Mediterranean Deltas and global change : Method to distinguish Tectonic subsidence and compaction from climatically - induced sea level variations

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The deltas of the Mediterranean, whether of large (Nile, Rhône, Po), moderate (Ebro, Ceyhan) or small size (more than 100 are known), and regardless of geographic/geologic setting, are characterized by low-lying coastal plains. The configuration of these delta plains is increasingly affected by man's intensified activities, including industrial and municipal waste, channelization and reduction of water flow (and, usually in consequence, sediment load) to the coast, and irrigation, agricultural and aquacultural projects. Effects of man-induced activities are in some cases quite serious, as exemplified by the Nile Delta of Egypt which is being markedly modified by a very rapidly increasing population density.

A substantial part of most lower delta plains lies within 1 m elevation above mean sea level. As would be expected, these low-lying environments, including wetlands, so vital for growing agricultural and aquacultural needs, are extremely sensitive to changes in position of delta plain surfaces relative to sea level. Ongoing multinational research at the Smithsonian Institution in Washington, D.C. is focusing on methods to more finely calibrate the nature and rates of delta land subsidence, eustatic sea level change, and their combined effects on delta margins.

It is of note that the modern Mediterranean deltas began to form at some time between 8000 and 7000 years B.P. (Fig. 1), and these dates correspond closely to those of deltas in other regions, including the Mississippi. This specific time period probably signals the initial phase of deceleration of rising sea level, when delta accumulation and progradation, rather than erosion, began to prevail along the world's coastlines.

Our method to distinguish sea level rise from subsidence involves radiocarbon dating of carefully interpreted deltaic facies in deep continuous borings recovered across delta plains. Particularly useful are peats and organic-rich (marsh and lagoon) layers which accumulated within about 50 cm from sea level. These dated horizons (Fig. 1) serve as distinct markers, and the depth of these strata in borings is compared to a series of eustatic sea level curves defined on the basis of a survey of such curves in different world oceans (numerous publications in the literature). We find that, almost inevitably, the age of these peaty facies which underlie outer delta plains occur at depths considerably greater than is indicated from the eustatic curves. Thus, if one subtracts the depth expected from an averaged sea level stand for a specific time period from the actual depth of recovery in the boring below mean sea level, one can obtain the amount of lowering (by compaction or isostatic depression, or both) since the time of deposition of a specific layer. This method indicates rates of subsidence in the northern Nile Delta ranging from 0.1 to 0.5 mm per year (Fig. 2).

Projected rates of sea level rise resulting from global climate change remain a source of contention. Regardless of such eustatic projections, our results indicate that the seaward margins of Mediterranean deltas are experiencing subsidence. This fact, coupled with the reduction of sediments carried by some of the principal rivers, is resulting in erosion leading to wetland loss. An equally serious consideration is the landward progression of saline groundwater and decreased agricultural productivity. In view of the serious consequences, an international effort is being initiated at the Smithsonian to monitor the evolution of different delta margins in the Mediterranean.

Examples of subsidence affecting the northern Nile delta of Egypt *(modified after D.J. Stanley, 1990. "Recent subsidence and northeast tilting of the Nile delta, Egypt." Marine Geology, 94:147-154)*

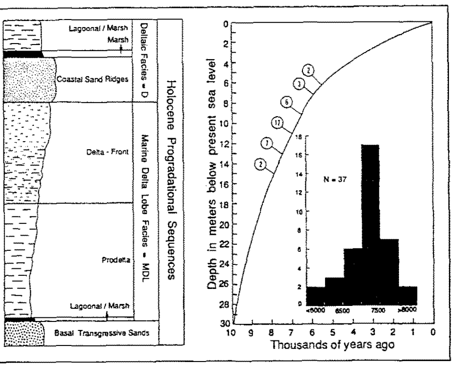

Fig. 1. Left: Generalized Holocene sequence on lithostratigraphic log showing MDL and D facies above basal transgressive sands. Right: Age of the base of the Holocene mud sequence above the transgressive sands. Histogram shows range of dates in yrs B.P., and these data are plotted on the eustatic sea level curve after Lighty et al. (1982).

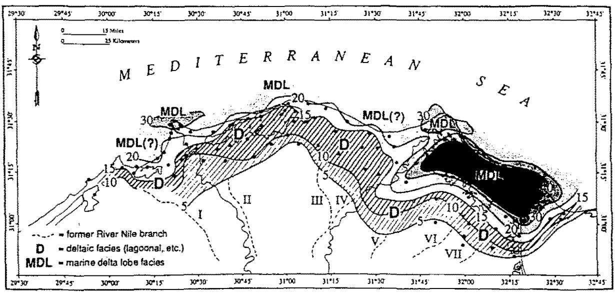

Fig. 2. Isopach map showing sediment thickness of mid-Holocene to present age lying above basal transgressive sands. D and MDL denote sediment facies depicted in Fig. 2. Contours in meters. Traces of former River Nile branches (after Toussoun, 1922, and Said, 1981): I=Canopic; II=Saitic; III=Sebennitic; IV=Bucolic; V=Mendesian; VI=Tanitic; VII=Pelusiac.