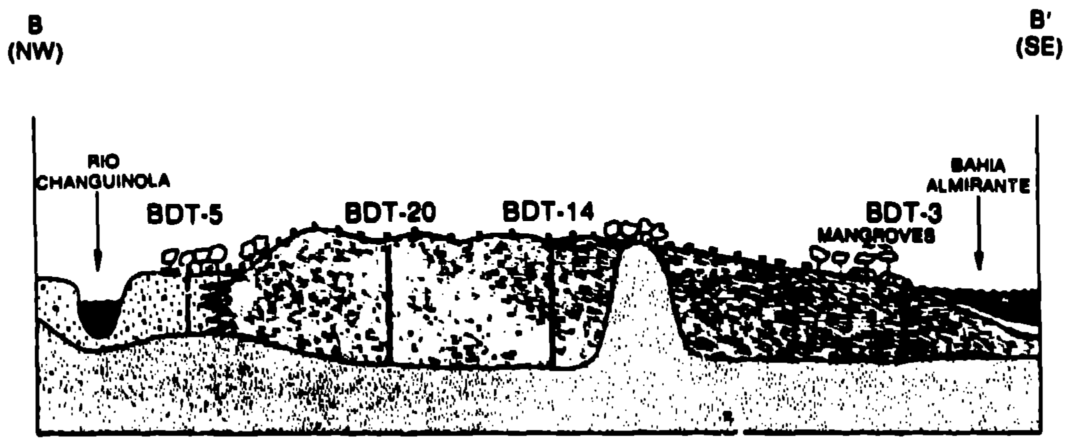

Figure 3b: Schematic longitudinal section of Changuinola deposit (not to scale).

not pond-like), nutrient-poor conditions. Scattered wetland shrubs and shrub hammocks are also present in this central area, as are floating aquatic plants in the occasional small shallow pond. Contrary to most of the soils and vegetation maps of Panama, the only mangrove vegetation covering this wetland region is present along the contact of this primarily freshwater wetland with Bahia Almirante.

PETROGRAPHIC/BOTANICAL COMPOSITION

Figure 4 shows the microscopically-defined peat types determined from cores representing cross section (A-A') and longitudinal section (B-B') (see Figure 1).

The samples are grouped into six peat types based on their botanical composition: (1) freshwater swamp-forest peat; (2) sedge-grass-fern peat; (3) Sagittaria et al. peat; (4) Nymphaea-Sagittaria peat; (5) marine Rhizophora (mangrove) peat; and (6) transitional brackish-water peat.

The Rhizophora (mangrove) and brackish transitional peats were found only at the base of core BDT-3, which occurs near the edge of the deposit at its boundary with Bahia Almirante.

The freshwater swamp-forest peat was found in all areas and was especially persistent in mineral-rich places such as at the base of most all cores and toward the edges of the deposit. Note the interfingering of this

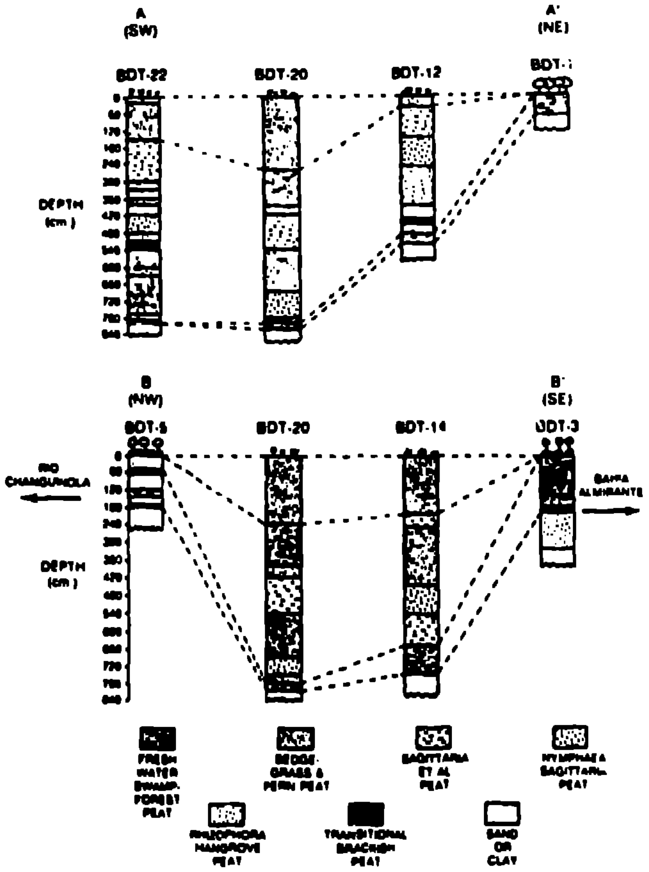

Figure 4: Sectional profiles A-A' and B-B' through Changuinola peat deposit showing peat types.

peat type with the Rio Changuinola floodplain sediments at the northwestern edge of the deposit and also its presence as a surface layer at the northeastern and southeastern edges of the deposit. This peat type consists of a diverse mixture of freshwater swamp trees, shrubs, and vines with ferns and tropical broadleaf herbaceous plants as common associates. Palm debris (probably Raphia) was also encountered occasionally in peats of this type (but only near the surface).

The most commonly occurring peat types ("Sedge-grass-fern" and "Sagittaria et al.") represent freshwater, open-marsh settings characterized by very shallow water and ephemeral dry periods. The Sagittaria-dominated peat type represents slightly wetter conditions than the sedge-grass-fern type. Even wetter conditions (i.e. areas of ponded water) are represented by the presence of a Nymphaea-dominated peat type. Note that this peat type never occurs near the tops of any cores (within less than 1-1/2 m of the surface), suggesting that persistent deep water conditions (ponds) have been rare in this region in recent times.

FIBER CONTENT

Figure 5 shows the frequency at which samples of each peat type fall into one of the three fiber categories used for classifying peats in the ASTM classification system (i.e. "fibric," "hemic," or "sapric") (ASTM, 1987). Since too few samples of mangrove or transitional peat were encountered, these types were not included on the graphs. These fiber categories generally represent the degree of decomposition of plant tissues composing a peat (that is, the greater the quantity of fibers, the less is the degree of decomposition).

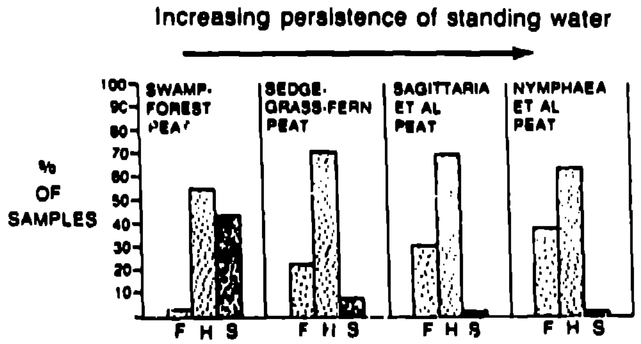

Figure 5: Fiber frequency of peat samples from Changuinola, Panama (fiber determined microscopically as area %); F = fibric(67-100%); H = Hemic (34-67%); S = Sapric (0-33%).

The peat types are shown from left to right in order of increasing persistence of standing water. Note that the occurrence of fibric peat increases from left to right and sapric peat decreases from left to right. Thus, swamp-forest peat samples (which form under drier conditions) are more likely to be more decomposed than Nymphaea or Sagittaria peats (that form under wetter conditions).

ASH CONTENT

Figure 6 shows the ash content of cores taken along cross section A-A'. Cores 22 and 20 were taken in the treeless central part of the deposit. The ash content of the peat in this area is very low (generally less than 2%). Note that ash content increases toward the edges of the deposit.

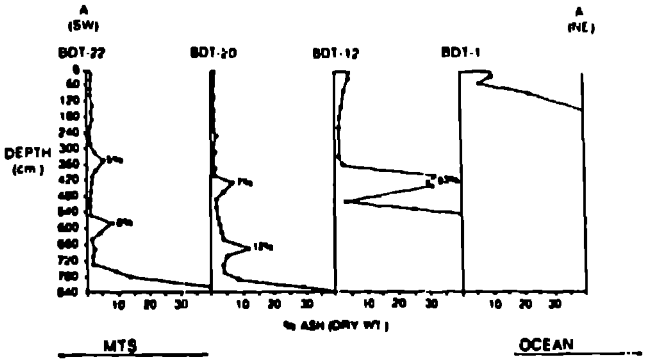

Figure 6: Sectional profile A-A' showing ash content of cores with depth (Changuinola, Panama).

The two small ash peaks in core BDT-22 are exactly the same distance apart as are the two ash peaks in core BDT-20. It is, thus, very likely that these peaks were produced in both areas at the same time. However, the peaks in core BDT-22 are approximately 120 cm higher in the section than are the peaks in core BDT-20. This probably results from the fact that we do not at this time have a topographic map of the surface of this deposit and have consequently made the surface of the deposit a horizontal line. However, either a difference in the surface topography or in the topography of the surface beneath the peat (or both) might explain this offset. Furthermore, the sources of the inorganic materials that produced these peaks are still unknown. If, for example, the source is windblown inorganics (e.g. volcanic ash), then this material could have been deposited at all elevations on a domed (i.e. curved) surface at the same time. On the other hand, note that there is a slight increase in percentage of ash in both peaks from core BDT-22 to core BDT-20. This would indicate that the source of these inorganics might have been from the northeast (ocean side) suggesting (but not proving) a marine origin for these inorganics. It is also possible that a tributary of the Rio Changuinola once occurred to the northeast of core BDT-12. This river would have flowed roughly parallel to the beach-barrier shoreline feature that presently bounds the swamp on its northeastern side.

FIXED CARBON AND VOLATILE MATTER

Fixed carbon and volatile matter tended to exhibit an inverse relationship to each other so that diagrams of fixed carbon content were sufficient to depict the distribution of both parameters.

Figure 7 shows fixed carbon (ash-free) with depth along cross section A-A'. Note that, with minor fluctuations, fixed carbon tended to increase with depth. These minor fluctuations are probably caused by the variability of peat types with depth, since different peat types undoubtedly have inherent differences in fixed carbon (resulting from inherent differences in chemical composition and environments of deposition).

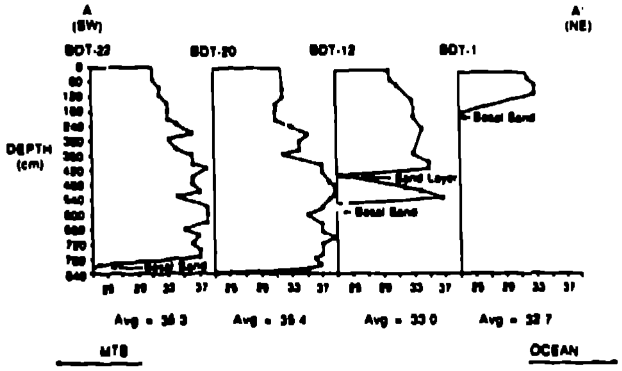

Figure 7: Sectional profile A-A' showing fixed carbon (dry, ash-free) with depth (Changuinola, Panama).

CALORIFIC VALUE

The average calorific value for 62 samples of peat from the Changuinola area was found to be 10,000 BTU/lb (dry) with a range of 8,824 to 11,310. On an ash-free basis, these values were 10,375 and 9,456-11,541.

Figure 8 shows BTU/lb (dry), for cross section A-A'. Note that in the thicker central portion of the Changuinola deposit (BDT-22 and -20), there is a tendency for BTU (1) to be slightly lower at the top of the cores, (2) to increase gradually with depth (but with numerous fluctuations), and (3) to decrease abruptly at the base of the core, where the ash content goes up. As previously suggested, these fluctuations cannot be accounted for entirely on the basis of increasing or decreasing mineral matter content, even though a general trend toward decreasing BTU with increasing ash can be shown to exist for all samples from the Changuinola area. It is more likely that these trends reflect variations in peat types

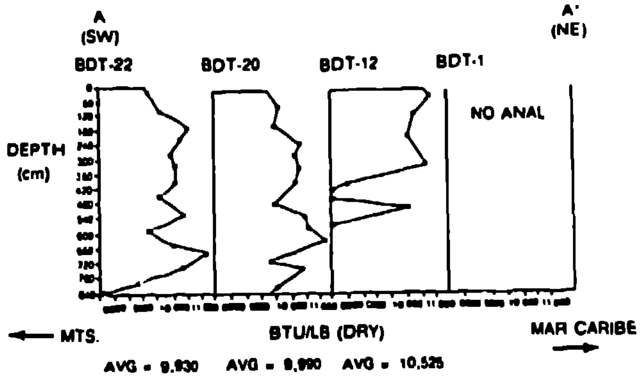

Figure 8: Sectional profile A-A' showing BTU/lb. (dry) with depth (Changuinola, Panama).

(i.e. chemical differences in original plant source ingredients) as well as differences in ash content. All of these differences may also be affected by the geographic positions of the core sites relative to the geometry of the deposit (e.g. domes or subsurface depressions) or to surrounding geomorphologic features (such as shorelines, mountains, rivers).

SULFUR CONTENT

Figure 9 shows total sulfur contents of the Changuinola peats along sectional profiles A-A' and B-B'. Total sulfur contents in the central, thicker portions of the deposit (BDT-22 and -20) are very low, averaging about 0.2% (dry wt.). Note that average sulfur contents tend to increase toward the Caribbean ocean (SW to NE) and toward Almirante Bay (NW to SE), with the highest values being near the brackish bay rather than the more saline ocean. These relationships of sulfur to marine conditions are consistent with those observed in many other coastal peat deposits of the world [e.g. in southern Florida (Cohen et al., 1984)].

The dramatically higher sulfur values encountered below about 180 cm in core BDT-3 reflect the presence of brackish and marine mangrove peats (see previous petrographic/botanical descriptions.

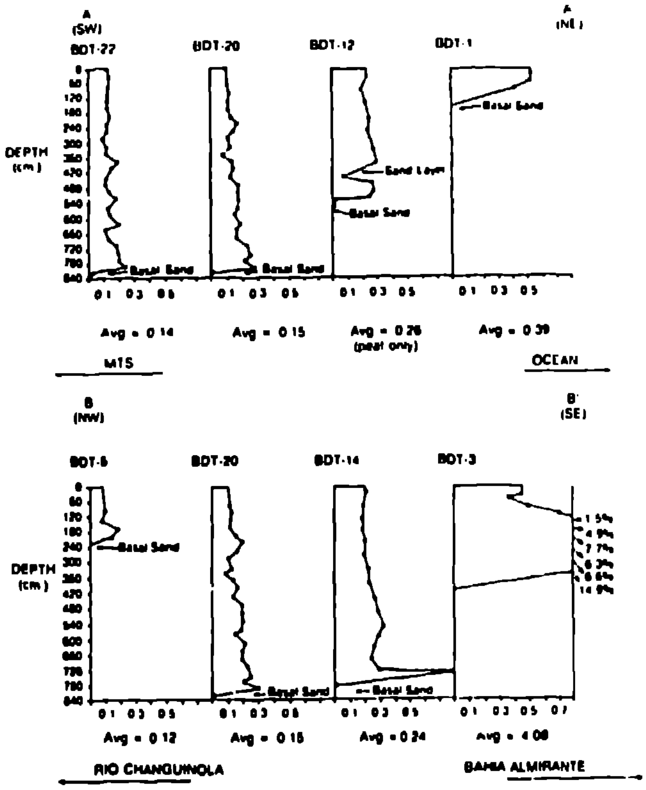

Figure 9: Sectional profiles A-A' and B-B' showing total sulfur content versus depth (Changuinola, Panama).

ORIGIN AND DEVELOPMENT OF DEPOSIT

One hypothetical explanation for the development of the Changuinola peat deposit and its associated inorganic sediments is given in Figure 10. The sediments directly beneath the peat deposit appear to be of marine origin and probably formed when the Caribbean shoreline was as shown in 10a. The Changuinola delta would have developed during a time of relative sea-level stability or regression. At a later time, marine transgression might have caused the delta to be eroded and begun formation of the spit (10b). Continued development of the spit (10c) and eventual restriction of the opening into Bahia Almirante (10d) would result in freshwater peat formation as shown in Figure 10e. More rapid marine transgression would result in reopening (or widening) of the inlet between the mainland and Isla Colon, erosion of some of the previously-formed peat, and widening of the bay (10f).

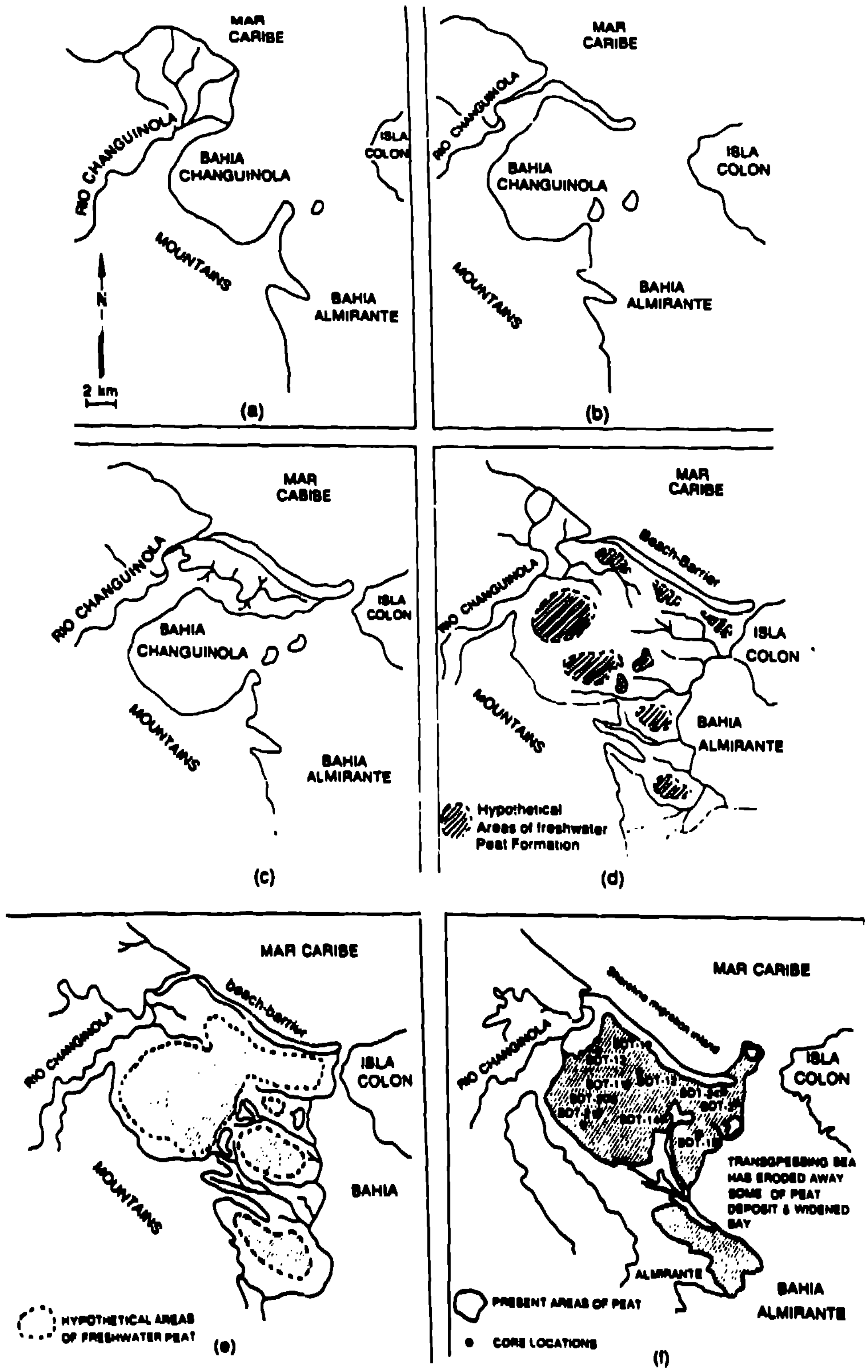

Figure 10: Hypothetical development of Changuinola peat deposit.

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