SEDIMENTATION IN A DISEQUILIBRIUM RIVER-DOMINATED ESTUARY. THE RASA RIVER KARSTIC ESTUARY (CROATIA)

Mladen JURACIC[1], Ivan SONDI[2], and Velimir PRAVDIC[2]

[1]Department of Geology, Faculty of Science, University of Zagreb, Zvonimirova 8
[2]Center for Marine Research, Ruler Boskovic Institute, Bijenicka 54
41000 Zagreb, Croatia

The paper describes sedimentation of terrigenous suspended matter in a small, rock-bounded, low-tidal estuary in the Croatian karst region : the Rasa River mouth in the northeastern Adriatic. It can be regarded as a model example of a disequilibrium river- (or input-) dominated estuaries (FAIRBRIDGE, 1980; KING, 1980).

Most of the incoming particulate material (more than 90 percent) is brought into the estuary as suspended matter, rather than as bed load. Suspended matter originates from the intensive weathering of Eocene flysch marls in the upper part of the drainage area (only 106 km^2 out of total 205 km^2) and, occasionally, from strong karst springs having catchment areas beyond the Rasa River topographic drainage area. The estuary is characterized by rapid sedimentation of fine grained, mostly clay mineral particles (BOLDRIN *et al.*, 1992; JURACIC, 1992). The rapid sedimentation in this salt-wedge estuary is enhanced by flocculation of fine-grained particles. A progradation of the estuarine (or bay-head) delta shown in Fig. 1.

A quantification of sediment accumulation in the prodelta zone (3 km long) indicates a mean load of approximately 80.000 t/y during the last thirty years (SONDI *et al.*, 1994). Classification schemes of transitional fluvio-marine environments, including estuaries (DALRYMPLE *et. al.*, 1992), and the conceptual classification of estuarine morphologies (COOPER, 1993) are considered.

On the basis of the results of investigations in the Rasa River estuary, it is proposed as a new typical model for disequilibrium river-dominated estuaries.

Indeed on the basis of its characteristics, it should be the foremost example of fluvial (input) dominated estuaries in the classification scheme in the ternary diagram involving wave, tidal and fluvial processes.

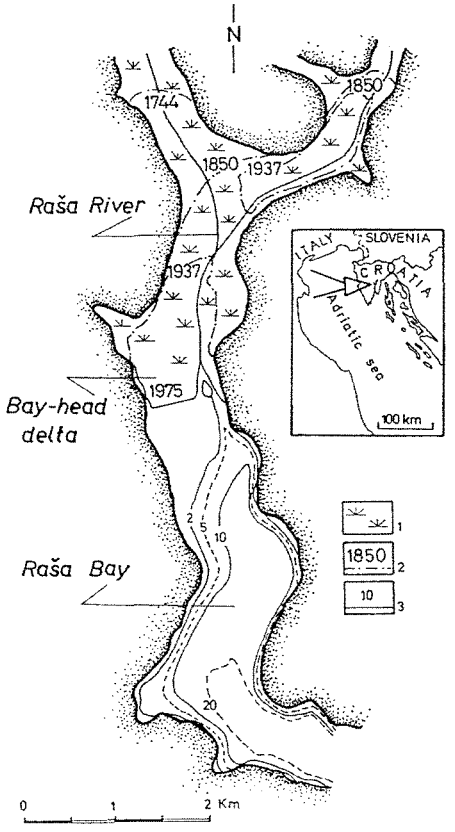

Fig.1. The Rasa River mouth. The time dependent filling of the rock bounded estuary is shown with indication of estuarine delta progradation: 1. alluvial sediments 2. historic progradation indicated by shore positions in respective years (after BENAC *et al.*, 1991); 3. recent isobaths in meters.

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THE DEPOSITIONAL ENVIRONMENTOF THE EVAPORITE MINERAL SERIES AT TUZLA, BOSNIA-HERCEGOVINA

G. KNIEWALD[1,2], V. BERMANEC[3] and D. TIBLJAS[3]

[1] Center for Marine Research Zagreb, Rudjer Boskovic Inst., 41000 Zagreb, Croatia
[2] Inst. of Applied Physical Chemistry, Research Center Juelich, 52425 Juelich, Germany
[3] Department of Mineralogy and Petrology, Faculty of Sciences, University of Zagreb, 41000 Zagreb, Croatia

Evaporites may occur in a variety of environmental settings ranging from coastal intertidal and supratidal zones (sebkhas), small coastal or atoll lagoons, deeper marine basins, sub-sealevel basins with marine inflow and non-marine interior basins. The tectonic and palaeogeographic circumstances span continental margins and shelves, interior cratonic basins and rifted continental margins. It is also highly interesting to note that evaporites having the mineralogy of non-marine facies sequences are rather rare in rocks older than Tertiary age.

The Tuzla salt deposit is located in the north-eastern part of Bosnia and Hercegovina and is the largest rock salt reservoir on the Balkan peninsula. The essentially stratified salt-dome type deposit is of middle Miocene age, hosted in a sedimentary series of banded halite and anhydrite. In spite of the rather well known geological setting of the occurence, there is no unambiguous evidence as to the depositional environment in which the evaporites formed. The geochemistry of coexisting brines and their saturation states imply that the formation environment may be interpreted in terms of the mixing-zone model, as opposed to the end-member marine or salt-lake type deposits (BERMANEC *et al.*, 1992). However, the close relationship of the evaporite series and associated dolomitic limestones, and evidence of progressive dolomitization may account for their formation under evaporative, non-evaporative or seepage reflux conditions (HARDIE and EUGSTER, 1971).

The mineral paragenesis of the evaporite series consists of halite, thenardite and anhydrite. The $a(H_2O)$ indicator couple is thenardite-mirabilite. In addition, several accessory minerals are present in varying amounts - the assemblage, as well as possible lithotype indicator minerals are being studied in detail (KNIEWALD *et al.*, 1986; BERMANEC *et al.*, 1992). Moreover, a new mineral with a pentaborate sheet structure has been discovered in the assemblage and was named tuzlaite (BERMANEC *et al.*, 1994). Its formation and stability are as yet unclear, but there are indications that diagenetic changes could have effectuated the nucleation kinetics of the normal succession of borate minerals in the sequence, resulting in the precipitation of tuzlaite.

The textures of the Tuzla anhydrite sequence provide no direct evidence that anhydrite might have grown directly from the brine. Gypsum is largely absent from the main evaporitic series, although some is associated with laterally correlated breccias indicating that the anhydrite-gypsum ratio was equilibrated over a series of metastable phases. Probable burial of an initially formed gypsum series and a consequent temperature rise due to the geothermaol gradient inevitably causes the transition to anhydrite. There is no evidence of ensuing rehydration, except - perhaps - in the case of the breccias described above. These characteristics can hint at the conclusion that uniformly lamellar anhydrite (or sulphate-carbonate sequence) formed in a protected "low energy" environment, usually to be understood in terms of a deep water basin, below the wave base. On the other hand, sharp brine stratification in an evaporite basin can attenuate wave motion at depths less than those expected for a uniform water column. The other type of intermediate anhydrite features irregularities characteristic of clastic sedimentation, such as ripples and cross bedding. In the case of anhydrite textural evidence is still ambiguous or conflicting.

Further studies, particularly involving the isotopes of sulphur and oxygen in the evaporites and limestones, should provide the rationale for a tenable assessment of the depositional setting of the Tuzla evaporite series.

ACKNOWLEDGEMENTS.

Part of this research was facilitated through a research fellowship awarded to GK by the Alexander von Humboldt Foundation of Bonn, Germany. Additional support was administered by the International Bureau of the Research Center (KFA) Juelich within the framework of the joint project Environmental Research in Aquatic Systems.

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