Transgressive coastal systems (2nd part): geometric principles of stratal preservation on gently sloping continental shelves

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ABSTRACT - This study focuses on the causes and mechanisms of coastal-lithosome preservation during transgressions driven by roll-over processes of barrier migration. Using the Shoreface Translation Model, a large range of idealised coastal settings was simulated to identify the environmental conditions of stratal preservation. Preservation occurs within two broad categories of experimental conditions. The first category relates to transgressive phases evolving under relatively constant conditions in which stratal preservation takes place only if the coastal barrier experiences positive net sediment supplies. The resulting deposits show tabular geometries, have poorly differentiated internal architectures and tend to extend continuously with quite uniform thickness up-slope across plain regions of the shelf. In the second category, by comparison, deposits are thicker and stratal preservation is more localised. Moreover preservation occurs as an adaptive morpho-kinematic response to environmental perturbations due to variations in: (1) the ratio of sediment supply (Vs) to accommodation generated by sea-level rise (SLR); (2) the substrate topography; (3) the morphology of the barrier profile. More specifically, changes of the ratio Vs /SLR, where SLR is an approximate surrogate for added accommodation space, directly promotes growth of the barrier (Vs /SLR >> 0) and its subsequent drowning (Vs /SLR ~0). The topographic variations of the substrate may include minor irregularities as well as sudden changes in gradient that afford other types of preservation, such as local fills and residual littoral packages. Finally, barrier-profile changes inducing stratal preservation may include the reduction in barrier width and depth of surf base as well as the increment in shoreface concavity and shoreface length. Simplified methods are given for relating the geometry of preserved deposits to rates of sea-level rise and sediment supply over different shelf slopes, and for identifying the position of the shoreline at specific times. Holocene evolution of some coastal deposits from the Tuscan shelf (Italy) is presented in a morpho-kinematic reconstruction to illustrate the geometric relationships for stratal preservation.

Key Words: coastal system, sea level rise, stratal preservation, kinematic models

INTRODUCTION

This study examines the causes and mechanisms of coastal lithosome preservation during transgressions driven by roll-over processes (Dean and Maumreyer, 1983; Leatherman, 1983; Cowell et al., 1999). Roll-over processes entail the continual reworking of sediments from the entire shoreface to the subaerial components of the coastal system (beach and back-barrier), allowing the barrier to be regenerated landwards of its original position and thus to migrate over the antecedent topography (Tortora et al., 2009, in this volume). Preservation refers to the portion of the barrier which is not transferred landwards and which, due to sea-level rise, is cut off from the coastal zone and potentially buried on the continental shelf (Heward, 1981; Belknap and Kraft, 1981; 1985).

The objective of the study was to explore conditions favourable to strata preservation under two broad sets of conditions: relatively constant and highly variable transgressive environments. The approach involved analysis of hypothetical cases synthetically generated by the Shoreface Translation Model (STM). This model, given the appropriate environmental parameters (input data), outputs the kinematics of barrier migration and the resulting morpho-stratigraphic effects in terms of a series of geometric forms recorded at equal time intervals along the landsea profile (Cowell et al., 1995).

Relevant characteristics of the STM, and details of roll-over migration and the experimental techniques used, have all been covered in Tortora et al. (2009, in this volume) and other works relating to the theory and application of the STM or similar models (Cowell and Roy, 1988; Dean, 1991; Thorne and Swift, 1991; Cowell et al., 1992; Cowell and Thom, 1994; Niedoroda et al., 1995; Stive and de Vriend, 1995; Cowell et al., 1999; Dillenburg et al., 2000; Kench and Cowell, 2001; Cowell et al., 2003a; 2003b).

BASIC CONCEPTS

Effects of sea level-rise are illustrated in Fig. 1 by comparing typical stratigraphic evidence of the transgression (in A) with a much simplified schematisation of kinematic reconstructions using the STM (in B). Both the illustrations show a coastal cell experiencing roll-over processes, by which the sediment previously eroded from the full length of the shoreface (cut) is redeposited on the subaerial barrier portion (fill). In A, the products of this redeposition are represented by the stratigraphic column 1, whilst the column 3 shows a preserved barrier portion affected by the cut in the earlier phase. Stratigraphic-columns 2, 4 and 5, are alternative columns to the third one. Therefore columns 2 through 5 idealise the possible transformations that the original barrier