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Volume 14, Number 2, August 1978

URI: https://id.erudit.org/iderudit/ageo14_2rep03

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Publisher(s)

Maritime Sediments Editorial Board

ISSN

0843-5561 (print)

1718-7885 (digital)

[Explore this journal](#)

Cite this article

Leatherman, S. P. (1978). Anthropical Structures in Coastal Sediments. *Atlantic Geology*, 14(2), 69–72.

Article abstract

Intense human activity in the coastal zone has resulted in widespread deformation of coastal features. Vehicular and pedestrian traffic are the primary means of creating anthropical structures. While the long-term preservation potential for these structures is generally quite low, geologic investigations have shown that a large number of modern environments contain deformed layers in their sedimentary records.

ANTHROPOLOGICAL STRUCTURES IN COASTAL SEDIMENTS

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Intense human activity in the coastal zone has resulted in widespread deformation of coastal features. Vehicular and pedestrian traffic are the primary means of creating anthropological structures. While the long-term preservation potential for these structures is generally quite low, geologic investigations have shown that a large number of modern environments contain deformed layers in their sedimentary records.

INTRODUCTION

Coastal environments are becoming subject to greater recreational pressures in recent years. Part of this increased usage has taken the form of pedestrian and vehicular traffic. The detrimental effects of off-road vehicles (ORVs) on various landforms has only recently been evaluated (Wilshire *et al* 1977). Research at Cape Cod, Massachusetts has illustrated the magnitude and range of impacts on coastal ecosystems (Godfrey *et al* 1975, Leatherman 1977, Godfrey *et al* 1978). Evidence of these large-scale impacts on the environment should be reflected in the recent record of the unconsolidated coastal sediments.

There have been few studies dealing with man-made deformation structures, although much emphasis has been placed on structural evidence in the interpretation of sedimentary environments. While textural and mineralogical information are quite important, recognition of structural relationships is often the key to identification. Process information can be directly extracted from the structural interpretations. Confusion in environmental interpretations can result from several processes or agents producing similar structures. Van der Lingen and Andrews (1969) described circular depressions in recent beach sands which could have been the products of "air-heave" or deformation by horse-hooves. Experiments demonstrated that these structures were actually horse-hoof prints, modified and infilled by swash. Deery and Howard (1977) described pseudoconvolute bedding due to penetration of the washover fan surface by hooves and feet of vertebrate animals. These structures were deemed to be geologically significant because it was difficult to distinguish the pseudoconvolute bedding from true convolute bedding. Dionne (1972, 1973) has recognized structures on the tidal flats of the St. Lawrence Estuary of a peculiar origin. Some of the sedimentary features resembled animal trails, but these ribbed grooves and tracks were actually caused by ice break-up (Dionne 1972). Off-road vehicle tracks and pedestrian foot prints, which are discussed below, are the most common anthropological structures in coastal sediments.

VEHICLE TRACKS

The extensive usage of off-road vehicles in coastal areas has resulted in a very rutted surface appearance (Fig. 1). Hobbs (1977) has noted parallel zones of highly disturbed and contorted sediment layers contained within otherwise undisturbed beach and dune sands. These tire tracks from vehicles and airplanes have been found from

Alaska's Copper River Delta to the uninhabited barrier islands of Virginia's Eastern Shore. Hobbs (1977) termed these zones of deformation, which could be preserved in the stratigraphic record, as "autogenetic structures."



FIG. 1 Vehicular and pedestrian traffic have resulted in a highly roughened surface on the beach backshore of Nauset Spit, Cape Cod, Massachusetts.

Tire tracks on the backshore of Nauset Spit beach, Cape Cod, Massachusetts, were buried intact by waterlaid deposits. During spring tide conditions, wave swash overtops the beach berm, depositing sand on the backshore (Fig. 2). In this case, our off-road vehicle tracks were covered only minutes after the passage of the wheels through the area (Fig. 3). While the preservation potential for these convolute layers on beaches generally is quite low, these structures have also been found in more stable environments such as washovers.

While trenching a washover fan on Nauset Spit, a convoluted layer was found at 0.75 m (2.5 ft.) below the present surface (Fig. 4). From a core analysis, the layer would have appeared to exhibit steeply dipping beds, indicative of pyramidal dune bedding (Goldsmith 1973). The trench showed that this feature was actually a single vehicle track in horizontally-layered washover sediments. This vehicle gives some indication of the historical



FIG. 2 Vehicle tracks are preserved on the beach backshore when covered by sediment transported by the swash overtopping the berm crest.

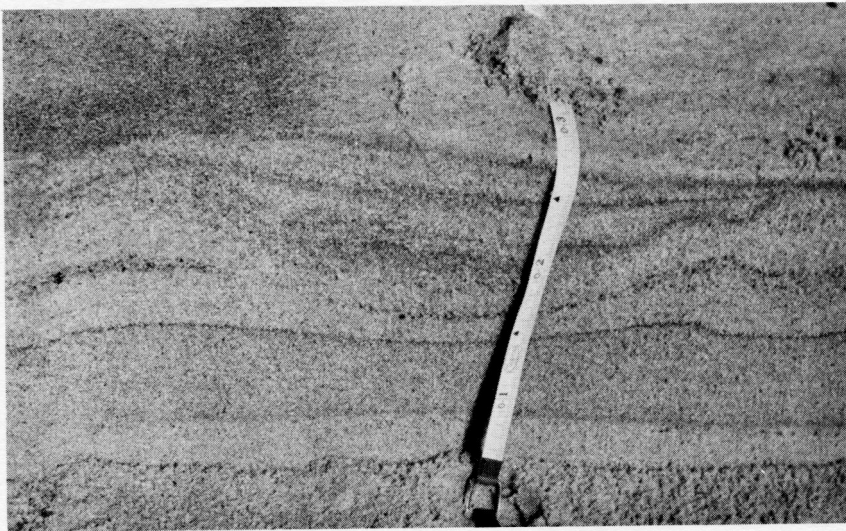


FIG. 3 A trench on the beach backshore showed that the tire tracks were preserved in tact by the depositional swash surges.

usage of this area for vehicular passage. Since there are no other contorted layers in the section, except in the surface sediments, the entire sedimentary section may be the result of a single storm event. If there were many smaller overwashes spaced through time rather than one large overwash, then ORV tracks would be expected throughout the section for each of the old surfaces. If the regressive nature of this shoreline were reversed, then the tire tracks could be preserved indefinitely in the sedimentary record.

PEDESTRIAN FOOT PRINTS

Pedestrian traffic in coastal areas has also

become of much concern due to damage inflicted on vegetation. In particular, dune grass is very sensitive to the stress of foot traffic, and dune blowouts soon develop. Although foot traffic does not generate the deep ruts of vehicle tires, the prints are much in evidence in soft, unconsolidated sediments. McKee and Bigarella (1972) have described contorted laminae from loading, caused by walking on coastal dune surfaces in Brazil. Leatherman and Williams (1977) trenched a washover fan at Assateague Island, Maryland, and found evidence of human disturbance. Surveyors, walking on the fan surface, had caused contorted layers and "micro-faulting." The alternating layers of quartz and concentrated heavy minerals apparently acted in an elastic nature

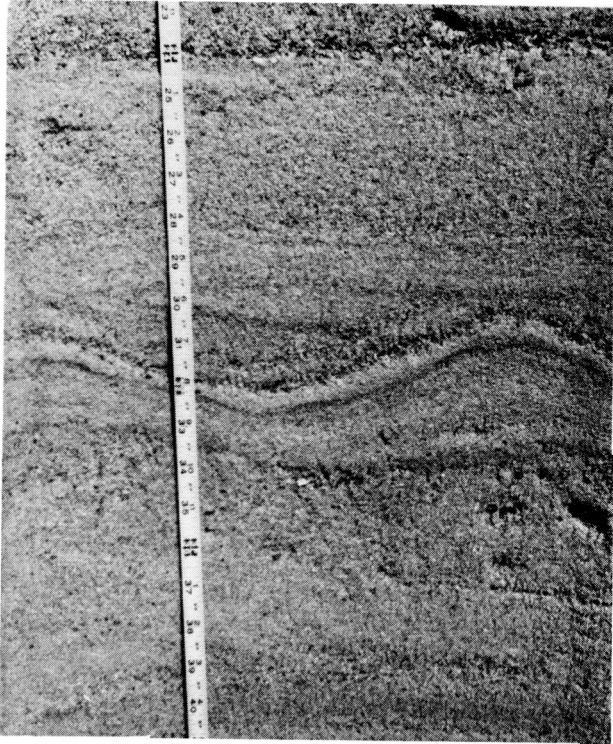


FIG. 4 A convoluted layer was found at two and one-half feet below the surface of a washover on Nauset Spit. This structure was interpreted to be a vehicle track since it is similar in size and form as known tire tracks (see Figure 3).

FIG. 5 A contorted bed was exposed for several hundred meters along a wave-scarped barrier dune at Fire Island National Seashore, New York.

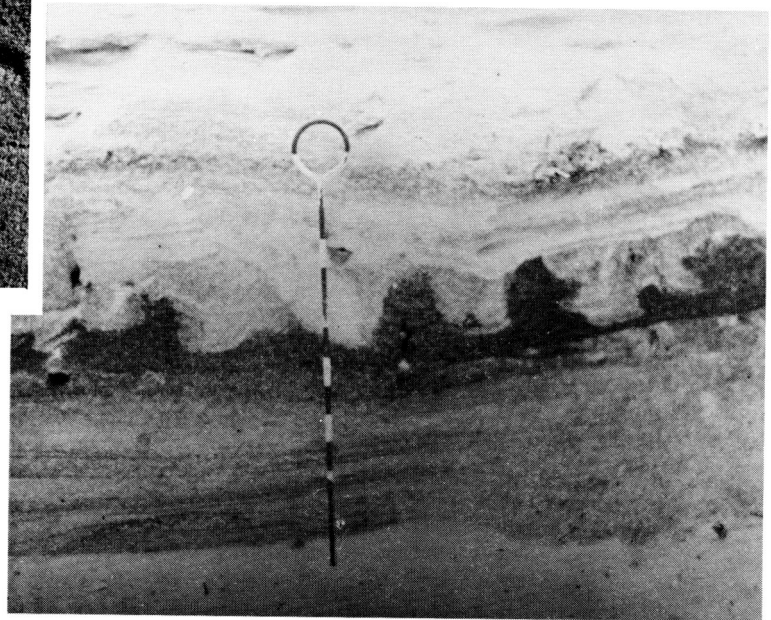
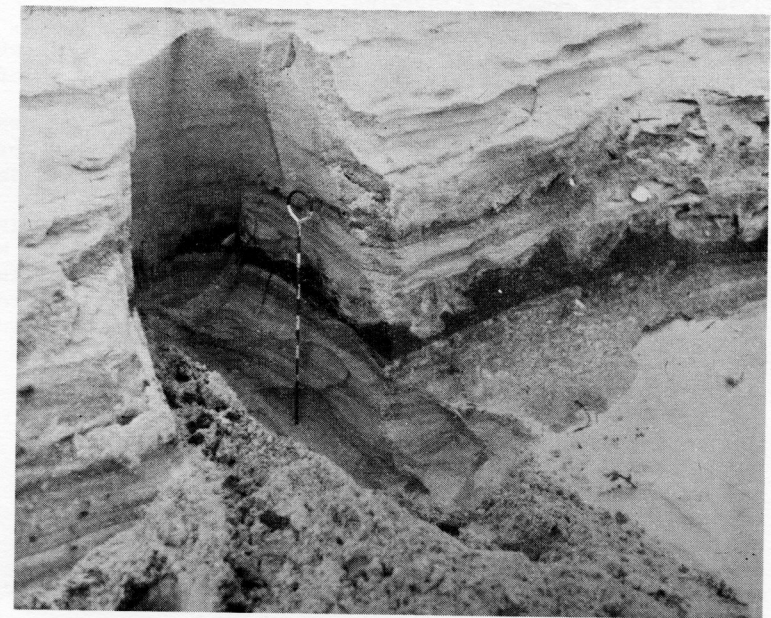


FIG. 6 The contorted beds at Fire Island are believed to be foot prints on a post-storm washover or beach backshore surface that was subsequently covered by eolian sedimentation.



so that slippage of several centimeters occurred along certain "fault" planes. These anthropical structures were buried to a depth of 40 cms by an overwash generated by a large northeaster (Leatherman *et al* 1977).

At Fire Island, New York, a curious contorted bed was found at the base of a 3-m high barrier dune (Fig. 5). The layer was shown to have a horizontal extent of hundreds of metres, as exposed in the wave-scarped dune face. Further examination showed that these features, which are believed to be footprints, were irregular in form in all three dimensions (Fig. 6). McCormick (1975) recognized some scour-and-fill structures, produced by retreat of a scarp up the beach, which are similar to the convoluted structures, but are not as irregular and jagged in appearance as the foot prints.

It is somewhat difficult to reconstruct the historical development of this area, but the concentrated heavy mineral layer would indicate a hydraulic origin (McCormick 1975). Therefore, this area was either a large washover area or beach back-shore environment with intense pedestrian traffic in evidence. It is a part of Robert Moses State Park, which has historically been a favorite site for seashore recreation. Since the very highly contorted nature of the beds has been preserved, it is believed that the sand that buried this old surface was wind-blown. Rapid dune growth was probably facilitated by the use of snow-fencing. These anthropical structures would probably have been incorrectly interpreted without previous recognition of these features and such a large exposure.

CONCLUSIONS

Anthropical structures are rather common in recent coastal sediments, particularly along barrier island beaches. The geologist who uses structure as the primary criterion for interpretation of process should be aware of the potential for man-induced convolute bedding structures. The examples cited in this discussion illustrate the wide range in geographic setting and type of sedimentary environment where anthropical structures can be found.

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