Slope, Rise and Deep-Water Basins

I. **Introduction:** the continental slope and rise system represents the thickest accumulations of sediments and a complex set of tectonic situations; the basins show thinner accumulations of sediments influenced by slope and rise sedimentary dynamics.

II. **Relict sedimentary systems:** much of the continental shelf and slope was shaped by low sea levels in the Pleistocene, which left coarse-grained deposits now under low energy, deep water conditions; these relict sediments become the basis of a "palimpsest" (a canvas reused for a new painting).

III. **Depositional systems:**

A. **Deeper shelf:**

1. **Hummocky cross-stratification (HCS):** undulating cross-sets both convex-up (hummocks) and concave-up (swales); related to storms; not confined to deeper shelf, but common there, sometimes as a relict.

B. **Open slope:** open portion of the continental slope.

1. **Pelagic sedimentation:** mostly fine silt and clay are deposited out of suspension; most derived from distant fluvial processes on the land; a considerable fraction comes from eolian transport of silts and clays.

2. **Gravity processes:** the actual angle of the slope is usually less than 2°, but enough to cause gravitational instability; slumps are common, as are small-scale *turbidity currents* (below); the sedimentary record often shows tight folds of strata created by *soft-sediment deformation*.

C. **Submarine canyons:** canyons cut through the shelf and the slope perpendicular to the continental margin; can be quite extensive; characterized by catastrophic sedimentation, from debris flows at the head to turbidity currents at the mouth.

1. **Turbidity currents:** dense currents of mixed sediment and water; often formed by storms on the shelf or distant earthquakes; the sediments are flushed through the canyons to spread out below like underwater alluvial fans.

2. **History of formation:** most modern submarine canyons are associated with large river systems (like the Hudson) which cut through the shelf when sea levels were low during the last glaciation; they are, at least in their upper parts, flooded river valleys.

D. **Deep sea fans:** the sediments deposited at the mouths of submarine canyons; the continental rise between the abyssal plains and the slope.

1. **Form:** have a form very similar to alluvial fans; coalesce along continental margins to form the continental rise.

2. **Resedimented facies:** sedimentary facies consisting of sediment that rested somewhere else and was then retransported and deposited; in this case, the result of turbidity currents.

a. **Bouma sequence:** typical sediment accumulation from a turbidity current; rarely found complete, we can nevertheless describe the ideal sequence.

E Clay (pelite) deposited from pelagic sources or very low energy turbidity currents; this portion is often eroded by a later high-energy turbidity flow.

D Clay and silt with parallel laminae.

C Sand and silt with ripples and wavy or convoluted laminae deposited in the lower part of the flow regime.

B Sand with planar parallel laminae deposited in the upper flow regime.

A Sand and granules with massive or graded bedding deposited rapidly under upper flow regime conditions.

3. Pelagic sedimentation: again, fine-grained sediment derived from the waters above, including skeletal remains, pellets and other biological contributions.

E. Deep-water basins: at the distal ends of the deep-sea fans and stretching until the next distal ends of deep sea fans; much more limited in extent than we thought in the past.

1. Pelagic sediments: sediment is derived from the waters above, primarily from plumes of fluvial clay-rich sediment and eolian silts and clays; again, organisms make major contributions, sometimes forming thick deposits (oozes) of skeletons (e.g. diatomaceous ooze, foraminiferan ooze; radiolarian ooze); accumulations of silica-rich skeletal ooze (like that of radiolarians or sponges) may lead to chert beds and nodules.

2. Carbonate Compensation Depth (CCD): the ocean is usually saturated with $CaCO_3$ in the upper few hundred meters where the majority of marine organisms live; saturation decreases with depth; at about 4 km of depth, $CaCO_3$ dissolution increases rapidly (the *lysocline*); just below this is the CCD, where carbonates completely dissolve; level varies for aragonite and calcite; generally, carbonate sediments will not accumulate below the CCD; the "snowline" of the CCD is sometimes evident on deep-sea topography; CO_2 increases with depth.