Geophysical Research Abstracts
Vol. 17, EGU2015-9074, 2015
EGU General Assembly 2015

The evolution of the Sf. Gheorghe (Danube) asymmetric deltaic lobe in association with the cyclic development of a river-mouth bar and present adaptations to human-induced sediment depletion

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The asymmetric Sf. Gheorghe lobe is the only active lobe in the Danube delta associated with a river mouth bar (and related barrier islands and spits) that has continuously deployed a cyclic development during the last 1500 years. During the early cycles, Sf. Gheorghe distributary experienced a significant increase in sediment load (by an order of magnitude) as a result of the successive avulsions of the neighboring branches Împuţita (southern distributary of the Sulina arm) and Dunavăţ (1.5 – 1.2 ka ago). Morphological and sedimentological analyses together with a newly obtained chronology throw light on the multiple ridgeset (10) structure of Sf. Gheorghe deltaic lobe, each ridgeset closely following a common evolutionary pattern reflected by the cyclic succession of the same stages: i) subaqueous mouth bar building, ii) barrier island emergence, iii) transformation into a barrier spit with several secondary spits. The spits become encased into the muddy deltaic plain as narrow sandy ridges building out on the downdrift side of the lobe as a barrier-marsh plain, whereas the updrift side constantly accreted fed by longshore currents, forming a classic beach ridge plain. The size of each ridgeset increased exponentially with every new cycle due to the constant lengthening of the coastline as the downdrift side of the lobe advanced seaward through a series of progressively larger similar quadrilaterals, yielding a geometric progression of the delta front size. Even though each newly formed ridgeset (cycle) had a longer lifespan (the latest cycles lasting 4 – 5 times longer than the first ones: 280 – 380 years versus 50 – 80 years), the evolutionary model remained unchanged as long as the balance between wave- and river-borne sediments, defined by the sedimentary index (Si), maintained constantly low ($Si \leq 0.1$), whereas the mean advancing rates of the river mouth remained constant at 10 m/yr. Abrupt changes occurred within the last cycle (since the beginning of the 20th century) as a consequence of human-induced depletion of sediment supply by the Danube flow and mainly expressed by the complete cessation of the updrift coastal progradation and the prevalence of erosion in front of the river mouth. These changes, which accompany a threefold rise of the Si (0.37 in the present), are reflected by the recent (1930s – present) river mouth dynamics, characterized by cessation of its long-term seaward expansion in favour of downdrift migration, indicating the transition of the Sf. Gheorghe mouth from an asymmetric to a deflected wave-influenced delta morphology, whose current developments mark a significant change in the multicentennial cyclic evolutionary pattern. The asymmetric to deflected transition reflects the net increase in the influence of wave-driven sediment circulation on river mouth morphology, corresponding to a critical Si threshold of ca. 0.2 (≤ 0.2: asymmetric; > 0.2: deflected).