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Geological and Exploration Models of Beach Placer Deposits, Integrated from Case-Studies of Southern Australia

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ABSTRACT

The processes leading to the formation of beach placer deposits generally begin inland and terminate at the coast, including source rocks being weathered, eroded and then transported by streams and rivers to the coast, where the sediments are deposited in a variety of coastal environments. The coastal sediments are reworked by the action of waves, tides, longshore currents and wind, which are effective processes for sorting the mineral grains based on differences in their size and density, resulting in laminated or lens-shaped packages of sediments up to tens of meters thick that are rich in heavy minerals. Detailed studies of sedimentary basins, as well as peripheral (paleo-)valleys that drained sediment source areas, are important tools in the exploration for heavy mineral resources. Knowledge of the (paleo-)basin, associated valley architecture and the source of heavy minerals concentrated in the shorelines and valleys are useful guides to the potential for, and location of, economic deposits. Evidence from sedimentology can be combined with that from other geological and geophysical characteristics to arrive at a general reconstruction of basin and paleovalley architecture and depositional environments. Complex paleogeography of the shorelines can influence or determine the sites of heavy mineral concentration. Heavy mineral sands tend to concentrate in certain shoreline settings during storm activity. Repeated storm erosion and reworking over centuries (e.g., the southeastern coast of Australia) or millennia (e.g., the Eucla and Murray Basins of Australia) can progressively enrich heavy mineral sand deposits. Preservation of these deposits over a geological timeframe of millions of years can ensue through subsidence of coastal sediments, and during sea-level change that results in either shorelines migrating inland (marine transgression) or seaward (marine regression), potentially burying or stranding earlier deposits or reworking them to form younger deposits. Refinements in remote sensing and geophysical techniques, data processing, sedimentology and computer-aided interpretations provide effective, economic and efficient methods for modeling coastal reconstructions and for exploring provinces and terrains prospective for heavy mineral sand deposits. Landscape topography analysis, combined with geophysical methods that can resolve physical property contrasts between the shoreline sediments and underlying sequences, are increasingly used in mineral exploration to locate and to reconstruct paleoshorelines and paleovalleys.

Australia has modern and ancient beach-placer deposits, both of which show many similar geologic features. The formation of these heavy mineral deposits provides one of the best examples of applying knowledge of modern systems (e.g., the west and east coasts of Australia) as an analogue to interpret and understand the geology and form of ancient deposits (e.g., the Eucla and Murray Basins of southern Australia). This study provides descriptive and exploration models of Australia's heavy mineral sand deposits formed in coastal environments, which can be applied to similar settings worldwide.

1. Introduction

Heavy mineral (HM) deposits associated with sediments in basins and paleovalleys are known in many places around the world. HM sands have two main deposit styles: (paleo-)shoreline/marine placers commonly associated with beach (including barrier and aeolian coastal dune) or shallow offshore deposits, and fluvial/alluvial (e.g., gold and diamond) deposits. Rivers and streams carry HM-bearing sediments sourced from weathered geological domains and deliver the detritus to marine basins. Deposition occurs in particular geological sites where the geological and hydrological conditions are suitable for concentrating the HM. The heavy (dense) minerals in the sediments, such as gold, diamond, rutile, ilmenite and zircon, can then be reworked by

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waves, tides, longshore currents and wind, and thereby concentrated in various fluvial and coastal depositional environments. Sedimentation can occur in channels, deltas, the beach face (foreshore), sand dunes behind the shore, offshore barrier islands, and tidal lagoons, as well as in estuarine channels and floodplains of streams and rivers within a coastal plain (Fig. 1).

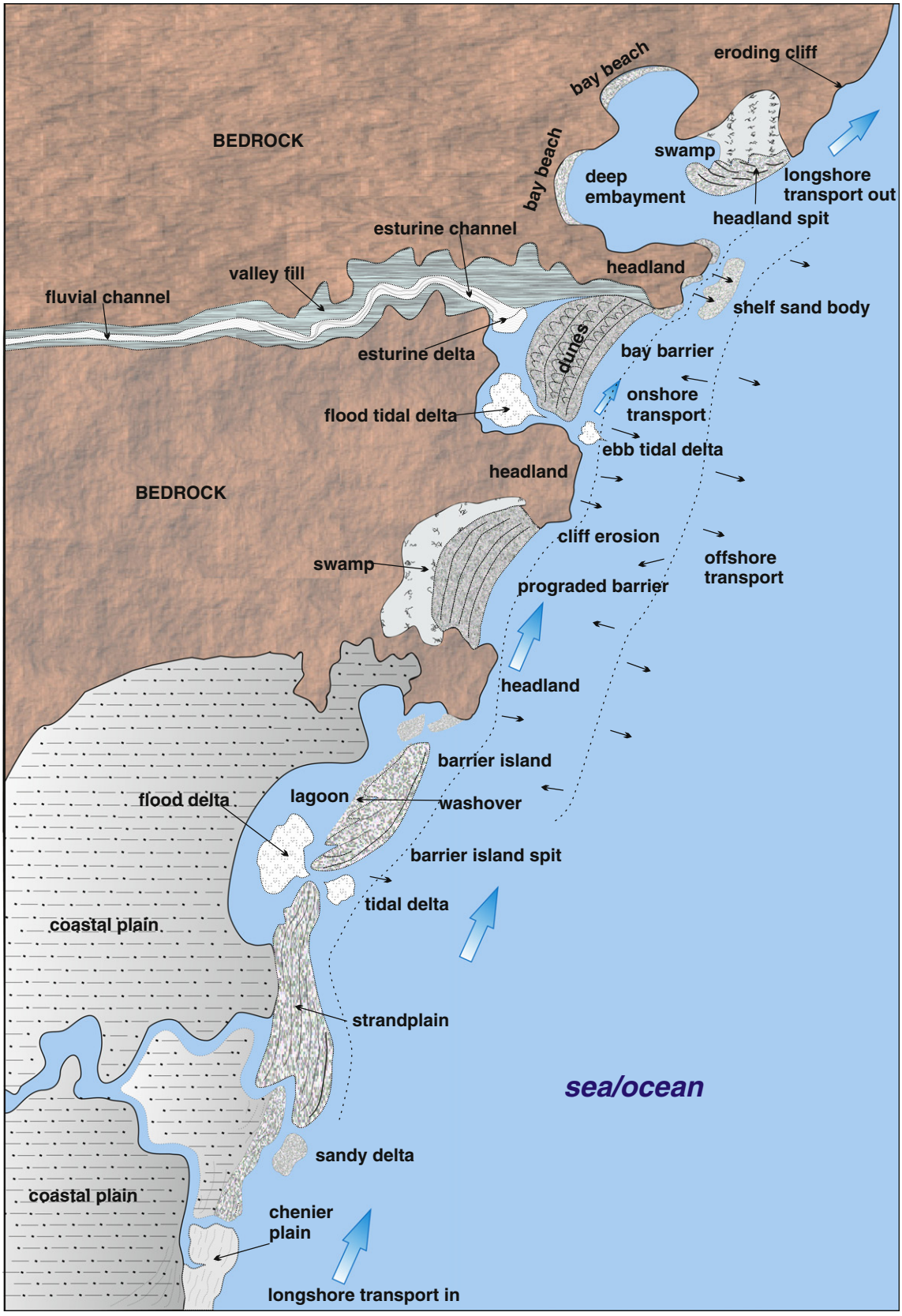

Fig. 1. Schematic of shoreline morphologies and deposits, showing distribution of coastal environments, including fluvial channels, estuaries, deltas, coastal barriers, strandplains, coastal plains, chenier plain, lagoons and cliffs; sources of sediments; and coastal sedimentation processes. After Hou et al. (2016).