A DESCRIPTIVE CLASSIFICATION
OF SHORE LINES

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Studies of shore lines and shore line processes have neglected the development and use of descriptive classifications and have emphasized the use of genetic classifications. Genetic classifications are theoretical, consequently they change, and perhaps become more complex as more is learned about the subject to be classified. While the genetic systems have served as useful bases for studying processes of shore development, they have, because of their many complexities and theoretical nature, made shore line description exceedingly difficult. There are several distinct classifications, each with its critics and supporters. In this fluid situation of argument and disputed interpretation even an expert must proceed with caution in applying explanatory-descriptive terms to shores. It is the purpose of this paper to propose a preliminary descriptive classification of shores that, first, will be useful in their description, and second, will be helpful in research.

The classification that the author proposes stems from the belief that genetic classifications are not a satisfactory means of identifying shore zones for descriptive purposes. During the course of several field seasons devoted to the investigation of marine terraces along the central California coast, the northeastern coast of Venezuela, the Netherlands Antilles, and on the coast of East Africa it has become more and more apparent that the classic Davis-Johnson genetic classification of shore lines does not provide a satisfactory means of distinguishing between different types of shores. Evidence from marine terraces and alluviated or drowned valleys indicates that coasts on which emergence has been responsible for the form of the shore are probably rare and that submerged coasts vary so widely in appearance as to have no common descriptive qualities. For example, study of the marine terrace deformation along Monterey Bay, California, showed that this part of the coast had been steadily uplifted, certainly since the mid-Pleistocene. However, logs of wells drilled into the flood plain alluvium of the local valleys indicated that during the last deglaciation the sea rose at least 200 feet with respect to the land. Thus, despite rising land, the Monterey Bay coast has submerged shore although the normal embayments are absent since the drowned river valley have been filled with alluvium. Furthermore, the deformation of the marine terraces on Bonaire and Curacao shows the islands have been rising continuously since the

1 As used here, shore refers to a zone of varying width extending landward to include the sea cliff, beach ridge or sand dunes and seaward to the outer edge of the low tide breakers. Coast refers to a zone of indeterminate width which extends inland from the top of the sea cliff or landward edge of the beach ridge or sand dunes.


early Pleistocene yet several drowned valleys on the islands are evidence of shore submergence. Both these examples of rising coasts presently have shores of submergence and though both are submerged the forms of their shores are quite different.

As Shepard correctly observed, the last deglacial rise in sea level was so great as to make invalid the emergent class of shores. This class is not successfully revived by Cotton's suggestion of a new basis of primary classification—"coasts of stable and mobile crustal regions." Along coasts of mobile regions the possibility does exist that the most recent diastrophic movements (which must have occurred since the last deglaciation) may well have resulted in emergence. However, observations on the coasts of northeast Venezuela and East Africa indicate that along those coasts where marine and stream terraces are absent it is very difficult to determine the presence or absence of late Pleistocene or more recent earth movement. It is apparent then that a classification based on the relative rise or fall of land is difficult, and, in some cases, impossible to apply correctly. There are other systems which do not emphasize land movement, but these too are difficult to apply in the field.

These other shore line classifications are all genetic to a varying degree, and they require considerable subjective judgement in their application. The following review recalls some of the more important attempts at shore line classification. One of the earliest mentioned was proposed by Richthofen. His system is based primarily on the relation of the coast (as used by Richthofen, coast includes shore) to the continental relief features, and secondarily on the vertical shore profiles and on the relation of the shore to secondary elements of land relief. These in turn can be subdivided according to the form of the vertical profile and the configuration of the coastline resulting from drowned valleys or alluvial deposition. Modifications of Richthofen's ideas have been used by others, i.e., Suess in defining Atlantic and Pacific coastal types.

Shepard relies upon marine and non-marine agencies in his classification to distinguish two major classes: (1) young shore lines, where the configuration is primarily due to non-marine agencies, and (2) mature shore lines, where the configuration is primarily due to marine agencies. Subclasses are devised according to the type of marine and non-marine agency responsible for the configuration of the particular shore.

In one of the most recent genetic shore line classifications, Valentin considers both relative movement of the land and marine erosion and deposition. His system distinguishes two primary types, advancing and retreating shores. Any given shore is the result of the interaction of four agencies of coastal formation: the (1) relative uplift or (2) depression of

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the land and (3) marine erosion or (4) deposition. Horizontal advance (outbuilding) of the shore represents the dominance of emergence and marine deposition over submergence of the land and marine erosion. Retreat of the shore results from the converse of these conditions. The primary types of shores are thus divided into two subtypes: the advancing class into shores of emergence and shores of deposition, the retreating class into shores of submergence and shores of erosion. These subtypes can be further subdivided according to the processes or agents involved in their origin.

Recognizing that genetic classifications, such as those mentioned, require trained personnel to apply them, Putnam\textsuperscript{11} proposes a broad system that seeks to minimize interpretation by using simplified terms such as “sea cliff” and “stream eroded plain” to describe shore and coast features. The classification deals with both coastal zones and shore lines and so is separated into two major parts—“a classification of coastal types determined by major landforms” (including a zone five to ten miles inland from the shore), and a “classification of coastal types determined by shore features” (shore lines proper). Coastal types are distinguished according to the major land forms, structure, and lithology within a five-to-ten-mile coastal zone. These coastal types are further subdivided on the basis of the principal agents which have shaped their surfaces. The agents, in turn, are grouped according to the climate in which they operate most effectively. Shore lines are first divided into two types on the basis of constructional or destructive shore features, and these are then subdivided according to the agents responsible for the features. Despite the use of noncontroversial terms to describe coast and shore features, Putnam’s classification is basically genetic and also requires a great deal of interpretation on the part of the user.

It is evident from the foregoing review that attempts to classify shores have developed largely in genetic terms. Genetic classifications however, do not provide adequate means of describing shores. Requiring interpretation of shore features, the application of genetic systems is necessarily restricted to persons well versed in shore and coastal studies. Furthermore, since interpretation is required, even expert application may be subject to question.

In view of the difficulties inherent in the genetic approach to shore line classification, a system based entirely upon shore form seems to have much to recommend it. This approach is not entirely without precedent. One of the elements used by von Richthofen,\textsuperscript{12} the shape of the vertical profile of the coast, is descriptive. Albrecht Penck\textsuperscript{13} also proposed a classification in which some coastal types are distinguished mainly on the basis of their appearance. His criteria involve coastal outline, vertical profile, coastal composition and rock structure. The outline of shores may be smooth, embayed or lobed. Lobed refers to shores with broad, open bays or small gulfs as found on Peloponnesos or on Celebes. In vertical profile

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Fig. 1. Bay types: A—Cone shaped bays on the eastern shore of Chesapeake Bay. B—Elongate bays on the coast of Norway. C—Pouch-shaped bay on the northeast coast of Curacao. D—Rectangular bays on the Siberian coast.
coasts are flat or steep. A steep coast is one where the slope of the land above sea level is steeper than that of the strand. If the slope of the land is less than that of the strand the coast is classified as flat. Flat and steep coasts are not only distinguished by their form but also by their composition. Six major types of coast are recognized on the basis of their appearance—smooth coasts, either flat or steep; and embayed and lobed coasts either flat or steep. The character of embayed shores is determined by the nature and origin of the bays. Additional major coastal types are distinguished by rock type and structure.

There are several practical difficulties in using the descriptive aspects of Penck's system. It provides no quantitative boundaries for distinguishing between smooth and embayed coasts. The distinction between steep and flat coasts may also be difficult to make in some cases. The slope of the strand, which is critical in making the distinction between steep and flat coasts, not infrequently varies from place to place quite independently from the above sea slope of the land. Consequently, with changing strand gradient, coasts with the same slope could be flat in some circumstances or steep in others. Furthermore, strands frequently have curved slopes or profiles. Under these circumstances decisions whether a coast is steep or flat can scarcely be consistently definitive.

To circumvent these difficulties, and to keep entirely within a descriptive framework, the classification proposed here uses only two easily recognized shore characteristics to establish the main types of shores—the vertical shore profile (cliffed or non-cliffed), and the shore outline (regular or irregular).

All shore zones are first recognized as either cliffed or non-cliffed. Cliff is defined as an abrupt, local increase of terrain slope forming a steep rock face at or near the shore. (In some instances the cliff may be separated from the waters edge by a wide beach or strand flat.) A shore is considered cliffed if the cliff is more than five feet high and is an enduring feature.

The cliffed and non-cliffed classes can each be further classified according to their horizontal configuration—they are either regular or irregular in outline. In the case of irregular cliffed shores the cliffing is confined to headlands between bays. Regular shores are those with generally smooth outlines, although in detail they may have small irregularities or crenate-shaped bays that are less deep (inland penetration) than wide and are open to the sea. Irregular shores are those having numerous bays of varying size and shape that are deeper than wide and are generally sheltered from the sea. At present the dividing line between regular and irregular shores has not been established firmly enough for objective application. It is evident, however, that the boundary between the two types must be related to the size of the estuaries or bays. Inspection of the coastal charts of northwest Spain, southeast Ireland, south China and the eastern United States indicates the following tentative boundary: if, for each unit of bay depth (inland penetration) there are at least five units of unembayed shore between bays, the shore belongs to the regular class—with less than five units of shore between bays and shore belongs to the irregular class.

The regular and irregular classes are broad types that can be subdivided to recognize local conditions. The regular shore type may include crenate shores, smooth, nearly straight shores, and lagoon shores with
association with both the cliffed and non-cliffed shores though lagoons barrier islands of sand or coral. All of the regular subtypes can be found in occur only very rarely with the cliffed class. The types of irregular shore are identified by the shape and dimensions of the bays in a given area. Some of the more common bay types are: long, relatively narrow, cone-shaped bays (sometimes with a winding pattern and branching tributaries); narrow, extended estuaries, frequently with many branches which may be called elongate bays; pouch-shaped bays; and rectangular bays (Figure 1). All bay types are common to both irregular cliffed and irregular non-cliffed shores. Not infrequently the bays occur on non-cliffed shores in conjunction with barrier islands and so form composite lagoon shores.

I. Cliffed shores

A. Regular
1. Smooth
2. Crenate (or scalloped)
3. Lagoon (rare)

B. Irregular
1. Cone-shaped bay
2. Pouch-shaped bay
3. Rectangular bay (or scalloped)
4. Elongate bay
5. Composite lagoon (rare)

II. Non-cliffed shores

A. Regular
1. Smooth
2. Crenate (or scalloped)
3. Lagoon

B. Irregular
1. Cone-shaped bay
2. Pouch-shaped bay
3. Rectangular bay
4. Elongate bay
5. Composite lagoon

Table 1. Outline of classification of shore lines.

The system can be applied with facility both in the field and on maps and charts. The classification is flexible since it can be expanded to accommodate additional information. For example, once a shore has been identified as to a specific subtype it can be further classed according to the rock type exposed in the cliff, the nature and composition of the beach, the slope of the near shore bottom and so on.

The classification has been used with apparent success in the field in a mapping assessment of the shore qualities of the coast of Tanganyika between Dar es Salaam and Tanga (an alternating cliffed and non-cliffed, regular, lagoon shore). Using a combination of observation and maps and charts the system has also been tested, again with apparent success, on the coasts of California between Davenport and the Pajaro Valley (cliffed, regular shore; Davenport to Santa Cruz: subtype crenate, Santa Cruz to the Pajaro Valley: subtype smooth), and northeast Venezuela (La Guaira to Cabo Codera, cliffed, regular, crenate shore). The system appears to be a satisfactory means of describing and classifying shores. Further testing will bring about additions and modifications to adjust the classification to additional shore forms or combination of forms that may subsequently be revealed.