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Estuaries*

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Introduction

Although estuaries are one of the most well-studied entities of coastal environments, our geological understanding is still rudimentary. Why such a divergence in our level of understanding? Most inquiry has centered on human needs in an effort to resolve competing demands for use of estuaries, e.g., for shipping and waste disposal as opposed to use as a recreational outlet or food sources. Far more effort has gone into detailed engineering, fishery, and pollution studies than into generalizing and understanding estuaries as a sedimentary environment. As a result, there are few unifying models of deposition, few clues for matching modern and ancient deposits. Our geologic understanding is further tempered by Schubel and Hirschberg (1978) who note that "estuarine deposits rarely can now be delimited unequivocally from other shallow water marine deposits in the geologic record because of their limited areal extent, their ephemeral character and their lack of distinctive features." Then why bother to understand the geologic attributes and processes in estuaries?

The authors believe estuaries figure significantly in the sedimentary make-up of a coastal system, or framework of estuarine environments: lagoon-bay-inlet-tidal flat and marsh. Taken together, these environments make up 80 to 90% of U.S. Atlantic and Gulf coasts (Emery, 1967); and they are found on every continent. Estuaries also have been abundant in the recent past, and they have persisted in periods before the Quarternary when sea level was relatively constant. Estuaries figure prominently because they function either to collect or to convey material between the land and the sea.

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an important segment of the sedimentary cycle. In vertical sequences, estuaries mark transitions between fluvial and marine environments, a key phase for tracing transgressions and regressions associated with petroleum reservoirs. Further, geologists studying ancient deposits still ask: What kind of environment was it? Under what conditions and in what manner did the sediment accumulate? These are difficult questions. To sharpen our understanding, it is necessary to examine estuaries as they now exist.

This chapter is written for those who need help to read the record of ancient coastal environments from a knowledge of modern environments. Therefore, the following sections review estuaries, their sediment characteristics, evolution, stratigraphic relationships, and processes showing how, within bounds of available data, they relate to the resultant sediments. Many questions are asked to emphasize fundamental ideas. The answers however, are often ambiguous and necessarily incomplete. The gaps in our understanding reveal where much work remains to be done; study has scarcely begun.

What is an estuary? In geomorphic terms, an estuary is “an inlet of the sea, reaching into a river valley as far as the upper limit of tidal rise” (Fairbridge, 1980). Fairbridge has proposed a physiographic classification of estuaries (Figure 2-1), modified by the regional history of sea level, morpho-tectonic factors, climatic factors, and freshwater and sediment supply.

In oceanographic terms, Pritchard (1967) has defined the estuary as “a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage.” The general characteristics of estuaries as classified by Pritchard are presented in Table 2-1. The distinction between the Pritchard and Fairbridge classifications is twofold. Pritchard's classification is a short-term dynamic scheme, because an estuary may change from a Class B to a Class C with a seasonal change in river discharge. Although Fairbridge recognizes short temporal effects, his classification explicitly considers long-term processes like climatic change and secular sea level rise. A second difference between the two schemes lies in the definition of the landward boundary of the estuary; Pritchard’s landward boundary is a chemical one (where the chlorinity falls below 0.01 % and the ratios of the major dissolved ions change radically from their ratios in sea water); Fairbridge’s landward boundary is physical (the upstream limit of a measurable tide). For some estuaries, the difference is trivial, but for others the Fairbridge estuary may extend 100 km landward of the Pritchard estuary. From a geological perspective, tidally associated bidirectional sediment properties found in what might otherwise be interpreted as fluvial sediments may represent that portion of the estuary landward of Pritchard’s boundary. Neither Fairbridge nor Pritchard deal with the geologically important seaward boundary in an acceptable manner. Both definitions assume that one can locate oneself inside a semienclosed basin or an inlet. This is seldom possible in geological studies with limited outcrop availability. Estuarine conditions, so far as sediment properties are concerned, can extend